2. Consideration of a Cooperation Strategy for Electric Power and Cross-Sector Initiatives toward the Realization of a Low-/de-carbonized Society

2.1 Review of JICA Cooperation Projects

2.1.1 Creation of Table of Issues/Challenges Based on a Review of Past JICA Projects

Past projects implemented by JICA related to the transition to low carbon/decarbonization were extracted for a review of public-private partnership projects, ODA projects (loan/grant aid) and technical cooperation projects. Based on the details of this survey, as shown below, development strategic objective, mid-term objective, mid-term sub-targets, and project example activities in the area of transition to low carbon/decarbonization have been organized in an issue classification table.

The development strategic objective was largely divided into three broad categories of electric power supply side decarbonization, including power generation, transmission and distribution, electric power demand side low- and de-carbonization, including the transportation and industry sectors, and transition to low carbon/decarbonization in both power supply and demand.

As a sector where JICA is already active, the mid-term objective for the transition to low carbon/decarbonization on the supply side was set as “Promoting the introduction of renewable energy,” “Provision and enhancement of systems toward the system integration of renewable energy,” “Low-carbonization of thermal power generation,” and “Low-carbonization of primary energy supply.”

The mid-term objective for the transition to low carbon/decarbonization on the demand side was largely divided into those of the transportation sector, industry sector, and urban development sector and the overall objective was set as “Promoting energy efficiency on the demand side.”

In the sector with regard to the transition to low carbon/decarbonization, which involves both power supply and demand, the common mid-term objectives necessary to achieve low carbon and decarbonized society were set as “Formulating a long-term energy plan,” “Use of CCS/CCUS” and “Initiatives toward the production and storage of hydrogen,” although not much support has been provided so far.

Table 154 Issues Classification Table

Development Strategic Objective	Mid-Term Objective	Mid-Term Sub-Targets	Project Example Activities
Transition to low carbon/decarbonization on the supply side	Promoting the introduction of renewable energy	Formulation of policies and systems for power generation infrastructure (inc. hydropower)	✓ Support for formulation of energy master plan and power supply plan ✓ Support for provision of systems relating to renewable energy
		Demonstration project for development and enhancement of power generation infrastructure	✓ Implementation of demonstration project to support the introduction of renewable energy

		Personnel training for development and enhancement of power generation infrastructure	✓ Training of engineers through the installation of renewable energy facilities ✓ Provision of advisory services for the promotion of private sector investment in renewable energy ✓ Investigation of finance schemes for the promotion of private sector investment in renewable energy
	Power system development and upgrading for grid integration of renewable energy	Institutional improvements related to the electric power system	✓ Support for national unified grid code (Bulk system + Distribution system) ✓ Support for the creation of a supply and demand management system(ancillary services market, capacity mechanisms, etc.)
		Grid planning including transmission and substation facilities, etc.	✓ Support for grid planning and enhancing system operating capacity ✓ Support for system stabilization by providing power transmission and substation facilities, etc.
		Upgrading of power distribution facilities	✓ Support for the formulation of a power distribution plan for efficient and economic distribution ✓ Support for upgrading of distribution system
		Provision of international electricity grid interconnection	✓ Support toward provision of international electricity grid interconnection
		Electric power sector reforms	✓ Consideration to unbundled power generation and transmission, and Support for financial and business improvement of off-takers

		Responding to the introduction of large-scale renewable energy by means of energy market liberalization	✓ Support for formulation of a plan for upgrading system operations (use of DR/VPP, etc.)
	Low-carbonization of thermal power generation	Higher-efficiency of thermal power generation	✓ Support toward higher efficiency of thermal power generation ✓ Support toward enhancement of Automatic Generation Controller (AGC) functions
		Demonstration project toward the use of alternative energy	✓ Implementation of demonstration projects related to ammonia co-combustion and hydrogen co-combustion ✓ Implementation of demonstration projects related to biomass utilization
	Low-carbonization of primary energy supply	Improvement of the efficiency of natural gas supply	✓ Support for formulation of master plan to promote the popularization of natural gas (system digitization, etc.)
		Promotion of research into the transition to low carbon/decarbonization of primary energy	✓ Support for strengthening the safety management and operation capacity and improving regulations of LNG terminals ✓ Research on the conversion of biomass into fuels
Transition to low carbon/decarbonization on the demand side	Low carbonization in the transportation sector	Policy and legal system preparation toward the introduction of electric vehicles (EVs)	✓ Studies of policies toward tighter control of exhaust emissions ✓ Studies of subsidies and tax incentives for the promotion of the use of EVs ✓ Support for the development of standards for storage batteries and systems for their reuse and recycling ✓ Support for the formulation of plans for the provision and expansion of renewable

			energy storage facilities and EV charging stations
		Modal shift toward public transportation	✓ Support for the formulation of plans for the promotion of the use of public transportation services ✓ Support toward the electrification and use of FC (fuel cells) by public transportation services (rail and buses, etc.) ✓ Support for the formulation of plans for the construction of intercity high-speed railway services
		Use of alternative fuels	✓ Support to promote the use of biofuel/synthetic fuel
		Higher efficiency of transport and transportation sector	✓ Sharing various optimization policies from the Japanese transport and transportation sector (through a variety of trainings)
	Promotion of energy efficiency in the industry sector	Reduction of fossil fuels in the industry sector	✓ High efficiency steel manufacturing (technical support, system support) ✓ Hydrogen DRI ✓ Ammonia production by means of green hydrogen materials ✓ Boiler heat pump conversion ✓ Support for the development of energy management systems

	Promotion of energy efficiency in urban development (buildings)	Promotion of energy efficiency in residential buildings	✓ Formulation of ZEB/ZEH promotion policies/plans and support for system introduction ✓ Financial support for ZEB/ZEH promotion ✓ Support for area development (including smart cities and smart grids) ✓ Support for promotion of energy efficiency in buildings (inc. support for green buildings and provision of building codes) ✓ Boiler heat pump conversion
	Promotion of energy efficiency on the demand side	Promotion of energy efficiency	✓ Support for the introduction of energy efficiency technology and equipment ✓ Support for the formulation and awareness of systems for energy efficiency management, energy efficiency standards and high-efficiency equipment (efficiency standards and labelling systems), and support for training, establishing and managing training centers ✓ Implementation of a high-efficiency air conditioner pilot project (as part of the program) ✓ Support for the formulation of an energy efficiency master plan ✓ Provision of two-step loans for the promotion of energy-efficiency
Transition to low carbon/decarbonization that involves both supply and demand	Formulating a long-term energy plan	Formulation of long-term plan for energy as a whole	✓ Support for the formulation of a long-term energy plan for carbon neutrality
		Energy data management	✓ Support to enhance energy data management systems

	Utilization of CCS/CCUS	CO_2 storage and use	✓ Studies of underground storage of carbon dioxide
	Initiatives toward the production and storage of hydrogen	Utilization of hydrogen	✓ Consideration given to the use of green hydrogen

(1) Transition to Low Carbon/Decarbonization on the Supply Side (development strategic objective)

A) Promoting the Introduction of Renewable Energy (mid-term objective)

Initiatives on the electric power supply side are essential to realize the transition to low carbon/decarbonization and there is also a need for initiatives to introduce renewable energy to meet the increasing demand for electric power. Therefore, the first priority is given to stimulating the introduction of renewable energy as a mid-term objective.

The three sub-targets have been set as specific approaches: (1) formulation of policies and systems for power generation infrastructure (inc. hydropower), (2) demonstration project relating to the construction and upgrading of power generation infrastructure, and (3) personnel training relating to the construction and upgrading of power generation infrastructure.

(1) Formulation of Policies and Systems for Power Generation Infrastructure (inc. hydropower) (mid-term sub-targets)

To promote the introduction of renewable energy, there are still issues in developing countries in terms of policies and systems such as specific introduction plans not being formulated and rules about grid connection not being established. In contrast, JICA has conducted numerous projects to support the formulation of electric power master plans and power supply plans, as well as the institutional improvement for renewable energy introduction, and this kind of support will continue to be effective.

Table 155 Examples of demonstration projects relating to power generation infrastructure (inc. hydropower)

Project Example Activities	Past Results (*)	Support Scheme
Supporting the formulation of electric power master plans and power supply plans	◎	Technical Cooperation
Supporting the institutional improvement for renewable energy introduction	◎	Technical Cooperation

*

◎ ＝ Many projects that include “Project example activities” (Approximately 10 in the past.)

○ ＝ Around 5 projects that include “Project example activities” (not many)

△ ＝ Small number of projects that include “Project example activities ”

× ＝ “Project example activities ,” currently not existing, but expected to be implemented in the future. (Same applies hereafter)

(2) Demonstration Project Relating to the Construction and Upgrading of Power Generation Infrastructure (mid-term sub-targets)

When installing equipment and facilities that have not been installed so far, or when verifying new technology, it is essential to measure and confirm the effectiveness of the project on a pilot basis under specific local conditions. Until now, JICA has achieved many relevant support outcomes, including small hydropower generation projects and rural electrification projects.

Table 156 Examples of demonstration projects relating to the construction and upgrading of power generation infrastructure

Project Example Activities	Past Results (*)	Support Scheme
Implementation of demonstration project toward supporting the introduction of renewable energy	◎	Technical Cooperation, PPP, Financial Cooperation

(3) Personnel Training Relating to the Construction and Upgrading of Power Generation Infrastructure (mid-term sub-targets)

In order to ensure long-term equipment maintenance and facility O&M, it is necessary to provide training for local personnel not only at the time of their introduction but also afterwards. One such example is the training of technicians/engineers through the introduction of renewable energy facilities.

Due to the increasing need in the target countries for not only local government-led renewable energy introductions but also involvement of private sector in its promotion, new projects to be tackled in the future include advisory services to promote private sector investment where no such investment is being implemented, and the investigation of finance schemes for the promotion of private sector investment.

Table 157 Examples of demonstration projects relating to personnel training of the construction and upgrading of power generation infrastructure

Project Example Activities	Past Results (*)	Support Scheme
Training for engineers/technicians through the introduction renewable energy facilities	◎	Technical Cooperation, PPP
Provision of advisory services for the promotion of private sector investment in renewable energy	×	Technical Cooperation, PPP
Investigation of finance schemes for the promotion of private sector investment in renewable energy	×	PPP

B) Power System Development and Upgrading for Grid Integration of Renewable Energy (mid-term objective)

As the introduction of renewable energy progresses, there will be a greater need for power system stabilization. In reality, in many countries, as the share of renewable energy increases, challenges arise, such as the inability to ensure the quality of electricity (frequency, voltage, etc.).

In terms of specific approaches in this regard, six sub-targets have been set, namely, (1) the institutional improvements related to the electric power system, (2) grid planning including transmission and substation facilities, etc. (3) upgrading of power distribution facilities, (4) provision of international electricity grid interconnection, (5) electric power sector reforms and (6) responding to the introduction of large-scale renewable energy by means of energy market liberalization.

(1) Institutional Improvements Related to the Electric Power System (mid-term sub-targets)

In order to support the establishment of power supply-demand management systems, in addition to institutional improvements through technical cooperation, it would be effective to consider the development of an ancillary service market in cooperation with private businesses. Although only a limited number of projects have been implemented until now, example projects include support for national unified grid codes, and support for the creation of a supply-demand management system (ancillary services market and capacity mechanisms, etc.), which is an area with no existing results.

Table 158 Examples of demonstration projects relating to the electric power system

Project Example Activities	Past Results (*)	Support Scheme
Support for national unified grid code (Bulk system + Distribution system)	△	Technical Cooperation
Support for the creation of a supply-demand management system (ancillary services market and capacity mechanisms, etc.)	×	Technical Cooperation, PPP

(2) Grid Planning Including Transmission and Substation Facilities, etc. (mid-term sub-targets)

There are many experiences of support for power transmission and substation facilities, with project example activities including support for grid planning and enhancing system operating capacity, and support for system stabilization by providing power transmission and substation facilities, etc. When installing and upgrading equipment/facilities, support that combines public-private partnership and financial cooperation will be needed.

Table 159 Examples of demonstration projects relating to grid planning including transmission and substation facilities, etc.

Project Example Activities	Past Results (*)	Support Scheme
Support for grid planning and enhancing system operating capacity	◎	Technical Cooperation
Support for system stabilization by providing power transmission and substation facilities, etc.	◎	Technical Cooperation, PPP, Financial Cooperation

(3) Upgrading of Power Distribution Facilities (mid-term sub-targets)

As the introduction of renewable energy progresses, there is a greater need for personnel training in connection to power distribution planning and operation. Specific support includes technical cooperation to facilitate the formulation of a power distribution plan for efficient and economic distribution.

Table 160 Examples of demonstration projects relating to upgrading of power distribution facilities

Project Example Activities	Past Results (*)	Support Scheme
Support for the formulation of a power distribution plan for efficient and economic distribution	◎	Technical Cooperation

(4) Provision of International Electricity Grid Interconnection (mid-term sub-targets)

Investigations of international electricity grid interconnection are carried out in every country toward ensuring the ability to meet the demand for electricity that increases in line with economic growth and toward preparing countermeasures for wide-area system stabilization. In this regard, the first priority example is that of support for the formulation of a plan in connection to the international grid interconnection by means of technical cooperation.

Table 161 Examples of demonstration projects relating to provision of international electricity grid interconnection

Project Example Activities	Past Results (*)	Support Scheme
Support toward provision of international electricity grid interconnection	△	Technical Cooperation

(5) Electric Power Sector Reforms (mid-term sub-targets)

In order to aim for transition to low carbon/decarbonization on the supply side, it will be necessary to carry out investigations into the participation of private business in the future, for example, and ensuring the health of the power sector is a prerequisite for this. In reality, due to inappropriate electric power fee settings, a low fee collection ratio, and high-level distribution loss, for example, the situation arises whereby it is not possible ensure a sufficient income for electric power companies. In response to this, as an initiative to improve corporate finances, the necessary activities include investigating unbundled power generation and transmission, including electric power company organizational reforms and power plant privatization, and support for financial and business improvement of off-takers.

Table 162 Examples of demonstration projects relating to electric power sector reforms

Project Example Activities	Past Results (*)	Support Scheme
Consideration to unbundled power generation and transmission, and Support for financial and business improvement of off-takers	△	Financial Cooperation

(6) Responding to the Introduction of Large-Scale Renewable Energy By Means Of Energy Market Liberalization (mid-term sub-targets)

As solar photovoltaic power generation, residential fuel cells and batteries, and electric vehicles become more widely available, there is a greater need for the establishment of a system for utilizing consumer energy resources in the electric power system including demand response (DR) and virtual power plants (VPP). An example of these activities is the formulation of a plan for upgrading system operations through technical cooperation (use of DR and VPP, etc.).

Table 163 Examples of demonstration projects relating to responding to the introduction of large-scale renewable energy by means of energy market liberalization

Project Example Activities	Past Results (*)	Support Scheme
Support for formulation of a plan for upgrading system operations (use of DR/VPP, etc.)	△	Technical Cooperation

C) Low-carbonization of thermal power generation (mid-term objective)

For thermal power generation, which accounts for the major part of total power generation in many countries, initiatives for the low-carbonization of thermal power generation itself are being considered, and the need for more efficient power generation is increasing more than ever. On the other hand, current initiatives are inadequate due to the lack of specific low-carbon and decarbonization technologies and insufficient local technical expertise for efficient operation.

Two sub targets have been set as specific approaches in this regard: (1) Higher efficiency of thermal power generation, and (2) Demonstration project toward the use of alternative energy .

(1) Higher Efficiency of Thermal Power Generation (mid-term sub-targets)

Many countries and regions have policies to achieve a transition to low carbon/decarbonization by increasing the efficiency of existing coal fired power generation and gas fired power generation. JICA has provided extensive support through public-private partnership and financial cooperation in this area, and there should be no change to the continuation of this kind of support in the future. In addition, although there have been no track records to date, the development of support for strengthening AGC (automatic generation control) functions that allow grid operators to detect load fluctuations on the grid and modify the output to stabilize frequency is another example activity.

Table 164　Examples of demonstration projects relating to higher efficiency of thermal power generation

Project Example Activities	Past Results (*)	Support Scheme
Support toward higher efficiency of thermal power generation	◎	PPP, Financial Cooperation
Support toward enhancement of Automatic Generation Controller (AGC) functions	×	Financial Cooperation

(2) Demonstration Project Toward the Use of Alternative Energy　(mid-term sub-targets)

In addition to the numerous existing records from supporting biomass utilization in projects related to alternative energy utilization, the implementation of demonstration projects related to ammonia co-combustion and hydrogen co-combustion for thermal power generation is another example activity that should be implemented in the future. Ammonia co-combustion and hydrogen co-combustion are technologies that aim to achieve low-carbonization by means of existing thermal power generation, which is attracting much attention worldwide, and demonstration projects are also underway in Japan.

Table 165　Examples of demonstration projects relating to the use of alternative energy

Project Example Activities	Past Results (*)	Support Scheme
Implementation of demonstration projects related to ammonia co- combustion and hydrogen co- combustion	×	Technical Cooperation
Implementation of demonstration projects related to biomass utilization	◎	Technical Cooperation, PPP

D) Low-Carbonization of Primary Energy Supply (mid-term objective)

Studies of the low-carbonization of the supply of natural gas as primary energy, in particular, are required in order to aim for energy utilization that contributes to greater low-carbonization by improving the efficiency of energy supply.

Two sub targets are set as specific approaches in this regard: (1) Improvement of the efficiency of natural gas supply, and (2) Promotion of research into the transition to low carbon/decarbonization of primary energy.

(1) Improvement of the Efficiency of Natural Gas Supply (mid-term sub-targets)

Many countries use imported natural gas because it can be liquefied for ease of transportation. Countermeasures to improve the efficiency of the natural gas supply include formulating a master plan to promote the popularization of natural gas and strengthening the safety management and operation capacity and improving regulations of LNG terminals.

Table 166　Examples of demonstration projects relating to improvement of the efficiency of natural gas supply

Project Example Activities	Past Results (*)	Support Scheme
Support for formulation of master plan to promote the popularization of natural gas (system digitization, etc.)	○	Technical Cooperation
Support for strengthening the safety management and operation capacity and improving regulations of LNG terminals	×	Technical Cooperation, Financial Cooperation

(2) Promotion of Research into the Transition to Low Carbon/Decarbonization of Primary Energy (mid-term sub-targets)

Many studies into the conversion of biomass into fuels, in particular, are being conducted, and it will be necessary to consider the utilization of wood, waste oil, and palm trees in response to local conditions.

Table 167 Examples of demonstration projects relating to promotion of research into the transition to low carbon/decarbonization of primary energy

Project Example Activities	Past Results (*)	Support Scheme
Research on the conversion of biomass into fuels	○	Technical Cooperation

(2) Transition to Low Carbon/Decarbonization on the Demand Side (Development strategic objective)

A) Low-Carbonization in the Transportation Sector (mid-term objective)

In terms of the transportation sector, which is the demand side, initiatives for low- and de-carbonization, particularly in railroad and automobiles (buses and trucks), are being considered. Low-carbonization in the transportation sector is set as a mid-term objective to be achieved through the introduction of new technology and improvement of the efficiency of existing systems.

Four sub targets are set as specific approaches: (1) Policy and legal system preparation toward the introduction of electric vehicles (EVs), (2) a modal shift toward public transportation, (3) use of alternative fuels, and (4) higher efficiency of transport and transportation sectors.

(1) Policy and Legal System Preparation Toward the Introduction of Electric Vehicles (EVs) (mid-term sub-targets)

Although there are no records from assistance projects relating to electric vehicles, this is a sector where the need will continue to increase as the use of electric vehicles expands in the future. Major example projects include the studies of policies toward tighter control of exhaust emissions and studies of subsidies and tax incentives for the promotion of the use of EVs , and support for institutional development, including support for the development of standards for storage batteries and systems for their reuse and recycling . In addition, support through technical or financial cooperation is also effective in connection to the formulation of plans for the provision and expansion of renewable energy storage facilities and EV charging stations.

Table 168 Examples of demonstration projects relating to policy and legal system preparation toward the introduction of electric vehicles

Project Example Activities	Past Results (*)	Support Scheme
Studies of policies toward tighter control of exhaust emissions	×	Technical Cooperation
Studies of subsidies and tax incentives for the promotion of the use of EVs	×	Technical Cooperation
Support for the development of standards for storage batteries and systems for their reuse and recycling	×	Technical Cooperation
Support for the formulation of plans for the provision and expansion of renewable energy storage facilities and EV charging stations	×	Technical Cooperation, Financial Cooperation

(2) Modal Shift Toward Public Transportation (mid-term sub-targets)

Replacing freight transportation and human mobility using automobiles, such as trucks and buses, with the use of railroads, which has less environmental impact, can contribute to the transition to low carbon/decarbonization. Therefore, supporting the formulation of plans for the promotion of the use of public transportation and plans for the construction of intercity high-speed railway services is an effective method. Moreover, it is also effective to implement initiatives for the electrification of public transportation (railroads, buses, etc.) and the use of FC (fuel cell) at the same time.

Table 169 Examples of demonstration projects relating to modal shift toward public transportation

Project Example Activities	Past Results (*)	Support Scheme
Support for the formulation of plans for the promotion of the use of public transportation services	×	Technical Cooperation
Support toward the electrification and use of FC (fuel cells) by public transportation services (rail and buses, etc.)	○	PPP
Support for the formulation of plans for the construction of intercity high-speed railway services	×	Technical Cooperation

(3) Use of Alternative Fuels (mid-term sub-targets)

In the transportation sector, promoting the use of biofuel and synthetic fuel as alternative fuels for the low- and de-carbonization of fuels is one of successful example projects.

Table 170 Examples of demonstration projects relating to the use of alternative fuels

Project Example Activities	Past Results (*)	Support Scheme
Support to promote the use of biofuel/synthetic fuel	△	PPP

(4) Higher Efficiency of Transport and Transportation Sectors (mid-term sub-targets)

Japan has implemented many initiatives, such as the improvement of logistics efficiency and the use of IoT, in the transport and transportation sectors in Japan and has knowledge of various efficiency measures in the transport and transportation sectors. Examples of activities to utilize and share these findings include dispatching experts to the sites and conducting trainings in Japan.

Table 171 Examples of demonstration projects relating to higher efficiency of transport and transportation sectors

Project Example Activities	Past Results (*)	Support Scheme
Sharing various optimization policies from the Japanese transport and transportation sectors (through a variety of trainings)	◎	Technical Cooperation

B) Promotion of Energy Efficiency in the Industry Sector (mid-term objective)

As the demand side, the industry sector is one of the sectors where low- and de-carbonization have not fully spread in developing countries, and the urgent issues include not only technical support but also awareness campaigns to deepen the understanding of the transition to low carbon/decarbonization among related stakeholders and the preparation of various policies and systems, so promotion of energy efficiency in the industry sector is set as a mid-term objective.

As a specific approach, (1) the reduction of fossil fuels in the industry sector is set as a sub target.

(1) Reduction of Fossil Fuels in the Industry Sector (mid-term sub-targets)

There are numerous cases in which support for the development of energy management systems for promotion of energy efficiency has been provided. In addition to boiler heat pump conversion, it is necessary to further implement activities such as higher efficiency in steel production, steel production by means of hydrogen DRI, and ammonia production by green hydrogen materials as specific energy conservation measures in the future mainly through public-private partnerships.

Table 172 Examples of demonstration projects relating to the reduction of fossil fuels in the industry sector

Project Example Activities	Past Results (*)	Support Scheme
High efficiency steel manufacturing (technical support, system support)	×	Technical Cooperation, PPP
Hydrogen DRI	×	PPP
Ammonia production by means of green hydrogen materials	×	PPP
Boiler heat pump conversion	△	PPP
Support for the development of energy management systems	◎	Technical Cooperation

C) Promotion of Energy Efficiency in Urban Development (buildings) (mid-term objective)

In the urban development sector, in addition to the development of smart cities and smart grids being implemented in certain areas, due to the increasing need for energy conservation measures for commercial buildings, etc., promotion of energy efficiency in the urban development sector is set as a mid-term objective.

As a specific approach, (1) the Promotion of energy efficiency in residential buildings is set as a sub target.

(1) Promotion of Energy Efficiency in Residential Buildings (mid-term sub-targets)

Initiatives for low carbon/decarbonization on an individual building level, such as Net Zero Energy Building (ZEB) and Net Zero Energy House (ZEH), are spreading also in developing countries. Japan has been working on ZEB and ZEH for a long time and has gained experiences in the field of energy conservation in buildings, and can expand its experiences overseas. It is effective to also provide support for institutional improvements and area development to promote energy efficiency in buildings at the same time.

Table 173 Examples of demonstration projects relating to promotion of energy efficiency in residential buildings

Project Example Activities	Past Results (*)	Support Scheme
Formulation of ZEB/ZEH promotion policies/plans and support for system introduction	×	Technical Cooperation
Financial support for ZEB/ZEH promotion	×	Financial Cooperation
Support for area development (including smart cities and smart grids)	△	PPP
Support for promotion of energy efficiency in buildings (inc. support for green buildings and provision of building codes)	△	Technical Cooperation
Boiler heat pump conversion	×	PPP

D) Promotion of Energy Efficiency on the Demand Side (mid-term objective)

Shared challenges/issues on the demand side include how to educate a wide range of stakeholders about the importance of energy conservation, develop necessary policies and systems, and promote the introduction of energy efficiency technology and equipment. As a specific approach, a sub-target of (1) promotion of energy efficiency is set, with the aim of implementing cross-sectional initiatives in each sector on the demand side.

(1) Promotion of Energy Efficiency (mid-term sub-targets)

Although there have been many records of support for the introduction of energy efficiency technologies and equipment, institutional improvements for the introduction of energy efficiency management, energy efficiency standards, and high efficiency equipment, and for the formulation of an energy efficiency master plan, the needs in developing countries are still high, and it is effective to continue to provide support.

In addition, it is effective to consider the possibility of financial cooperation in the future, as the demand for funding for the introduction of energy efficiency equipment and facilities in developing countries is increasing.

Table 174 Examples of demonstration projects relating to promotion of energy efficiency

Project Example Activities	Past Results (*)	Support Scheme
Support for the introduction of energy efficiency technology and equipment	◎	Technical Cooperation, PPP
Support for the formulation and awareness of systems for energy efficiency management, energy efficiency standards and high-efficiency equipment (efficiency standards and labelling systems), and support for training, establishing and managing training centers	◎	Technical Cooperation
Implementation of a high efficiency air conditioner pilot project (as part of the program)	◎	PPP
Support for the formulation of an energy efficiency master plan	◎	Technical Cooperation
Provision of two-step loans for the promotion of energy efficiency	△	Financial Cooperation

(3) Transition to Low Carbon/Decarbonization that Involves Both Supply and Demand Sides (Development strategic objective)

A) Formulating a long-term energy plan (mid-term objective)

A common target for both the supply and demand sides is the development of a long-term energy plan to enable planning and implementation of the low carbon/decarbonization of energy as a whole while also providing support on the supply side and the demand side, respectively.

Two sub targets are set as a specific approach: (1) formulation of a long-term plan for energy as a whole and (2) energy data management.

(1) Formulation of a Long-Term Plan for Energy As a Whole (mid-term sub-targets)

In Japan, having formulated the Strategic Energy Plan (October 2021), long-term plans including issues and responses for the achievement of carbon neutrality by 2050 and policy measures for 2030 towards 2050 have been formulated by breaking it down into specific actions. On the other hand, although long-term targets for low carbon/decarbonization have been set in developing countries, few have been able to formulate a long-term plan for energy as a whole. To address these issues, it is effective to provide support for the formulation of a long-term energy plan for carbon neutrality.

Table 175 Examples of demonstration projects relating to formulation of a long-term plan for energy as a whole

Project Example Activities	Past Results (*)	Support Scheme
Support for the formulation of a long-term energy plan for carbon neutrality	×	Technical Cooperation

(2) Energy data management (mid-term sub-targets)

When formulating a plan for energy as a whole, energy data with a certain degree of reliability must be prepared. Since it is difficult to formulate a highly accurate plan without accurately preparing energy statistics, such as energy supply and demand and CO2 emissions records or trends, in chronological order, it is effective to provide support for strengthening energy data management systems as a countermeasure.

Table 176 Examples of demonstration projects relating to energy data management

Project Example Activities	Past Results (*)	Support Scheme
Support to enhance energy data management systems	△	Technical Cooperation

B) Utilization of CCS/CCUS (mid-term objective)

Initiatives such as CCS (Carbon dioxide Capture and Storage) that stores and injects CO2 into the ground and CCUS (Carbon dioxide Capture, Utilization and Storage) that utilizes separated and stored CO2 are being implemented on the supply side to reduce CO2 emissions mainly from thermal power generation and on the demand side to reduce CO2 emissions from industrial activities.

As a specific approach, (1) CO2 storage and use is set as a sub target.

(1) CO2 Storage and Use (mid-term sub-targets)

In order to proceed with CCS, it is necessary to find geological formations that can store a sufficient amount of CO2, and an effective approach is to investigate the geological storage of carbon dioxide.

Table 177 Examples of demonstration projects relating to utilization of CCS/CCUS

Project Example Activities	Past Results (*)	Support Scheme
Studies of underground storage of carbon dioxide	×	Technical Cooperation, PPP

C) Initiatives Toward the Production and Storage of Hydrogen (mid-term objective)

Initiatives such as fuel batteries utilizing hydrogen and air on the supply side and hydrogen and fuel vehicles that use hydrogen as energy on the demand side are being implemented. There is a growing need for the establishment of a hydrogen supply chain for decarbonization in various countries and regions.

As a specific approach, (1) the utilization of hydrogen is set as a sub target.

(1) Utilization of Hydrogen (mid-term sub-targets)

Hydrogen is classified by the type of production process. Hydrogen produced by water electrolysis using renewable energy is green hydrogen, and it is distinguished from blue hydrogen (a method to capture carbon dioxide before it is released into the atmosphere by splitting it into hydrogen and carbon dioxide through steam methane reforming, automatic pyrolysis, or another method) and grey hydrogen (the same production method as blue hydrogen but with the release of carbon dioxide into the atmosphere).

In addition to considering the utilization of green hydrogen, which is expected to be in high-demand, it is effective to include support for the establishment of a hydrogen supply chain from now on.

Table 178 Examples of demonstration projects relating to utilization of hydrogen

Project Example Activities	Past Results (*)	Support Scheme
Consideration given to the use of green hydrogen	×	Technical Cooperation, PPP

2.1.2 Recommendations for Business Promotion Through Public Private Partnership (PPP)

In order to provide a reference for the formulation of guidelines related to JICA's future assistance in the field of decarbonization, the Survey Team summarized the trends of assistance from other donors in the same field. The three target sectors are the increased introduction of renewable energy, increased energy efficiency, and hydrogen, for which there is a lot of interest in developing countries.

(1) Trends of Assistance from Other Donors in the Renewable Energy and Energy Efficiency Field

When identifying the target countries for the study, developing countries are classified by the share of renewable energy in the energy mix and the energy intensity[710] [711]. The 14 target countries are classified by this matrix and the support trends of other donors in each group are outlined after reviewing their characteristics[712].

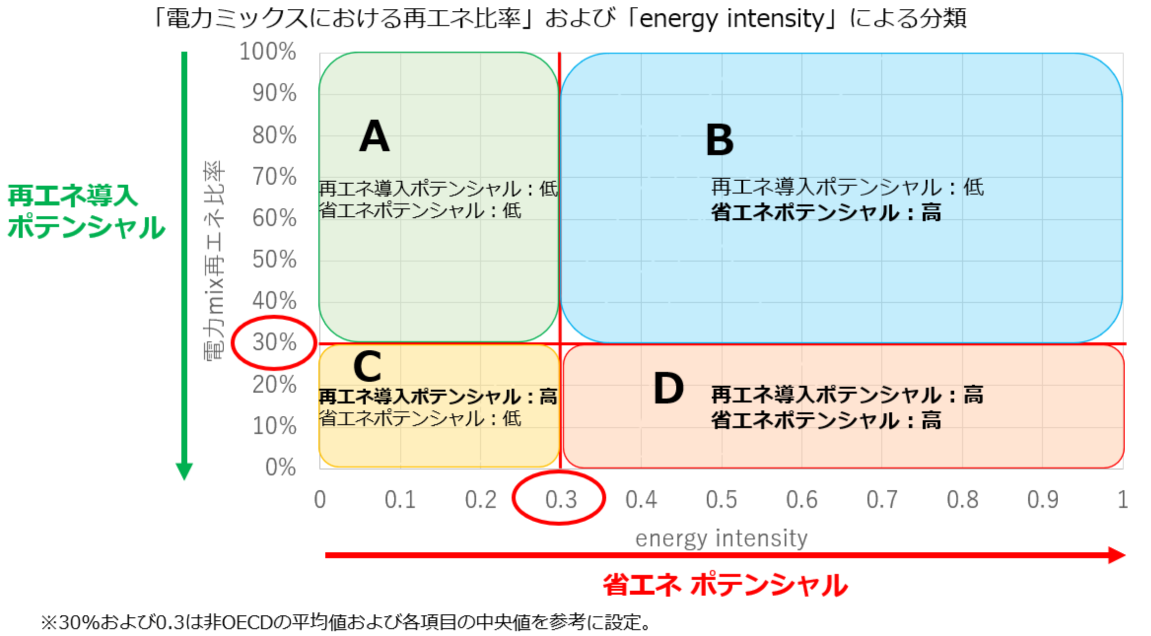

Figure 248　Four-Quadrant Classification by the Share of Electricity Generation from Renewables and Energy Intensity

The following research target countries are included in each group.

Group A：Group with a relatively high share of renewable energy and a relatively low energy intensity (high energy efficiency)

⇒Peru

Group B：Group with a relatively high share of renewable energy and a relatively high energy intensity (low energy efficiency)

⇒Cambodia, Myanmar, Laos, Viet Nam, and Mozambique

[710] Measure of energy conservation calculated by energy intensity = energy use/economic activity (GDP, etc.), with the smaller numbers signifying higher energy efficiency. (Reference) Energy intensity https://sustainablejapan.jp/2017/05/08/intensity/26728

[711] The thresholds of 30% renewable energy share and energy intensity of 0.3 are set based on the average values of non-OECD countries and the median for each item.

[712] The main targeted donors are the World Bank, Asian Development Bank (ADB), and *German Agency for International Cooperation* Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ).

Group C：Group with a relatively low share of renewable energy and a relatively low energy intensity (high energy efficiency)
⇒Indonesia, Philippines, Morocco, Bangladesh, and Egypt

Group D：Group with a relatively low share of renewable energy and a relatively high energy intensity (low energy efficiency)
⇒Thailand, South Africa, and India

(1) Supply side - Transmission and Distribution

Regarding the supply side, Multilateral Development Banks (MDBs) seem to have a mainstream policy of focusing on the expansion of renewable energy and not on the support for the higher efficiency of thermal power generation[713]. Additionally, in some cases, such as in India, the share of renewable energy exceeds 20% in some states, making grid (power system) stabilization an urgent issue, and support in connection to storage batteries is also seen.

Cases where the share of renewable energy in the composition of power generation sources exceeds 30% like Groups A and B are seen in countries with a high share of hydropower generation, not countries with a high share of variable renewable energy (VRE) such as solar power and wind power. Electricity shortages in the dry season are an issue in many countries in Asia, especially those with a high share of hydropower generation. However, it is expected that hydrogen will be utilized in the future, which can store electricity for a long period of time and at large capacities, and ADB is also conducting quantitative analyses using Nepal as an example (discussed later).

In addition, the introduction of digital technologies such as smart meters and smart grid is almost always included in the support menu in the transmission and distribution field.

(2) Demand Side

On the demand side, the transportation sector accounts for the largest share of energy consumption for all the groups. The support provided by MDBs is mainly EV related or for public transportation improvement. However, there are many issues/challenges such as the high cost of EVs and the development of charging infrastructure. As for the direction of the support JICA provides, it will be necessary to consider a well-balanced support menu that is not limited to EV introduction but that also includes the decarbonization of internal combustion engines (use of biofuel and synthetic fuel) in the countries with a high share of thermal power generation such as Groups C and D, given the possibility that the CO2 emissions reduction effect may not be significant if the LCA (Life Cycle Assessment) is used as a basis [714,715].

As for energy efficiency in the industry and commercial sectors and urban development sector, first of all, this includes the development of regulations and policies, and capacity building of related ministries and other agencies. Once these are settled, the issues are the lack of willingness to provide financing due to a low awareness of energy efficiency, the lack of know-how in financial institutions, and high risk. Support is therefore provided mainly in the form of (1) the development of legal systems and regulations and capacity building of related ministries and agencies, (2) raising awareness of energy efficiency and introduction of relevant technologies and processes (in the case of the ESCO business, capacity enhancement of ESCO) among private companies and financial institutions, and (3)

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[713] From interviews with decarbonization project research ADB, World Bank, etc.

[714] An approach to emission boundary. LCA includes CO2 emissions for the entire life cycle from the manufacturing stage of vehicles to the disposal stage.

[715] The Long-Term Vision for Global Warming Countermeasures by Japan Automobile Manufacturers Association also states that “Infrastructure needs to be developed to make BEV/PHEV/FCEV more widespread, and the low carbon/decarbonization of power generation sources and hydrogen is necessary to achieve the environmental performance of these electric vehicles, so we will proceed in cooperation with governments and energy suppliers. Decarbonization of internal combustion engines is another means of reducing CO2 emissions, and we will work to increase the efficiency of internal combustion engines and to develop new fuels with an eye to the future use of carbon-free biofuels and synthetic fuels.”https://www.jama.or.jp/eco/vision/index.html

provision of risk reduction tools (guarantees, etc.) for financing by financial institutions to encourage investment in energy efficiency, in accordance with the stage in which the target countries are situated (whether regulations have been developed, etc.).

As the direction for future support to be provided by JICA, support for the low-carbonization of industrial processes (e.g. using heat pumps for heat supply) may make a significant contribution if the industrial structures of the target countries match with the areas in which Japan has a competitive edge for energy efficiency and low-carbon technologies because such support is rarely seen from other donors. In addition, the Blended Finance Schemes discussed in the "JICA Data Collection Survey on Global Green Finance" are also expected to be utilized as a measure to encourage investment in energy efficiency.

(3) Miscellaneous

One of the characteristics of the support MDBs provide is that perspectives on gender equality promotion are added to individual projects. Whether it is a renewable energy project or energy efficiency project, they often include parts in connection to job training especially for women, for example. In view of the fact that the promotion of gender equality is also stated in JICA's Medium-Term Plan for FY2022 to 2027, consideration should be given to incorporating perspectives on gender equality promotion into each project in the decarbonization field as well.

（2） Characteristics of support provided by MDBs for each Group

1: Group A

The share of renewable energy of this Group exceeds 30%, and its energy intensity is less than 0.3. This group has a relatively high share of renewable energy and relatively high energy efficiency.

In many cases, the hydropower generation accounts for the largest share, and in terms of energy efficiency, cases can be seen where energy-intensive industries are simply not well-developed. Among the surveyed countries, Peru falls into this group.

(1) Characteristics of Energy Mix and Electric Power Market

As for the energy mix, the share of hydropower generation is considered to be high in many cases, but there are also cases where power shortages occur due to climate and weather conditions (drought, dry season, etc.). Also, in some cases, it will be necessary to develop power supply other than hydropower generation in order to address the increase in electricity demand caused by economic growth.

In Peru, domestic production of natural gas began at the end of the 1990s, and the share of natural gas has been increasing in the conventional energy mix that was mainly based on petroleum. The consumption of conventional biomass and other energy sources is declining as the economy develops. The challenge faced by Peru is to replace expensive imported LPG with domestically produced natural gas.

A common characteristic in South American countries is the high share of hydropower in total power generation. However, when droughts occur, the output of hydropower generation is reduced and power shortages occur. Therefore, the share of natural gas-fired power generation in Peru has increased alongside domestic natural gas production, and the share of coal-fired power generation is extremely low. Peru has a high poverty rate, so electric power supply through PV panels is promoted as an electrification countermeasure in areas where connection to the electric power grid is difficult.

The electric power market has been liberalized. In addition, power generation, transmission, and distribution are separated, and the structure is designed so that the same company cannot enter multiple sectors.

(2) Characteristics of Energy Consumption

Besides cases where there is low energy intensity but high energy efficiency, there may also be cases where energy-intensive industries are not well-developed.

Among the low-carbonization project research target countries, Peru falls into this category, but a breakdown of the country's final energy consumption by sector shows 30% in industry, 50% in transportation, 11% in residential, and 7% commercial/public services in 2019, showing that the transportation sector consumed the most energy. In the five-year growth from 2014 to 2019, transportation was the highest at 5.8%, followed by residential at 4.1%.

Peru has a low share of fossil fuels due to the lack of developed energy-intensive industries and low heat demand. Among the industries in Peru, electric power has the largest energy consumption, with a share of 42% in 2019.

(3) Trends in Support From Donors

In countries where the demand for electric power is further increasing, the development of power sources other than hydropower could be a challenge.

In Peru, where the share of renewable energy (hydropower generation) is high and the electric power market is liberalized, technical and institutional support are being provided, such as support for the introduction of digital technology into the electric power sector (smart grid, etc.) and reform of the regulatory frameworks of the electric power market, etc.

IDB is scheduled to provide institutional and technical support for electric power sector reforms in the period of 2020 to 2023. It includes (i) transformational development activities for the introduction of new technology and digitalization of Peruvian electric power sector, including reviews of regulatory frameworks from technical and economical perspectives, (ii) technical support for the multi-sectorial committee (CRSE) aimed at electric power sector reforms to advance the work plan and roadmap, and (iii) contributions toward the preparation of the White Paper (WP) and corresponding regulatory and legal sector reforms. The focus of the WP is on analyses and recommendations on the following four priority themes.

- Systems, energy planning, sectorial structure
- Wholesale markets, competition, ancillary services, storage
- Power transmission, international grid interconnections
- Power distribution (smart grid), decentralized power generation, retail competition

In addition, based on capacity-building of the Ministry of Energy and Mines, and a comprehensive approach covering technological, economic, environmental, and social issues, IDB is providing support for the development of a new sustainable energy matrix (NSEM) that meets Peru's development goals.

2: Group B

The share of renewable energy of this Group exceeds 30%, but its energy intensity is more than 0.3. Although the share of renewable energy is high, energy efficiency is relatively low, and improving energy efficiency will be the main challenge. Among low-carbonization project research target countries, Cambodia, Myanmar, Laos, Vietnam, and Mozambique fall into this Group.

(1) Characteristics of Energy Mix and Electric Power Market

As for the energy mix, the share of hydropower generation is considered to be high in many cases, but there are cases where power shortages occur due to climate and weather conditions (drought, dry season, etc.). Also, in some cases, it will be necessary to develop power supply other than hydropower generation in order to address to the increased electricity demand caused by economic growth.

The common characteristics of all of the low-carbonization project research target countries are a high share of hydropower generation, and the participation of the private sector primarily in power generation market (except for Mozambique).

Table 179 Group B Energy Mix and Electric Power Market Characteristics

	Characteristics of Energy Mix	Characteristics of Electric Power Market
Cambodia	Until around 2011, petroleum was the taking the lead, but from 2012 onwards, the use of hydropower increased, and from	Power generation/ transmission/distribution is being liberalized, and the private sector is now

	2013 onwards, the use of coal increased, with the ratio of oil-fired power decreasing to 4% in 2018. The supply capacity has been enhanced in line with the increasing demand for electric power centering on coal-fired power. Coal-fired power generation exceeded hydropower for the first time in 2015, and that trend continued thereafter but hydropower exceeded coal-fired power in 2018.	investing funds in power generation/power transmission.
Myanmar	Using a wealth of hydropower resources, hydropower generation accounts for approx. 50% of electric power generation. However, in recent years, due to concerns about the adverse impact on social and environmental aspects, hydropower development has stagnated, and development prospects have become unclear. Also, while gas-fired power development has recently been promoted, natural gas is a means of acquiring valuable foreign currency, and so, as of 2016, approx. 80% of domestic production is being exported to Thailand and China, which means that domestic resources are not necessarily being used within the country.	The generation, transmission, and distribution of electricity are segregated, and private investors (IPPs) are allowed to participate in the generation sector.
Laos	Until 2014, hydropower generation comprised 100%, but since the start of the operation of the Hongsa coal-fired power plant in 2015, the use of coal has increased, and, as of 2019, the share of coal-fired power has increased to 40%.	Although recognition was given for the participation of IPPs in power generation projects, power transmission/distribution is dominated by state-managed businesses.
Vietnam	Conventionally, hydropower took the lead due to the abundance of resources, but with the sudden increase in the demand for electric power from 2000 onwards, the development of thermal power generation, primarily coal, has progressed, and, as of 2019, coal-fired comprises 50% of generated electric power while hydropower comprises 28%.	Only power generation has been liberalized.
Mozambique	The share of hydropower in the energy mix is almost 80%. While power generation has been reliant on hydropower, from 2004 onwards, the production of natural gas has come into full effect, and its use in power generation has increased since 2013. In Mozambique, the ratio of access to electric power is low, at 35% (57% in urban areas, 22% in rural areas).	All power distribution and transmission are conducted by the state-managed EdM. In addition, Hidroeléctrica de Cahora Bassa (HCB), which was established by the Governments of Portugal and Mozambique in 1975, develops, operates and manages the Cahora Bassa dam, and there are also other IPP, as well as the power transmission company Mozambican Transmission Company (MOTRACO), which was established in 1988 with ⅓ investment from EdM, ⅓ from the South African state-managed ESKOM and ⅓ from Swaziland's SEC with the objective of supplying stable

		electricity to the aluminum smelting company MOZAL.

Source: Prepared by JICA Survey Team

(2) Characteristics of Energy Consumption

This Group has comparatively low energy efficiency. Depending on the level of economic development and the type of major industries, the industrial sector will consume a larger proportion of electricity. In the case that energy-intensive industries are developing (e.g. aluminum smelting in Mozambique), energy efficiency in the industrial sector will be a challenge.

All of the low-carbonization project research target countries are characterized by the high-energy consumption of the transportation sector. In Viet Nam, Myanmar and Mozambique, the industrial sector consumes the most energy.

Table 180 Group B Energy Consumption Characteristics

	Final Energy Consumption By Sector
Cambodia	In 2018, industry comprised 12%, transportation 61%, residential 11%, and commercial/public services 13%, showing that the transportation sector consumed the most. Commercial/public services had the largest average annual change from 2013 to 2018 at 38.4%, followed by industry at 22.4.
Myanmar	In 2019, industry comprised 36%, transportation 23%, residential 8%, and commercial/public services 8%. In 5-year growth between 2014 and 2019, despite the small amount of consumption, commercial/public services grew rapidly to 38.8% followed by industry at 13.6%, and residential at 14.7%.
Laos	In 2018, industry comprised 22%, transportation 61%, residential 10%, and commercial/public services 7%, showing that the transportation sector consumed the most. Transportation had the largest average annual change from 2013 to 2018 at 10.1%, followed by residential at 8.9%.
Vietnam	In 2019, industry comprised 51%, transportation 25%, residential 13%, commercial/public services 5% showing that industry consumed the most. In 5-year growth between 2014 and 2019, industry had the greatest growth at 7.7% followed by transportation at 7.1% and residential and commercial/public services at 3.9%, with a high level of overall growth.
Mozambique	A large ratio was taken up by industry at 43% and transportation at 41% (2019), while residential (6%), commercial/public services (0%), and others (8%) were negligible. In 5-year growth between 2014 and 2019, despite the small amount of consumption, there was strong growth in commercial/public services at 4.1% and transportation at 3.7% followed by industry at 2.1% and residential at 1.5%.

Source: Prepared by JICA Survey Team

(3) Trends in Support From Donors

(Supply side)

In the energy mix, while there are many cases with a high proportion of hydropower generation, in countries where the demand for electric power is rapidly increasing, the development of other power sources is becoming important. Looking at the example of Viet Nam, in the area of power generation, support is being provided to promote the introduction of solar power/wind power generation.

Table 181 Examples of Support from Other Donors in Group B (supply side)

Sector	Main Support Overview
Power generation	• Support for the selection of IPPs in subsidy-based competitive bidding with the objective of providing support for competitive bidding implemented by the Government of Viet Nam in connection to sustainable solar photovoltaic power generation in order to mobilize large-scale private sector investment (World Bank/ADB, scheduled for 2021 to 2025) • Supplying project financing for the installation of photovoltaic power systems (ADB, 2019 onwards)

	• Support for the installation of floating solar facilities in artificial reservoirs in hydropower plants (ADB, 2019 onwards) • Evaluation of Vietnam's PV market and grid readiness and current status for utility-scale PV deployment (technical cooperation) (World Bank)
Distribution	• Projects to improve the efficiency of the power transmission network and the distribution network are being conducted, including (1) strengthening the power transmission and distribution infrastructure, (2) smart grid development, and (3) capacity building (loans and technical cooperation) for power transmission and distribution companies (World Bank)

Source: Prepared by JICA Survey Team

While hydropower generation is the main power source, in countries with rainy seasons and dry seasons, insufficient electricity in the dry season is often a problem. In such cases, using Nepal as an example, ADB has made quantitative analyses and proposals for the use of hydrogen for longer-term and higher-capacity energy storage in the industry/transportation sectors by supplying electric power that was produced and stored during the rainy season to fuel cells in the dry season.[716]

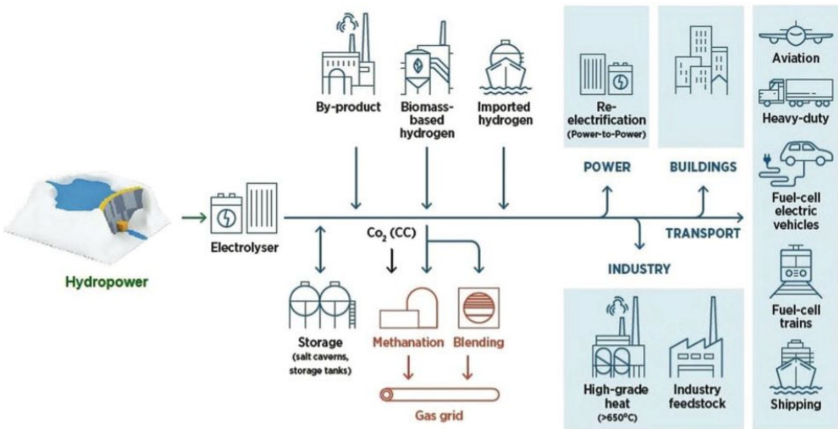


Figure 249 Nepal Potential Hydrogen Value Chain

Source: ADB "A Study on the Prospect of Hydropower to Hydrogen in Nepal" (2020.8)

(Demand side)

In this Group, there are many cases in which the industry sector costumes the most energy. As an example, in Viet Nam, for the industrial sectors with the highest energy consumption, capacity building for regulatory agencies and businesses is taking place, as well as risk reduction measures provided to promote energy efficiency project financing. In the building sector, regulations are being established, and capacity building for the relevant parties is taking place.

Table 182 Examples of Support from Other Donors in Group B (demand side)

Sector	Main Support Overview
Industry/commerce	• In order to successfully implement national energy efficiency programs in key industries, the measures that have been carried out include (1) capacity building for the Government of Vietnam and other major stakeholders (energy efficiency action plan for key industry sectors), (2) energy business capacity development, and (3) capacity building in connection to energy efficiency project and policy implementation, monitoring and assessments (GEF 2011-2017)

[716]716In Nepal, ADB has proposed the use of hydrogen for the storage of electric power. ADB "A Study on the Prospect of Hydropower to Hydrogen in Nepal"(2020.8) https://www.adb.org/publications/study-hydropower-hydrogen-nepal

	• Introduction of ISO energy management standards incorporating industrial energy system optimization (GEF 2011-2015) ▪ (1) Financing for investment in energy efficiency (financing to supply the funds required in order for businesses to implement sub-projects for energy efficiency), and the provision of operation manuals for financial institutions showing sub-project and borrower selection criteria and evaluation methods, project implementation structure, technical assessments, socio-environmental evaluations, procurement and financial management frameworks, and (2) capacity building for MOIT for project monitoring and supervision, including auditing project activities and implementing safeguards (World Bank, 2017 onwards) ▪ (1) Support for the establishment of risk sharing facilities (support for RSF establishment with the objective of providing PFIs (participating financial institutions) with partial credit guarantees (RSF guarantee) in order to provide compensation for potential debt default on PFI loans provided to manufacturing businesses and energy service companies (ESCOs) by PFIs as funding for energy efficiency sub-projects), and (2) technical support for Viet Nam's MOIT (Ministry of Industry and Trade) and other government agencies utilizing the results of past World Bank and GEF support for the formulation of energy efficiency policies and independent agreements in industry (Clean Production and Energy Efficiency Project) (World Bank, GEF, 2019 onwards)
Urban development	• (1) EEBC (Energy efficiency building code) improvement and implementation, and (2) capacity building in order for relevant parties in the building sector to plan, fund and implement energy-saving measures (establishment of financial support mechanisms including financial guarantee funding, etc., development of economic evaluations and modelling tools for energy-efficiency/conservation countermeasures, capacity building of CEEB (Centers for Energy Efficiency in Buildings) staff for energy management models/tools, energy auditing, monitoring/assessments, report production and more, and implementation of training for ESCO and consulting companies in connection to energy conservation technologies, energy auditing, cost-effectiveness analyses, and life cycle analyses) (GEF, scheduled for 2015-2019?)

Source: Prepared by JICA Survey Team

3: Group C

Although the share of renewable energy of this Group is 30% or below, its energy intensity is also low of 0.3 or below. The share of thermal power generation in the energy mix is high in many cases, so the main challenge is the expansion of renewable energy and other low-carbon power sources. On the other hand, energy efficiency is relatively high. The energy consumption in the industry sector is not so high, or the share of services in industry is high, indicating that there are not many energy-intensive industries.

Among low-carbonization project research target countries, Indonesia, the Philippines, Morocco, Bangladesh, and Egypt fall into this Group.

(1) Characteristics of Energy Mix and Electric Power Market

In many cases, the share of thermal power generation in the energy mix is high, and, electricity demand is increasing. The main challenge is the expansion of renewable energy and other low-carbon power sources. Among the low-carbonization project research survey target countries, all of them had a high share of fossil fuels in their energy mix. With regard to the electric power market, the liberalization of power generation/power transmission/distribution has progressed in the Philippines but the participation of private sector businesses is limited to power generation in the other countries.

Table 183 Group C Energy Mix and Electric Power Market Characteristics

	Characteristics of Energy Mix	Characteristics of Electric Power Market
Indonesia	With the recent increased demand for electric power, there has been a move toward coal-fired power from oil, which has dropped in production volume, with the share of coal-fired power in total power generation in 2019 reaching 59%. From now on, Indonesia will also focus on environmental measures, and has set a policy of reducing its dependence on coal-fired power generation and developing renewable energy sources. The expansion of geothermal power generation, which has the greatest potential of all renewable energies but no progress in terms of development, is one of the key points in the transition to low carbon/decarbonization.	Public electric power companies and private sector businesses (IPPs) are involved in power generation, but distribution is provided by state-managed electric power companies and their subsidiaries. Off grid electric power supply is being provided by a government-sponsored inter-*village cooperative* (KUD).
The Philippines	The share of coal-fired power in total power generation in 2010 was 37%, which increased to 55% in 2019. Also, with the world's second largest geothermal power generation facility (behind the U.S.), and hydropower generation, which has a great potential, the share of renewable energy is increasing. The government has indicated a policy of expanding solar photovoltaic power generation in the future.	Power generation business: While public electric power companies and IPPs are taking the lead, the state-managed power company is scheduled to be privatized by 2022. Power transmission business: State-managed businesses have assets, and private sector businesses dominate business. Power distribution business: Private sector distribution businesses, local government-owned businesses, and electrification cooperatives are responsible for this service.
Morocco	The use of cheap coal-fired power is increasing, providing 65% of electric power in 2019. In terms of growth, renewable energy (except for hydropower) is showing the fastest growth, with an annual average rate of growth of 18.6% between 2014 and 2019, comprising 18% of the electric power supply in 2019. On the other hand, petroleum (heavy oils and diesel), natural gas and hydropower are declining. From the perspective of a transition to a low-carbon economy, an increase in natural gas power generation and hydropower is preferred, but there have been no such movements in around a 10-year period.	Power generation business: In addition to public electric power companies, private sector businesses are able to participate. Power transmission business: Dominated by state-managed businesses. Power distribution business: Public businesses, private sector businesses with contracts with local governments, and local public businesses.
Bangladesh	While gas-fired power is the mainstay, recently, the use of oil-fired power has been progressing. In the future, it is expected that oil-fired power will decrease, and that the anticipated increase in the demand for electric power will be supplemented primarily by gas-fired power, coal-fired power and imports of electric power. However, while coal has been viewed as an important energy source to substitute natural gas, there has been heavy public	Power generation is provided by public power companies and private sector businesses, while power transmission and distribution is provided by public businesses.

	criticism, and coal-fired power development will be limited from now on. Regarding electric power imports, power is currently imported from India, and studies are underway regarding the future importation of clean electric power by means of hydropower generation from Bhutan and Nepal.	
Egypt	Previously, hydropower and petroleum (diesel engine) were the mainstays, but capacity enhancement to match the increased demand for electric power is centering on gas-fired power, which now has the highest share. However, even as of 2019, 13% of the electric power supply comes from high-priced petroleum.	Power generation is provided by public power companies and IPPs, but power transmission/distribution is dominated by public businesses.

Source: Prepared by JICA Survey Team

(2) Characteristics of Energy Consumption

The energy consumption in the industry sector is not so high, or the share of services in industry is high (e.g. the Philippines), indicating that there are not many energy-intensive industries. Among the low-carbonization project research survey target countries, in Indonesia, the Philippines, and Egypt, there were a higher level of consumption in the industry/transportation sector. On the other hand, Morocco and Bangladesh consumed most of their energy in the transportation and residential sectors.

Table 184 Group C Energy Consumption Characteristics

	Final Energy Consumption By Sector (2019)
Indonesia	Industry comprised 37%, transportation 39%, residential 13%, and commercial/public services 4%, showing that the transportation sector had the highest share. In 5-year growth between 2014 and 2019, industry had the greatest growth at 8.0% followed by residential at 4.1% and transportation at 2.9%.
The Philippines	Industry comprised 22%, transportation 44%, residential 14%, and commercial/public services 16%, showing that the transportation sector had the highest share. In 5-year growth between 2014 and 2019, commercial/public services had the greatest growth at 8.3% followed by residential at 8.1% and transportation at 6.8%.
Morocco	Transportation comprised 40%, while residential (24%) and industry (20%) had almost the same share, and commercial/public services was 4%, and others were 12%. Looking at growth in the past five years (2014 to 2019), the most active growth is seen in transportation with average annual growth of 4.3%, followed by commercial/public services (3.4%), and residential (3.2%). Conversely, industry has had slow growth, at an average annual rate of 0.9%.
Bangladesh	Industry comprised 43%, transportation 16%, residential 27%, and commercial/public services 3%, showing that industry had the highest consumption share. In 5-year growth between 2014 and 2019, growth in industry, which has a high level of energy consumption, was 11.4%, commercial/public services had the same share (11.4%), while residential was 10.3%.
Egypt	Industry comprised 29%, transportation 30%, residential 20%, commercial/public services 6%, and others were 14%. In 5-year growth between 2014 and 2019, industry took the lead with 3.7%. Transportation, on the other hand, had negative growth for two consecutive years in 2017 and 2018, but began to grow in 2019.

Source: Prepared by JICA Survey Team

(3) Trends in Support From Donors

(Supply side)

Given the relatively high dependence on thermal power generation, the support is being provided mainly for the transition to low-carbon power sources (expansion of renewable energy). In the case of Morocco, in addition to measures promoting private investment in the power generation sector, renewable energy management centers are being introduced for the purpose of power grid stabilization, and support is being provided to reduce technical/non-technical loss, for example.

Table 185 Examples of Support from Other Donors in Group C (supply side)

Sector	Main Support Overview
Power generation/distribution	・ (1) Financing for the National Office of Electricity and Drinking Water (ONEE) PV Program, (2) provision of environment for the participation of the private sector in decentralized solar photovoltaic power generation, (3) provision of centralized management center (improving the ability of ONEE to implement long-term electric power plans that include energy efficiency and technology improvement), (4) programs to protect income (reduction of non-technical loss, introduction of surcharge systems according to timeslots). (World Bank 2015-2019)

Source: Prepared by JICA Survey Team

(Demand side)

In Morocco, where the residential sector has relatively high energy consumption, GIZ is providing support for the energy efficiency of multiple buildings, including support to make mosques environmentally friendly.

Table 186 Examples of Support from Other Donors in Group C (demand side)

Sector	Main Support Overview
Transportation	・ (1) Improvement of national data collection methods in the transportation sector, (2) implementation of best practice in emissions volume recording and forecasts, (3) support for NDC processes by developing and implementing effective climate change countermeasures in the area of transport, (4) knowledge-sharing with the objective of promoting the development of local source of knowledge.
Urban development	・ PEEB (Programme for Energy Efficiency in Buildings), a facility from GIZ and AFD, (1) supports the Ministry of Housing and enforces building standards acts by training 100 government personnel, (2) strengthens the National Alliance for Buildings and the Climate (AMBC) by means of capacity development and planning, (3) mobilizes technical researches and resources, (4) supports the private sector by means of technical advice for large-scale and highly-energy efficient building projects, (5) provides funding pipelines of 180 million euros for public housing development businesses (Al Omrane) for the purpose of highly-energy efficient buildings and electrification products (GIZ, AFD 2017-2021) ・ *PEEB provides support in Morocco, Vietnam and other countries in advisory services and financing.
Other	(Energy model support) ・ Training for the development of systems of energy modelling that can make long-term predictions about energy scenarios (GIZ 2020-2022) (Carbon pricing support) First component: ➢ Analysis and recommendations regarding the means of determining carbon pricing ➢ Proposal of appropriate governance frameworks ➢ Organizational frameworks and operation requirement design for MRV system (general and sectorial) ➢ Pilot MRV system ➢ Establishment of baseline for each target sector (electric power, cement, phosphate) ➢ Evaluation of mitigation potential in each target sector ➢ Support to establish regulatory frameworks for mitigation measures in the three target sectors. Second component: Capacity building

	➢ Preparation and implementation of plans to build capacity to monitor, report, and verify government and private sector emissions and changes in emission levels. Third component: Project management ➢ Includes establishing and operating project management units (PMU) within the Ministry of the Environment (MDE) mandated by the Minister of Energy, Mines, Water and Environment, PMR activity implementation/management, and coordination with relevant programs and initiatives

Source: Prepared by JICA Survey Team

4: Group D

The share of renewable energy of this Group is less than 30%, but its energy intensity is more than 0.3. The proportion of thermal power generation in the energy mix is incredibly high, and energy efficiency is relatively low, which means that the expansion of renewable energy and the optimization of energy consumption are challenging issues. Thailand, South Africa and India fall into this Group.

(1) Characteristics of Energy Mix and Electric Power Market

One characteristic is the incredibly large share of thermal power generation in the energy mix. The share of thermal power generation in the energy mix is high in all of the countries targeted by the low-carbonization project research. Gas-fired power has the highest share in Thailand, while the share of coal-fired power in South Africa and India is extremely high. Regarding the electric power market, private sector businesses are participating in power generation in all of these countries.

Table 187 Group D Energy Mix and Electric Power Market Characteristics

	Characteristics of Energy Mix	Characteristics of Electric Power Market
Thailand	Gas-fired power is the mainstay, with the share of gas-fired power in electric power generated in 2019 reaching 64%. However, as domestic production is declining, natural gas imports are increasing. Also, from around 2010, power generation from renewable energy sources has been increasing, comprising 14% of total power generation in 2019.	Although power generation has been liberalized, power transmission and distribution are managed by public businesses.
South Africa	Dependent on coal for 89% of its power (2019).	Power generation business: Although 10% is from IPPs, the remaining 90% is managed by public power companies. Power transmission business: Dominated by public power companies. Power distribution business: In addition to public power companies (45% of demand households), there are many local government businesses (licenses are held by 188 local governments) and a small number of private power distribution companies
India	The coal-fired power share is 73%. Recently, renewable energy has been introduced mainly on solar PV power generation.	Electricity businesses are divided into the central sector, state sectors, and private sectors. The central sector is responsible for policy making at the national level and for multi-state generation and transmission businesses. State governments each devise their own state policies and are responsible for generation, distribution and transmission businesses. Independent regulatory

		committees are installed separately in central and state governments to provide pricing regulations, rulemaking, and dispute resolution. Although state governments have limited participation in nuclear/coal policy making, in terms of electric power and the introduction of renewable energy, they are given the freedom to draft and implement original policies.

Source: Prepared by JICA Survey Team

(2) Characteristics of Energy Consumption

A relatively large number of countries are highly industrialized (e.g. Thailand's automobile industry, India's steel industry, etc.), and in some cases, energy consumption in the industrial sector is high. In all of the countries targeted by the low-carbonization project research, the share of energy consumption in the industrial and transportation sectors is high.

Table 188 Group D Energy Consumption Characteristics

	Final Energy Consumption By Sector
Thailand	In 2019, industry comprised 27%, transportation 30%, residential 7%, and commercial/public services 6%, with the highest share being that of industry and transportation. In 5-year growth between 2014 and 2019, transportation had the greatest growth at 4.7%, followed by commercial/public services at 3.3% and residential at 3.1%.
South Africa	In 2019, industry had the highest share at 34%, followed by transportation (30%), residential (15%), other (13%), and commercial/public services (8%). In 5-year growth between 2014 and 2019, residential had the greatest growth at 3.5%, followed by commercial/public services at 2.8% and transportation at 2.0%. On the other hand, industry had negative growth (-2.7%).
India	In 2018, industry comprised 38%, transportation 23%, residential 13%, and commercial/public services 4%, showing that industry had the greatest consumption. In 5-year growth between 2013 and 2018, commercial/public services had the greatest growth at 7.7%, despite its current low volume of consumption, followed by transportation at 5.7%.

Source: Prepared by JICA Survey Team

(3) Trends in Support From Donors

(Supply side)

Given the relatively high dependence on thermal power generation, the support is being provided mainly for the transition to low-carbon power sources (expansion of renewable energy, transmission and distribution network development for renewable energy integration). There are cases in which support includes the issuance of Green Bonds in countries where the financial market has a certain level of maturity, like Thailand, for example.

Taking India as an example, on the supply side, the low creditworthiness of power distribution companies as off-takers is one of the barriers to expanding renewable energy, and ADB and other donors are building capacity for power distribution companies. Support in connection to storage batteries is another characteristic, with some states introducing variable renewable energy, while the Government of India is also promoting domestic development of sustainable battery ecosystems.

Table 189 Examples of Support from Other Donors in Group D (supply side)

Sector	Main Support Overview
Power generation	In India, in some States, variable renewable energy is being introduced, including solar power/wind power, while other States have urgent issues with system stabilization. The World Bank is implementing financing and technical cooperation (capacity building for regulatory agencies, etc., SECI in its business planning, management of sub-projects, etc.) for utility scale renewable energy + battery energy storage system

	(BESS) projects in Andhra Pradesh State (scheduled for 2019 to 2024), while the following pipelines are also being studied. ・ A) Building a market structure that supports investment in battery energy storage systems; B) increased investment in battery energy storage systems; C) Strengthening the capacity of relevant institutional stakeholders to support the implementation of battery energy storage systems. ・ Promotion of commercial financing for BESS and electric vehicle charging infrastructure, strengthening the abilities of the main stakeholders.
Power transmission	Support is mainly provided by the ADB. The details include connecting State PV to power transmission networks, enhancing power transmission networks and substations, and smart grid technology, as well as ERP system introduction, supporting/reviewing due diligence on technical, financial, and economic aspects of power transmission system implementation, environmental and social safeguard reviews and other support in each State.
Power distribution	Support is mainly provided by the ADB. In India, State distribution companies have poor financial situations and high offtaker risk[717]. Therefore, support is being provided to reduce the technical/non-technical loss of distribution companies and to improve financial management.

Source: Prepared by JICA Survey Team

(Demand side)

In cases where energy conservation laws and other regulations are provided, support details are often related to financing for investment in energy efficiency. India is one such case.

Table 190 Examples of Support from Other Donors in Group D (demand side)

Sector	Main Support Overview
Industry/commerce/urban development	・ Businesses (secondary steel products businesses, paper/pulp businesses) that are not party to the Perform Achieve and Trade (PAT) system, which is the core of the National Mission for Enhanced Energy Efficiency,[718] have limited knowledge regarding the latest EE technology, for example, so capacity development is provided for such companies. Specifically, this includes the capacity development of State Designated Agencies (SDA),[719] setting benchmarks for energy-

717 In India, there are three types of transaction: (1) Power generation businesses execute Power Purchase Agreement (PPA) with SECI (public business independent from MNRE) or NTPC, and SECI/NTPC signs Power Sale Agreement (PSA) with state distribution companies, (2) PPAs are concluded with state distribution companies, and (3) open access whereby power generation businesses and consumers execute direct electric power sales contracts. In the case of PPA for a project where SECI/NTPC is responsible for procurement, a sovereign guarantee is issued against the offtaker risk, but in the case of PPA for a project where State governments are responsible for procurement, no sovereign guarantee is issued.

718 The National Mission for Enhanced Energy Efficiency (NMEEE), formulated in 2009, comprises four energy efficiency initiatives with the target of a converted saving of 23 million tons of fuel per year (greenhouse gas emissions reduction of 98.55 million tons/year).

1) Perform Achieve and Trade (PAT)

Regulatory instrument to reduce Specific Energy Consumption (SEC) in energy intensive industries

2) Energy Efficiency Financing Platform (EEFP)

Promoting the development of the ESCO market in terms of financial and human resources. Creation of an energy efficiency financing platform.

3) Framework for Energy Efficient Economic Development (FEEED)

Establishment of a partial risk guarantee fund for energy conservation projects and energy efficiency venture capital funds.

4) Market Transformation for Energy Efficiency (MTEE)

Use of international funding for the promotion of energy conservation and use of CDM in energy conservation promotion.

719 State agencies established under the Energy Conservation Act 2001 to formulate and promote energy conservation measures in the state. Managed by the Board of Energy Efficiency (BEE) in Central Government. In the Energy Conservation Act, it specifies the creation of energy manager and auditor systems, the designation of energy intensive industries as Designated Consumers, the nomination of energy managers, the submission of annual reports, the obligation for energy audits, etc., as well as the establishment of state-level energy conservation promotion organizations,

	intensive processes, the provision of DB to technology providers, FS and pilot demonstration of main technologies/processes, provision of web platforms, workshops and training courses, and Peer-to-peer learning between SDA and non-PAT companies (GIZ 2020-2023)
	・ Partial risk share facility for energy efficient investment: This is a GEF facility whereby guarantees are issued from CTF to reduce the risk on EE financing from financial institutions. It includes standardized assessments and trade documentation, report templates, the development of energy efficiency guidelines, enhancing project report production, capacity building and training, online support, as well as technical support and capacity building for financial institutions, ESCO, and beneficiaries. (World Bank, scheduled for 2015- 2035) ・ ADB EESL financing: ADB provides financing for EESL to carry out the following sub-projects. (i) introduction of decentralized solar PV power generation systems, smart meters, electric vehicles (EV) with charging stations in rural areas; and (ii) awareness raising and capacity building among end users for energy efficiency. (ADB, scheduled for 2019-2025) ・ Based on the India Cooling Action Plan (ICAP),[720] (1) analysis and evaluation of technically, economically and financially appropriate response measures to reduce GHG emissions from local cooling systems, and development of a strategic roadmap with conditions and targets of policy framework, to be introduced into the policy processes by BEE. (2) Work with relevant actors, especially the private sector (e.g., building developers, architects, central cooling system manufacturers, energy service companies) to develop business models and prepare the necessary framework conditions. (3) Advice about application processes is also given in the case that BEE decides to apply for international funding (e.g. NAMA Facility, Global Environment Facility (GEF)) in order to incorporate and implement the solutions from (1) and (2) into its own policy processes. (GIZ, scheduled for 2019 - 2022)

Source: Prepared by JICA Survey Team

(3) Directionality of each Group

With respect to the energy mix, energy consumption, and other donor support trends of each of the above Groups, the general directionality of support can be summarized as follows.

Table 191 Draft Directionality of Support of Each Group

	Group A	Group B	Group C	Group D
Supply side	・High share of hydropower generation. On the other hand, VRE is also being	・High share of hydropower generation. On the other hand, VRE is also being	・High share of thermal power generation. On the other hand, VRE is also being	・High share of thermal power generation. On the other hand, VRE is also being

establishment of energy conservation regulations for buildings, and mandatory setting and labeling of energy standards for energy-consuming equipment.

720 This is an action plan created by the Government of India in order to carry out a comprehensive approach in all impacted sectors across the next 20 years with the objective of reducing direct and indirect GHG emissions from cooling systems. Based on support from the Ministry of Environment, Forest and Climate Change (MoEF & CC), it was created with stakeholders including BEE, industry in India, civil society agencies and research institutes. The ICAP implementing agency is BEE.

	introduced. It is important to continue to provide support in order to optimize hydropower generation, including the rehabilitation of existing power plants, and to increase the introduction of VRE, including in the electricity T&D. ・There will be support for regulatory frameworks for the electric power market, including ancillary services, in the case that the market is liberalized. Also, support may also include the introduction of BESS in preparation for the higher share of VRE (procurement support, domestic ecosystem roadmap production, etc.).	introduced. It is important to continue to provide support in order to optimize hydropower generation, including the rehabilitation of existing power plants, and to increase the introduction of VRE, including in the electricity T&D. ・In Asia, electricity shortages during the dry season are often a challenge, and the ADB has also published a report proposing the future storage of surplus electricity from hydropower generation using hydrogen during the rainy season.	introduced. It is important to continue to provide support in order to increase the introduction of VRE, including in the electricity T&D. ・Basically, MDBs are not providing support for the upgrading of thermal power plants, and their main focus is on expanding renewable energy. However, in view of the fact that the use of thermal power generation is unavoidable in the short-to-medium term, it will also be necessary to provide support to modernize thermal power plants.	introduced. It is important to continue to provide support in order to increase the introduction of VRE, including in the electricity T&D. ・Basically, MDBs are not providing support for the upgrading of thermal power plants, and their main focus is on expanding renewable energy. However, in view of the fact that the use of thermal power generation is unavoidable in the short-to-medium term, it will also be necessary to provide support to modernize thermal power plants.
Demand side	・Rather than having high energy efficiency, there may be cases where energy intensive industries have not developed. In such cases, the main support should be provided for low-carbon transition in the transportation and residential sectors. ・In the transportation sector, there is a high share of low-carbon power sources in the	・There are many cases where laws and standards relating to energy conservation have not been provided or are insufficient. ・Regarding the transportation, in Group B, there is a high share of low-carbon power sources in the	・Rather than having high energy efficiency, there may be cases where energy intensive industries have not developed. In such cases, the main support should be provided for low-carbon transition in the transportation and residential sectors. ・In the transportation sector, in view of the high share of low-carbon power	・In many cases, the manufacturing industry is becoming more industrialized. A low-carbon transition of industrial processes will also be important. ・In the transportation sector, in view of the high share of

	energy mix, and, even when considering the LCA, the introduction of EVs is often effective in terms of CO_2 reduction.	energy mix, and, even when considering the LCA, the introduction of EVs is often effective in terms of CO_2 reduction.	sources in the energy mix, balanced support is needed with a view toward not only EVs but also using low carbon fuels for internal combustion engines (biofuel, etc.).	low-carbon power sources in the energy mix, balanced support is needed with a view toward not only EVs but also using low carbon fuels for internal combustion engines (biofuel, etc.).

Source: Prepared by JICA Survey Team

2.2 Feasibility Analysis for Export of Low Carbon/Decarbonization Systems

2.2.1 Organization of Promising Technologies/Products, Packages and Business Models for ODA Projects Through Interviews of Resources in Japan (businesses, universities, government)

Interviews were conducted at businesses, research institutes, public administrations (government) in Japan regarding the status of low carbon/decarbonization technologies, prospects for expansion into the global markets and other related issues. Due to the fact that promising technologies and products have been described in a previous section (1.2 Organization of trends in low-carbon and decarbonization energy policies, technologies, services, utilization and commercialization in major developed/ developing countries), the main focus in this section consists of a summary of the current status and future prospects in each field related to low carbon/decarbonization (including project packages and business models).

(1) Solar Photovoltaic Power Generation, Wind Power Generation

The products / technologies of Japanese companies in the fields of solar power and wind power cannot compete on a cost basis with overseas products, making it difficult to envision a scenario for the overseas expansion of Japanese products. In addition, the price of solar panels has been dropping every year, making it difficult to maintain price competitiveness.

Furthermore, when the products of Japanese companies are exported overseas as is, there are cases in which the product may break due to an inability to withstand the fluctuation in frequency with the quality of the overseas power supply. Therefore, there will most likely be a tendency in the future for companies to provide added value with new technological innovation or create packages that combine with other products or maintenance technologies rather than export individual products.

On the other hand, since it is expected that offshore wind power generation projects will be implemented in the seas around Japan, skills and experience will be accumulated in construction and transportation techniques in Japan, providing the country with the capability to utilize this expertise in overseas projects, with this knowhow first being shared and implemented in Asia.

(2) EMS

It is easy to install an EMS when it is integrated into a microgrid powered by renewable energy. In addition, an overseas project has not been implemented yet, but work is proceeding on the supply of EMS for factories in Japan, and there are cases in which this has actually resulted in energy savings effects.

For example, if the system has the capability to adjust the output of diesel power generation and utilize batteries while monitoring the output of renewable energy, it will provide Japanese companies with a competitive edge. On the other hand, there is the challenge of a lack of awareness toward energy efficiency and conservation in emerging countries.

(3) Hydrogen

Europe has a lead in the production of hydrogen, and there is a trend toward large production systems. There is the possibility that the European standard will become the global default if this trend continues.

Technology needs to be established that provides the capability to stably produce hydrogen even when the amount of power generated fluctuates. Effectively increasing the operating rate of power generation is the main challenge that needs to be addressed in the future concerning the use of solar photovoltaic power generation and wind power generation for the production of green hydrogen. In addition, since the regulations concerning the handling of hydrogen differ in each country, these regulations first need to be created, which is particularly important for developing countries.

Japanese companies are taking on the challenge of demonstration projects for the production of green hydrogen derived from renewable energy in Japan and abroad, providing them with a competitive edge since they possess water electrolysis technology for large-scale electrolytic production systems and other such systems.

Hydrogen production is most likely to be implemented in countries with cheap surplus electricity and high renewable energy potential. For example, a country like Laos, which has a stable power source with abundant hydropower, is one of the countries where it is possible to implement green hydrogen production. Since approximately eighty percent of the cost of water electrolysis is the price of the power, it cannot compete with the existing production of hydrogen by means of steam reforming unless inexpensive electricity is available. At the very least, it is unimaginable at this point in time that hydrogen can be produced by means of water electrolysis and exported due to the high cost of electricity in Japan. The business of producing hydrogen in a country with abundant cheap renewable energy and providing that hydrogen to Japan or other countries will most likely be feasible in the future.

(4) Inverters

The merits of inverters which have a competitive edge in intermediate climates are being lost in countries which are constantly hot, with air conditioning products that do not have an inverter gaining a competitive edge in terms of performance. There are differences depending upon the country, but when attempting to promote inverter technology in countries where local manufacturer(s) already exist, since this will place the local manufacturer(s) which do not possess inverter technology in a tough situation, coordination with the local manufacturer(s) will be a challenge.

Since inverters are used in products that have been widely used in Japan (multiple manufacturers have a proven track record) and are being expanded to developing countries, this technology is trusted locally. In order to correctly evaluate the performance of inverters in the future, the CSPF (Cooling Seasonal Performance Factor) standard needs to be disseminated.

(5) Heat Pumps / ZEB

The main challenges concerning the dissemination of these products in ASEAN consist of awareness and cost. There are many cases in which local people are not aware of heat pump technology. In addition, due to the fact that Japanese products often have excessive specifications for newly industrialized countries, high cost becomes an issue. It should be possible to solve the issue of cost by obtaining a grasp of specifications that match local needs, customizing products and marketing them.

It is expected that there will be a large market for heat pumps in the future, and Japan is the global leader in heat pump technology, but if progress is not made on the approach toward expansion overseas, there is the possibility that this market will be dominated by companies from other countries.

The international approach that Japan is taking consists of establishing the Asian Heat Pump & Thermal Storage Technologies Network (AHPNW) in seven countries (Japan, China, South Korea, Vietnam, India, Indonesia and Thailand), and reaching out to government officials in each country to promote the dissemination of heat pumps.

Furthermore, the ISO is working on standardization for ZEB, and initiatives are being undertaken in ASEAN countries in order to promote adoption of a ZEB standard.

(6) Storage Batteries

The weak points for Japan consist of inadequate cost competitiveness, a lack in production capacity, as well as a small market for storage batteries in Japan. It is not currently possible for companies in Japan to win in a price competition for individual storage batteries with China or South Korea.

The competitive advantages of Japan consist of quality (safety and energy density), and products like the redox flow battery have the merit of being scalable due to large storage capacity, combined with their long life and fire-retardant characteristics. Additionally, these batteries do not need a considerable amount of local maintenance, making them easy to manage.

In the field of storage batteries, efforts should be made to secure a competitive edge in the next 30 years by envisioning secondary use (or tertiary use), in view of the fact that Japanese style quality control will not be accepted even if it is introduced in newly industrialized countries.

In order to create a market for storage batteries, the preparation of indicators capable of evaluating the deterioration of batteries and development of distribution routes are required. For example, in the field of VPP and V2X, a social demonstration will be needed in the future in order to determine whether or not many small-scale storage batteries can be gathered and used to supply electric power. In addition, there is high demand for storage batteries for microgrids in areas that are not electrified.

(7) Fuel Cell Vehicles (FCVs)

FCVs will not become popular unless their merits are shown to far exceed automobiles that use gasoline or diesel since the price for FCVs is quite high. There is the potential for the popularization of large FCVs which do not require an extensive refilling infrastructure when strong efforts are made to achieve carbon neutrality if the prerequisite of producing clean hydrogen can be achieved. It will be difficult for Japan to maintain a competitive edge in the future if it does not take the lead in promoting global standardization and normalization.

Even if the cost of installing hydrogen stations decreases as a result of easing of regulations and technological innovation, it will be difficult to promote the installation of hydrogen stations unless a certain level of FCV sales can be projected. Therefore, hydrogen stations must be more profitable than existing gas stations in order to facilitate the wide popularization of hydrogen stations.

(8) Urban Development

Japanese companies are seeds-oriented, and need to become more aware that the technologies and services that Japan wants to provide are detached from local demands. A detailed approach to determining needs is required for this, and Japan does not have an adequate system in place to accurately discern local demands and effectively respond to them (where the government and corporations work together in an integral manner to strategically provide a detailed response from upstream to downstream). In addition, it is also important within the country that corporations which compete with one another are able to cooperate effectively for overseas activities.

When there is price competition with other countries, combining and packaging technologies is more effective than using individual technologies since Japanese companies will not be able to monetize projects otherwise. For example, one possible countermeasure consists of combining low-priced technologies that are not complex and using a sales approach that also incorporates management technology.

(9) CCUS (Carbon Capture, Utilization and Storage)

The United States is the country that has the high potential for CCUS and has the most interest in this field since it has EOR (Enhanced Oil Recovery) and other such storage locations. Developing countries that have potential in this field consist of countries in the Middle East with oil wells, Indonesia and Malaysia in Asia, and other such countries. It is practical for countries which have depended on fossil fuels up until now to implement CCUS that includes blue hydrogen production as parts of the efforts to end their reliance on fossil fuels. Another example of the effective utilization of CO2 consists of the CO2 consumption model which is installed in a vegetable production plant.

The results of interviews of these Japanese companies indicate that the optimum approach for overseas expansion consists of locally developing standards and systems that match created standards for technologies and services for which standardization is possible, and deploying matching projects, or combining multiple technologies and services into packages and marketing them. In addition, possible business models for overseas deployment other than actually selling and expanding products and services overseas consist of direct investment (capital injection) into companies that are conducting low carbon/decarbonization related projects, and jointly starting up business together with local companies.

Regarding the possibility of exporting infrastructure systems, the countermeasures for the common issues potentially confronted by Japanese companies are organized below.

Table 192 Issues Confronted by Japanese Companies When Deploying Overseas and Proposed Countermeasures

Issue	Countermeasures
Cannot accurately grasp local needs • Gap between technology/service Japan wants to provide and local demands. • Japan products have excessive specs. for local needs. • Technology/service Japan wants to provide does not match local needs.	Further dialogue with local institutional stakeholders • When deploying overseas, develop integral system that combines private sector companies and Japanese government in order to obtain detailed grasp of local needs. • Utilize periodic communication with local stakeholders and top-level talks when marketing individual projects.
No linkage between domestic companies and no system established • It is important that companies which compete with each other in Japan effectively cooperate when expanding overseas. • It is difficult for the private sector to take the lead in business-to-business cooperation.	Partnership with different industries/companies in the same sector • When deploying new technologies overseas, partnering with other companies is an option, as well as combining with local governments and developers. It would be effective in some cases if it is promoted within the framework and support provided by the Japanese government.
Product cost not competitive • When there is price competition for product that is not high quality, Japanese companies do not have a competitive edge. • It is difficult to expand overseas with Japanese products when cost is a large issue.	Propose package rather than individual technology • Combine/package low-carbon/decarbonization technology, e.g. combine technologies to increase their values, or combine tangible (product, technology) and intangible aspects (management, operation, maintenance) in order to propose new services. • In addition to concepts such as reducing environmental load/energy conservation, create business model that includes elements that improve quality of life and security as local needs.
Japanese technology is not adequately recognized locally and local market is uncertain • Technology possessed by Japanese companies is not recognized overseas. • Uncertainty is particularly high in newly industrialized country markets, making	Dissemination of technology/creation of standards • Holds events locally to introduce technology, match with local companies and do other activities to raise awareness. • Establish and standardize criteria to properly evaluate Japan's high efficiency and high quality technologies. Various support by Japanese government

Issue	Countermeasures
it difficult for Japanese companies to take risk of entering opaque areas where outlook is unknown.	• Since local legal system is a hurdle when starting a business, Japanese government will provide support for legal issues. • At stage where demonstration project is difficult with own funds, work to establish a mechanism to advance the project using government funds.

2.3 Organization and Analysis of Challenges (Issues) and Countermeasures, Formulation of Cooperation Strategies

2.3.1 Organization from Perspectives of Policy and Institutional Challenges, Technological Challenges, Economic and Financial Challenges

The most common challenges faced by the supply side and demand side in preparation for achieving low carbon/decarbonization were identified, and organized into the following categories: policy/institutional challenges due to lack of or inadequate government policies/plans, technological challenges due to insufficient technical capabilities in specific fields, and economic and financial challenges caused by the inability to secure sufficient funds and profitability.

Table 193 Challenges in supply side and demand side

Sector	Challenges/Issues	Policy/ Institutional Challenges	Technological Challenges	Economic and Financial Challenges
Electric Power Generation and Supply	Concrete policies not adequate for low carbon thermal power generation (ammonia co-combustion, *transition* from *diesel*-fueled *electricity* to *renewable energy in rural communities*, etc.). Insufficient technical expertise for low carbon and decarbonization pathways.	✓	✓	
	Policies/plans not adequate to reduce dependence on thermal power generation.	✓		
	Legal system not adequate for large scale introduction of renewable energy.	✓		
	System development/ improvement required to facilitate renewable energy system integration, but there is not adequate expertise to stabilize system.		✓	
	Capacity market and ancillary service market need to be established in order to provide incentives for construction of new plants (power sources), or repair/maintenance of existing ones in order to stabilize power supply/quality.	✓		

Sector	Challenges/Issues	Policy/ Institutional Challenges	Technological Challenges	Economic and Financial Challenges
	Financial/management performance of electric companies, power transmission /distribution companies and other companies needs to be improved.			✓
Biofuel	Technical expertise concerning biofuel production is not adequate.		✓	
	Adequate supply chain for utilization of biofuel has not been established.	✓	✓	
	Economic incentives need to be upgraded to increase awareness of biofuel and promote dissemination.	✓		
Industrial / Commercial	Efforts to promote use of decarbonization technology for industrial processes (electrification promotion, alternative energy use, etc.) and energy efficiency devices not adequate.		✓	
	Financial support needed for boosting recognition of energy conservation by small and medium companies and promotion of energy efficiency investments.	✓		✓
	Not enough people have knowledge concerning rationalization of energy use (Example: qualified person for energy management).	✓	✓	
Transportation	Alternative fuels (electricity, hydrogen, biofuel, etc.) not being adequately used.	✓		
	Policies and roadmap for popularization of EVs are inadequate. In addition, sales promotion by means of introducing purchasing subsidies etc. is not sufficient.	✓		✓
	Not enough EV charging infrastructure has been installed.	✓		✓
	No policy for boosting battery production or promotion of battery reuse.	✓		
Urban Development	Electrical power demand for buildings is increasing and energy consumption of buildings is still not being made more efficient.		✓	

Sector	Challenges/Issues	Policy/ Institutional Challenges	Technological Challenges	Economic and Financial Challenges
	Approach to energy efficiency labeling and minimum energy efficiency standards is not sufficient as an energy efficiency measure.	✓		

(1) Policy/Institutional Challenges

Policy/institutional challenges consist of the lack of a legal system for the transition to low carbon thermal power generation and the introduction of renewable energy, and inadequate consideration of plans for the stabilization of electrical power supply and utilization of biofuel. There are cases in which coordination between multiple government agencies is required in addition to specific departments and agencies, and cases in which development/planning cannot be performed with the knowledge of a particular country alone, but in all situations, work needs to proceed while obtaining the cooperation of technical experts who possess the necessary expertise.

In the sectors of industry and commerce, the challenge is to raise awareness of energy conservation among micro, small, and medium-sized companies (MSMEs) and to develop human resources with knowledge on rationalization of energy use. The awareness of energy conservation is still quite low in developing countries, and there are many cases in which there is not an adequate understanding of the transition to low carbon/decarbonization at small to medium sized companies in particular. This is partly due to the lack of personnel with knowledge of rationalization of energy use. Therefore, the awareness of energy conservation needs to be heightened, people need to be educated on the importance of the transition to low carbon/decarbonization, and the necessary human resources need to be developed.

In the sector of transportation, although policies have been outlined to strive to make the transition to low carbon/decarbonization through the use of alternative fuels, only a portion of countries have actually created concrete plans/policies that include EVs. In addition to policies to promote the introduction of EVs, the main challenges consist of the lack of progress of the discussion on policies associated with EVs, such as the development of an EV charging infrastructure and reuse policy for batteries used by EVs.

In the sector of urban development, the challenges consist of a lack of progress on the introduction of the necessary structure/mechanism, such as an energy efficiency labeling system to promote progress on energy conservation and minimum energy efficiency standards.

Technological challenges/issues consist of inadequate technical expertise concerning the transition to low carbon / decarbonization pathways for thermal power generation. Demonstration projects for ammonia co-combustion and hydrogen co-combustion for thermal power generation are being conducted in Japan, but even though this is understood as a field in which efforts should be made in the future in developing countries, concrete approaches are not being made since there is not adequate technological expertise. It will be necessary to implement similar project overseas in the future that take the track record in Japan into consideration.

System stabilization measures are important as progress is made in introducing renewable energy. However, the technology for system stabilization is inadequate in many developing countries, and there are not enough technicians/engineers in the related fields. Technology transfer by means of dispatching experts and support for the training of local technicians/engineers are effective measures to address this issue. In the same manner, consideration of the approach to facilitate the transition to low carbon/decarbonization through the utilization of biofuel is needed, and similar support consisting of the dispatch of experts and training of local technicians/ engineers is indispensable.

(2) Economic and Financial Challenges

Challenges faced by the supply side consist of financial/management performance improvements by electric power companies and transmission/distribution companies etc. One of the causes for these challenges is that the company is not free to set its own electricity rates and continues to rely on government subsidies to operate its business. Striving to make improvements by taking necessary actions in the electric power sector such as power sector reforms, including operational improvements and privatization, are important in countries and areas where electric power generation by the private sector is permitted since it is difficult to promote private sector investment when the company is not functioning as an off-taker and its financial solvency is inadequate.

Challenges faced by the demand side consist of insufficient willingness to allocate private sector funds for energy efficiency investments and EV purchases. In particular, the merits to make energy efficiency investments are inadequate for small to medium sized companies, and purchasing of EVs by general consumers is not progressing due to their high price. Possible measures to address this situation consist of providing government subsidies for investments / purchases and furnishing tax incentives.

In addition, there are also cases in which entrance into a local market is not possible due to excessive risk for the private sector entity resulting from an inability to have the risk shared in an appropriate manner. While the private sector is willing to minimize uncertainty as much as possible, a major challenge consists in the fact that the current system imposes a great majority of the business risk on the private sector.

2.3.2 Deep Analysis of Concrete Measures to Implement in Developing Countries from Perspectives of Policy Formulation, System Design, Investment Climate Creation and Promotion of Technology Introduction

The following points should be taken into consideration before JICA begins to provide assistance: the possibility of providing assistance not only to specific countries/regions but also to a wide range of countries/regions; the possibility of providing assistance by effectively utilizing the technologies of Japanese companies; the high level of actual local needs; and the need for assistance in areas where other donors are not providing sufficient assistance. The main support measures that should be implemented as a priority in the future are organized in the sections below.

Priority approach (1) : Support for creation of action plan to introduce hydrogen co-combustion for gas thermal power generation (technical cooperation)

Background / Challenges

In countries/regions that use gas thermal power generation, discussions are underway on measures to facilitate transition to low carbon/decarbonization for existing gas thermal power generation. Although CO_2 emissions by gas thermal power generation facilities are lower compared to coal thermal power generation facilities, since many countries are striving to achieve carbon neutrality in the long term, measures to facilitate a more aggressive transition to low carbon/decarbonization are an urgent issue.

Therefore, hydrogen co-combustion at gas thermal power generation facilities is an effective means to achieving the transition to low carbon/decarbonization, and multiple demonstration projects are taking place in various countries around the world to increase the mixed fuel burning ratio. On the other hand, in order to implement hydrogen mixed-fuel combustion, procurement of clean hydrogen as fuel, and development of the appropriate legal system and various regulations are required.

Support Content

Support for the approach by the local government shall be provided by creating an action plan for the introduction of hydrogen co-combustion/dedicated combustion, including the hydrogen supply chain, as well as technical cooperation (dispatch of experts) for the development of the various required regulations.

In anticipation of dedicated hydrogen combustion at the final stage after the introduction of hydrogen co-combustion, a hydrogen supply chain plan will be formulated for the domestic production of hydrogen and procurement means of clean hydrogen (blue hydrogen, green hydrogen) from abroad, and a future action plan will be created. In addition, the required regulations for the use, transport and storage of hydrogen as a fuel will be developed, and the required regulations for new facilities will also be prepared.

Points to consider

Demonstration projects for hydrogen co-combustion are being conducted at various locations in Japan to facilitate the transition to low carbon/decarbonization of thermal power generation plants. Training will be conducted in Japan as necessary (by inviting trainees) while support is provided in the form of technical cooperation. It is also effective to share knowledge acquired through demonstration projects and introduce promising technologies and other such work.

Priority approach (2) : Support to facilitate advanced system operation (financial cooperation, technical cooperation)

Background / Challenges

The stabilization of systems is an important issue that needs to be solved to facilitate the large-scale introduction of renewable energy power generation.

Measures consist of AGC (Automatic Generation Control) systems that enable the system operator to detect system load variations and change output in order to stabilize the frequency, and VQC (Voltage and reactive power Control) systems which have an automatic voltage adjustment function for individual power stations and entire systems in order to reduce transmission loss and maintain voltage stability.

In addition, a large impact by the climate represents a feature of renewable energy power generation, and since fluctuations in the weather have a large impact on the system, renewable energy output forecasts made based on weather forecasts can be an effective measure in order to facilitate stabilization of the power system.

Furthermore, as the popularization of renewable energy proceeds, there is the risk of large-scale fluctuation in the power current volume of the system interconnection between regions and facility overloads caused by an uneven distribution of facility volumes or other such factors, with the danger that this may interfere with the stable operation of the power system. Therefore, the creation of various regulations is needed, such as connection requirements for renewable energy power generation systems and congestion processing rules for interconnections.

Support Content

The required financial cooperation (grant aid, ODA loans) will be provided to allow the system load-dispatching facilities to introduce AGC systems and VQC systems. Qualified persons for system operation supervisors will be trained locally.

In addition, technical cooperation will be provided by dispatching experts to leverage the knowledge of Japan for institutional development that enable power system stabilization.

Points to consider

In addition to simply introducing systems, the local training of personnel, implementation of training and other ongoing support to facilitate system stabilization are required. There are many institutional systems for the stabilization of power systems also in Japan, and this is a field that requires specialized knowledge. Therefore, when providing support for system development locally, it is important that a combination of support is provided, consisting of the dispatch of personnel in an appropriate manner, the invitation of local counterparts to Japan, on-site observation visits, and other such activities.

Priority approach (3) : Support to promote introduction of industrial heat pumps (financial cooperation, technical cooperation)

Background / Challenges

The share that the industrial sector occupies out of final energy consumption in developing countries has been increasing in recent years, making the boosting of energy efficiency by the industrial sector indispensable to facilitate the transition to low carbon/decarbonization by the country as a whole.

Large companies in many countries have made a certain amount of progress in energy conservation in order to improve energy efficiency in the industrial sector, but there is the concern that the approach by small to medium sized companies in this area is still inadequate. In addition, heat utilization by small to medium sized companies is generally performed at low temperatures, and the International Energy Agency (IEA) recommends that companies use high-efficiency heat pumps rather than fossil fuel to boost thermal efficiency in this type of case. Japan has a competitive edge around the world in heat pump technology, and can make a contribution to the world by expanding the introduction of heat pumps. Private sector companies need to implement measures to facilitate the smooth procurement of investment funds to enable the introduction of industrial heat pumps.

Support Content

Due to the fact that the level of awareness of using heat pumps to satisfy thermal demand is generally low, technical experts will be dispatched from Japan as an integral part of technical cooperation in order to deepen the understanding of involved persons in the local government and industrial sector of the features of heat pumps, energy efficiency performance, safety (installation, operation) and other details, as well as facilitating the future formulation of policies and systems related to energy conservation by utilizing heat pumps.

In order to execute concessionary loans to provide the funds to allow private sector companies to introduce energy efficient equipment, financial cooperation will be provided by two-step loans through local financial institutions.

Points to consider

Local stakeholders need to be educated by showing them how effective heat pump technology is in making the transition to low carbon/decarbonization. In particular, it is very important to further increase the awareness of energy conservation at small to medium sized local companies and deepen understanding to facilitate the introduction of heat pumps.

Priority approach (4) : Support for capacity building and financing among local stakeholders to promote the introduction of ZEB (Net Zero Energy Buildings) (financial cooperation, technical cooperation)

Background / Challenges

In the sector of urban development (office buildings, housing, etc.) in developing countries, a considerable amount of effort is being made to introduce renewable energy and achieve energy efficiency, but the approach to achieving Net Zero Energy Buildings by combining these systems is inadequate. It is expected that the local need for ZEB will continue to increase in the future, and discussions on measures to facilitate the transition to low carbon/decarbonization in the urban development sector in each country will progress. Efforts will be made to enhance energy use efficiency through the introduction of ZEB, as a part of the approach to stabilizing energy demand and making the transition to low carbon/decarbonization.

Support Content

Experts will be dispatched as an integral part of technical cooperation related to the formulation of the framework to promote ZEB, formulation of the ZEB related standards, and consideration of incentives to promote the introduction of ZEB, utilizing the experience and knowledge in Japan.

In addition, policymakers in the government, at private sector companies and at financial institutions will be invited to seminars that will be held in Japan to deepen the understanding of ZEB concepts.

The introduction of ZEB related equipment (renewable energy and energy conservation) will be promoted by means of two-step concessionary loans to local private sector companies to provide funds.

Points to consider

Technical knowledge that combines the approach to renewable energy and energy efficiency measures is needed to introduce ZEB, rather than simply introducing energy efficient equipment alone. Progress has been made in Japan to popularize ZEB, and providing information on introduction cases, policies and systems placed in Japan will be effective.

The priority issues to be discussed in the future for cooperation in the low carbon/decarbonization field are described below.

(1) Formation of Cooperation Program Matching Needs in Each Country

The approach to making the transition to low carbon/decarbonization differs in each country, and there are various priority low carbon/decarbonization fields and future plans. Japan needs to propose programs in areas where cooperation can be performed, taking into consideration the local need for cooperation and the status of support by other donors.

Since there are cases in which the challenges faced by large cities and medium-sized cities in rural communities differ even in the same country, it is also useful to discuss programs that target specific geographic areas.

In addition, there are many cases in which local governments have authority beside the central government depending upon the country, and when a project is implemented in multiple regions, it may take more time than expected, making it necessary to note that in some cases, proceeding with state-by-state studies first may lead to rapid assistance.

(2) Cooperation with Local institutional Stakeholders

Although the central government is generally the local counterpart agency, there are cases in which related organizations and industry groups outside the government have a grasp of information for practical issues. Daily communication with these related organizations is effective in order to obtain a grasp of local needs at the right time. Examples of measures to achieve this consist of deepening cooperation between local industry organizations and industry organizations in Japan and the establishment of a platform that allows the periodic exchange of opinions with related organizations.

(3) Overseas Implementation in a Technology Package

Rather than only forming respective programs containing renewable energy technology or energy conservation technology as in the past, the formation of package programs that combine renewable energy, energy conservation, EV, battery, EMS (Emergency Management System) and other such technology to support ZEB projects and smart community projects is needed. Furthermore, by adding disaster response technology and disaster prevention technology in which Japanese companies have a competitive edge, more effective support can be proposed than those by other countries.

(4) Expanded Utilization of Domestic Resources

While there are Japanese companies that have technology with a global competitive edge in the field of low carbon/decarbonization, the structure to strive for overseas implementation in coordination with JICA activities is not necessarily adequate. Additionally, understanding of the JICA support tools for technical cooperation, financial cooperation, private sector cooperation projects and other such work have not permeated adequately, resulting in the approach for public/private sector cooperation being insufficient.

A structure / system needs to be established that enables support to be provided to developing countries at the right time in cooperation with the JICA approach to facilitate utilization of domestic resources in the future. These consist of future challenges for consideration, including the utilization of knowledge that has been accumulated within JICA to date.

(5) Delay in Financial Support Required to Achieve SDGs

The significance of climate change measures has been widely recognized, and the momentum to facilitate implementation is increasing globally. In addition, there is a particular focus on the economic rationality of energy conservation and renewable energy out of all climate change measures. On the other hand, there is a delay in formation of the financing scheme to achieve the desired goals, presenting the concern that this may cause a delay in achieving goals.

There are cases during discussions held in various developing countries that the parties give up on receiving support from Japan when they find out that there is a long road to obtaining financing at the point they ascertain the time schedule required. In situations in which even speedier financing support is required, improvements will need to be made to further simplify and shorten procedures.

2.3.3 Proposed evaluation indicators in low and decarbonized subclusters

This section is organized with reference to the framework for the effectiveness assumptions of the Energy Sector Management Assistance Program (ESMAP), a partnership between the World Bank and 18 development donors, including Japan, that provides assistance to developing countries in the low- and decarbonization sectors. The table below summarizes the ESMAP framework.

The table below shows proposed qualitative and quantitative evaluation indicators common to each project, based on the "Outcomes & Indicators" adopted by ESMAP.

Table 194 Evaluation Indicators for the "Low-/de-carbonization Sub-Cluster" (common)

Outcome	Index	
	Qualitative Indicators	Quantitative Indicators (Common)
Development financing informed	• Identification and formation of new financial cooperation projects • Consistency with ongoing financial cooperation projects • Identification and formation of opportunities to provide other financial resources, such as private funding • Planning and implementation of financial expenditures by the counterpart government	• Scale of Financial Cooperation • Scale of Private Sector Funds • Amount of fiscal expenditure by the counterpart government • Scale of reduction in additional investment
Policy/Strategy Informed	• Reflected in the policies and strategies of the counterpart government • Increased interest in the partner country • Reflection in other donors' cooperation strategies • Reflection in Country Development Cooperation Policies • Reflection in JICA sector strategies	-
Client Capacity Increased	• Contribution to the improvement of policy/strategy formulation capacity • Contribution to the improvement of M&E capacity related to the implementation of policies/strategies • Contribution to improving capacity for monitoring and evaluation of policy/strategy implementation	-
Knowledge Increased	• Knowledge sharing of best practices to counterparties • Knowledge sharing of best practices to other donors	-

Outcome	Index	
	Qualitative Indicators	Quantitative Indicators (Common)
Innovative approaches and solutions generated	・ Presenting advanced and cutting-edge approaches/solutions that contribute to problem solving ・ Development of advanced and cutting-edge approaches/solutions that contribute to problem solving ・ Utilization of innovative technologies, concepts, and know-how in the partner country	-

As for quantitative indicators, since the indicators will differ depending on the nature of the project, the proposed evaluation indicators are organized for each intermediate goal against the development strategy goals.

Table 195 Evaluation Indicators for the "Low-/de-carbonization Sub-Cluster" (by Interim Targets)

Development strategy goals	Intermediate goal	Index
		Quantitative Indicators
Low-/de-carbonization on the supply side	Promote the introduction of renewable energy	・ Amount of renewable energy introduced ・ Ratio of renewable energy generation ・ CO2 emissions reduction
	Grid development and upgrading for grid integration of renewable energy	・ Power transmission and distribution loss ratio ・ Number of power outages ・ Power outage duration ・ Frequency time stay rate
	Low-carbon thermal power generation	・ Power generation efficiency ・ CO2 emissions reduction
	Low-carbon primary energy supply	・ CO2 emissions reduction
Low-/de-carbonization on the demand side	Low-carbon transportation sector	・ CO2 emissions reduction ・ Fuel efficiency improvement rate
	Promote energy conservation in the industrial sector	・ Energy consumption efficiency ・ CO2 emissions reduction
	Promoting energy conservation in urban development	・ CO2 emissions reduction ・ BEI（Building Energy Index）
	Promoting energy conservation on the demand side	・ CO2 emissions reduction

2.4 Methods for Energy Supply Chain Analysis

2.4.1 Current Status of Energy Supply Chain Analysis and its Future

(1) Types of standard models in energy supply chain analysis

Types of mathematical models used in the analysis of power and energy systems are described in the table below. Each model has strength in different areas. The model appropriate for the purpose should be used.

Table 196 Classification of models

Model type	Feature	Example model

Integrated assessment model (Cost-benefit type)	・Simplified long-term (over 100 years) model of economy, energy, and global system. ・The optimal reduction path is calculated by maximizing utility over a period of time, taking into account all mitigations, adaptations, and damage associated with climate change.	DICE, PAGE, FUND
Energy demand and supply model	・Model of the entire energy of one country/region ・Useful for energy planning ・Limited to rudimental representation for power sector in general.	TIMES(MARKAL), MESSAGE, IEEJ-NE, AIM/Enduse, DNE21+
Power supply model (Facility planning type)	・Modeled specifically for electricity sector ・Useful for planning electric power development and transmission line extension ・Low temporal resolution, individual plants often not considered	PLEXOS、RPM、Aurora、OPGM
Power supply model (Optimal operation type)	・Simulate optimal operation with fixed facilities ・Can also represent operations in individual plant and nonlinearity ・Modeling for specific regions. Not suited for facilities planning	PROMOD, GE-Maps, PLEXOS, MR
Reliability evaluation model	・Simulate transmission networks in 30-second to one-minute increments ・Evaluate flow analysis to confirm operational feasibility, system response to anomalies, among others	PSLF, PSSE

(Source) IRENA(2017), Planning for the sustainable future

The following section describes the overview of each model.

a) Integrated assessment model

An integrated assessment model takes at least some part of energy supply/demand, GHG emissions, climate change, damage to human society caused by them, and many other phenomena and combines them into one representation. Since climate change is a particularly super long-term event, models may be built with a view into the future, up to the year 2500.

In this context, there have been a long history of evaluating optimal GHG reduction paths using cost-benefit analysis by calculating models that reflect the costs associated with GHG emission reductions and the damage caused by climate change over a very long period of time. This approach has contributed to policymaking in many ways, including the evaluation of the social cost of carbon(the future cumulative cost of increasing carbon dioxide emissions by one ton today) in the US. Energy representation is often rudimental in such models. A specific model geared for energy should be used to develop detailed energy policies.

b) Energy demand and supply model

This model is used for finding the optimal energy technology mix for the target country or region over a long period (generally between five and 100 years) and requisite investment plan. In general, the analysis covers not only electricity but also energy supply and demand as a whole, providing useful information for the formulation of energy policy in each country and region. While the model can provide a big-picture analysis, it tends to have coarse temporal and geographic resolution (number of time steps and regions within the model). For example, it may not adequately follow detailed output fluctuations and regional characteristics of renewable energy.

c) Facility planning model

This model is designed to analyze power-related sectors for the purpose of planning the development of generation and transmission facilities. A typical model of this type takes a given demand over a period of time (months to years) and calculates the cost-optimal equipment configuration and operating pattern that will satisfy the demand. Its temporal and geographic resolutions are higher than the aforementioned energy supply and demand model, and can take into account power system characteristics to some extent. Still, the resolution is not enough for reliability evaluation or flow calculation. In addition, plants generally tend to be grouped together by region, and it is not possible to simulate the operation of individual plants.

d) Optimal operation model

This model can simulate the operation of a given power system at a relatively high time resolution (down to one hour). The operation pattern for all plants that has the lowest total cost will be calculated reflecting grid constraints. Differences between individual plants are represented, providing an analysis that is more detailed than the model above. On the other hand, the facility configuration in the grid is a given and not subject to optimization, so it is not suitable for facility development planning as done by models (1) and (2).

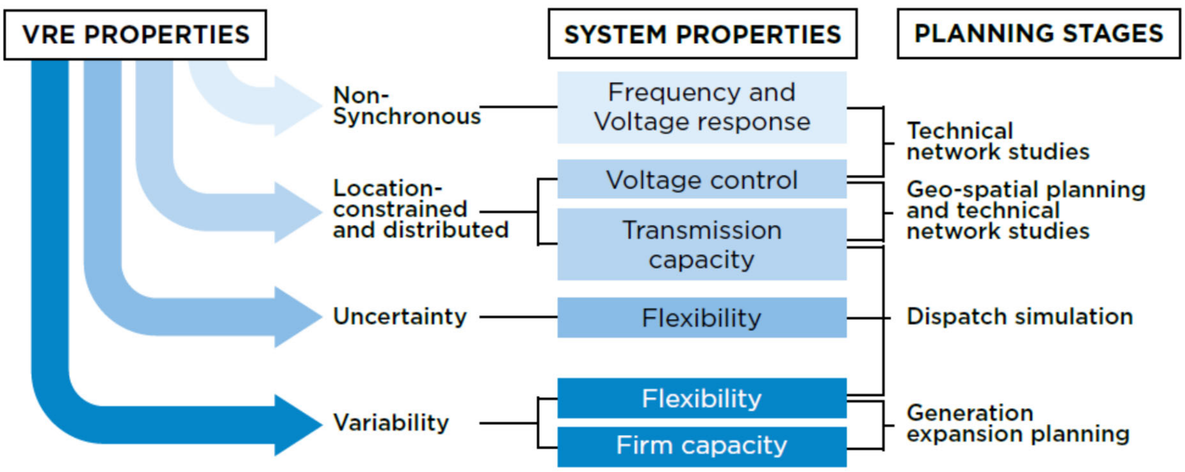
e) Reliability evaluation model

The purpose of this model is to study measures to improve grid congestion and to evaluate grid stability against disturbances. It simulates the target power system with extremely fine temporal resolution of milliseconds to tens of seconds, and calculates frequency and power flow. This type of model has characteristics different from those previously described and is not intended for economic investment planning or operation calculations.

In general, it is useful to use b), c) or d) to develop an energy master plan for a country.

(2) Model requirements for mass implementation of VRE

In long-term energy planning, existing models (long-term power supply expansion models) have limitations in assessing the challenges associated with connecting massive variable renewable energy (VRE) to the grid, and improvements in accuracy are underway. According to IRENA (2017), the first step is to improve the temporal and spatial resolution of existing models. The main characteristics that distinguish VRE from conventional power sources are: 1) it is an asynchronous power source, 2) it is geographically constrained, 3) forecasting is subject to uncertainty, and 4) it is variable with seasonal and daily fluctuations due to its weather dependency.



(Source) IRENA(2017), Planning for the sustainable future

Figure 250 Key links between VRE, power system properties, and plannning

In this context, IRENA (2017) identified the following model requirements for mass implementation of VRE.

a) Temporal resolution

Temporal resolution refers to the "time slice," which is the block of time over which the variability of demand is evaluated. The typical number of time slices used in long-term power supply expansion models consists of four seasonal demand variations, two weekly demand variations (weekday and weekend), and four six-hour blocks of daily variations, giving a total of 32. As the percentage of VRE increases, the variability of VRE supply must also be considered. By understanding the variability of supply, the costs associated with over- or under-generation of VRE can be properly represented. By increasing the temporal resolution, the economic rationale can be pursued, as VRE power sources can be considered valuable if the generation profile of VRE is consistent with its demand profile. These economic impacts cannot be factoring if the time resolution is low. The decision to introduce a higher time resolution should be needs to consider the uncertainty of VRE generation pattern.

b) Geographic resolution

Geographic resolution refers to the divided regions that make up the model, referred to as "nodes" in the power supply expansion model. They reflect the spatial distribution of load, VRE and non-VRE sources. The number of nodes is often small in the long-term power supply expansion model, and domestic transport by domestic transmission lines is not analyzed. Increasing geographic resolution is important in the sense that the uniqueness of each VRE location can be assessed and an approximation of the amount and cost of transmission augmentation can be obtained. Increasing geographic resolution also allows the model to better analyze the need for investment in transmission lines by better reflecting resource availability and temporal profiles, and by allowing the model to take into account the options available for transmission between nodes.

c) Increased capacity credit constraints

Since the increase in time slice is limited by computational capacity, a simplified constraint that evaluates the contribution of VRE to stable capacity can be incorporated. Although the long-term power supply expansion model itself incorporates capacity credits as parameters calculated outside of the model, by assigning capacity credit values to various types of power plants, including VRE, a model can be developed that can guarantee that power supply expansion will provide sufficient stable capacity.

d) Built-in flexibility supply constraints

Flexible supply is made possible by controllable power plants, demand response, and international electricity trading. These options can be incorporated into the model by turning them into parameters for flexible supply. The results obtained from the model can also be further scrutinized using detailed evaluation tools to determine if they are sufficiently flexible.

e) Link to generation cost model

Generation cost models, which have been used to validate the results of long-term power supply expansion models and complement the weaknesses of temporal resolution, can translate operational flexibility requirements into operational investment decisions, reflecting short-term variations in VRE and load, technical constraints and their associated costs.

2.4.2 Typology of Representative Low-carbon or Decarbonized Energy Supply Chain Analysis Models

(1) Development in model analysis research

In formulating the Sixth Strategic Energy Plan, the government council (the Strategic Policy Committee of the Advisory Committee for Natural Resources and Energy) held discussions based on the results of model analyses by various research institutes. The discussion was based on the estimates using models of the energy supply-demand structure and necessary costs to achieve the 46% reduction in greenhouse gas emissions (against 2013 levels) in 2030 and carbon neutrality in 2050, as per the

plan. This section outlines the characteristics of the various models used in this discussion, the results and their use in the master plan.
The planning process used different models for each of the three main purposes.

(a) Use of econometric models (planning for 2030)
An econometric model is used to make forecasts based on the relationships among variables in actual data. In the study for the Strategic Energy Plan, energy demand estimate for each sector was based on economic indicators such as GDP and population.

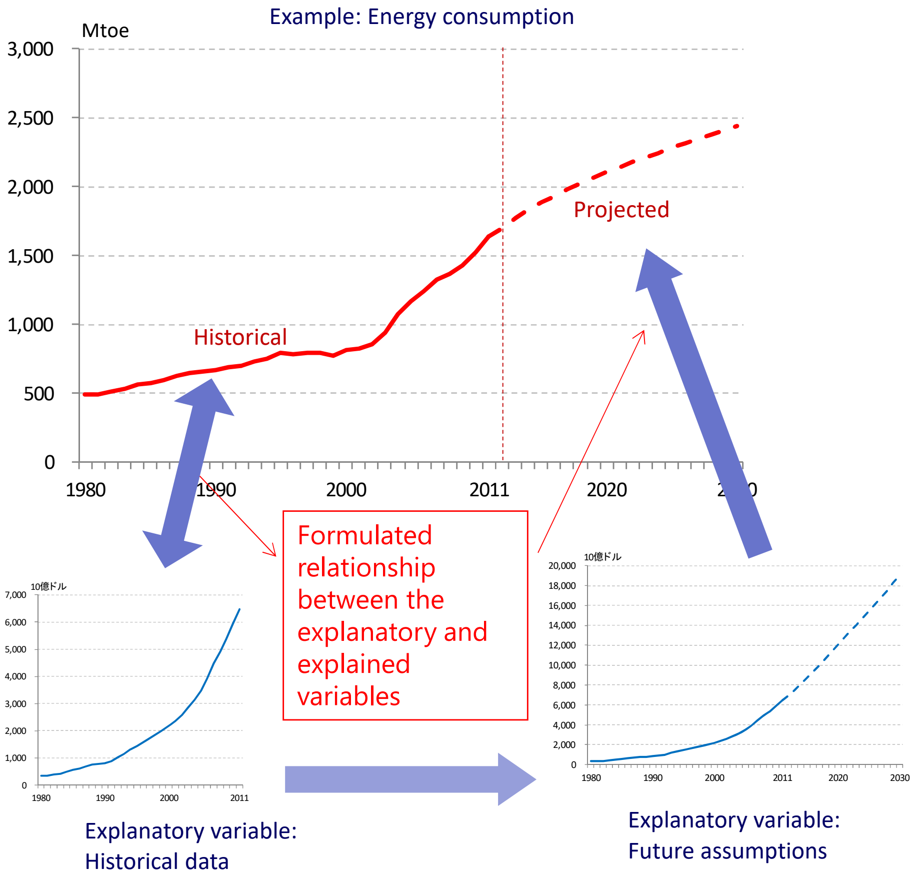


Figure 251 Schematic illustration of econometrics

As the first step in preparing the energy mix for 2030, future energy demand was projected by a econometric model based on historical data (the Comprehensive Energy Statistics). Next, the estimated amount of energy savings was subtracted from the first figure, giving the final energy demand estimate for 2030[721]. This number was used to find electricity and non-electricity mixes.
Energy demand for each consumption sector was obtained by estimating activity indicators (material production for the industrial sector, transportation volume for the transportation sector) from the population (age cohorts), then multiplying them by the energy consumption intensity. However, considering the fact that technologies and actions for saving energy will have evolved further by 2030, the final energy consumption was calculated by subtracting the demand capped by such technologies and actions.

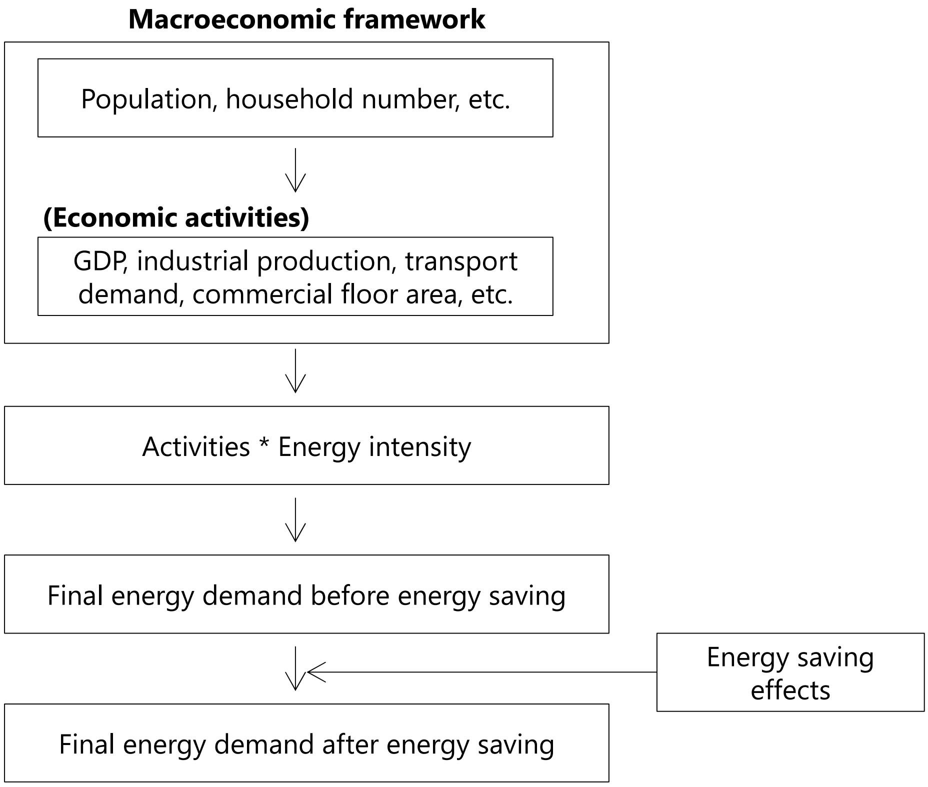


Figure 252 Structure of the econometric model used for the Strategic Energy Plan

(Source) METI, "Outlook for the energy supply and demand situations in 2030"
https://www.enecho.meti.go.jp/category/others/basic_plan/pdf/20211022_03.pdf

2030 energy demand was calculated according to the logic described above to formulate the energy mix in the Strategic Energy Plan. Compared to the previous Strategic Energy Plan, economic growth assumptions have been lowered for the latest version due to the impact of the new coronavirus and other factors, while energy saving assumptions have been ambitiously drilled down, resulting in the energy demand estimate of 280 million kl in 2030.

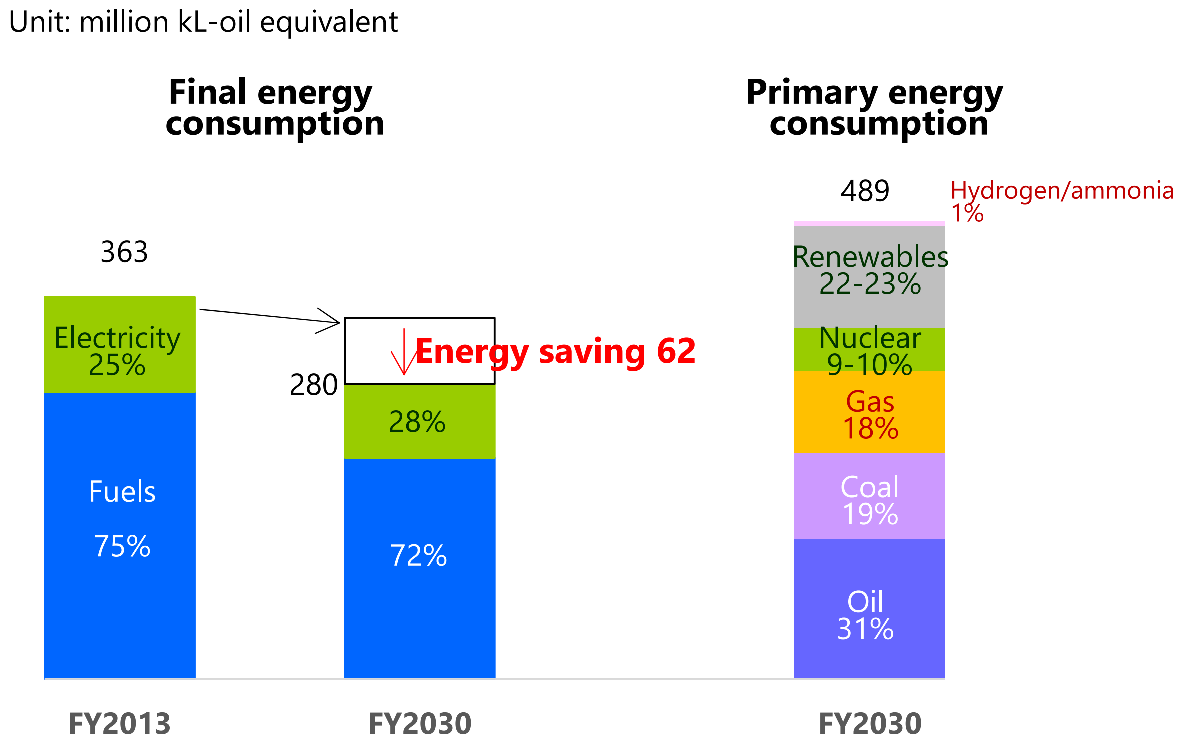


Figure 253 Energy supply and demand in 2030 in the Strategic Energy Plan

(Source) METI, "Outlook for the energy supply and demand situations in 2030"
https://www.enecho.meti.go.jp/category/others/basic_plan/pdf/20211022_03.pdf

Econometric models were used in this manner to calculate future energy demand in relation to existing energy and economy performance. However, this econometric approach assumes that the existing data (in this case, energy and various economic indicators) will remain relevant to some extent even in the future. As it is difficult to assume social changes that would significantly alter these relationships, the effective range of this method is several years to several decades, in which the impact of these changes is expected to be small.

(b) Use of technology mix model (planning for 2050)

The energy mix to achieve the assumed carbon neutrality in 2050 was calculated, with its cost and the volume of CO2 recovered. This type of analysis was used for the first time during the formulation of the Sixth Strategic Energy Plan. It was agreed that the results of the model analysis from the five research institutes and other organizations will be presented at the government council meeting. All the institutes used linear programming energy supply and demand models. Their characteristics will be summarized in the following sections.

All the energy demand-supply models used calculate the combination of technologies that minimizes costs for a given set of demand and constraints.

Taking the IEEJ-NE Japan model from the Institute of Energy Economics, Japan as an example, characteristics of this model are shown in the table below. Using the cumulative energy system cost for all of Japan in 2015-2050, taking into account discount rates, as the objective function, the energy mix that satisfies the demand of each consumption sector in the least costly way was calculated, taking various constraints into account. Characteristically, the consumption sector is considered in detail, and energy demand and supply technologies are modeled in detail (over 300) as options in each sector.

Table 197 Overview of IEEJ-NE Japan

Regional and temporal resolutions	Japan was divided into five regions (Hokkaido, Tohoku, Kanto, Western Japan, and Kyushu/Okinawa). **Generation based on one-hour supply and demand**
Analysis target period	2015-2050
Objective function	Cumulative energy system costs for all of Japan, after discount
Greenhouse gas	Energy-derived CO2
Domestic transportation	Electricity, hydrogen, methane, CO2
Final consumption sector	Industrial (steel, cement, chemical, paper-paper...), transportation (passenger vehicle, bus, truck, rail, air, and shipping), household, and business. Demand for households and businesses take different applications (hot water, kitchen, cooling, heating, lighting, others) into account
Number of technologies	Bottom-up modeling of **over 300 energy supply- and demand-side technologies**
Examples of carbon reduction technologies modeled	**Energy savings:** Consider high performance equipment on the energy supply and demand sides **Renewable energy:** ground-mounted solar power, roof-mounted solar power, wall-mounted solar power, on-shore wind power, fixed offshore wind power, floating offshore wind power, general hydropower, small and medium hydropower, geothermal, biomass **Energy storage and demand response:** pumped hydro, Li-ion batteries, NaS batteries, compressed hydrogen storage, VtoG for electric passenger vehicles, and heat pumps for demand response **Nuclear power:** Light water reactors **CO2 capture:** captured in power generation, hydrogen production, and directly from air (DAC: use of electricity assumed) **CO2 utilization and storage:** methane synthesis, liquid fuel synthesis, geological storage inside Japan, storage outside Japan **Hydrogen utilization:** hydrogen mono-fuel thermal power, hydrogen direct reduction steelmaking, fuel cell vehicle, fuel cell vessel, fuel synthesis (methane, etc.) **Direct use of ammonia:** ammonia mono-fuel power, coal/ammonia co-fired power, ammonia vessel **Negative emission:** DACCS, BECCS

(Source) METI

The basic characteristics of the models by other research institutes that were used for this project were the same as the IEEJ model. A model that is effective for studying long-term energy mix will seek for a combination of energy that can minimize the objective function (cost in most cases) by allowing for various technology options on the demand and supply sides as well as considering CO2 emission caps and other constraints. However, how region types, technology types, and constraints are considered somewhat varies depending on the purpose of each institution's analysis. Uncertainties also exist in cost, efficiency, and available potential of technologies in long-term analysis. Assumptions on those factors can make a difference. Model characteristics and results are compared in the table below.

Table 198 Comparison of five quantitative models

	RITE	IEEJ	NIES	Deloitte	REI
Model characteristics	One node Hourly data	5 nodes Hourly data	10 nodes Hourly data	351 nodes 4 seasons * 4 time slices	9 nodes Hourly data
Optimal renewable/nuclear share	54%/10%	50%/14%	74-76%/8-9%	70%/10%	100%/0%
Marginal/average electricity cost for the optimal case (JPY/kWh)	25/13	16-17/16	-/12	23/12	-
Marginal/average electricity cost for the RE100 case (JPY/kWh)	53/18	28-33/27	-	52/19	-/9.2

(Source) METI

The models used in this study had different temporal and regional resolutions. There are often trade-offs between them because of the computation time. Models that can consider electricity demand in hourly increments could have around 10 regions at most, while models that used four seasons and four time periods instead achieved a higher geographic resolution of 351 regions.

There were differences in the results calculated by each model. For example, the share of renewable energy in the power supply mix assuming carbon neutrality in 2050 ranged from 50% to 100%.

In addition, the marginal and average costs of electricity were also within a certain range, albeit narrower. These differences are the result of various impacts, from the cost of the generation facilities themselves to the costs associated with transmission, distribution, and supply-demand coordination coming from differences in the power grid and supply-demand coordination options for each model.

(c) Use of power supply models (Generation cost verification and integration costs)

The economics of different power sources have traditionally been evaluated using an index called the levelized cost of electricity (LCOE). For each power source, all costs from the start of construction to the end of operation and waste disposal of the power plant were aggregated as the value at the point of starting power generation and presented as the per unit cost of power generated. When considering policies for the electric power sector, promoting the introduction of power sources with least costs based on this index as much as possible is an important means to achieve the economic rationality, one of the Three Es (environmental compatibility, energy security, and economic rationality) which are the goals of any energy policy.

Still, the limitations of this LCOE-based evaluation of electricity sector's economic performance have been questioned in recent years. The LCOE of variable renewable energies (VRE: wind and solar), introduced globally in larger numbers in recent years, has declined significantly in many countries. It is now often lower than that of conventional power sources (thermal and nuclear). However, if these VRE power sources are introduced in large quantities, costs associated with their natural variability, e.g., costs associated with energy storage systems, output capping, and higher transmission and distribution losses, will have to be addressed. An economic evaluation that takes into account these so-called "integration costs" will be extremely important in planning future energy policies.

With this in mind, in the formulation of the Strategic Energy Plan, Mr. Ogimoto of the Power Generation Cost Verification Working Group estimated the cost impact on the power system when the 2030 energy mix is achieved, using the MR model proprietary to J-POWER Business Service Corporation. This estimation takes into account not only the facilities used for power generation but also those related to grid reinforcement and supply-demand adjustment. In order to incorporate these factors, an MR model that simulates the operation of the power system was employed. This model is one of the power supply models (optimal operation type) described in the previous typology section, and calculates the annual optimal operation for a given facility configuration and power demand.

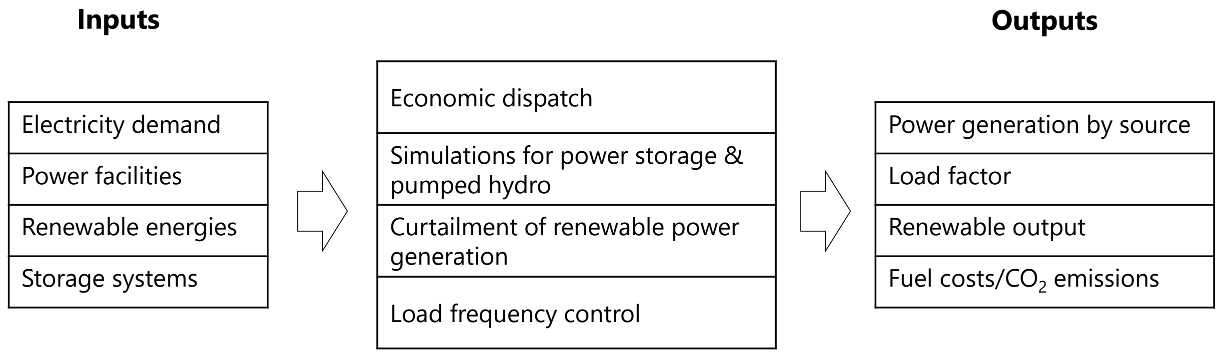


Figure 254 Overview of the power sector model MR

(Source) J-POWER Business Service Corp.

The model divides Japan into 10 regions and simulates the one-year supply and demand operations of each plant with a mixed integer linear programming approach. The analysis was based on the assumption of a power system with an energy mix in 2030, and analyzed how much adjusting power would be required for fluctuations in renewable energy output and demand, and what the marginal cost of each power source would be.

The LCOE is the sum of the costs specific to power supply, such as capital, fuel, and operation and maintenance costs, which had been calculated by the relevant working group. However, this LCOE did not include costs outside of the generation facility, i.e., costs of tasks such as balancing supply and demand, securing adjusting power, and efficiency reductions associated with output control and partial load operation. To solve this problem, the "marginal cost by source (LCOE*) had to be studied and evaluated using a power source model. This is the changes in the entire power system cost when each power source is increased in certain increments for a given energy mix. For details, see 3-1-1(2).

(2) Actual operations in developed countries and regions

As described in the previous section, many researches exist on modeling the impacts on energy and power systems during mass deployment of VRE, resulting in significant advances in the capabilities of various models. In response to these advances in modelling capabilities, developed countries and regions such as Europe, the US, and Japan are attempting to analyze the impact of massive VRE adoption using latest models. This section describes representative cases from Europe, the US, and Japan as examples of the practical application of latest models, and also summarize other models.

(a) Europe: EC creates A Clean Planet for all

A Clean Planet for all (announced November 2018) is the European Commission's (EC) net-zero GHG emissions vision, which was created by extensively using energy supply and demand models. In this communique, eight scenarios with different technologies mixes and other factors were analyzed to guide policies required for achieving net-zero emissions. In this process of analyzing scenarios, various interlinked models were used, including the Prospective Outlook on Long-term Energy Systems (POLES-JRC) and the Price-Induced Market Equilibrium System (PRIMES) in the energy sector. Overviews of POLES-JRC and PRIMES are described below.

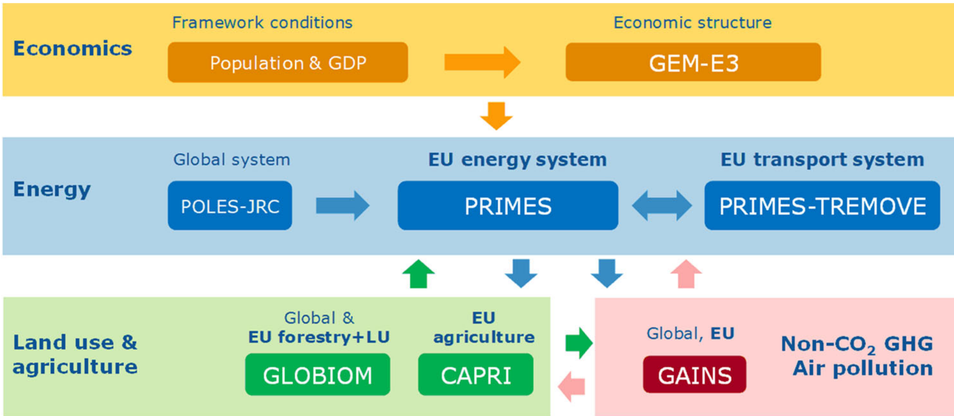


Figure 255 Model inter-linkages

(Source) European Commission (https://ec.europa.eu/clima/eu-action/climate-strategies-targets/economic-analysis/modelling-tools-eu-analysis_en)

POLES-JRC is a partial equilibrium model for analyzing the global and long-term evolution of GHG emission reduction policies and energy markets. The entire world is divided into 66 regions for analysis. Energy demand is estimated as a function of activity indicators and prices. In addition, in the electric power sector, one year is divided into six representative days to calculate dispatch for each distributed and centralized power source. The development of POLES-JRC began in 1990s at what is now the Grenoble Alpes University. The model is currently in operation at the Joint Research Centre (JRC), a scientific research organization directly reporting to the EC.

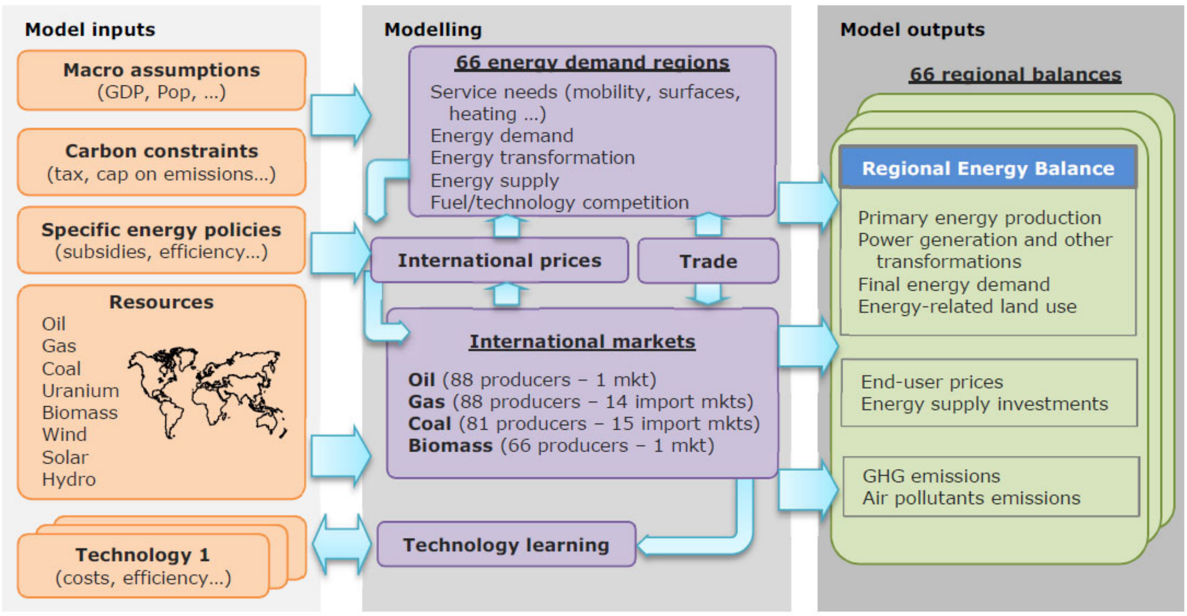


Figure 256 POLES-JRC model structure

(Source) JRC (2018), POLES-JRC model documentation

PRIMES is a partial equilibrium energy system model that can provide detailed assumptions about energy supply and demand, prices, and future investments. In this model, calculations are performed by connecting multiple sub-modules. Analysis using this model can cover EU member states and neighboring European countries for evaluations up to the year 2070 in five-year increments. In this model, energy demand is represented by a nonlinear function based on microeconomics rather than linear programming (mathematically formulated as equilibrium program with equilibrium constraints, or EPEC). For the power generation sector, the analysis is based on the electricity demand curve for a representative day, which also reflects seasonal variations, etc., rather than by-the-hour modeling. PRIMES was developed by E3 Modelling, a consulting firm in Greece.

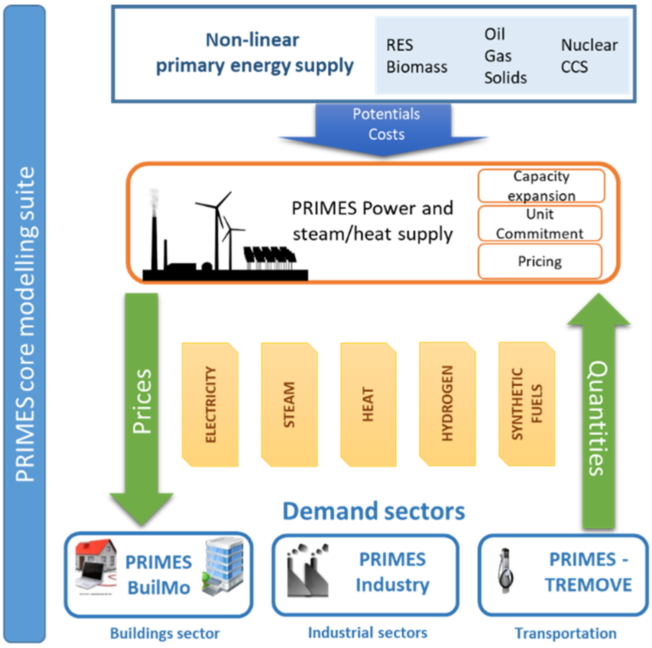


Figure 257 PRIMES model structure

(Source) E3 Modelling (https://e3modelling.com/modelling-tools/primes/)

(b) Europe: ENTSO-E creates TYNDP

The European Network of Transmission System Operators for Electricity (ENTSO-E) was established under the rules of the EU's Third Energy Package (2009). This organization's task is to strengthen coordination among grid operators and support the establishment of a pan-European electricity system in line with EU policy objectives. ENTSO-E utilizes different models for creating the 10-Year Network Development Plan (TYNDP).

The TYNDP is the medium- to long-term pan-European grid development plan that ENTSO-E is required to prepare by EU regulations. The plan envisions the international grid infrastructure needed for the future pan-European energy market, and evaluates the cost-benefit performance of planned international grid infrastructure development projects proposed by grid operators and other stakeholders in the region.

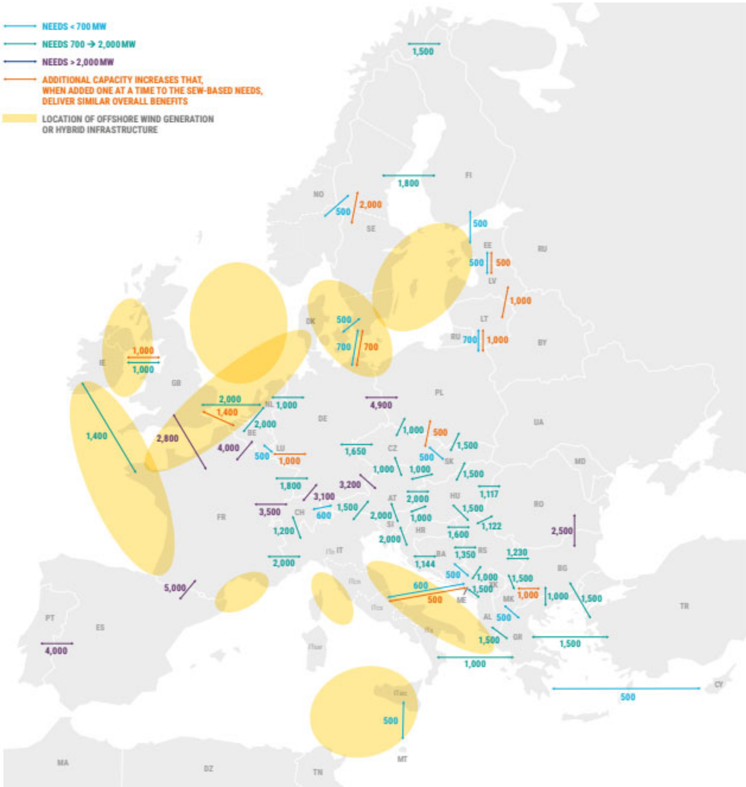


Figure 258　A TYNDP analysis for 2040

Source：ENTSO-E(2021) , Completing the map Power system needs in 2030 and 2040

After the TYNDP is prepared, the EC will select a group of high priority projects for implementation in order to achieve climate change and energy policy objectives of the EU, with reference to the cost-benefit assessment and other information in the document. The projects chosen are given the status of European projects of common interest (PCI) and become eligible for preferential treatment in terms of accelerated planning, licensing, and approvals. In other words, within the process of forming the region's international grid infrastructure, the TYNDP can help filter project proposals that will be effective in achieving the EU's policy goals and will receive a boost in realization.

There were four key steps (TYNDP Process)[722] for creating the TYNDP 2020.

(1) Creation of multiple scenarios for future pan-European energy and power systems
(2) Identification of needs for international grid infrastructure
(3) Collect and identify proposed infrastructure development projects in the region
(4) Cost-benefit evaluation of the collected project proposals

ENTSO-E used different models for each of these steps, as shown in the table below.

722 https://tyndp.entsoe.eu/

Table 199 Overview of the models used for TYNDP 2020

<table>
<tr><th>Name</th><th>Overview</th></tr>
<tr><td>Ambition Tool</td><td>Excel-based internal energy balance model[723]. It is used in Step (1) to convert qualitative storylines into quantitative annual scenarios.

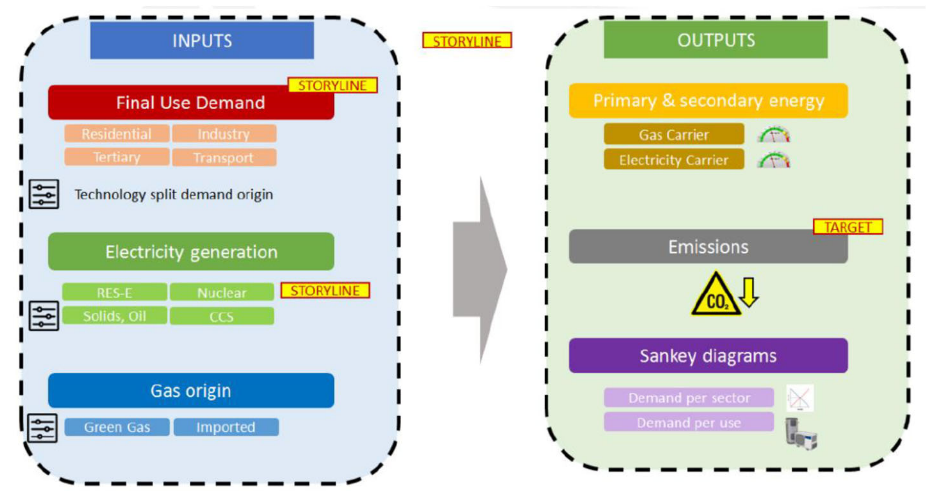


FIGURE 8: HIGH LEVEL DESCRIPTION OF THE AMBITION TOOL</td></tr>
<tr><td>TRAPUNTA</td><td>Software for power demand estimation. Used in Step (1) is to create hourly electricity demand profiles by market node, year, and scenario based on the Ambition Tool calculations[724].

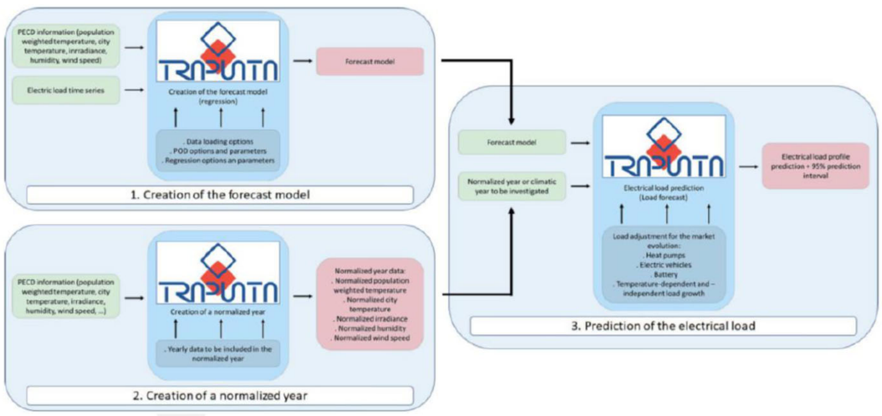


FIGURE 20: THREE PROCESS STEPS IN TRAPUNTA</td></tr>
<tr><td>PLEXOS</td><td>An integrated energy model that allows for grid cost minimization calculations, etc[725]. Used in steps (1) and (4).</td></tr>
</table>

[723] https://2020.entsos-tyndp-scenarios.eu/wp-content/uploads/2020/06/TYNDP_2020_Scenario_Building_Guidelines_Final_Report.pdf

[724] https://2020.entsos-tyndp-scenarios.eu/wp-content/uploads/2020/06/TYNDP_2020_Scenario_Building_Guidelines_Final_Report.pdf

[725] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jan/IRENA_Planning_for_the_Renewable_Future_2017_JP.PDF?la=en&hash=B5338F5F277030834FFEE20812C3E0898BD92FB1

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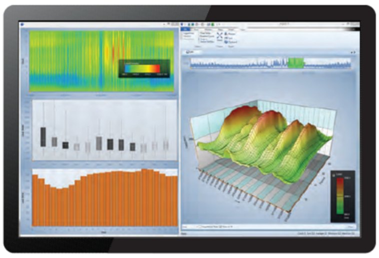
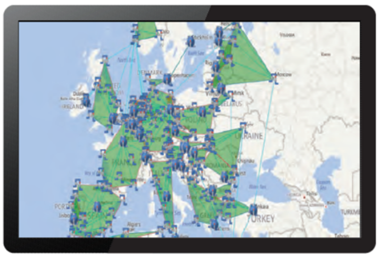

高度な視覚化ツールによる電力需要(使用電力)統計グラフ

発電量、入札価格、入札量など発電施設に関する数量・価格表示モード

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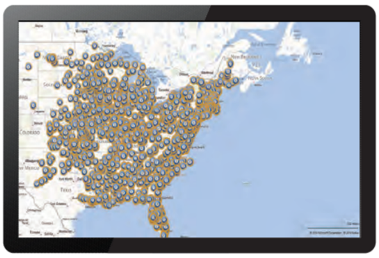
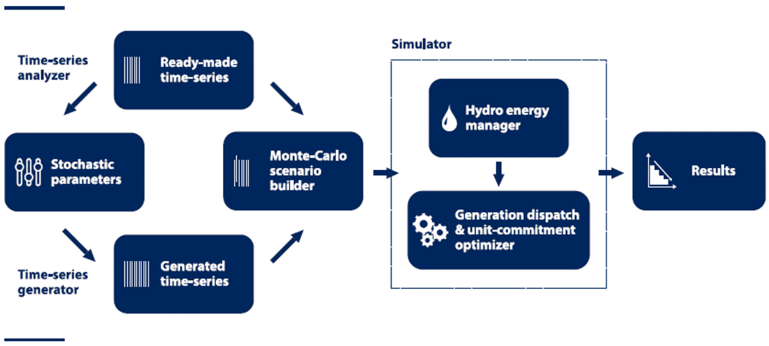
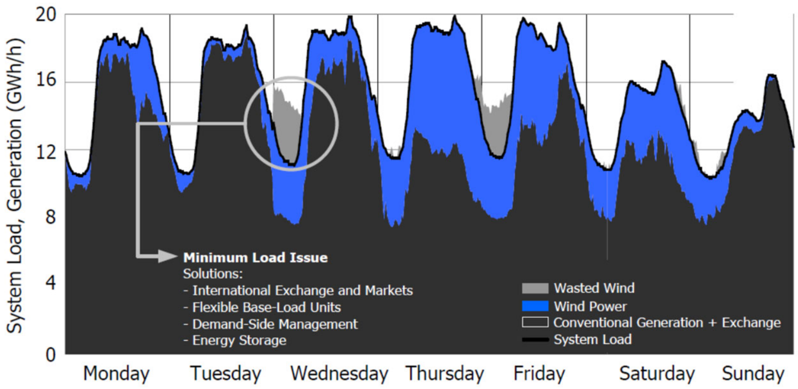

米国東部発電施設マップ
</td></tr>
<tr><td>ANTARES</td><td>Open source software for evaluating the adequacy and economic of international energy systems[726].
Used in all steps.
(Steps (2) and (3) use an extended model called ANTARES-Xpansion)


</td></tr>
<tr><td>POWRSYM</td><td>A tool to simulate optimal dispatch (power supply) for the short- and medium-term demands in electricity, gas, and heat727. Used in step (4).


</td></tr>
</table>

[726]https://antares-simulator.org/
[727]http://www.powrsym.com/PowrSym4.htm

PROMED	A tool that can calculate, for example, the optimal dispatch that minimizes system costs[728]. Used in **step (4)**.
Convergence	System research and development software for flow optimization and other calculations[729]. Used in **Step (4)** to integrate the grid models collected from each TSO.
Integral	Software for load-flow simulation, etc[730]. Used in **step (4)** to integrate the grid models collected from each TSO.
PSS/E	Both are commercially available tools for power flow and stability analysis[731]. Used in **Step (4)** to integrate the grid models collected from each TSO.
PowerFactory	

(Source) TYNDP 2020, etc.

Outside of this list, BID3 is also used as a model for calculating generation output in the pan-European power dispatch model. Details of BID 3, ANTARES and POWERSYM are shown in the table below.

Table 200 Models used for TYNDP 2020

Key feature	BID 3	ANTARES	POEWRSYM
Simulated days	365	365 (52 weeks per cycle for economic simulation, 365 days for adequacy simulation)	365
Result resolution	Hours, one year	Hours, days, weeks, months, years	Hours, days, weeks, months, years, fiscal years
Probabilistic/Deterministic	Deterministic (probabilistic analysis for hydraulics)	Deterministic, deterministic (including derating), or Monte Carlo method. Includes planned and forced outages for thermal, inflows and reservoir levels for hydro, intermittency for wind and solar, and load uncertainties	Deterministic, deterministic (including derating), and Monte Carlo method. Including outages of other units, hydro and wind fluctuations, load fluctuations, and uncertainties regarding the amount of transmission system availability
Start-up cost model	Available	Startup and fixed costs are not considered in the initial unit commitment, but are added later for feed-in	Explicitly modeled and considered in determining total costs and unit operations
Reserve capacity model	Not available	Multiple options available (rated or optimized values for frequency control, etc.)	Frequency control, operational power adjustment system, and control area. Combinations of

[728]http://userpage.fu-berlin.de/ffu/realise_forum/www.realise-forum.net/pdf_files/051215-16_Benini.PDF

[729]https://www.rte-international.com/digital-solutions/?lang=en

[730]https://eepublicdownloads.blob.core.windows.net/public-cdn-container/tyndp-documents/TYNDP2020/Foropinion/TYNDP2020_CBA_Implementation_Guideline.pdf

[731]https://www.irena.org//media/Files/IRENA/Agency/Publication/2017/Jan/IRENA_Planning_for_the_Renewable_Future_2017_JP.PDF?la=en&hash=B5338F5F277030834FFEE20812C3E0898BD92FB1

			these parameters can be specified for each area.
Hydropower modeling, reservoir management	Optimization available	Optimization of monthly energy, reservoir capacity modeling	Reservoirs with weekly energy allocations, hourly minimum and maximum generation can be configured. Natural inflow, upper and lower elevation limits for each reservoir, turbine flow and efficiency can be configured as inputs for hydropower
Pumped storage hydropower model	Optimization (weekly optimization only)	Optimized (daily/weekly) or fixed according to the purpose of the analysis	Optimization: use pumped storage to minimize weekly system costs. Modeled storage volume (both top and bottom)
Cost of unsupplied energy	Included	Included	Included
Shutdown cost	RES is capped by additional cost of 0€/MWh	Penalty can be imposed, usually set to 0	Can be modeled by including it in the cost function. Cost and scale vary by week or whether the facility already exists.
Maintenance optimization	Fixed fee specified by LAC[732]	Not available (randomly generated or pre-fixed)	1. Fixed maintenance schedule. 2. Maintenance schedule calculated based on weekly load loss probability leveling. 3. Maintenance schedules calculated to minimize annual production cost.
Minimum start/shutdown time model	Available	Available	Available
Ramp-up/down-rate modeling	Power plants for inter-regional grid connection are not included. Can be handled if data is available.	Not available	Unit ramp rate can be used. Considered in both frequency reserve level and feed-in cost optimization
Possibility to model multiple constraints (e.g., maximum import/export volume)	Available	Available	Available

732 LAC (Long-term Adequacy Correspondents)

Possibility to build loss models	Available, but applies 0.01€/MWh cost for inter-regional grid connection to prevent unrealistic flows	Not available	Available
Possibility of modeling physical flows	Not available	PTDF [733]Matrix: available. Impedance: available. For pan-EU analysis, only NTC[734]modeling is considered.	Flow rates are modeled by NTC or PTDF.

Source：ENTSO-E, Data and expertise as key ingredients

(c) Europe: UK National Grid ESO creates FES

National Grid ESO, the UK's transmission and gas supplier, has developed Future Energy Scenarios (FES), a scenario analysis model for achieving net-zero GHG emissions by 2050, using various models such as BID 3.

BID 3 is a power analysis model developed by Swedish-Finnish consulting firm AFRY. In the FES analysis, the conditions entered are future generation facilities and transmission lines, annual electricity demand, and the size and price of demand-side response. Outputs include power generated at stations and sent through transmission lines, and CO2 emissions.

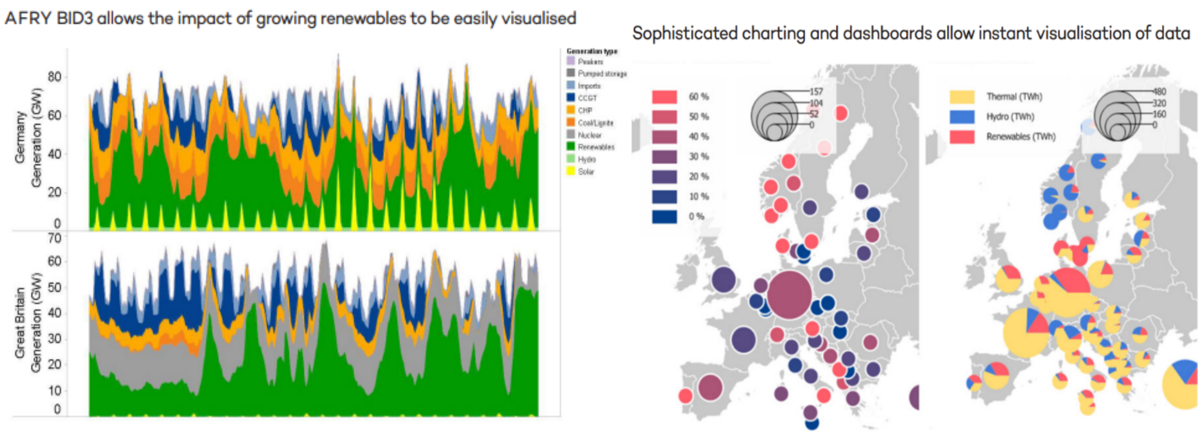


Figure 259 An analysis by BID 3

(Source) AFRY website (https://afry.com/sites/default/files/2021-02/afry_bid3_flyer_v100_2021.pdf)

(d) USA: NEMS[735]used in EIA

The Energy Information Administration (EIA), a statistics and analytical agency under the U.S. Department of Energy, is developing its own energy economic modeling system, the National Energy Modeling System (NEMS). The model is primarily used to predict the potential impact of energy markets, the economy, the environment, energy security, and other factors may have on US energy systems under a variety of assumptions. NEMS can forecast energy production, imports, conversions,

[733] PTDF (Power Transfer Distribution Factor)
[734] NTC (Net Transfer Capacity) (See https://eepublicdownloads.entsoe.eu/clean-documents/pre2015/ntc/entsoe_NTCusersInformation.pdf)
[735] https://www.eia.gov/outlooks/aeo/nems/documentation/electricity/pdf/m068(2020).pdf

consumption, prices, and other data over a 20-25 year period by setting various conditions. EIA uses these features to produce reports such as the Annual Energy Outlook and to respond to requests for analysis from the US Congress and US government agencies.

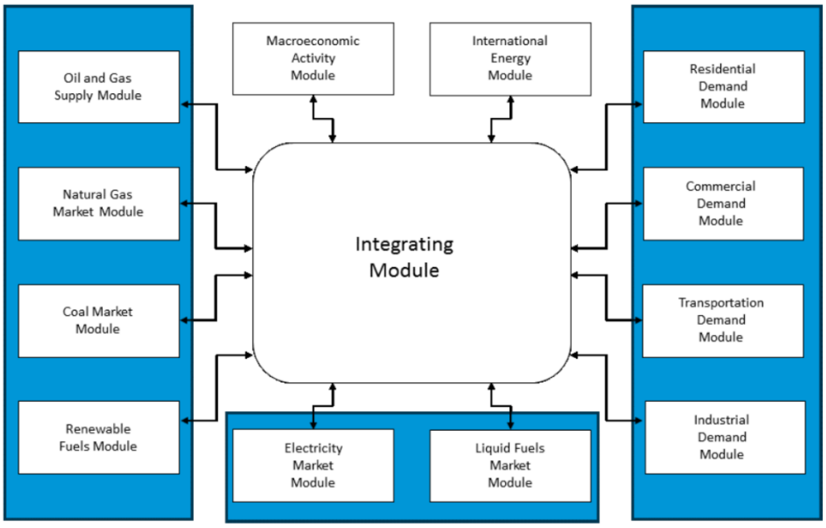


Figure 260 Structure of NEMS

(Source) EIA(2019) , The National Energy Modeling System: An Overview 2018

NEMS consists of a number of modules that focus on different energy sources and final consumption sectors. Among these is the Electricity Market Module (EMM), a component also relevant to renewable energy generation. The EMM calculates the most economically rational generation pattern (including distributed generation) for the utility based on information such as electricity demand, fuel prices, and macroeconomic parameters sent from other NEMS modules or inserted from outside the model. The information derived from the calculations, such as electricity prices, fuel consumption, CO2 emissions, are then sent to other modules.

The EMM can be further broken down to five sub-modules. A summary of each sub-module is shown in the table below.

Table 201 Submodules of EEM

Submodule	Overview
Electricity Load and Demand Submodule	The sub-module that depicts seasonal and hourly electricity demand for power plant operations and capital investment planning.
Renewable Storage Submodule	A linear programming model that determines the dispatch of different generation technologies to minimize generation costs.
Electricity Capacity Planning Submodule	The sub-module that determines how the power industry will transform its generation facility mix into the future.
Electricity Fuel Dispatch Submodule	The sub-module that allocates generation capacity to minimize costs while taking operational and environmental factors into account.
Electricity Finance and Pricing Submodule	The sub-module that forecasts financial information (including the electricity sales price) for electric power companies based on assumptions such as facility plans and operating costs.

(Source) EIA (2020), The Electricity Market Module of the National Energy Modeling System: Model Documentation 2020

(e) Japan: OCCTO develops a wide-area grid development plan

The Cross-Regional Coordination of Transmission Operators (OCCTO) of Japan uses PROMOD, a power system modeling and economic evaluation simulation software. The OCCTO is obligated under the Electricity Business Act to develop a wide-area grid development plan. In order to identify economically rational projects from among the numerous grid enhancement candidates to be included in the plan, it is necessary to evaluate the cost-benefit of each project based on a rationally estimated future power flow across the country. However, the Excel-based interconnection line power flow simulation model previously used by OCCTO was limited to areas and interconnection lines, and did not include local backbone systems in its analysis. For these reasons, the OCCTO introduced PROMOD as a tool for analysis with the level of accuracy required for planning.

An example of the effective use of PROMOD by the OCCTO is the provision of simulation results in the process of developing a master plan for the cross-regional interconnected power grid system. The "Study Committee on the Master Plan for the Wide-Area Grid and Rules for Grid Utilization," for which OCCTO serves as the secretariat, is discussing the long-term policy for the wide-area grid and new mechanisms for facility formation and grid utilization, with the goal of developing a master plan by the end of FY2022. PROMOD simulation results (scenario-specific analysis) have been presented to the study committee to facilitate these discussions[736].

OCCTO inputs data for grid analysis (electricity demand, renewable energy output, power supply-related information, grid data, etc.) received from general electric utilities into PROMOD, and builds a nodal model (about 1,200 nodes and 1,400 branches) with the wide-area interconnected system (upper two voltages) set up in units of transmission lines and substations. The model is constructed by inputting data such as the upper two voltages. Based on this information, power flow assumptions (8,760 hours) based on the wide-area merit order are made to minimize the total cost including startup costs (fuel cost + CO2 countermeasure cost) per weeks, taking into account various operational constraints. Congested systems are identified, while fuel costs, CO2 countermeasure costs, etc. with and without congestion system enhancements are calculated and compared.

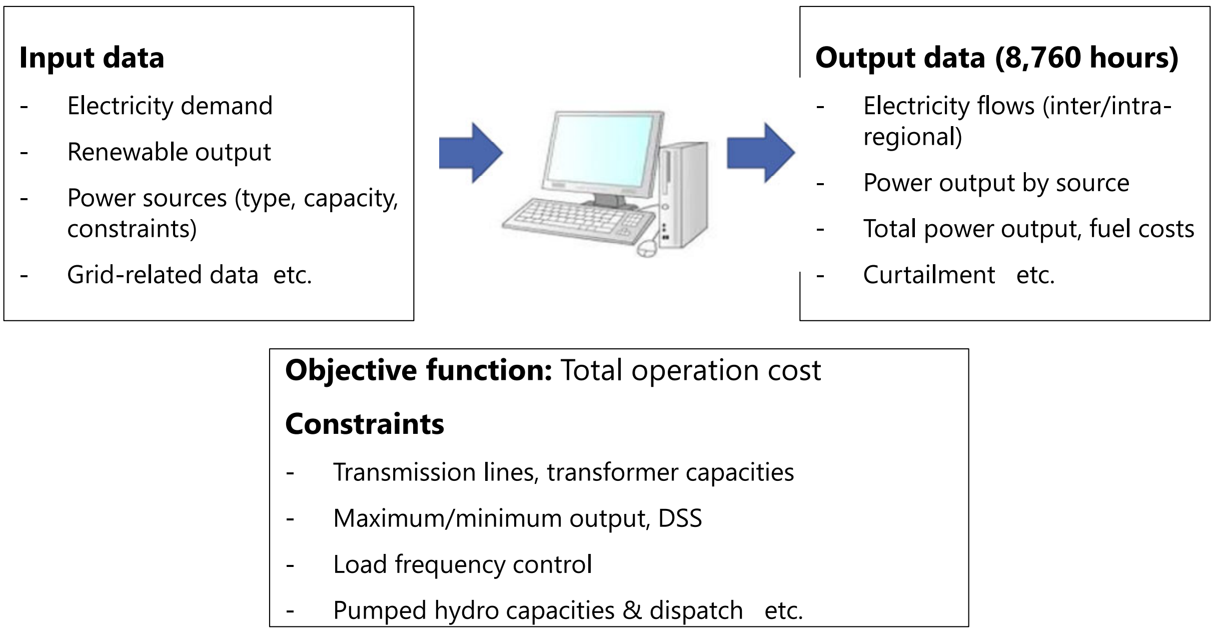


Figure 261 Simulation model by OCCTO

736 OCCTO (2021) (https://www.occto.or.jp/iinkai/masutapuran/2021/files/masuta_10_02_01.pdf)

(Source) OCCTO (2020)

The Planning Department of the OCCTO Secretariat is tasked with PROMOD operation. The OCCTO classifies this operation as "work that requires a high degree of expertise as well as continuity within the institution." The operation team members are mostly young people directly hired by the OCCTO. However, the OCCTO is currently forced to rely on people seconded from electric power companies to perform various tasks because the proportion of direct hires is low (as of June 30, 2020, only around 16% of the total workforce was directly hired), and also because latest expert knowledge is needed to configure various systems and operations. On the other hand, in order to maintain its principle as a neutral public interest organization, the OCCTO has medium- and long-term plans to reduce the percentage of seconded staff members and re-establish itself as an entity run by direct hires. This leads to the assumption that one of their challenges at this moment could be to have direct hires familiarize themselves with PROMOD operations quickly.

(f) Other models

Models other than already described in above real-life examples are outlined below.

(f-1) EnergyPLAN

EnergyPLAN is an energy supply and demand model (freeware) developed by, among other members, engineers at the Sustainable Energy Planning Research Group at Aalborg University. Instead of overall energy supply and demand, the model evaluates only power generation, heating and cooling, and automobiles in hourly increments, and can deterministically optimize facility operations only (not capital investment). The model tends to be used more often in academic papers.

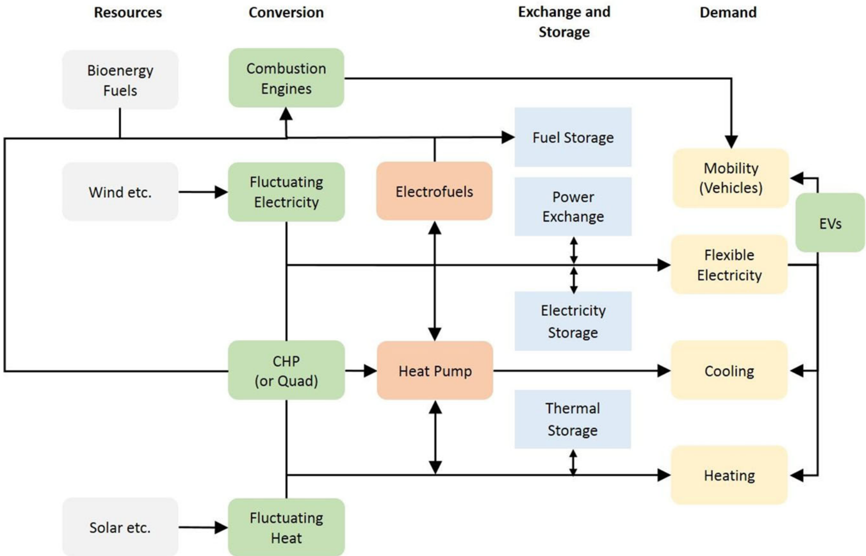


Figure 262 Model structure of EnergyPLAN

(Source) EnergyPLAN website (https://www.energyplan.eu/)

(f-2) TIMES

The Integrated MARKAL-EFOM System (TIMES) is an energy system model developed and maintained by the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency (IEA). The model is used for policy analysis in many countries. For example, an estimate for energy systems that can achieve zero emissions in Japan, the model consisted of one regional category (Japan), five year intervals, and six time slices per year.

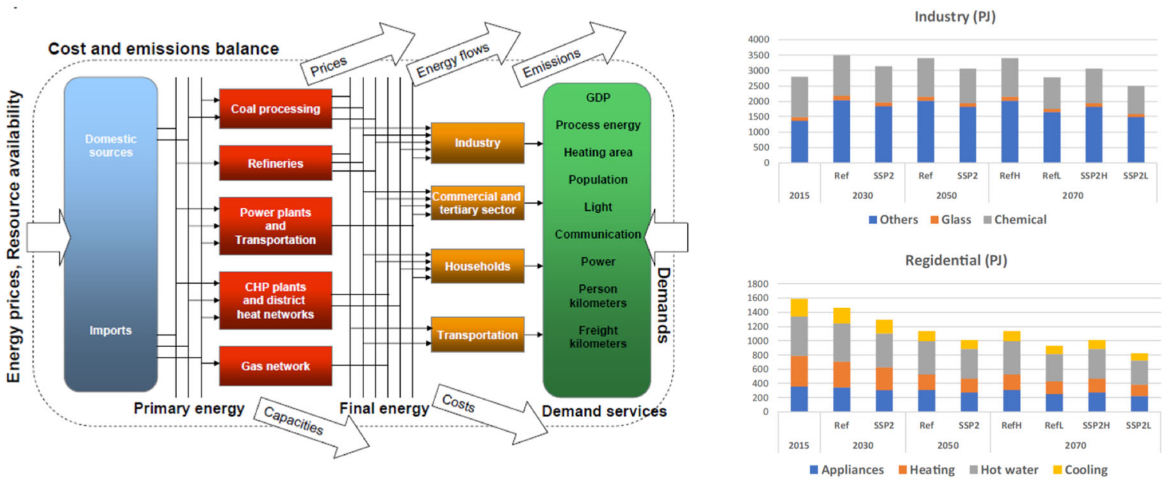


Figure 263 Model sructure of TIMES and Japan's energy demand calculated by TIMES

(Source) ETSAP website (https://iea-etsap.org/index.php/etsap-tools/model-generators/times) and E. Kato, A. Kurosawa (2021), Role of negative emissions technologies (NETs) and innovative technologies in transition of Japan's energy systems toward net-zero CO2 emissions

(f-3) MESSAGE

MESSAGE (MESSAGEix) is a linear programming (LP) global energy model developed by the International Institute for Applied Systems Analysis (IIASA). The model divides the world into 11 regions for analysis. It was used to calculate RCP8.5 of the IPCC's Fifth Assessment Report. There is an agreement allowing the IAEA and its member states to use the model for analysis.

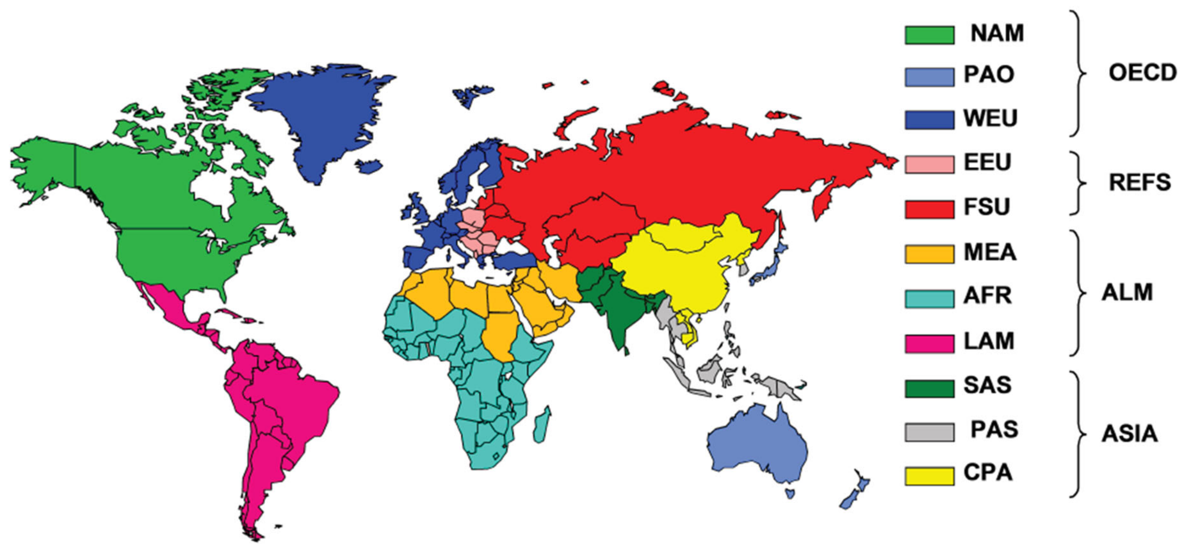


Figure 264 Regional divisions by MESSAGE

(Source) IIASA(2021) , MESSAGEix-GLOBIOM Release 2020

(f-4) WASP

The Wien Automatic System Planning Package (WASP) is a long-term power planning model developed by the International Atomic Energy Agency (IAEA). In the model, a year consists of 12 load duration curves (meaning hourly output variations are not modeled). Optimizations are possible, even for new generation facilities. The model was developed in the 1970s and later provided free of charge to IAEA member states. User trainings were offered in the past. It has also been used to formulate power supply development plans in developing countries. However, there are few examples using this model in recent studies.

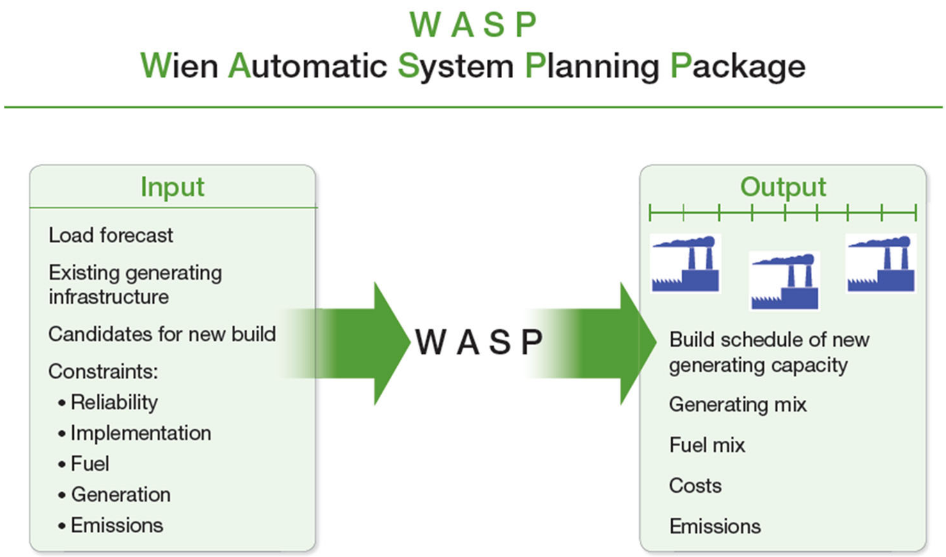


Figure 265 Major imputs and outputs (WASP)

(Source) IAEA(2009) , IAEA Tools and Methodologies for Energy System Planning and Nuclear Energy System Assessments

(f-5) REMIND

REMIND is a general equilibrium model for energy and economy (linked to macroeconomic models and bottom-up energy technology models) developed by the Potsdam Institute for Climate Impact Research. The model divides the world into 12 regions and covers analysis up to the year 2100. The model also explicitly takes into account more than 50 different technologies for energy conversion (e.g., power generation).

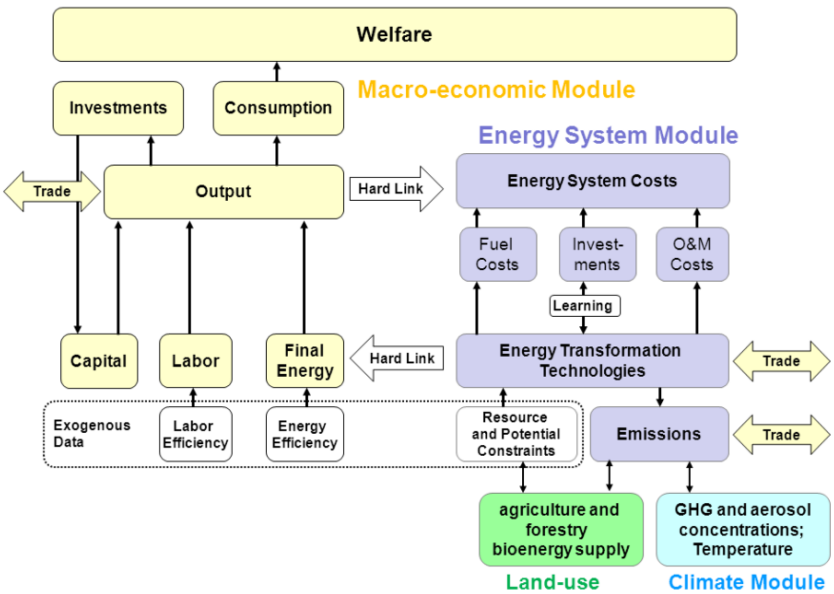


Figure 266 Model structure of REMIND

(Source) Luderer et al.(2015) , Description of the REMIND model (Version 1.6)

(f-6) IMAGE

The Integrated Model to Assess the Global Environment (IMAGE) is an integrated assessment model from the Netherlands Environmental Assessment Agency (PBL). The scope of analysis includes not only energy supply and demand but also an assessment of the impacts of earth systems and climate change. The model divides the world into 26 regions and allows analysis up to the year 2100. It has been under development since around 1990 to analyze global environmental changes. In addition, it has been used in the preparation of RCP2.6 of the IPCC's Fifth Assessment Report.

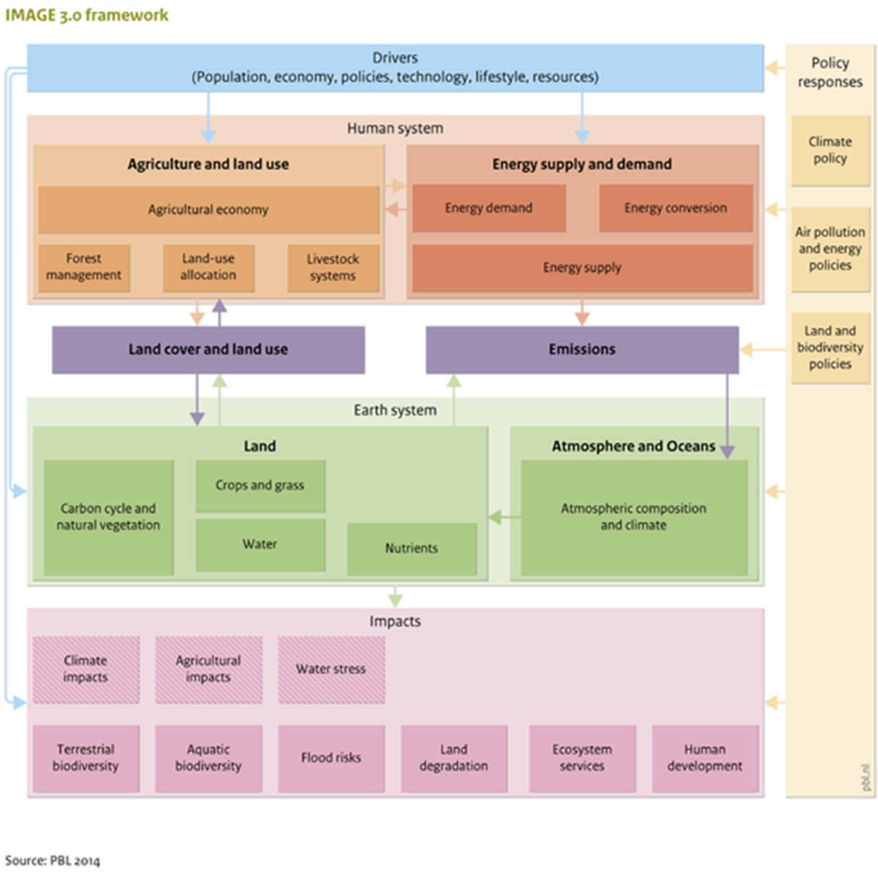


Figure 267 Model structure of IMAGE

(Source) PBL(2014) , Integrated Assessment of Global Environmental Change with IMAGE 3.0Model description and policy applications

(f-7) GCAM

The Global Change Assessment Model (GCAM) is an integrated assessment model developed by the Pacific Northwest National Laboratory (PNNL). Rather than cost optimization, the model handles market equilibrium (prices matching between supply and demand means maximum profit for producers and minimum cost for consumers) . 32 regions in the world have changes in their economy, energy, land use, water, and earth systems. In addition, it has been used in the preparation of RCP4.5 of the IPCC's Fifth Assessment Report.

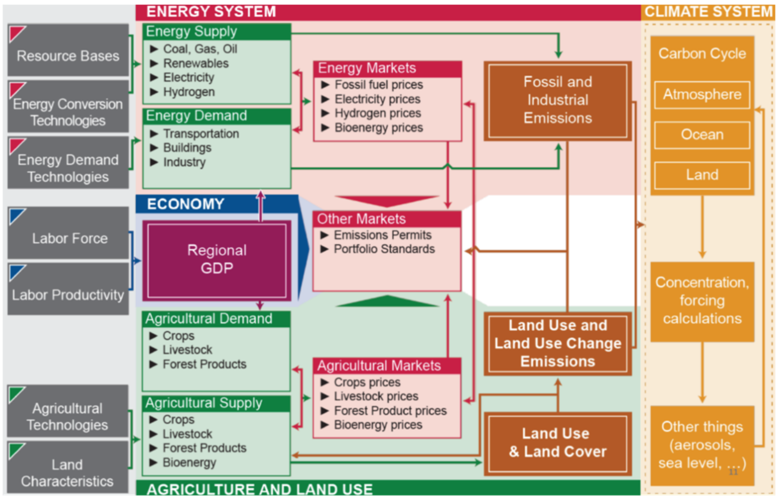


Figure 268 Model structure of GCAM

(Source) JOINT GLOBAL CHANGE RESEARCH INSTITUTE(2018) , Overview of the Global Change Assessment Model (GCAM)

(f-8) WITCH

The World Induced Technical Change Hybrid (WITCH) is an integrated assessment model developed by the European Institute for Economic and Environmental Research (EIEE) in Italy. A comprehensive assessment of climate change mitigation and adaptation is made possible by modeling economy and energy and linking the model to the GLOBIOM model for land use and the MAGICC model for climate change. It covers 17 regions of the world and can evaluate up to the year 2100. WITCH optimization maximizes the utility of each region instead of minimizing cost. The model also takes into account the free-rider effect, whereby one region's emissions cause significant climate damage to the entire world. This model is provided as open source.

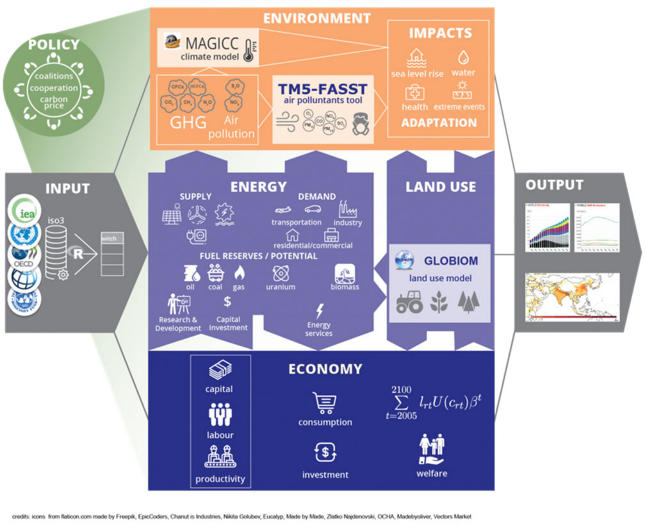


Figure 269 Model structure of WITCH

(Source) EIEE website (https://www.eiee.org/tool/witch-world-induced-technical-change-hybrid/)

(f-10) LUT

A research group from the Lappeenranta-Lahti University of Technology (LUT) and other institutions estimated energy supply and demand under 100% renewable energy using by-the-hour models for 145 countries and regions around the world. Until around 2017, the analysis was limited to the electricity sector, but starting with the 2019 version, the industrial, consumer, and transportation sectors are modeled to estimate overall energy supply and demand.

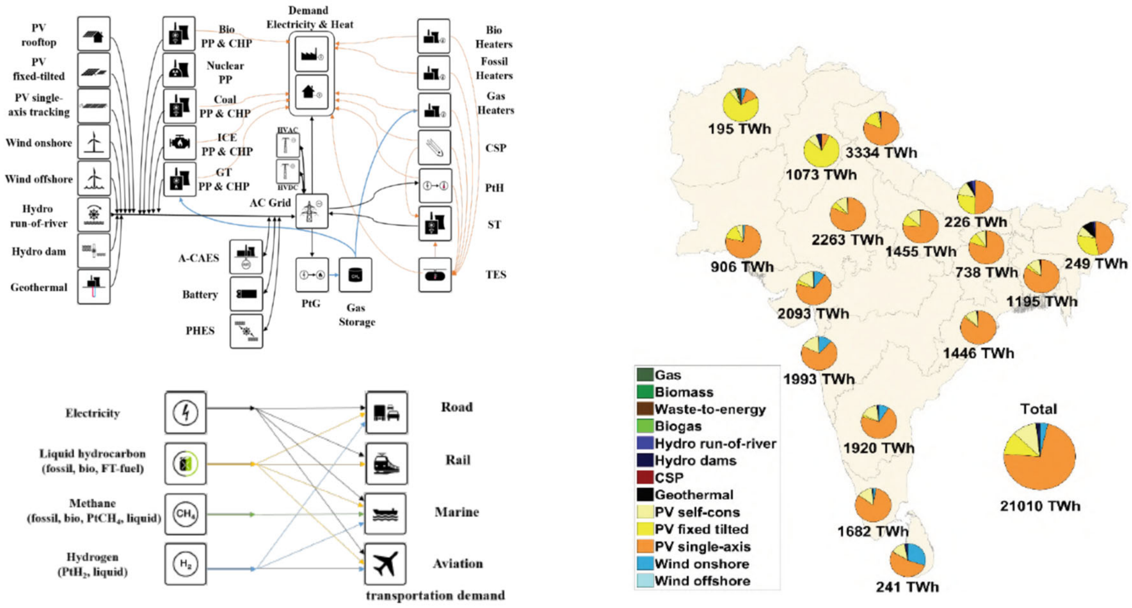


Figure 270 Energy System Transition model by LUT

(Source) Ram et al.(2019) , Global Energy System based on 100% Renewable Energy -Power, Heat, Transport and Desalination Sectors

(f-11) WORLD ENERGY MODEL

This is the set of models used by the International Energy Agency (IEA) for the World Energy Outlook. Future energy demand is estimated by an econometric model based on the IEA energy balance table. The cost minimization approach is then used to calculate the optimal deployment of energy-related technologies and estimate the final energy consumption for each scenario. The power supply sector utilizes an hourly power supply configuration model for evaluation.

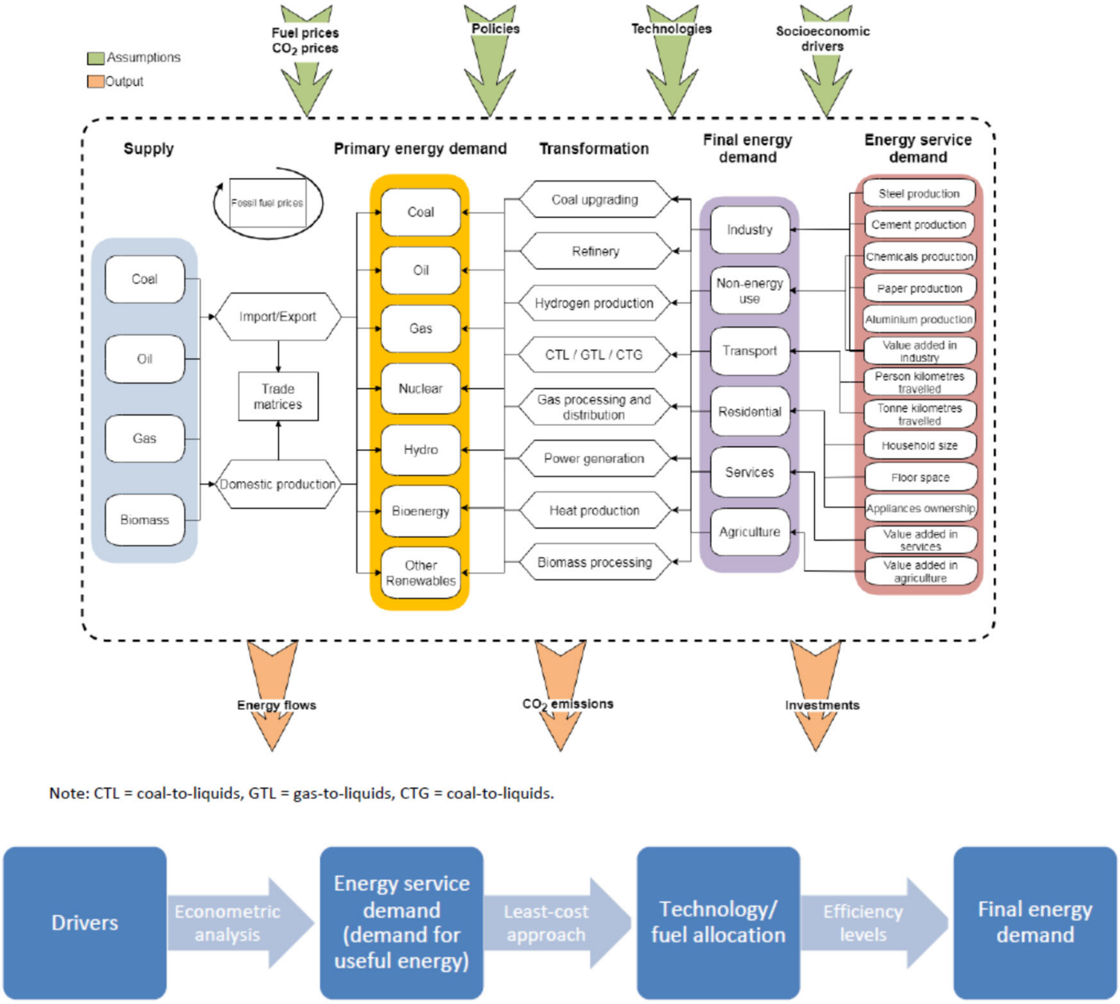


Figure 271 Structure of the World Energy Model and how energy demands are calculated
(Source) IEA(2020) , WORLD ENERGY MODEL DOCUMENTATION 2020 VERSION

(3) Examples of studies for practical application of new model analysis

A comprehensive review of energy supply and demand structure and energy system is expected in order to build a decarbonized society in the future. In addition to the various models that have been used and developed for model analysis of energy systems, mainly in the electric power sector, there is now a need to build models that enable analysis of sector coupling across sectors and cross-border analysis by covering more regions. Specifically, models now being developed can be used for comprehensive studies that include not only electricity as secondary energy but also the use of heat, hydrogen, and other sources, as well as for multilateral analysis. Examples studies in new model analyses and their application are described below.

(a) Europe: METIS model by the European Commission

METIS [737]is an energy model development project led by the European Commission Directorate-General for Energy (DG ENER). The model can estimate the supply and demand of electricity, gas, and heat in Europe for one year in hourly increments, contributing to evidence-based policy making by

[737] https://ec.europa.eu/energy/data-analysis/energy-modelling/metis_en

the European Commission. It consists of modules for power system, power demand, gas, heat, demand, among others.

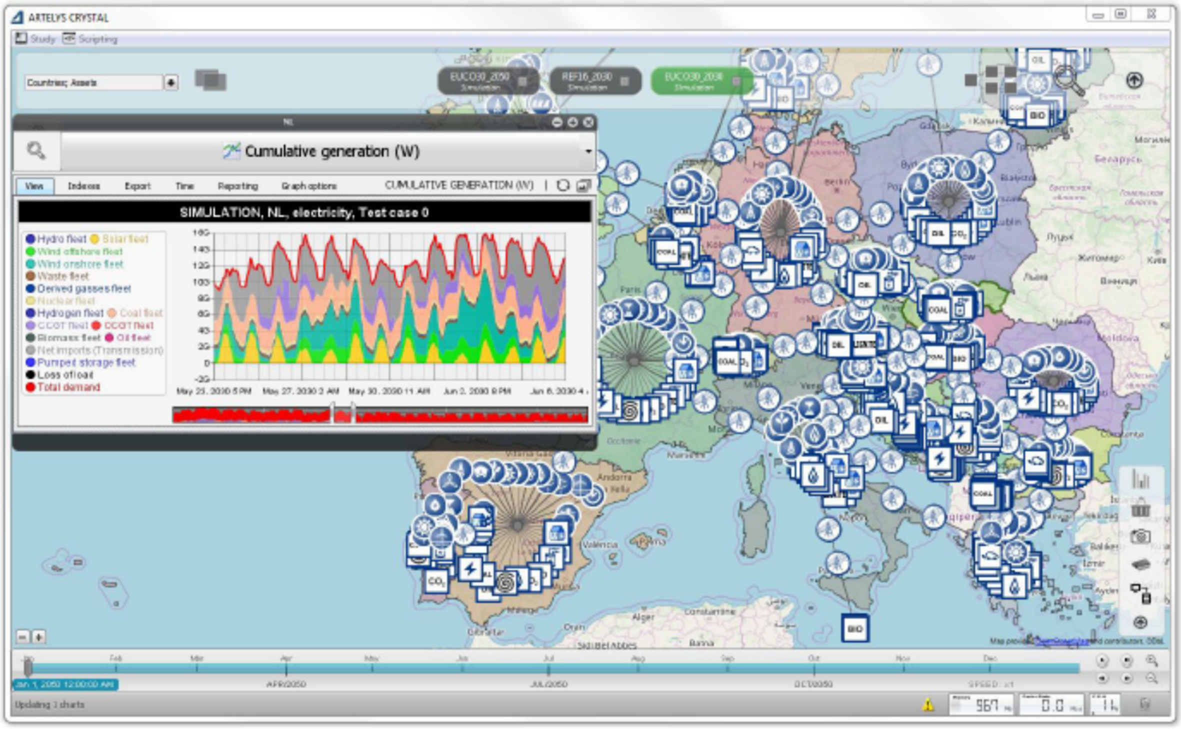


Figure 272　Energy system analysis for Europe

(Source) European Commission(2020)、Introduction to METIS models

The METIS generation sector module is particularly unique electricity model that performs optimization calculations by profit maximization (rather than cost minimization). The model can evaluate electricity adequacy, impacts of renewable energy integration, inter-regional electricity supply, and impacts of EV and DR. In addition, the entire European region is divided into each country (for some purposes, several countries can be combined into a single node). Furthermore, there is a separate power market module for calculating, for example, imbalance market.

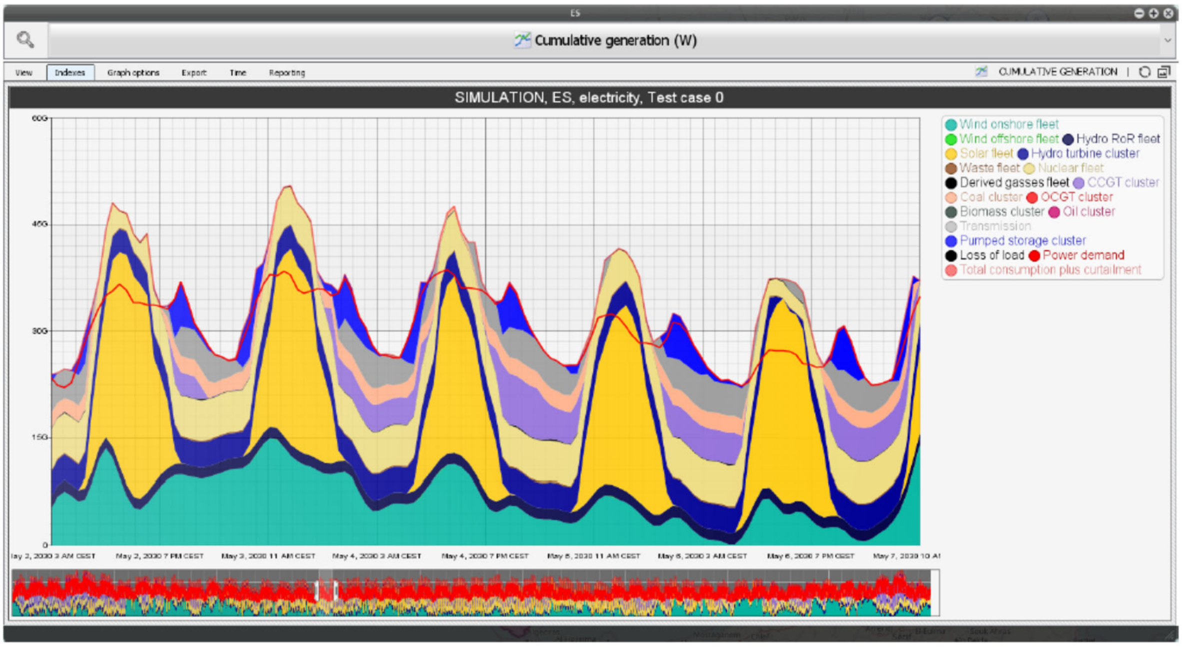


Figure 273　Power sector of Europe

(Source) European Commission(2017)、METIS Technical Note T5

The EC uses METIS as a mathematical model to support evidence-based policymaking on electricity and gas. The EC uses METIS to prepare its proposals on renewable energy and energy security issues as well as on the design of new energy markets.

METIS can simulate energy system and market operations on an hourly basis over the course of a year, taking into account uncertainties such as weather fluctuations, and analyze the hourly impacts of renewable energy use. This model can be used at the national or regional level and is built on a number of interconnected modules.

Table 202　Major outputs of METIS

	Module	Studies
Power systems	Power system module (TN1 + TN6)	S4 – Generation and system adequacy analysis S2 – Assessing TYNDP 2014 PCI list (power) S7 – The role and need of flexibility in 2030 S7b – Flexibility in 2030: focus on storage S11 – Effects of high RES shares on power systems
Power markets	Power market and stochasticity module (TN2 + TN3)	S12 - Assessing market design options in 2030 S16 – Weather-driven revenue uncertainty for producers S18 – Simulating electricity market bidding and price caps
Gas system and markets	Gas module (TN 7)	S5 – Impacts of PCIs on gas security of supply
Heat	Heat module (TN 8)	S6 – System benefits of decentralised heat pumps S9 – Cost-efficient district heating development
Synergies between energy vectors	Demand module (TN 8)	S13 – Electric vehicles: power system impacts and RES integration S8 – The role and potential of power-to-X in 2050 S1 – Synergies between energy networks S14 – Market revenues and producer risks
Other documentation	Technical Notes 4 + 5	Overview of European Electricity Markets METIS introduction and architecture
	html documentation	Description of all assets, KPIs, behaviours etc.

(Source) Artelys(2019), Session 1:METIS in a nutshell METIS 1 Dissemination event

After the initial project that began in 2015, the European Commission has addressed the following issues for the period 2018-2021 in METIS2.

- ➢ Integration of distribution and transmission, grid modeling
- ➢ Dedicated data collection
- ➢ Flow-based vs. net transfer capacity (NTC)
- ➢ Grid model to assess local flexibility impacts

To study the above topics, the EC is considering six studies into model development, market design evaluation, and the assessment of future flexibility measures. In addition, a web-based version of METIS is being developed to visualize the assumptions and results of model analysis. The following points were also presented as future issues at METIS promotion events, together with achievements using METIS.

- ➢ **Future roles of flexibility**
  - ✧ Evaluate the need for flexibility using different timescales.
  - ✧ Identify and characterize local flexibility solutions.
  - ✧ Optimize flexibility portfolio at the member state level.
- ➢ **Power-Gas-Heat (multi-energy approach and quantification of benefits)**
  - ✧ Electrification of demand - potentials and limitations
  - ✧ Power-gas linkage
- ➢ **Electricity market up to 2050**

(b) Europe: search for Common Grid Model at ENTSO-E

- ● **ENTSO-E**[738]

ENTSO-E announced the Common Grid Model Program will enter its operation phase in 2018, making the Program available across multiple countries for member organizations. ENTSO-E has stated that the study of a common grid model is only a starting point for further study in the future. Its multilateral agreements and system operation guidelines have suggested the following four services as requiring regional coordination.

➢ **1. Coordinated capacity calculations:** the goal is to maximize network transaction capacity while maintaining system security.

➢ **2. Coordinated operational security analysis:** coordinated checks for compliance with security standards (N-1 standards).

➢ **3. Coordinated outage plans:** regional coordination of plans to disconnect grids for maintenance.

➢ **4. Coordinated short- and medium-term adequacy forecasting:** coordinated analysis of whether each TSO has sufficient capacity to cover the demand in the area it operates.

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738 https://eepublicdownloads.entsoe.eu/clean-documents/Publications/SOC/entsoe_CMG_leaflet_170620_web.pdf https://eepublicdownloads.entsoe.eu/clean-documents/Scenarios/2020/consultation/TYNDP_2020_Scenario_Methodology_Report_consultation.pdf

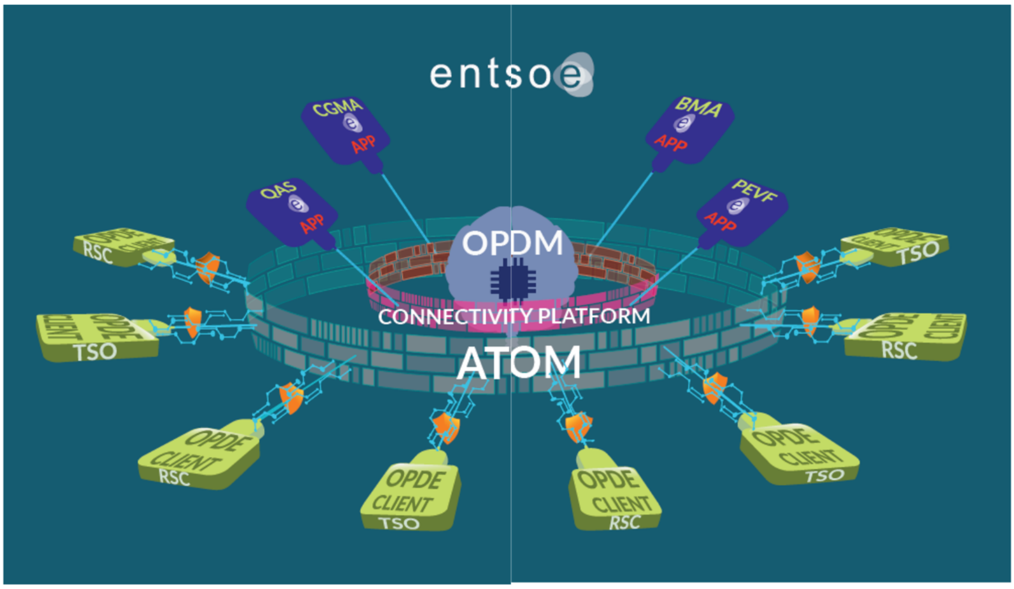

Figure 274 Illustration of ENTSO-E platform

(Source) ENTSO-E, WHERE THE DIGITAL TRANSFORMATION OF THE EUROPEAN ELECTRICITY SYSTEM STARTS:

ENTSO-E also states that power system operation is a highly skilled and data-intensive business that requires real-time situational awareness and support for making decisions. Once those conditions are met, it says the common model provided by ENTSO-E will contribute to the business of member countries and member TSOs in the following ways.

- ➢ Market consolidation, increased interconnection, further growth of wind and solar generation, as well as decentralized demand response within generation, storage, and low voltage, also further coordination between gas, heating, and transportation sectors, all of which will require more data collection and processing on a pan-European scale, and more data between transmission and distribution.
- ➢ The common model will support ENTSO-E's mission, such as network development plans for the next 10 years, a transparency platform for the energy market, and a review of bidding zones.
- ➢ There will be stronger interconnections between TSOs, RSCs, capacity calculation regional units, Joint Allocation Office (JAO), and ENTSO-E with increasing need for a common ENTSO-E model.
- ➢ Cooperation between power exchanges and distribution system operators (DSOs) is important. Linking TSO/DSO and wholesale/retail data is the key to implementing the provisions proposed by the EC in its Clean energy for all Europeans package.

ENTSO-E has positioned itself as the organization that coordinates TSOs in Europe. As such, it has been providing a platform for planning and market collaboration among member TSOs as well as improving its services.

(c) Europe: search for comprehensive National Grid model

● **National Grid**[739]

National Grid, which is responsible for grid operations and gas supply in the UK, has created its Future Energy Scenario (FES) forecasting future energy supply and demand. National Grid, the grid operator, has analyzed electricity and gas demands together in the FES to provide information on

[739] https://www.nationalgrideso.com/document/173796/download

future issues and infrastructure development.

For the power generation sector, the FES has calculated generation output since 2017 using a model called BID3, a pan-European electricity dispatch model created by the AFRY that can simulate GB and other electricity markets. Microscopic information not analyzed by the FES, such as data for the portion of grid inside various facilities, were analyzed separately and made available as assumptions for BID3. Network and operability constraints for transmission networks and low-voltage networks have not been part of FES power supply analysis. For this reason, the analysis assumes that the GB network has no internal network constraints. Also, for grid operations, the scenarios would not include plant information needed to provide grid stabilization services, such as inertia, frequency response, or voltage support. Network capacity on these issues is evaluated as part of the network options assessment (NOA). In addition, issues related to future grid operations are analyzed in the system operability framework (SOF) [740].

In the UK, issues and milestones related to grid operations are summarized as follows, and various model analyses, etc. are being conducted to solve these issues.

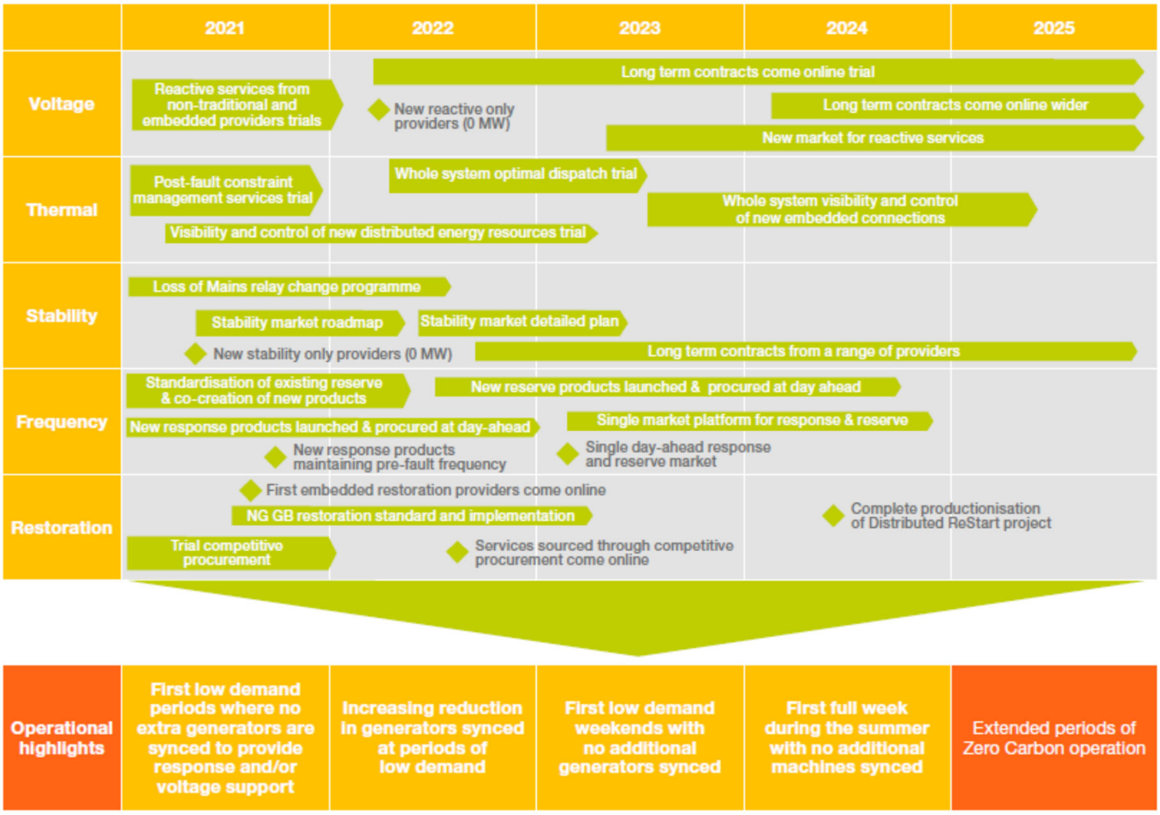

Figure 275　Operability Milestones (UK)

(Source) nationalgridESO(2020), Operability Strategy Report 2021

(d)　US: Search for extended comprehensive DOE/EIA model

● **EIA** [741]

US DOE/EIA uses the National Energy Modeling (NEM), which consists of multiple model modules, to analyze future prospects, etc. For example, the Electricity Market Module is for renewable energy generation. EIA has been reviewing and updating each module whenever

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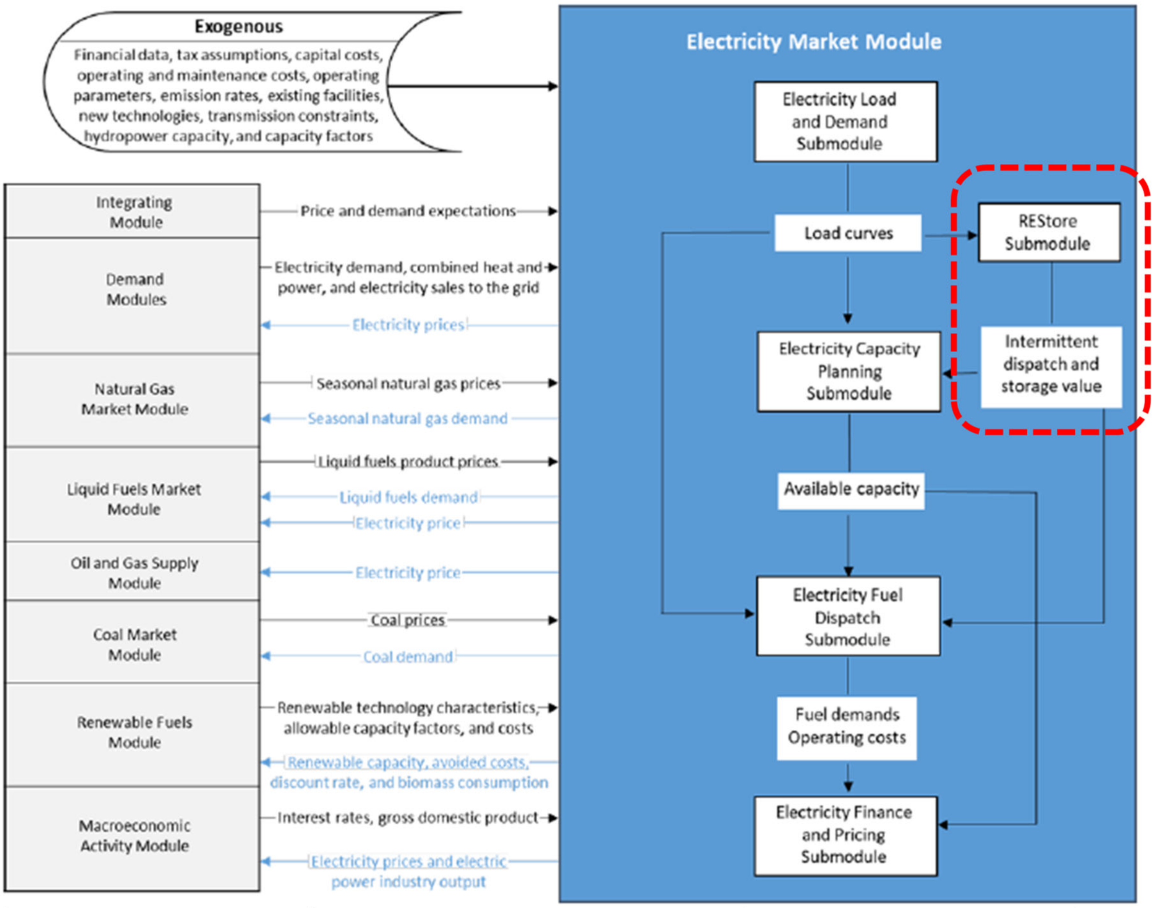
740 https://www.nationalgrideso.com/research-publications/system-operability-framework-sof

741 https://www.eia.gov/outlooks/aeo/nems/documentation/electricity/pdf/m068(2020).pdf

necessary. The July 2020 report states that the following points have been updated and improved.

- Updated operation and maintenance (O&M) costs and annual capital expenditures for fossil fuel plants.
- Added more detailed descriptions for availability and usage of renewable resources and battery storage by adding a renewable storage sub-module (REStore).
- Revised power supply regions to better represent electricity market conditions in light of changes in Independent System Operator (ISO)/Regional Transmission Organization (RTO) memberships.
- Updated capital cost estimates for utility-scale generation technologies.

In particular, the Renewable Storage Submodule (REStore) is a new component that was announced in the July 2020 Model Documentation as a new addition to the EEM. The sub-module focuses specifically on assessing the impact of energy storage technologies. The main indicators to be quantified by REStore include marginal power prices and generation profiles by time of day, output curtailment, excess power demand, storage and discharge patterns, and minimum charge requirements. As this example shows, by adding new sub-modules for evaluating renewable energy and storage batteries, and by evaluating intermittent energy feeds, etc., EIA is improving its model to be ready for mass adoption of renewable energy in the future.



EMM Outputs	Inputs from NEMS	Exogenous Inputs
Electricity prices and price components	Electricity sales	Financial data
Fuel demands	Fuel prices	Tax assumptions
Capacity additions	Cogeneration supply and fuel consumption	Capital costs
Capital requirements	Electricity sales to the grid	Operation and maintenance costs
Emissions	Renewable technology characteristics, allowable capacity, and costs	Operating parameters
Renewable capacity	Renewable capacity factors	Emissions rates
Avoided costs	Gross domestic product	New technologies
	Interest rates	Existing facilities
		Transmission constraints

Figure 276 Electricity Market Module

(Source) EIA,(2020) The Electricity Market Module of the National Energy Modeling System: Model Documentation 2020

(e) US: Search for extended comprehensive NREL model

- **NREL**[742,743]

The National Renewable Energy Laboratory (NREL) in the US is working on the Grid Modernization, a grid design project. The agenda for this project are distribution integration, transmission integration, transient & dynamic stability analysis, power market design, integrated energy system simulation, and SMART-DS. In particular, as part of the Advanced Research on

742 https://www.nrel.gov/grid/carbon-free-integration-study.html
743 https://www.nrel.gov/grid/ergis.html

Integrated Energy Systems (ARIES) platform, it is working with partners on energy system integration projects aimed at evaluating diverse approaches, including renewable energy and energy storage technologies. The NREL has released Hierarchical Engine for Large-Scale Infrastructure Co-Simulation (HELICS)[744], a software for planning and building energy systems.

Table 203 High-Impact Projects Overview in ARIES (NREL)

Partners	Project
	2019
Anterix	Enabling Realistic Communications Evaluations for ADMS (ERCEA)
Salt River Project	Residential Battery Impacts on Home Owners and Grid
Centrica Business Solutions	Resilient and Cost-Effective Hybrid Li-ion Battery Energy Storage System for Sites With Solar Generation and EV Charging
Eaton	Modular Expeditionary Technology Evaluation Resource
	2020
Colorado State University	Development of Statistical Fault-Detection Algorithms for Modern Power Grid Networks
U.S. Department of Defense: Environmental Security Technology Certification Program	Large-Scale Energy Storage and Microgrids
Cummins	Advanced Microgrid Controller
Exelon/EWF	Zero-Export Feeder Through Transactive Markets

(Source) NREL(2020), ESIF 2020

The institution is also studying the impact of various scenarios for carbon-free generation in the power system for the Carolinas region (both North Carolina and South Carolina combined) to understand the possibility of integrating carbon-free resources at the transmission level. To this end, Duke Energy has been commissioned to conduct a study for understanding the future integration, reliability, and operational challenges and opportunities in integrating renewable and distributed energy resources into the electric power system. The company aims to cut CO2 emissions by at least half (compared to 2005 levels) by 2030 and to achieve zero CO2 emissions by mid-century.

In Phase 1 of the study, NREL analyzed the integration of carbon-free resources in the Carolina region. 12 scenarios were evaluated to determine the impact of increased photovoltaic (PV) generation has on the total percentage of carbon-free generation. The evaluation of scenarios for wind, storage, and solar PV penetration revealed that they will reach 80% of annual carbon-free energy. Phase 2 utilizes NREL's proprietary tools to investigate the portfolio costs and operational feasibility following increased carbon-free resource integration in the Carolina region, including the potential investments required to achieve carbon-free energy resource integration, transmission impacts, among other factors. The three key topics in the survey report are listed below.

- **Geographic distribution of potential resource**

Use the renewable energy potential (reV) model for detailed evaluation of renewable energy resources, together with their geospatial relationship to grid infrastructure and land use characteristics.

- **Capacity buildup plans and generation costs**

Use the potential resource and costs developed in reV, the ReEDS model to examine proposed

[744] https://www.nrel.gov/grid/integrated-energy-system-simulation.html

generation and transmission investments for the reference case and low-carbon case to maximize carbon-free resource integration. Also use a set of technology, commodity, and policy-based scenarios to determine cost-optimal resource planning based on the reference and low-carbon cases.

- **Operability**

Use Plexos to analyze the operating conditions of the facilities after the power plant expansions and transmission line upgrades identified by the ReEDS. Typical outputs include fuel costs, O&M, capacity factor, and transmission utilization, from which the operational state of the assumed infrastructure configuration is confirmed.

As described above, transmission, distribution, markets, security, and more diverse individual technologies are being studied under Grid Modernization at the NREL, with integration also being considered in this context. The NREL finds business partners and utilizes its various tools for field studies. In this context, the feasibility of large-scale introduction of carbon-free energy is being studied in detail together with business operators and other parties.

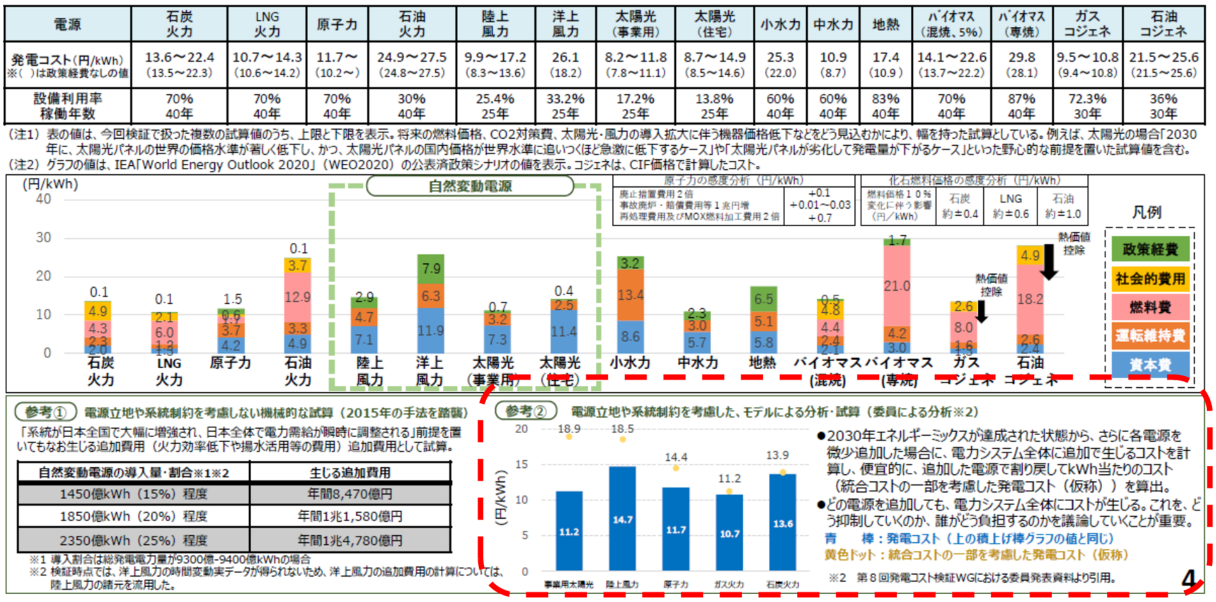
(f) Using models to calculate new power supply costs

There is a new approach for evaluating power source costs leveraging certain models. Instead of assessing only the cost of the power source itself, the impact to the entire system can be evaluated. Particular models are expected to be utilized for this type of quantitative evaluations.

For example, Ogimoto and Matsuo (2021) [745]have acknowledged that LCOE (equalized cost of electricity), a cost indicator of just the power source itself, is easy to understand, because power supply costs calculated with LCOE can be used to compare the cost structure of power sources, such as capital and fuel costs, based on the specific costs of each power source. On the other hand, they have pointed out its limitations. Generation costs are determined by energy mix as well as geographical and temporal structure of demand, but the LCOE The LCOE cannot incorporate the costs associated with changes in such supply-demand balance of electricity. Based on this understanding, they argue that, in order to evaluate the cost of power generation facilities more accurately, it is necessary to evaluate the additional cost for the power system as a whole when any new power source is introduced.

As shown in the figure below, the Advisory Committee for Natural Resources and Energy has summarized the cost of power generation in Japan. There is also a mention of cost evaluation incorporating the cost of system integration in this summary.

[745] Ogmoto and Matsuo (2021) (https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/mitoshi/cost_wg/2021/data/05_05.pdf)



Note: The middle row shows LCOE for each power source. The right-bottom chart shows marginal integration costs (See the next figure).

Figure 277 LCOE estimation by the Japanese government

(Source) Power Generation Costs Analysis Working Group

Calculations by Ogimoto and Matsuo (2021) has focused on integration costs, specifically on marginal integration costs by source. These values show the economic efficiency of each power source by explicitly taking in the costs associated with VRE output fluctuations, compared to the traditional unit cost of electricity generation (LCOE). They claim that these values have been used by the OECD, UK government, and other bodies for evaluation during their policy planning processes, and also in Japan where the fluctuation is driven by shifting energy mix. Since an elaborate power source composition model is necessary for this evaluation, the MR (wide-area supply-demand adjustment program) proprietary to J-POWER Business Service Corporation was used to analyze the power source composition. The result of this analysis was then used to estimate the marginal integrated cost for each power source.

This an example of how new model analyses are being used to organize new concepts of power source and power system costs.

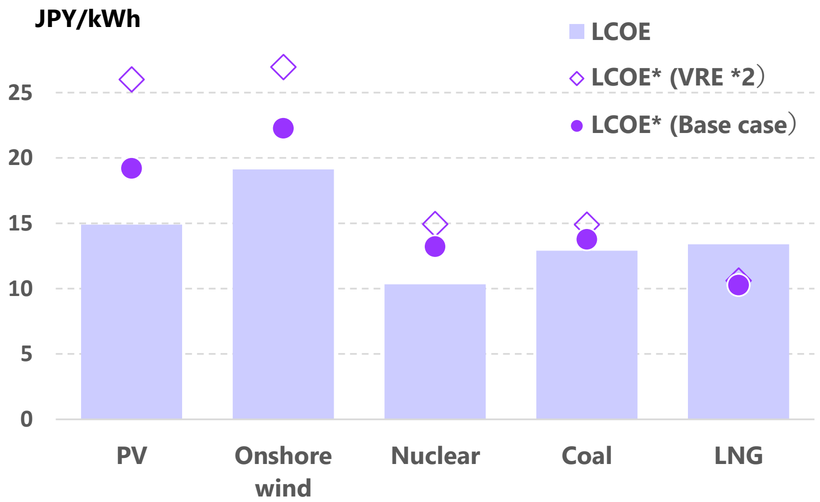


Figure 278 Marginal integration cost estimated by MR

(Source) Ogimoto and Matsuo(2021)

In the UK, the enhanced levelized cost factor has been added to the original LCOE for incorporating the impact on the entire system and on the transmission network into cost analysis. The gray bars in the figure represent the LCOE, while the blue dots represent the enhanced levelized cost, or marginal cost, by power source (see figure below).

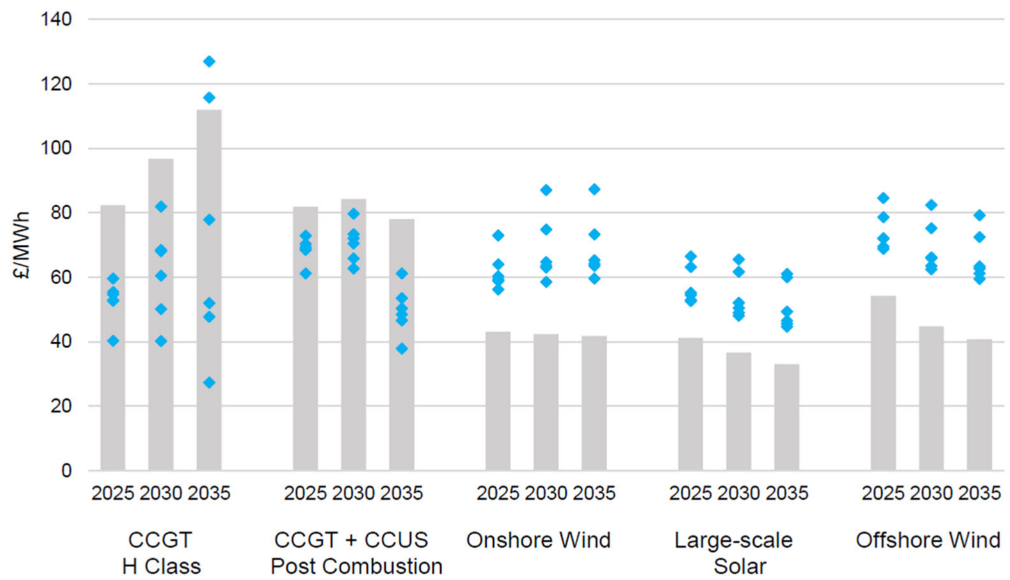


Figure 279 Enhanced levelized cost by BEIS

(Source) BEIS(2020)、ELECTRICITY GENERATION COSTS

The analysis presents six assessment results for six different energy mixes. Since the difference in facility utilization for each power source is an important factor in the cost analysis, the BEIS's dynamic dispatch model was used to calculate this cost. This model sets sample days for weekdays and weekend/holidays to calculate the optimal operation, taking into account VRE output and seasonal variations as well (see figure below).

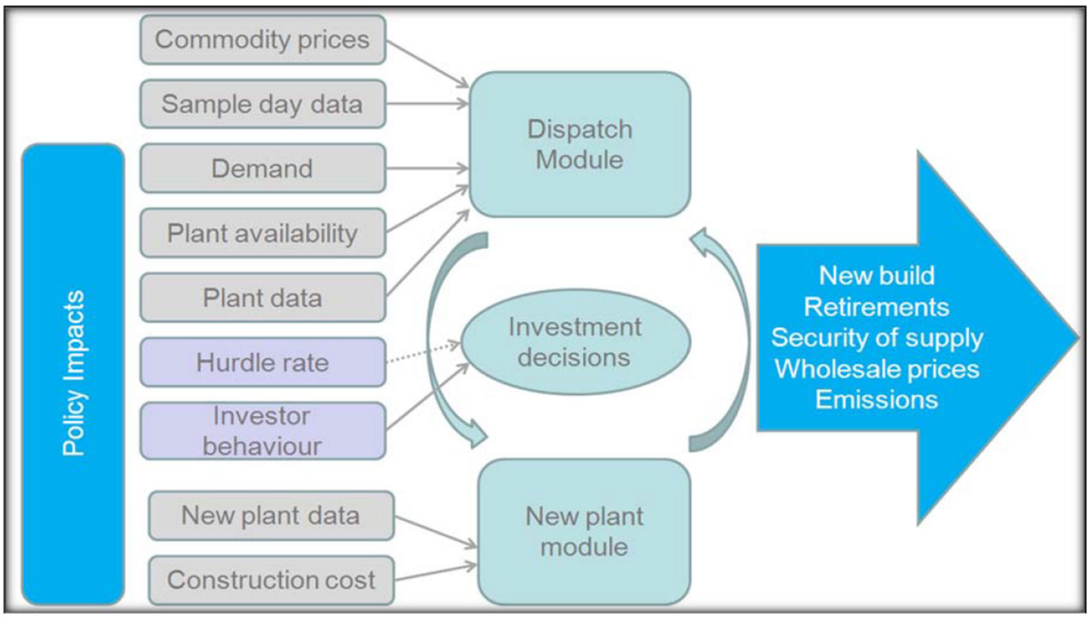


Figure 280 Overview of BEIS Dynamic dispatch model

(Source) DECC(2012)、DECC Dynamic Dispatch Model (DDM)

As an international organization, the IEA has also proposed value-adjusted LCOE (VALCOE), an index based on the LCOE of the power source itself and further takes into account the contribution of power sources to the system in terms of cost. This is calculated by factoring in the values of energy, capacity, and flexibility in the LCOE as indicators of marginal cost for each power source. Because the impact to and contribution of the entire power system had to be incorporated, as was done for the studies in Japan and the UK, the IEA calculations are made by the standard hourly power supply configuration model, a component of the World Energy Model.

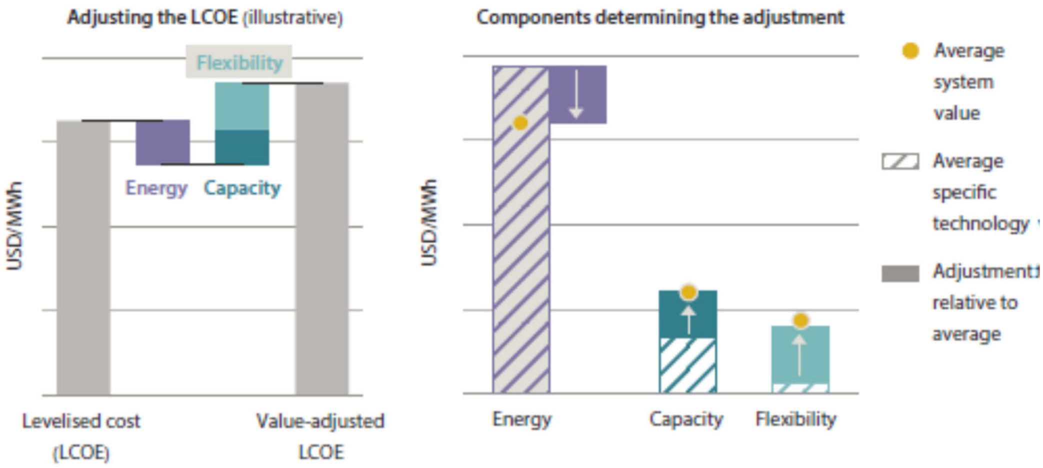


Figure 281 Value-adjusted LCOE (VALCOE) by the IEA

(Source) IEA＆OECD/NEA(2020)、Projected Costs of Generating Electricity 2020 Edition

As these examples show, model analysis has evolved together with corresponding indicators, and the use of model analysis to clarify indicators and model development are also moving forward. It is expected that the study of these indicators, together with the practical application of a new model analysis that can incorporate total energy as well as power sources, will promote the study of energy mix that minimizes social costs.

2.4.3 Search for Methods of Autonomous Operation by Developing Countries

(1) Considerations for model analysis

Among the models described in section 3-1-1, the energy supply and demand model and the power supply model can generally have implications that can be directly affect the development of master plans. The former is suitable for examining the overall energy supply and demand including non-power demand, while the latter is suitable for examining the best mix in the power sector.

Table 204 Classificaiton of energy models

	Description	Examples
Integrated assessment model (Cost-benefit analysis)	Optimizes the total economic effects to identify the optimal mitigation pathways	DICE, PAGE, FUND
Integrated assessment model/Energy supply and demand model	Useful for energy planning Representation of the power sector can be rough	TIMES, MESSAGE, IEEJ-NE, AIM/Enduse, DNE21+
Power generation model (Power system planning)	Useful for power generation/transmission planning	WASP, PLEXOS, RPM, Aurora, OPGM
Power generation model (Optimal dispatch)	Fixes the power generating facilities and optimizes the operation Detailed representation of specific plants	PROMOD, GE-Maps, PLEXOS, MR
Reliability evaluation model	Detailed simulation of the transmission/distribution networks (e.g. 30 seconds to 1 minute resolution)	PSLF, PSSE

Below is a list of key agenda to keep in mind when using such model analysis for energy planning.

(a) Generation cost assumption.
(b) Evaluation of VRE introduction potential.
(c) VRE output fluctuation data.
(d) Electricity demand fluctuation data.
(e) Electricity demand flexibility.
(f) Decarbonization technologies and sector coupling in non-power sectors.
(g) Presentation of evaluation results (e.g., economic impact).

These factors have issues such as uncertainties and data availability. There are no perfect assumptions. Accuracy should be as high as reasonably achievable. Additional information on some of these points is provided below.

(c) VRE output fluctuation data

Estimate renewable energy output fluctuation data based on wind speed and solar radiation for each location. The use of different output patterns at multiple locations also makes the evaluation more practical.

Wind speed and solar radiation patterns naturally change every year, resulting in model output (necessary measures and costs) variation. Plans should be made more robust by using meteorological data over multiple years for estimation.

However, while several analyses evaluating this impact have been found in academic papers since about 2020, they have not yet been widely used in policy-making circles.

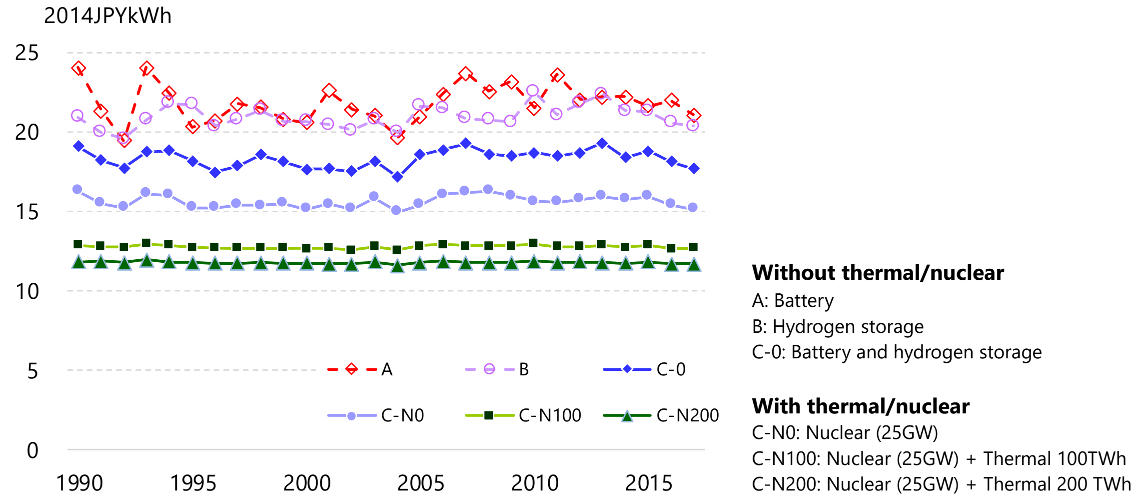


Figure 282 Variation in the average power generation cost depending on the meteorological data inputs

Source :Y. Matsuo et al. (2020), Applied Energy, 267, 113956.

(d) Electricity demand fluctuation data

Hourly and year-round electricity demand curves may not be available in developing countries. In such cases, the next best thing is to analyze using representative dates for each season and weather pattern. In addition, it is difficult to foresee changes in the demand curve several decades from now. Any analysis must start with the current situation and try to cover as many elements as possible.

(e) Electricity demand flexibility

It is assumed that in the future, electricity demand will be flexible enough to absorb VRE output fluctuations, reducing the costs associated with increased VRE implementation. Refinement of associated models is one of the challenges for improvement on current approaches (including inside academic circles).

Chief adjustment measures on the demand side can be (1) electric vehicle, (2) heat pump water heater, (3) energy storage system [batteries, pumped storage hydropower, hydrogen, thermal storage], and (4) others. Discussions on simulation methods for these factors are still on-going, as researchers and analysts are still configuring some elements of demand-side flexibility individually.

For electric vehicles, current back-flow into the grid (VtoG) and "single-day constraint" are issues to be discussed. Regarding the latter, all of capacity of vehicle-mounted cannot be used flexibly for the convenience of the power side. Certain restrictions must be considered. The "single-day constraint" is an approach based on the assumption that the amount of power stored at midnight is equal to the amount of power stored at next midnight. The following figure shows the simulation results using the IEEJ-NE Japan model for scenarios with and without VtoG and single-day constraint. If these constraints are strict, it will be difficult to use electric vehicles as buffers for balancing supply and demand. More compressed hydrogen storage and storage batteries will need to be introduced.

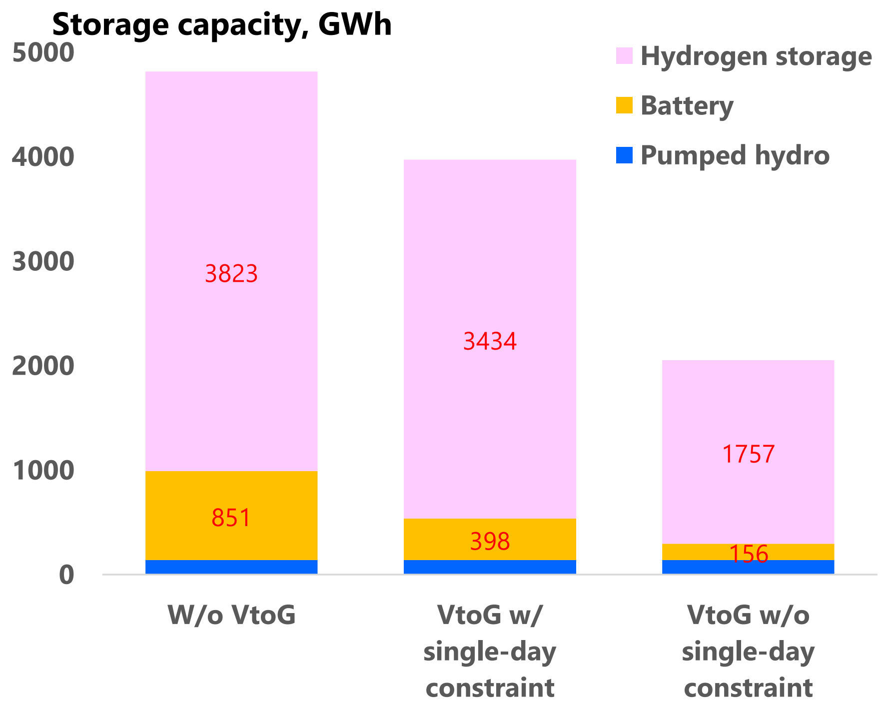


Figure 283 Estimated energy storage capacities (2050, RE 100 scenario)

Source :METI

(g) Presentation of evaluation results

In interpreting the assessment results, the marginal abatement cost of GHGs is one indicator of the difficulty of decarbonization. For example, under the IEEJ-NE model, the marginal abatement cost (equivalent to carbon price) for zero CO2 emissions in Japan by 2050 would be about 60,000 yen/tCO2. This is significantly higher than the current abatement costs and carbon prices in other countries.

Also, projections for 2050 Europe show [746] a carbon price of about €250/tCO2 based on a scenario with 80% GHG reduction by 2050, and about €350/tCO2 based on another scenario with 100% GHG reduction. The latter scenario examines the impact on GDP using multiple evaluation models assisted by economic models, the resulting estimated range being -1.30% to +2.19%.

(2) Search for methods of autonomous operation by developing countries

Based on these discussions, measures for developing countries to operate autonomously were conceived. This section groups the above-mentioned topics to be considered for model analysis into three areas: (a) data required for analysis of large scale introduction of renewable energy (PV and wind power fluctuations, the amount that can be introduced, fluctuations in electricity demand, etc.), (b) implementing entities and human resource (Utilize domestic government agencies, research institutes, etc., or foreign consultants), and (c) establishment of an appropriate project structure (Quantitative assessment of the energy mix for decarbonization and status of consideration of key issues).

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[746] EC, "Clean Planet for all" https://ec.europa.eu/clima/sites/default/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf

3. Formulation of Cooperation Programs

3.1 Analysis of the Current Situation in the Field Study Countries

3.1.1 Draft Roadmap Based on Country Analysis

(1) India

The supply side of India is divided into three categories: Thermal Power Plants, Renewable Energy Installation and Bioenergy. Each of the current status, challenges, and measures in each, as well as other donor support are summarized on the following table. Roadmaps were compiled based on the results of the analysis.

Table 205 Analysis of Low-carbonization of Existing Thermal Power Plants

Current status	Issues	Possible measures	Major support by development partners
- The proportion of coal-fired generation in today's generation mix is large. - There are many relatively new coal-fired plants (15 years on average) - Average heat rate of the existing coal-fired plants is not so high (approx. 35%). - It is expected that coal-fired generation will continue to be operated to a certain extent from the viewpoint of effective utilization of domestic coal resources.	Decarbonized operation of coal-fired plants	- Reduced dependence on coal through combined approaches - Biomass co-firing, ammonia co-firing, highly-efficient gas-fired generation, hydrogen, in the long run - Electricity market development - Regional decarbonization through optimal electricity interchange with adjacent countries (with an appropriate Grid Code) - Enhanced adjusting capacity by connecting all thermal power plant units to the AGC. [Short term: >5 years] - Stronger environmental measures and improvement of heat rates - Electricity market development underpinning decarbonized system operation [Mid term: 5 to 10 years] - Stronger environmental measures and improvement of heat rates - Effective electricity interchange [Long term: 10 to 20 years] - Hydrogen/ammonia mixed combustion - CCS/CCUS - Optimal electricity interchange	India-US Clean Energy Agenda 2030 Partnership Pilot project towards minimum output reduction (50% to 40%) of coal-fired power plants @ Gujarat (USAID). Decarbonising coal-fired power, CCUS study (ADB)

Table 206 Analysis of Renewable Energy Installation (1)

Current status	Issues	Possible measures	Major support by development partners
There are increasing concerns about negative impacts of RE integration on the power system in some states	- Development and upgrading of the power system for RE integration addressing: - Emergence of large-scale duck curves - Overloading of interconnectors - Lack of system inertia - Shortage of transmission capacity - Fluctuations of frequency and voltage - Difficulty in accurate forecasting of VRE outputs	[Short term: >5 years] ** for the states with large RE integration, in particular* - System stabilization (adjustable speed pumped storage, batteries, use of EVs, peak shaving/shifting, expansion of transmission and substation facilities, expansion and improved maintenance of T&D facilities, expansion of interconnectors, advanced system planning and operation, deployment of AGC at thermal power plants, Advanced VRE forecasting methods, deployment of stabilizing control systems) [Mid term: 5 to 10 years] - "Nationwide" System stabilization - Expansion of interconnectors (domestic, cross-border) [Long term: 10 to 20 years] - Optimal electricity interchange (interconnector operation)	- Green Energy Corridors (Germany) - Wind-Solar Hybrid RE, demonstration and commercialization support for FSPV＋BESS @Andhra Pradesh (WB) - USD 500 million fund to the Renewable Energy Development Agency to be used for large-scale solar and wind parks. (ADB) - Support for automation of substations @ Andhra Pradesh (WB)

Table 207 Analysis of Renewable Energy Installation (2)

Current status	Issues	Possible measures	Major support by development partners
There are increasing concerns about negative impacts of RE integration on the power system in some states	- Development of human resources responsible for power system analyses, investment plans and bidding documents (technical specifications)	- Technical support for system planning and the preparation of technical specifications	- Implementation of financial, technical and other DD for investments in power distribution equipment @Maharashtra (ADB) - Building an intermediary model through a public financial institution (Punjab National Bank). (ADB)
	- Establishment of a capacity market to incentivise power supply construction and power plant maintenance. - Ancillary services market established - Improved financial and operational performance of DISCOMs	- Unbundling *for the states where utility operations have not yet been unbundled - Regulatory and other environmental arrangements for the creation of capacity markets and ancillary services markets.	- Capacity building for T&D companies, procurement of smart meters, cost optimization through ICTs @Jharkhand, Andhra Pradesh (WB) - Implementation of technical assistance for system operators, introduction of BESS in transmission and distribution system @ Puducherry, AGC utilisation and dynamic voltage control (hydro power plants in Karnataka, Solar PV of NTPC in Andhra Pradesh), pilot activities for market reform (others @ Tamil Nadu, Rajasthan, Gujarat, Maharashtra) (ADB)
	- Securing project development sites	- Introduction of floating solar PVs (FSPVs) - Rooftop solar installation	- Introduction of FSPVs @Andhra Pradesh (WB) - USD 500 million loan to Rooftop solar installation programme as TA for solar ecosystem (ADB)
	- Introduction of P to X (e.g., Power-to-Gas)	- Demonstration and commercialization support for P to X facilities - Support for the establishment of hydrogen supply chain	
	- Expansion of electricity storage (storage batteries, pumped storage)	- Battery industry ecosystem support - Development and enhanced operation of pumped storage power plants	Support for credit line drawdown for battery-related projects through loans to SBI (State Bank of India). Provides incentives to battery manufacturers (Production Linked Incentive Scheme). (WB)

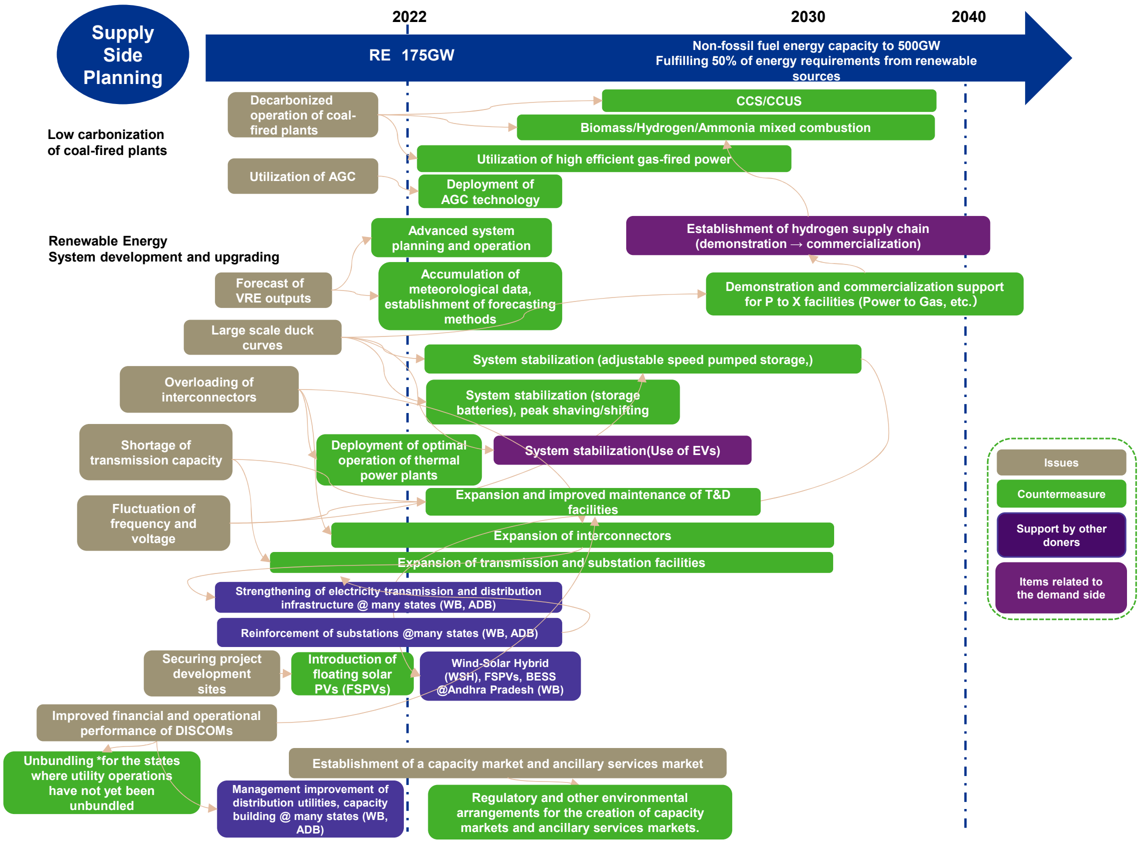

Figure 284 Roadmap of Low-carbonization of Existing Thermal Power Plants and Renewable Energy Installation

Table 208 Analysis of Bioenergy

Current status	Issues	Possible measures	Major support by development partners
- Promotion of biofuel blending in petrol or diesel (especially bioethanol blending in petrol)	- Definition of technical specifications for biofuel production - Establishment of supply chains for materials - Nurturing awareness of biofuels	- Implementation of demonstration projects - Building the value chain - Public information campaign on biofuels	- TA for the development schemes for bioethanol demonstration plants, for compressed bio-natural gas demonstration plants, and for biodiesel demonstration plants (cooking oil to biodiesel), and building a biofuel value chain that encourages women's participation @Nationwide, Gujarat, Haryana, Uttar Pradesh (ADB)
	- Introduction of economic incentives	- Expansion of economic incentives (subsidies, favorable taxation) to promote biofuels	–
	- Securing adequate domestic supply to meet growing demand for ethanol with the introduction of EBP	- Strengthening bioethanol supply capacity - Expansion of production capacity - Development of 2nd generation biofuels	–
- Promotion of biomass cogeneration, biomass power generation and biogas power generation	*The JICA India office is conducting a separate study.*	*The JICA India office is conducting a separate study.*	–

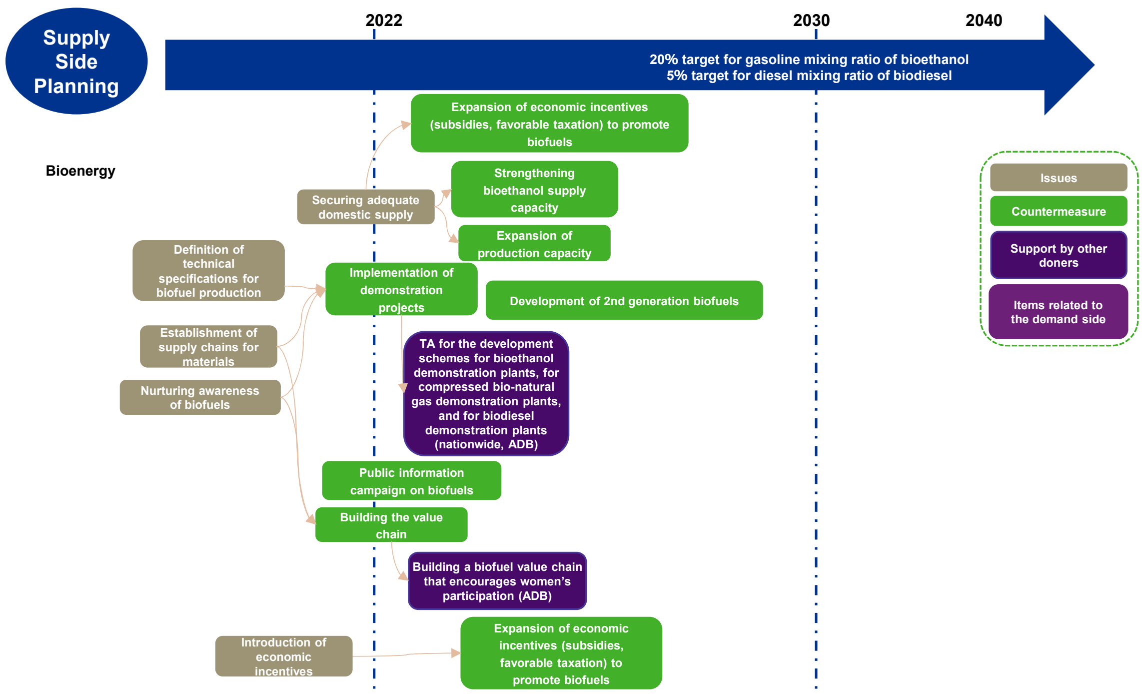

Figure 285 Roadmap of Bioenergy

The demand side of India is divided into three categories: industrial and commercial sector, transport sector, and urban development. Each of the current status, challenges, and measures in each, as well as other donor support are summarized on the following table. Roadmaps were compiled based on the results of the analysis.

Table 209 Analysis of Industrial and Commercial Sector

Current status	Issues	Possible measures	Support by development partners
- Industrial sector accounts for 38% of final energy consumption, and the main energy sources are coal and electricity. - In the industrial sector, coal is consumed mainly in the iron and steel industry and the cement industry while electricity is the main energy source in other industries.	- Promote electrification of industrial process - Promote the use of energy-efficient devices and reduce energy consumption in buildings etc.	- Replacement of fossil fuel combustion boilers to heat pumps (electrification). - Use of heat pumps in light industries where the required heat temperatures are relatively low - Improvement of efficiency of equipment, cogeneration using unutilized heat, waste heat, heat storage, etc., FEMS - Promotion of the introduction of more energy efficient equipment (e.g. air conditioner, hot water supply, lighting, etc.) in buildings through the diffusion and tightening of existing regulations (see Urban Development sector) - Urban Development sector) - Establishment of facility finance for loans to above mentioned EE investment, application of blended finance scheme	- EE investment in public street lightnings (SLNP Program), Support for business model development (air conditioning, demand side management for agriculture, EE building program) (WB)
Current status	**Issues**	**Possible measures**	**Support by development partners**
- Various policies and institutional arrangements have been put in place by the Energy Conservation Act. It is necessary to expand the targets of regulations from companies with large energy consumption to the ones with middle and small energy consumption for the diffusion and tightening of existing regulations.	- Improving awareness of EE among micro, small and medium-sized enterprises (MSME)	- Support for the introduction of energy efficient devices (presentation of the devices) - EE education (free energy conservation diagnosis, dispatch of lecturers), audit of EE approaches, summarizing the Best Practices, presentation of existing ESCO services	- Expansion of EE knowledge by defining KPI such as improvement of awareness, capacity building, demonstration of advanced EE technologies for the introduction to MSME (@ Hyderabad, Varanasi, Dehradun, Ludhiana, WB)
	- Improving awareness about advantages of ESCO services - Encouraging EE investments by asset owners and financial institutions, and increase their knowledge of the typical contract regimes for ESCO services - Improving finance and fundraising capability of financially-vulnerable ESCOs	- Seminars and trainings concerning contract regimes of ESCO services, EE-related loans, etc. - Improvement of financial management capability of ESCOs	- Capacity building for EESL, Support of business model development in EE segment (nationwide, WB)
	- Encouraging EE investments by MSME, promote loans	- Creation of facilities and funds for EE-related loans - Capacity building for financial institutions	- Creation of facility for partial guarantee, Technical cooperation such as legal due diligence etc. (nationwide, WB)

Current status	Issues	Possible measures	Support by development partners
- India's heavy industry such as iron and steel, chemical fertilizer (ammonia) and petroleum refining is highly competitive internationally, and further development is expected. However, decarbonization is difficult with existing technologies only. - It is estimated that the demand for cement as construction material will increase twofold, and that the demand for iron and steel will increase almost threefold due to the urbanization and the increase in population.	- Decarbonization of the heavy industry through the employment of the hydrogen technologies - Improving operation of iron industry	- Iron and steel manufacturing with the hydrogen reduction method - Ammonia production with green hydrogen - Hydrogeneration refining (desulfurization) with the utilization of green hydrogen, etc. - Sending experts to improving operation, and introducing low carbon technologies by cooperating with the Japan Iron and Steel Federation	–

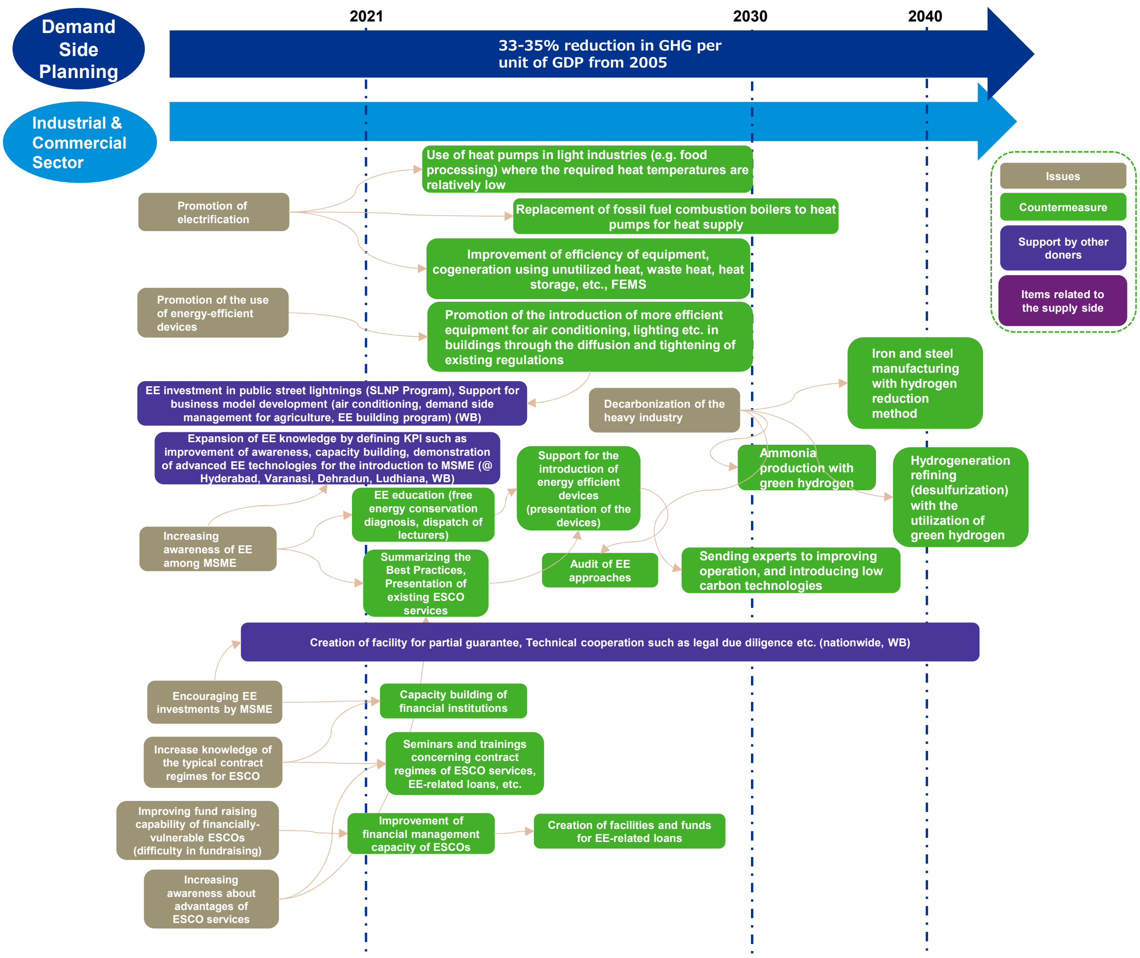

Figure 286　Roadmap of Industrial and Commercial Sector

Table 210 Analysis of Transport Sector

<table>
<tr><th>Current status</th><th>Issues</th><th>Possible measures</th><th>Support by development partners</th></tr>
<tr><td>The use of public transportation and bicycles, walking and the use of highly-efficient and clean energy are being promoted under the National Urban Transport Policy (Formulated in 2006, revised in 2014) in order to reduce GHG emission from the transport sector.</td><td>Modal shift to public transport (rails, in particular)</td><td>- Promotion of railway electrification
- Modernization of existing routes, investment for solving bottlenecks of main artery (extension of existing routes, construction of new routes etc.), and construction of inter-city rapid railway
- Securing income through the use of Land Value Capture (LVC), etc., and injecting government subsidies to maintain affordable rail fares and improve the quality of services and the safety
- Coordination with transport modes such as the removal of tax exemptions for road and air transport
- Introduction of FC railways</td><td>- USAID started to cooperate with Ministry of Railways for carbon neutrality. Decarbonization roadmap of railway sector was formulated and assistance for implementation will be conducted. (USAID)</td></tr>
<tr><td rowspan="3">- Recent growth rate of transport demand is the biggest compared to other sectors
- More than three-quarters of stocked vehicles are either two or three-wheeled vehicles, while cars and trucks emit more CO_2.
- Bharat Stage VI (BS-6, equivalent to EURO VI), the automobile emission standards, was introduced across India in April 2020 as air pollution from vehicles is a problem.</td><td>Use of alternative fuels (especially, biofuels)</td><td>- Expansion of the economic incentives to promote biofuels
- Strengthening bioethanol supply capacity
- Expansion of production capacity
- Development of second generation biofuels</td><td>–</td></tr>
<tr><td>Reduction of fossil fuel consumption by commercial vehicles such as trucks and buses</td><td>- Electrification of commercial vehicles
- Introduction of FC trucks and FC buses (for the long run)
- Establishment of large hydrogen stations for commercial vehicles</td><td>–</td></tr>
<tr><td colspan="3">Diffusion of EVs</td></tr>
</table>

Table 211 Analysis of Transport Sector (EV)

Current status	Issues	Possible measures	Support by development partners
xEV is being promoted	- Employment of EVs in public transportation	- Assisting procurement of e-buses - Formulation of a business model for e-buses subscription	–
	- Promotion of EV-related technology development	- Domestic production of EVs and lithium-ion batteries - Domestic sales of EVs with fast charging capability	- Production of 10,000 EVs and installation of charge spots (nationwide, ADB) - TA for the formulation of integrated development plan for EV promotion, and the formulation of roadmap for storage batteries development (nationwide, ADB) - QII (Quality Infrastructure Investment) is currently organizing proposal for developing the e-mobility ecosystem (facilitating investment environment) in India. (nationwide, ADB)
	- Improvement of the production capacity of storage batteries and promotion of their reuse	- Domestic production of lithium-ion batteries - Installation of battery testing centers - Securing the supply of raw materials for storage batteries, and establishing and reducing the cost of recycling technologies - Reuse of storage batteries, formulation of storage battery swapping business and development of technical standards for storage batteries	
	- Reduction in the prices of EVs	- Grants for EV purchase - Deduction of income tax for EV purchase loans - Removal of tariffs on certain components of EVs	- Grant to EESL for procurement of 500 EVs (nationwide, ADB) - Leveraging 5 million USD from ADB grant, EESL procured 250 EVs from TATA and Hyundai Motor to replace official vehicles of central and state government (nationwide, ADB)
	- Installation of charging infrastructure	- Expansion of EV charging stations - Governmental support for workplace charging - Optimizing the location of charging stations - Investment in relevant infrastructure	- Production of 10,000 EVs and installation of charging spots (nationwide, ADB)
	Enabling the grid connection	- Development of regulations and guidelines for managing load increases on the power grid (on both the power grid side and the charging infrastructure side) - Planning and securing financial resources for infrastructure upgrading and expansion	- Formulation of an integrated development plan for EV promotion and a roadmap for storage batteries development (nationwide, ADB)
		- Market design to enable EVs' participation in the electricity market (Demand Response)	–

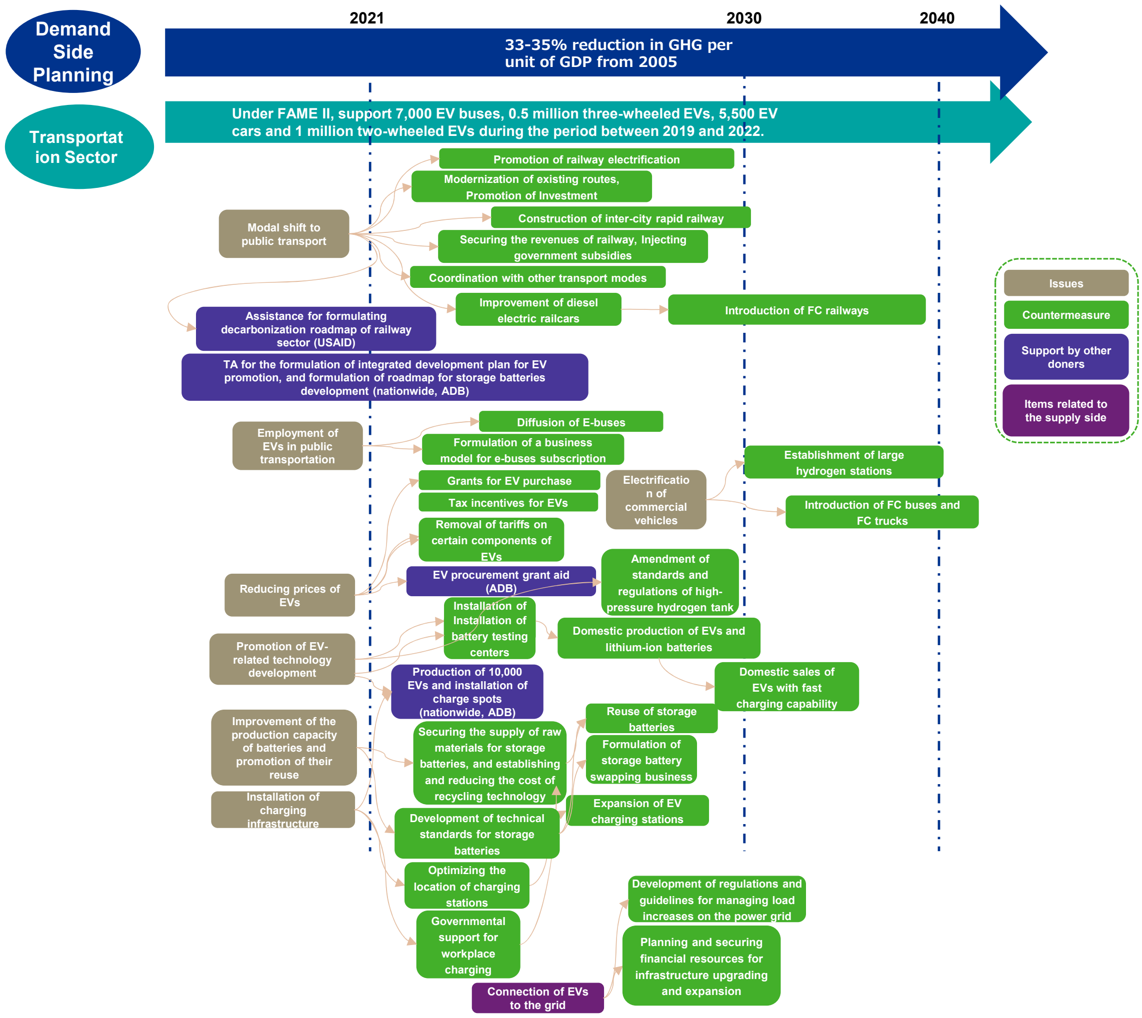

Figure 287 Roadmap of Transport Sector

Table 212 Analysis of Urban Development

Current status	Issues	Possible measures	Support by development partners
- (Housing) Traditional biomass is broadly used as residential energy resource in rural areas.	Reduction in increased fossil fuel consumption caused by the shift from the use of firewood to the use of LPG	- Electrification of rural areas - Diffusion of LED - Diffusion of clean cooking devices	–
- (Housing) Electricity demand is increasing due to the urbanization and the diffusion of home electric appliances.	Suppression of GHG emission caused by the increasing electricity demand for buildings (Demand of air-conditions is expected to increase sixfold by 2040)	- Strengthening and diffusion of EE management and standards for residential buildings - Strengthening and diffusion of the efficiency standard and labeling system for home electric appliances - Introducing incentives and increasing awareness of companies and citizens to diffuse above mentioned systems - Diffusion of high-efficiency devices	- Installation of high-efficiency light bulbs, ceiling fans and tube lights for houses (nationwide, ADB)
- Pilot projects related to introducing ZEB was conducted - The growth rate of cooling energy consumption is 16 % which is highest in the world, and high demand for electricity	Improving efficiency of buildings' energy consumption	- Diffusion and improvement of existing EE standards (ECBC2017) - Promoting EE for cooling (diffuse and tighten regulation, diffuse high efficiency equipment) - Decreasing electricity demand inside buildings (e.g. installing LED) (diffuse and tighten regulation, diffuse high efficiency equipment) - Expanding the use of net zero energy buildings - Finance for ZEB investment by leveraging blended finance scheme	- Supporting EESL for installing high efficiency HVAC system (ADB) - Implementing technical support to Green Business Center with CII @Hyderabad, Supporting installation of new ZEB buildings @Andhra Pradesh, supporting introduction of ZEB in campus of Nalanda University @Bihar (USAID)
- (Cities) Infrastructure development in line with the "Smart Cities Mission" is being proceeded.	Improving road infrastructure and public transportation, promoting alternative fuel vehicles and EVs etc.	- Necessity of taking measures based on issues and needs of each regions - Refer to the Transportation sector (p.26-30) for common issues - Technical and funding assistance to city-level initiatives after "Smart City Mission" is completed - Smartification of cities which were not selected in "Smart City Mission"	- Introduction of high-efficient LED to streetlights, and streetlight remote management system (nationwide, ADB)

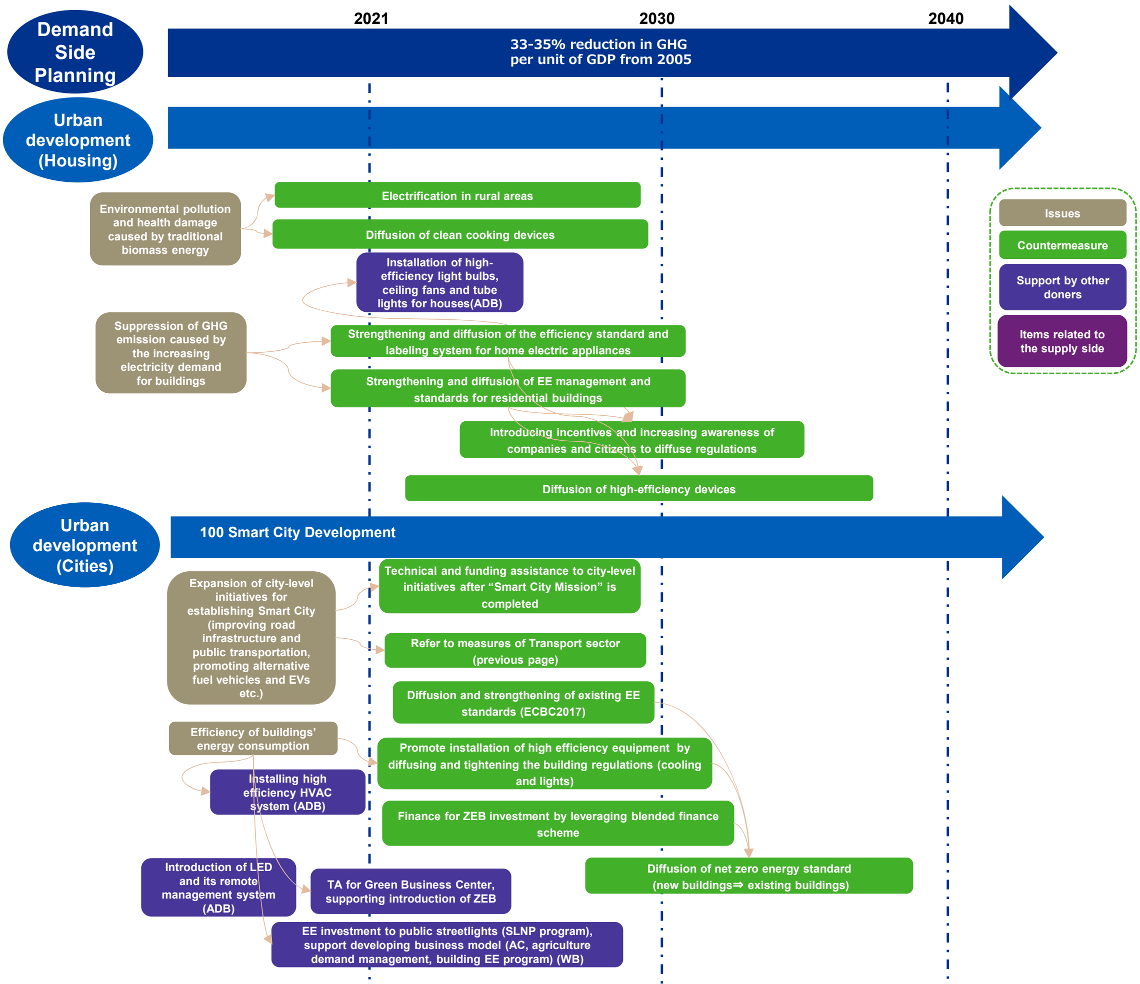

Figure 288 Roadmap of Urban Development

(2) Thailand

Current status, issues, possible measures and support by development partners are analyzed for each of the key focus areas mentioned by the Ministry of Energy, Government of Thailand.

The key focus areas are; xEV/Battery/Infrastructure/Incentives; Solar application (Farm, Rooftop)/EES/Smart Grid; Hydrogen/Carbon Reduction Technology; Energy Efficiency Technology and other technology related to CN. The roadmap for each of the key focus areas are also described as follows.

Table 213 Analysis of xEV/Battery/Infrastructure/Incentives

Current status	Issues	Possible measures	Support by development partners
- The promotion of EV utilization, the construction of EV charging stations and battery testing centers, and the formulation of an environmentally-friendly battery waste management plan will be proceeded at the early stage. ✓ Installation charging stations and battery replacement stations Financial support and tax incentives ✓ Definition of safety standards applicable to EV integration to smart grid development ✓ Securing battery manufacturing capabilities in accordance with domestic EV production	Development of necessary rules and regulations	- Stricter vehicle emission regulations - Promotion of EV utilization (purchase subsidies, incentive taxation) - Creation of manufacturing eco-systems and promotion of domestic production - Battery waste management plan - Promotion of domestic production through excise tax restructuring - Safety standards for EV integration to smart grid projects	- Support for transport sector GHG analysis and projections (UNIDO) - Support for integrated renewable energy infrastructure program (UNIDO) - Identification of optimal charging locations through data analytics (UNIDO) - EV-related entrepreneurship support (UNIDO) - Green loans for EV charging networks (ADB)
	Development of related infrastructure and employment of advanced technologies	- Development of charging infrastructure and expansion of distribution system network - Production of automotive storage batteries (liquid LiB and all solid-state LiB) - Construction of battery testing centers - Technologies for reuse and disposal of storage batteries - Rapid charging technologies - System operation (V2G) technology - Establishment of commercially-viable business models - Electrification of public transportation (e.g. bus)	- Support for transport sector GHG analysis and projections (UNIDO) - Support for integrated renewable energy infrastructure program (UNIDO) - Identification of optimal charging locations through data analytics (UNIDO) - EV-related entrepreneurship support (UNIDO) - Green loans for EV charging networks (ADB) - The Thailand Automotive Institute (TAI) and Japan External Trade Organization (JETRO) are collaborating to establish a battery testing center for electric vehicles (EV) in Thailand's Chachoengsao province.
	Recovery of diminished employment opportunities in the conventional automotive industry	- Capacity building of workers	- Support for transport sector GHG analysis and projections (UNIDO) - Support for integrated renewable energy infrastructure program (UNIDO) - Identification of optimal charging locations through data analytics (UNIDO) - EV-related entrepreneurship support (UNIDO) - Green loans for EV charging networks (ADB)
	Decarbonization of electricity supply (generation)	* *Refer to 2.Solar application (Farm, Rooftop)/EES/Smart Grid section and 3.Hydrogen / Carbon Reduction Technology* - Consideration of LCA	

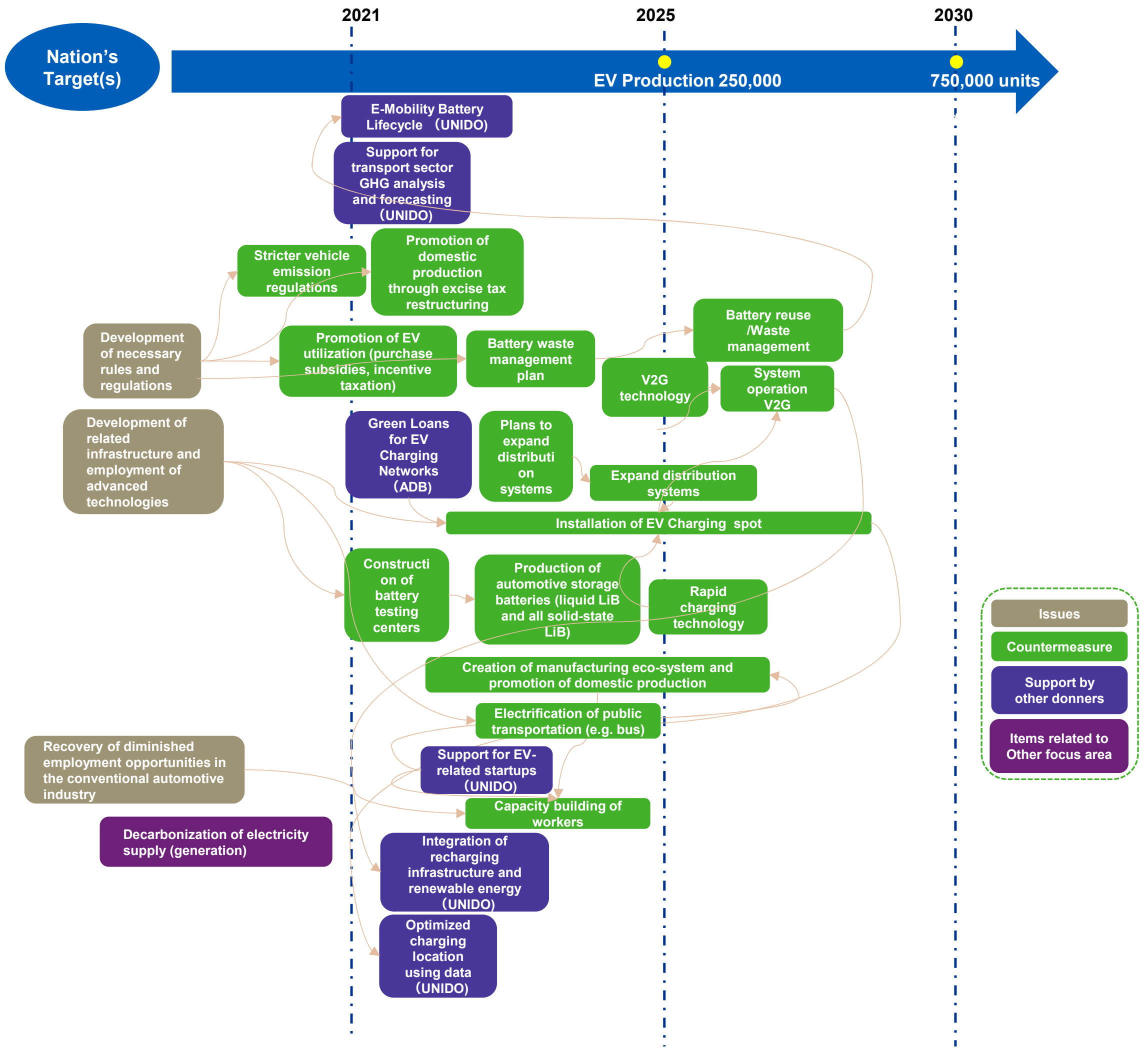

Figure 289 Roadmap of xEV/Battery/Infrastructure/Incentives

Table 214 Analysis of Solar application (Farm, Rooftop)/EES/Smart Grid

Current status	Issues	Possible measures	Support by development partners
The share of renewable energy ratio is still modest (12% as of 2018)	Effective incentive mechanisms for renewable energy projects	Not yet introduced - RPS (RE portfolio standard) - Development of electric market Need to be Confirmed - FIP - Mitigation of restrictions on land acquisition - Favorable treatment in grid connection and access.(prioritized connection/dispatch, discounted network costs, etc.) - Carbon pricing & emissions trading - Tax incentives, financing benefits, construction cost subsidies - P2P trading	- Capacity additions of solar PV (ADB) - Construction of WtE plants (ADB)
	- Securing adequate system flexibility for RE integration (Up to VRE share of 15%) - Ensuring more flexibility in EGAT's system operation	- Increase in contractual flexibility through the reform of commercial and contractual structures of PPAs (e.g., mitigation of EGAT's minimum-take obligations, review of the take-or-pay clause in natural gas procurement) - Establishment of nationwide renewable energy management centers (IEA recommendations) - Nationwide grid code (IEA recommandations) - Application of （the concept of) Non-Firm Access	

Current status	Issues	Possible measures	Support by development partners
The share of renewable energy ratio is still modest (12% as of 2018)	- Ensuring adequate system flexibility to address: ✓ Appearance of the Duck Curve ✓ Overloading on interconnections and lack of inertia ✓ Insufficient substation capacity ✓ Increased frequency/voltage fluctuations ✓ Voltage surge in distribution network (Ferranti effect) ✓ Difficulties in accurate VRE output estimation	- Employment of technologies to improve system flexibility ✓ Adjustable speed pumped storage, BESS ✓ Small BESS, EV utilization (V2G), load shaving/shifting ✓ Power to Gas（Green hydrogen) ✓ Expansion of interconnectors ✓ Automatic Generation Control (AGC) for flexible operation of thermal power plants Expansion of substation facilities ✓ Installation of voltage control devices such as Static Var Compensator (SVC) in distribution network or in the RE plant ✓ Accumulation of climate data/refinement of forecasting methods ✓ Refinement of grid operating systems	
	Enhancement of the awareness and knowledge on green financing	Support for financing renewable energy projects such as green bonds	- Green Loans for investments in renewable energy projects (ADB) - Long-term loans for solar and wind power generation (ADB) - Issuance of green bonds for wind power generation (ADB) - Loans for hybrid systems of wind power generation and storage batteries (ADB)
	Long-term and local currency-denominated financing for renewable energy projects		

Figure 290 Roadmap of Solar application (Farm, Rooftop)/EES/Smart Grid

Table 215 Analysis of Hydrogen / Carbon Reduction Technology

Current status	Issues	Possible measures	Support by development partners
The share of fossil generation is still high (with natural gas at 63% and coal at 20% as of 2018)	- Employment of low-carbon thermal power generation technologies - Need to design road map to energy transition - Financing energy transition	- Hydrogen/ammonia-mixed combustion - Production of green hydrogen - Conversion of coal-fired generation to gas-fired generation - Using CC(U)S (AETI is planning to support decarbonization technologies) - Road map for energy transition(AETI is planning to support to design road map) - Support for transition finance (AETI is planning to sharing the idea of Asian transition finance)	-Asia Energy Transition Initiative (METI, Japan)

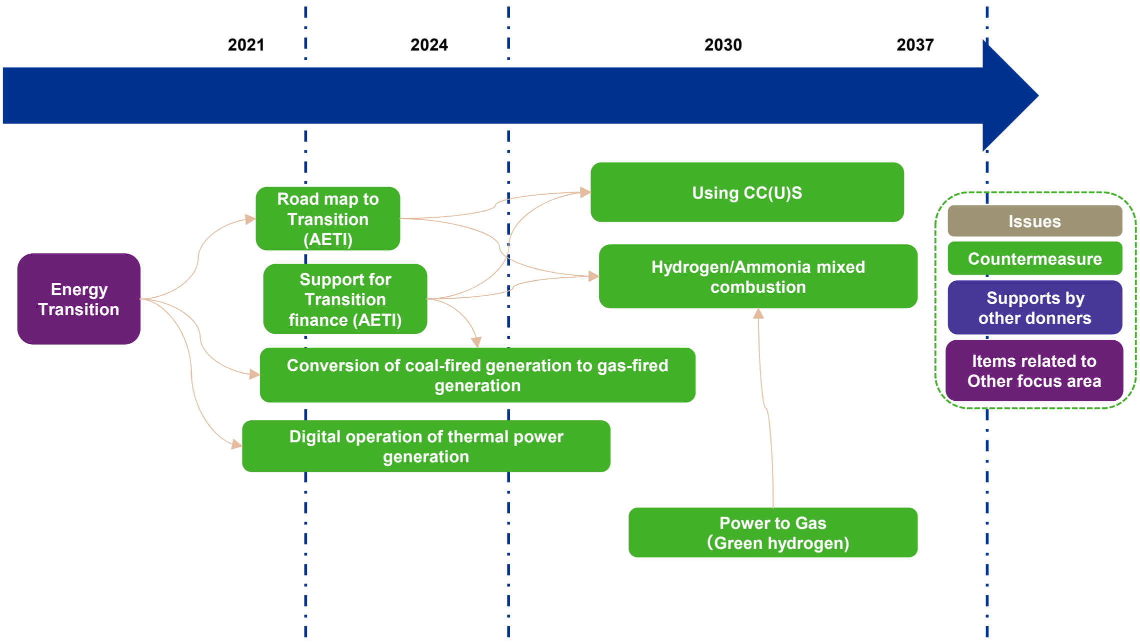

Figure 291 Roadmap of Hydrogen / Carbon Reduction Technology

Table 216 Analysis of Energy Efficiency Technology and other technology related to CN -1

Current status	Issues	Possible measures	Support by development partners
- The main energy sources in the industrial sector are electricity and coal, and electricity in the commercial sector. - In the industrial sector, coal is consumed mainly in the cement industry electricity is the main energy source in other industries.	Reduction of fossil fuel consumption in the industrial sector（Introduction of energy-efficiency technologies）	- Replacement of fossil fuel combustion boilers to heat pumps (electrification) - Use of heat pumps in light industries where the required heat temperatures are relatively low - Improvement of efficiency of equipment, cogeneration using unutilized heat, waste heat, heat storage, etc., - FEMS - Promotion of the introduction of more efficient equipment for air conditioning, hot water supply, lighting, etc. in buildings through the diffusion and tightening of existing regulations - Using Biomass	-
- it is observed that almost all of the policies and institutional arrangements for energy efficiency have already been put in place (e.g., energy management/manager system, MEPS, labeling system, tax incentives, energy conservation promotion fund). - Preparing Climate Change Act (including CO2 emission reporting obligation)	- Expansion of targeted premises (to less energy intensive enterprises) - Introduction more strict regulations under the existing institutional arrangements for energy efficiency	- Education for targeted enterprises (e.g., free energy efficiency diagnosis, dispatch of lecturers) - Audit of energy efficiency approaches - Provision of guidance summarizing Best Practice	- Control of HCFC consumption (WB) - CDM projects (WB) - Supporting the greening of the metal scrap industry (UNDP) - Improvement of the emissions trading system (WB) - Establishment of the Capacity building, Education Center, database, etc., for SMEs concerning heat generation using RE (UNIDO)

Table 217　Analysis of Energy Efficiency Technology and other technology related to CN -2

Current status	Issues	Possible measures	Support by development partners
- Priority development efforts are being made in Bangkok, Chonburi (a part of Eastern Economic Corridor) and Phuket, designated as the candidate cities at ASN (ASEAN Smart City Network) .	Accelerated development of smart cities	Necessary assistance referred to in ASCN "Smart City Action Plans" (June 2018 Chonburi 【Smart Grid Project】 • Technical assistance on managing electrical networks, generation systems, transmission systems, and power distribution system with energy management and storage system • Local authorities: Provincial Electrical Authority, Electricity Generating Authority of Thailand, and Energy Regulatory Commission 【WtE】 • Technical support during the proposal preparation process • Waste-to-Energy technology expert	- Creation of City System Management Plans, etc. (UNDP) - Demand management through AI (ADB) - Cooling using clean energy (ADB) - Demand management through AI (ADB) - Cooling using clean energy (ADB) - Green housing: labeling, capacity building (UNEP) - Green housing: design of Incentive financing schemes (UNEP)
	- Enhancement of awareness and knowledge of GHG emissions [For green housing] - Capacity development to quantify energy efficiency - Expansion of green housing to middle- and low-income households - Creation of green funds for housing	Support for the design of systems, such as capacity building（e.g. availability to assess emissions reduction in a quantifiable approach), the home labelling scheme, and incentive mechanisms for promoting energy efficient green homes, and support for the introduction of technologies green houses	- Creation of City System Management Plans, etc. (UNDP) - Demand management through AI (ADB) - Cooling using clean energy (ADB) - Demand management through AI (ADB) - Cooling using clean energy (ADB) - Green housing: labeling, capacity building (UNEP) - Green housing: design of Incentive financing schemes (UNEP)
- Priority development efforts are being made in Bangkok, Chonburi (a part of Eastern Economic Corridor) and Phuket, designated as the candidate cities at ASN (ASEAN Smart City Network) .	General issues surrounding the development of data-oriented smart cities - Development and application of standardized architectures for smart cities - Addressing information security issues - Harmonization with existing laws and regulations, and deregulation	- Utilization and protection of personal information - Protection from cyber attacks, information leakage	

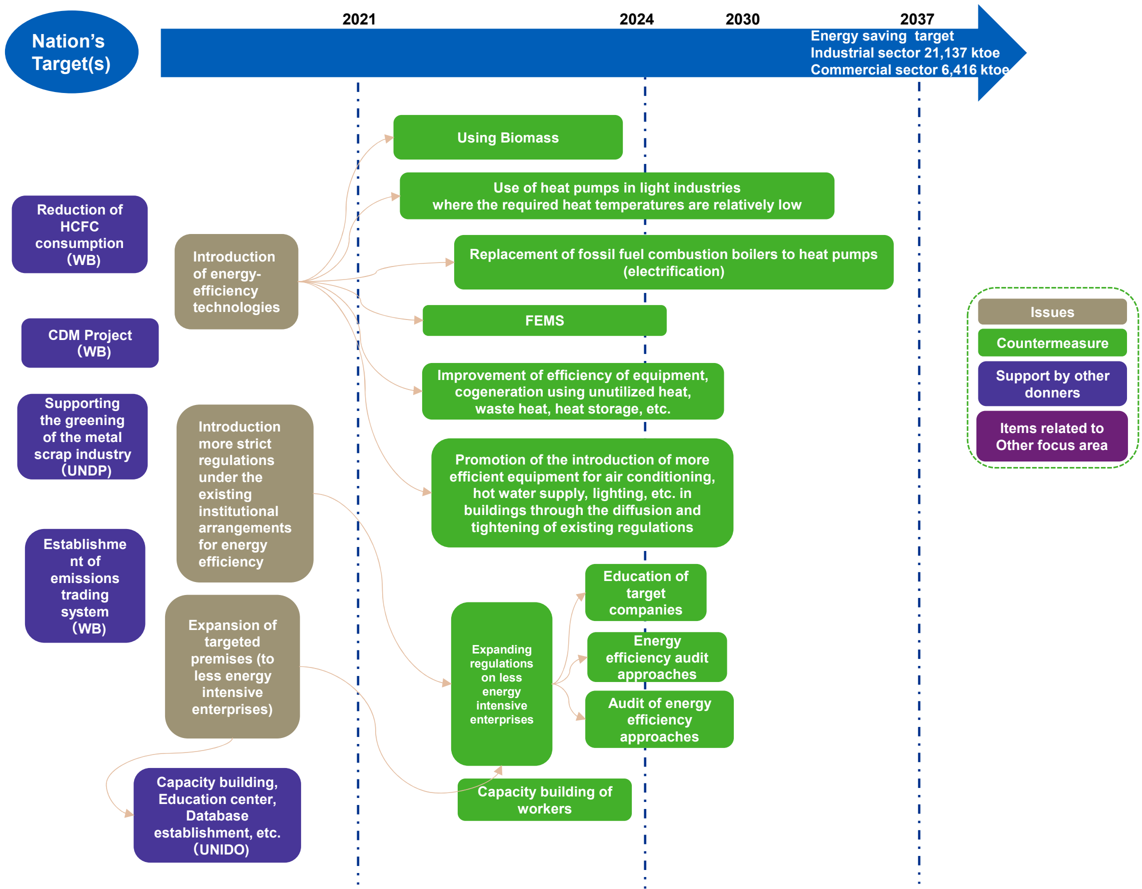

Figure 292 Roadmap of Analysis of Energy Efficiency Technology and other technology related to CN -1

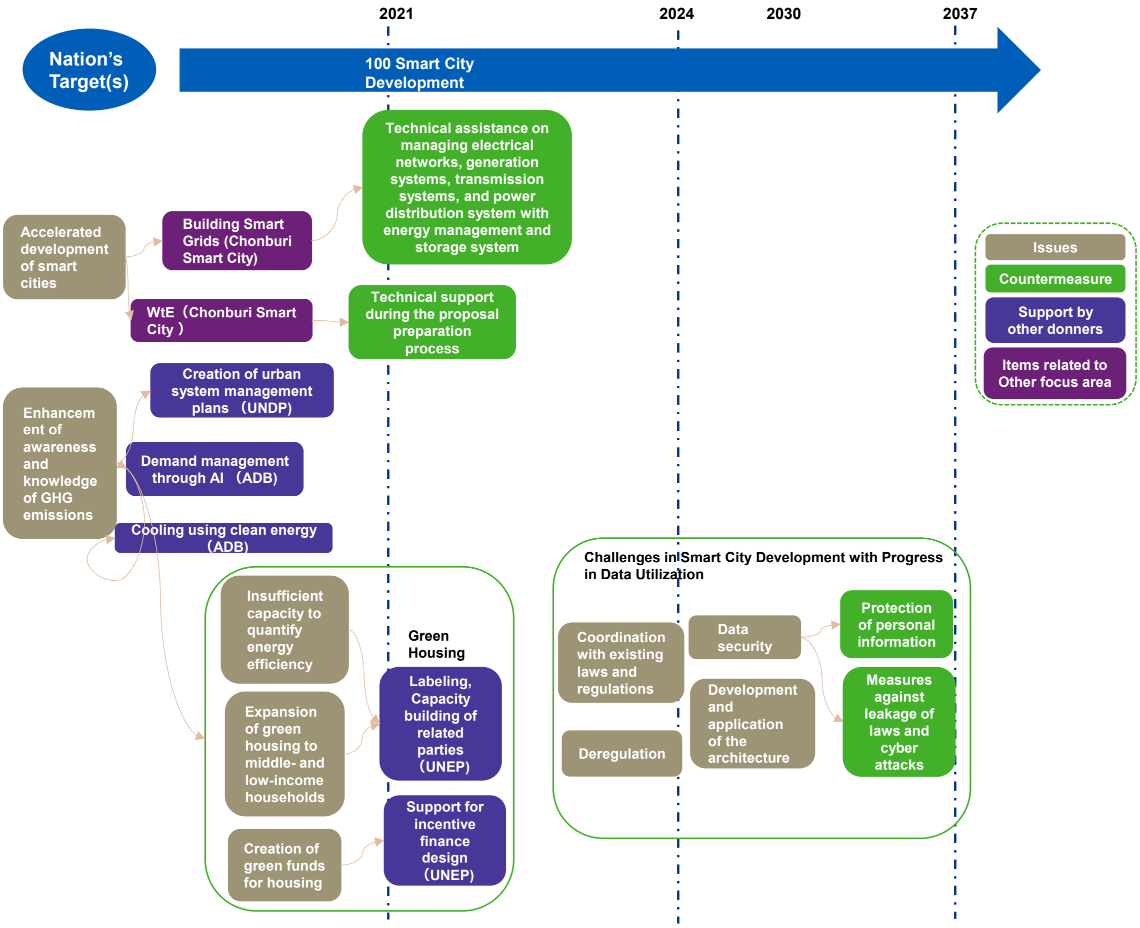

Figure 293 Roadmap of Analysis of Energy Efficiency Technology and other technology related to CN -2

(3) Morocco

The supply side of Morocco is divided into three categories: Thermal Power Plants, Renewable Energy Installation and Grid Stabilisation. Each of the current status, challenges, and measures in each, as well as other donor support are summarized on the following table. Roadmaps were compiled based on the results of the analysis.

Table 218 Analysis of Low-carbonization of Existing Thermal Power Plants

Current status	Issues	Possible measures	Support by development partners
Coal-fired generation accounting for approx. 60% of the major generating resources.	- Low-carbonisation of coal-fired generation	<Mid term: 5 to10 years> - Replacement of coal-fired generation by gas-fired generation (CCGT) - Employment of the ammonia co-firing technology - Development of a roadmap toward net zero	Feasibility Study on Ammonia Co-firing Project for a Coal-Fired Generating Plant（METI, Japan）
Natural gas generation The government has a policy of switching from coal-fired generation to gas-fired power generation.	- Reducing the cost of natural gas use - Development of supply infrastructure, such as pipelines, necessary for expanding the use of natural gas. (to be confirmed through interview)	<Short term: < 5 years> - Strengthen natural gas supply capacity (implementation of Gas-to-ower projects) <Mid to Long term: 5 to 20 years> - Transition to using hydrogen in favor of natural gas	
Carbon market mechanisms - The government is focused on preparing for the employment of market mechanisms, accumulating experience in the CDM, and introducing additional financing to the national mitigation program.	- Improving systems for taking advantage of market mechanisms - Enhancement of the capability to understand the current status and future prospects of the carbon markets	- Building a system based on market mechanisms - Capacity building for personnel of related organisations	- MRV system development and analysis support, MRV capacity building for government agencies and private companies, project management unit establishment and operatioal support (WB)

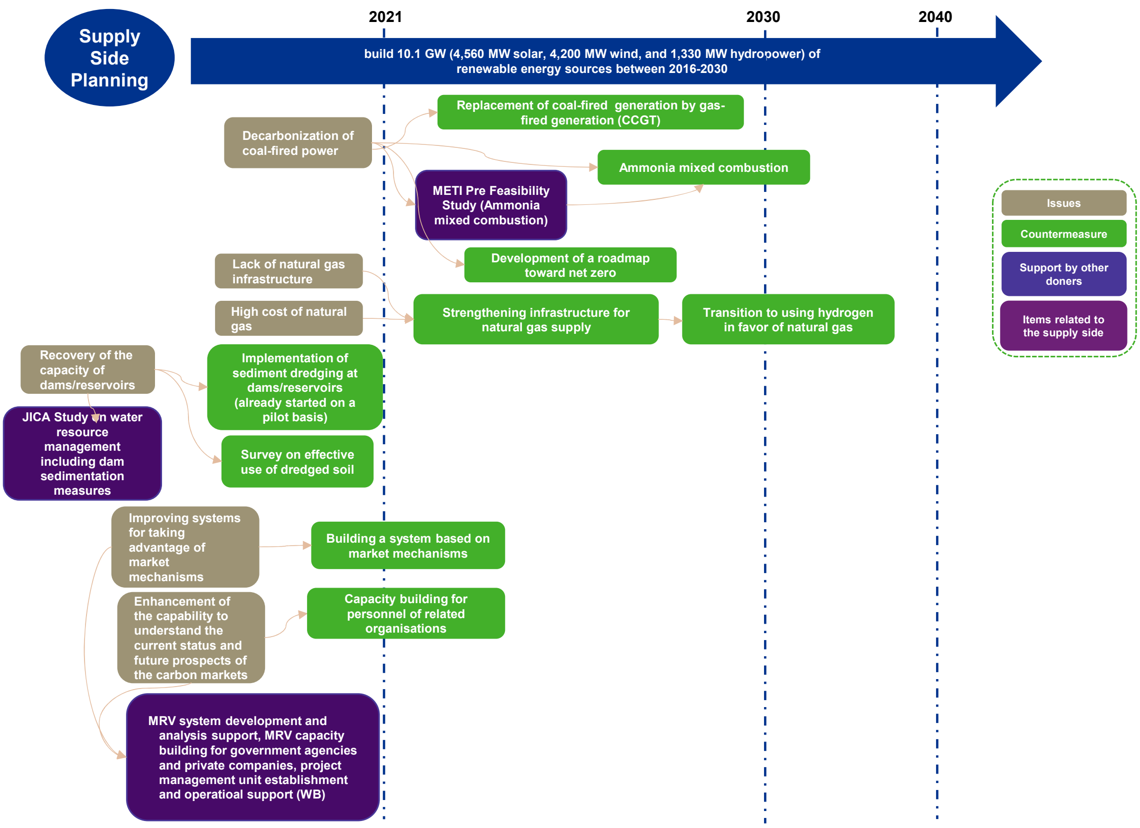

Figure 294 Roadmap of Low-carbonization of Existing Thermal Power Plants

Table 219 Analysis of Renewable Energy Installation (Hydropower)

Current status	Issues	Possible measures	Support by development partners
Hydropower - The share of hydropower generation in the overall electricity supply is declining. - There is a high need for pumped storage generation. (to be confirmed through interviews) - Hydropower capacity as of 2020 was 1,306MW and the annual generation was 1,263GWh in 2019 (IRENA). - Pumped storage capacity as of 2020 was 464MW, and the annual generation in 2019 was 391GWh in 2019 (IRENA). - Precipitation is on the decline, and the water resources availability is decreasing. - Water resource supply capacity is decreasing due to the sedimentation into dam storage, one of the main water resources.	- Increase/recovery of water resources. - Recovery of the capacity of dams/reservoirs	- Implementation of sediment dredging at dams/reservoirs (already started on a pilot basis) - Investigation on effective utilisation methods of dredged soil (study already started)	- Data collection and confirmation survey on water resource management including dam sediment control （JICA）

Table 220 Analysis of Renewable Energy Installation (Solar PV/CSP)

Current status	Issues	Possible measures	Support by development partners
Solar PV/CSP - High potential for solar energy backed by abundant solar radiation throughout the country - On-grid generation capacity as of 2020 was 171MW for PV and 540MW for CSP, and the annual on-grid generation was 395GWh for PV and 1,186GWh for CSP in 2019 (IRENA). - The northwestern part of the Atlas Mountains, where there is a high concentration of population and industries, has serious siting constraints and there are many locations where the potential cannot be exploited. - The southwestern part of the Atlas Mountains is dominated by sand and gravel and desert areas, making it difficult to install transmission lines for large-scale development.	- Promotion of solar and electricity network development in the areas with small siting constraints - Mitigation of negative impacts of the massive RE integration on the power system	- Construction of clean energy parks in the locations suitable for RE resources, investment promotion for RE projects with preferential treatments in land use and taxation - Transmission development - Use of solar generation for irrigation pumps - Grid stabilization in response to the massive VRE integration *(see p.12-13)*	- Construction of medium-scale distributed solar power plants, expansion of T&D facilities, installation of TOU (time-of-use) smart meters to promote peak-shifting (Missour, Erfoud, Zagora) (WB)

Table 221 Analysis of Renewable Energy Installation (Wind Power)

Current status	Issues	Possible measures	Support by development partners
Wind power - On-grid capacity as of 2020 was 1,400MW, and the annual generation was 4,699GWh in 2019 (IRENA). - The northwestern part of the Atlas Mountains, where the city is located, has generally poor wind conditions, and the potential for onshore wind is small. - Development along the Strait of Gibraltar is likely to be difficult due to heavy vessel traffic - Development off the coast of Essaouira in the south will require the reinforcement of transmission lines.	- Promotion of the development of wind turbines and electricity network in the areas with small siting constraints - Mitigation of negative impacts of the massive RE integration on the power system	- Construction of clean energy parks in the locations suitable for RE resources, investment promotion for RE projects with preferential treatments in land use and taxation - Transmission development - Use of solar generation for irrigation pumps - Grid stabilization in response to the massive VRE integration *(see p.12-13)*	

Table 222 Analysis of Grid Stabilisation

Current status	Issues	Possible measures	Support by development partners
Power Grid - There is the interconnection between load centres and power sources via 400kV long-distance transmission lines - The Moroccan power system is interconnected with the Spanish power system, the western end of the European system. *Source : "Data Collection Survey on the Introduction of Smart Grids in the Kingdom of Morocco" (JICA, January 2017)*	- Addressing the concerns about grid stability and voltage stability to be observed in the future. There is a long-period swing mode inherent in the European-Moroccan grid. - Addressing the concerns about inadequate regulation control & output curtailment of thermal power plants and inadequate reserves due to the massive RE integration - In the future, there will be a concern about insufficient system inertia.	- Enhancement of VQC and other voltage regulation capability - Re-tuning of Power System Stabilizers (PSS) for thermal generating units - Installation of BESS and variable speed pumped storage plants - Strengthening DC interconnection with Portugal and AC interconnection with Spain, and coordinating operation of DC interconnection between Italy and Tunisia - Ensuring adequate system flexibility to address: ✓ Emergence of duck curves ✓ Overloading on interconnections and lack of inertia ✓ Insufficient substation capacity ✓ Increased frequency/voltage fluctuations ✓ Voltage surge in distribution network (Ferranti effect) ✓ Difficulties in accurate VRE output estimation ✓ Introduction of seawater pumped storage generation technology	

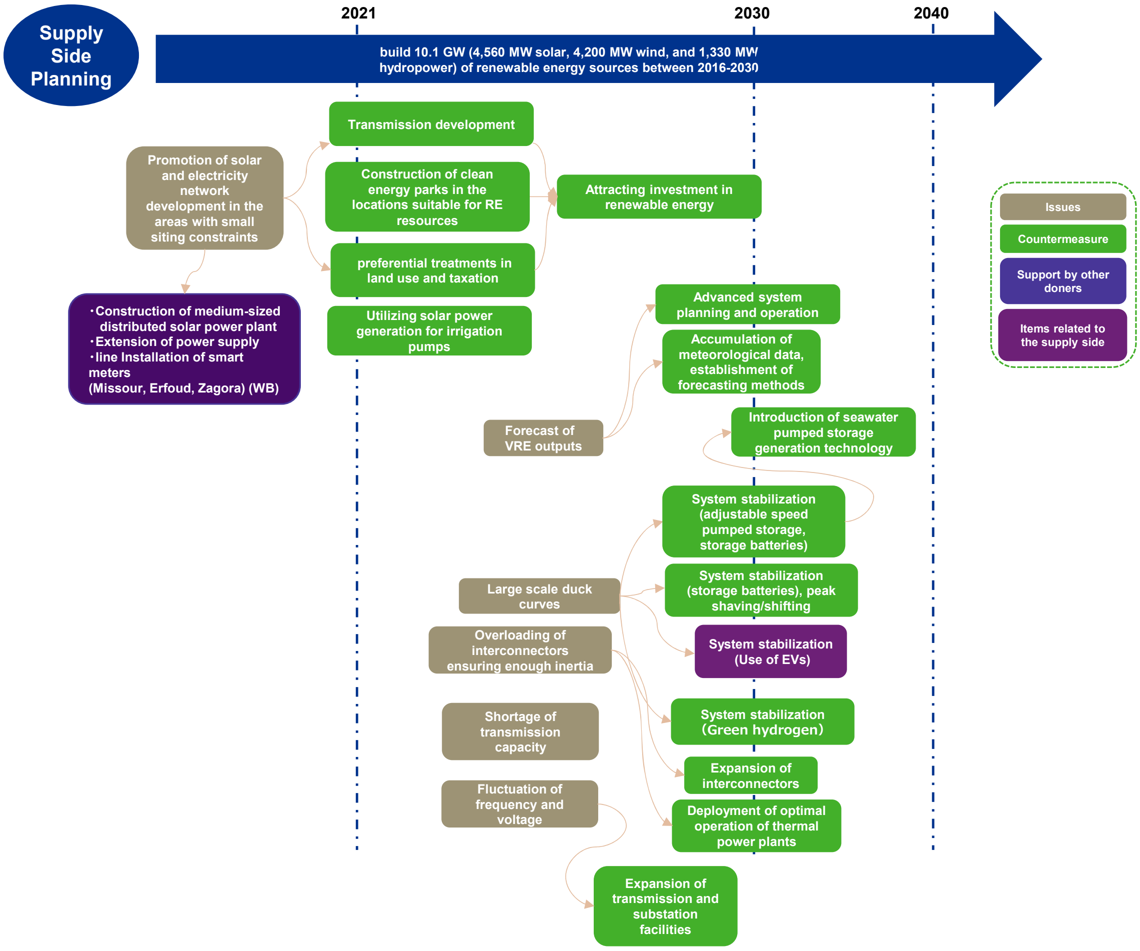

Figure 295 Roadmap of Renewable Energy Installation and Grid Stabilisation

The demand side of Morocco is divided into three categories: industrial and commercial sector, transport sector, and urban development. Each of the current status, challenges, and measures in each, as well as other donor support are summarized on the following table. Roadmaps were compiled based on the results of the analysis.

Table 223 Analysis of Industrial and Commercial Sector

Current status	Issues	Possible measures	Support by development partners
- Energy consumption in the cement industry is the highest, with oil accounting for most of the energy sources, followed by the mining and food industries where electricity accounts for a larger share than oil.	- Improving energy efficiency in the industrial sector	- Operation of the energy efficiency benchmarks for the industrial sector - Employment of proper energy management practices in energy-intensive industries - Use of heat pumps in the food industry - Strengthen activities to improve energy efficiency in SMEs	
	- Reduction of electricity consumption (for lighting, air conditioning, hot water supply, etc.) in the industrial and commercial sectors	- Introduction of the minimum efficiency standards for equipment such as lighting and air conditioning	
- Morocco is the world's second largest producer (after China) and largest exporter of phosphorus ore, the raw material for phosphorus, one of the three elements in chemical fertilizers (about 30% of world demand).	- Increasing domestic production of ammonia ➢ While Morocco is blessed with phosphate resources, it is not blessed with fossil fuel resources, so it can only produce a small amount of ammonia, the source of nitrogen fertilizer (the main ingredient in chemical fertilizers), and much of it is imported.	- Promotion of green hydrogen using RE, resulting in larger domestic production of ammonia	

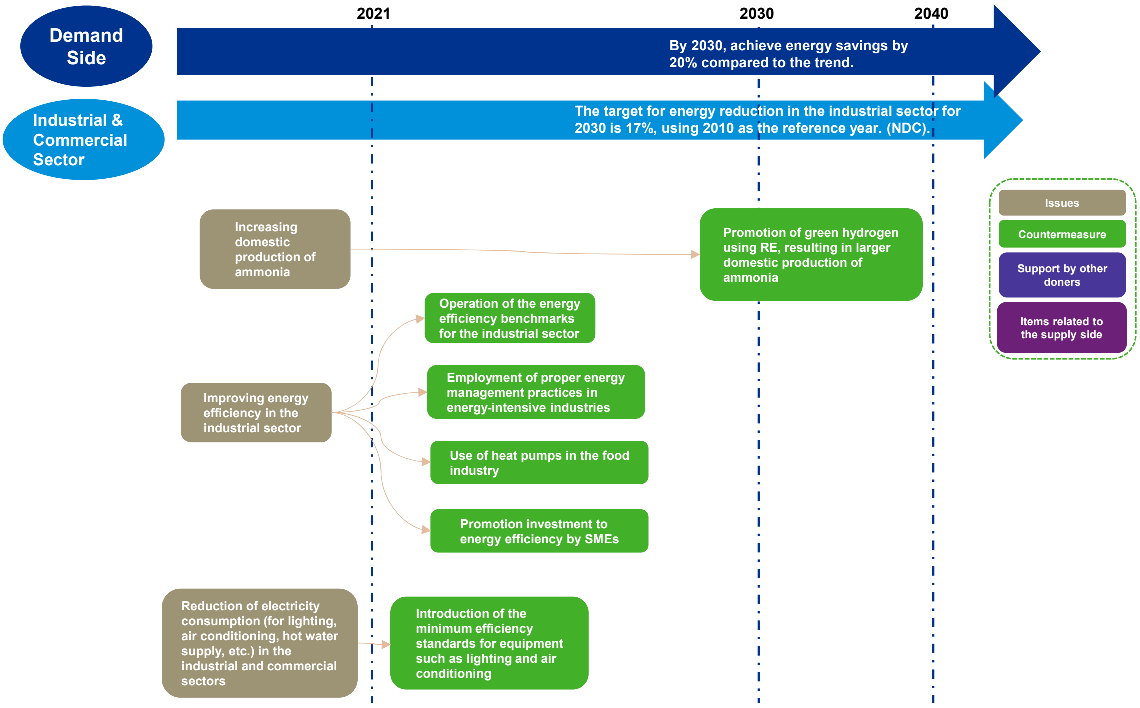

Figure 296 Roadmap of Industrial and Commercial Sector

Table 224 Analysis of Transport Sector

Current status	Issues	Possible measures	Support by development partners
- Petroleum demand for automobiles is significant. - Transportation accounts for the largest share of final energy consumption by sector, at 40% (2019). - CAGR of final energy consumption for 2014-2019 was 4.3%	- Low-carbonization of the automotive sector	- Improving fuel efficiency of automobiles - Introduction of alternative fuel vehicles - Introduction of fuel efficiency standards for automobiles	Developing a National Roadmap for Sustainable Mobility (GIZ) Strengthening climate-friendly sustainable mobility at national and local levels (GIZ)
		- Expansion of public transportation and promotion of modal shifting - Policies for reduced automobile use	Organisational strengthening and capacity building for low carbon development, training of trainers in eco-driving, design and implementation of studies and inventories on GHG emissions from rail and road logistics vehicles （UNDP)
- There is a certain interest in the development of EVs and hydrogen vehicles - A German car company, Opel, started EV production in September 2021.	- Domestic production of EV - Promotion of EV-related technology development - Domestic diffusion of EV	- In the “EV Roadmap I (2021)” developed by CGEM, they divided the period from 2022 to 2035 into 3 phases and announced their activities in each phase. - Phase I (2022-2025): Production of EV and charging equipment; development of charging services, regulations, and standards; setting mandatory targets for bus and public procurement; introduction of tax breaks, green loans, and subsidies; introduction of initial fast-charging networks, etc. - Phase II (2025-2030): Production of battery, review of incentives, installation of public charging facilities in major cities, etc. - Phase III (2030-): Reuse and recycle batteries, install public charging facilities in all cities, etc.	

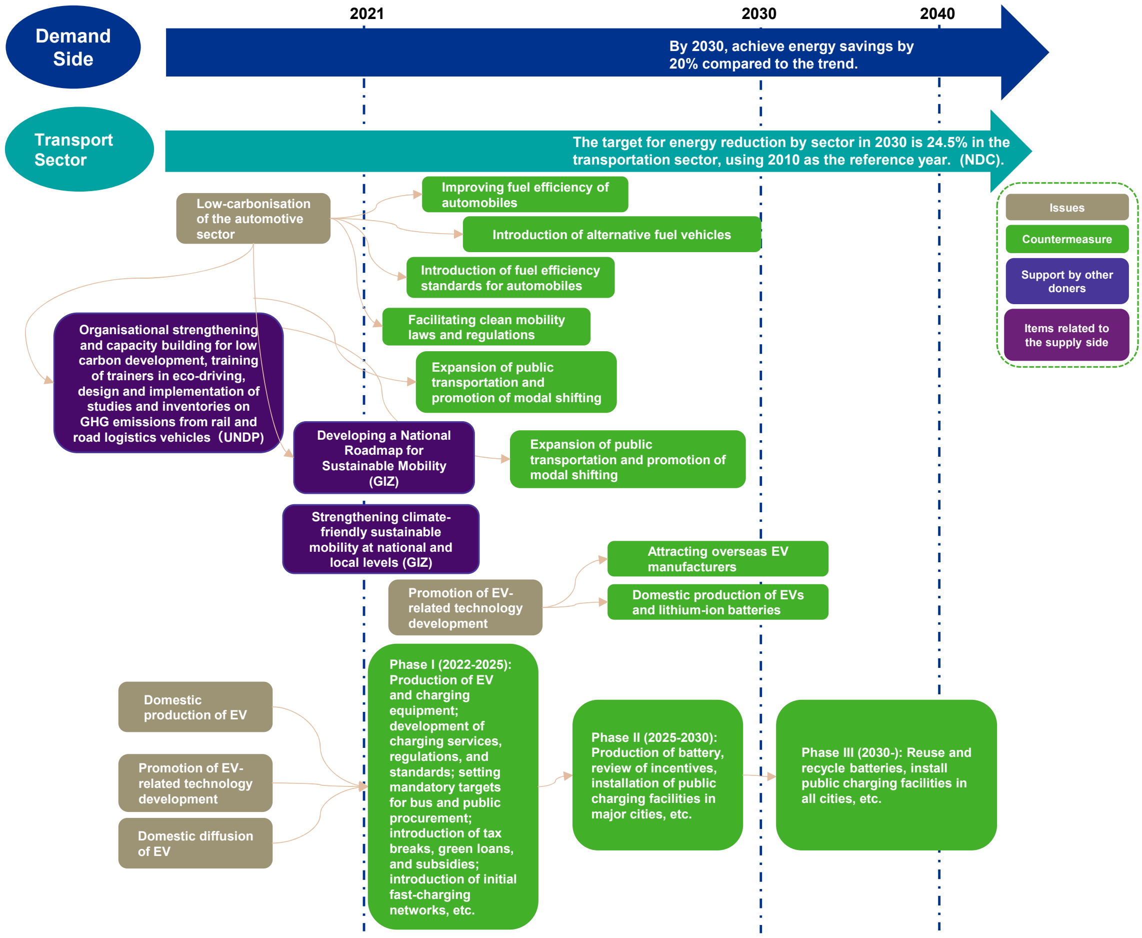

Figure 297 Roadmap of Transport Sector

Table 225 Analysis of Urban Development

Current status	Issues	Possible measures	Support by development partners
- Residential energy consumption is 73% for oil (LPG) and 27% for electricity (in 2019). - The share of energy consumption for cooking is very large at households.	- Reduction of oil consumption for cooking and hot water supply	- Use of heat pumps for hot water heating - Promotion of solar water heaters - Formulation of a framework for financial support for the purchase of energy efficient equipment - Electrification of cook wares	
- Electricity demand is increasing with the urbanisation and the spread of home appliances. - The household penetration rate of air conditioners is expected to increase from 18% in 2019 to 40% in 2030.	- Improving energy efficiency in the residential sector, where electricity demand is increasing - Necessity of private investment including overseas	- Expansion of the number of devices covered by the labeling system, facilitating investment environment - Expansion of equipment subject to the Minimum Energy Performance Standards (MEPS) - Introduction of stricter energy saving standards - Organize MEPS audit structure - Improve energy efficiency for cooling - Capacity building for energy conservation in buildings	

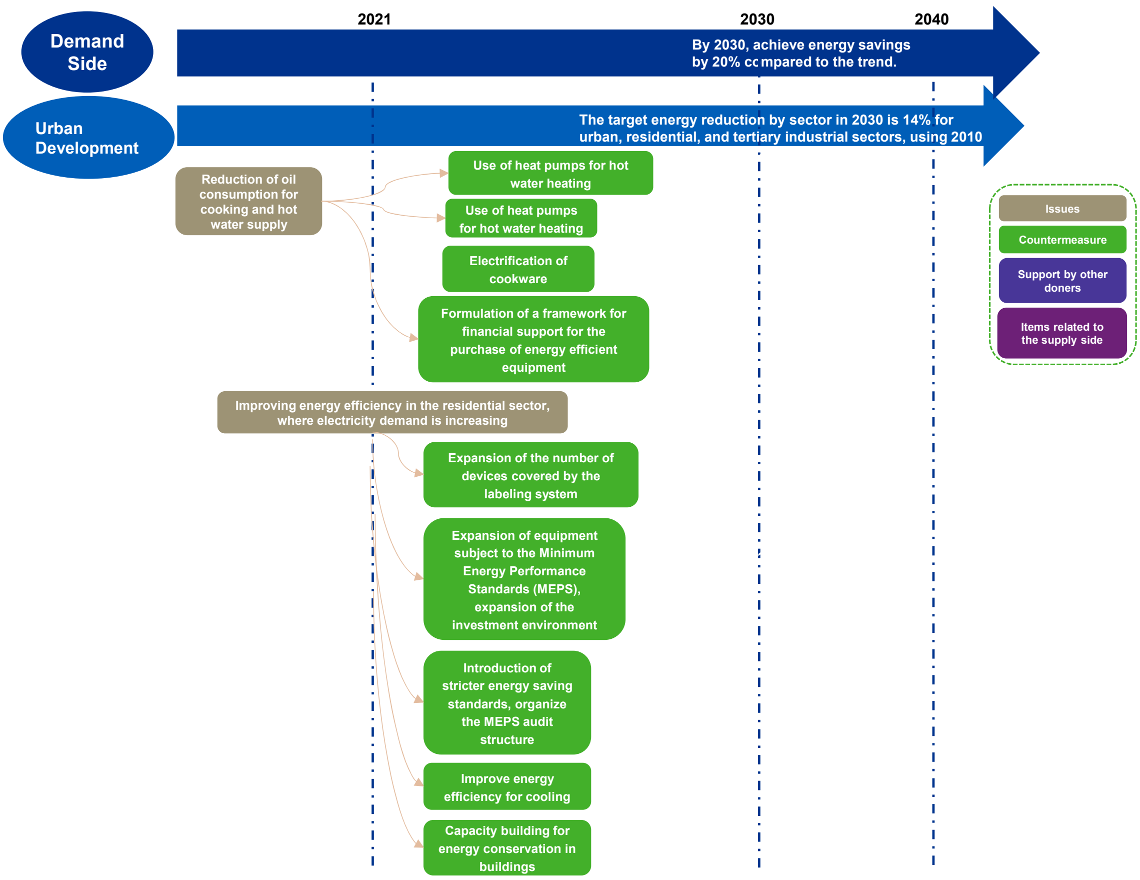

Figure 298 Roadmap of Urban Development

(4) Indonesia

The supply side of Indonesia is divided into three categories: Thermal Power Plants, Renewable Energy Installation and Bioenergy. Each of the current status, challenges, and measures in each, as well as other donor support are summarized on the following table. Roadmaps were compiled based on the results of the analysis.

Table 226 Analysis of Low-carbonization of Existing Thermal Power Plants

Current status	Issues	Possible measures	Support by development partners
The share of thermal power generation in the power sector is large. Dependence on coal-fired power generation is particularly large.	- Reducing dependence on coal-fired power generation (e.g., biomass, ammonia utilization) - Introducing low-carbonization technologies for coal-fired power plant (e.g., clean coal, CCS, etc.)	- Combined approach to reduce dependence on coal, low-carbonization of coal-fired power plants. - Introduction of carbon tax and ETS (to be implemented) [Medium term] (5-10 years) - Biomass co-firing - Early retirement of coal-fired power plants - Demonstration o ammonia co-firing in coal-fired power generation [Long-term] (10 to 20 years) - Ammonia co-firing in coal-fired power generation - CCS/CCUS	- Electricity tariff hike and subsidy reduction, diesel subsidy reduction, measures to increase natural gas usage, pilot support for CCS and/or CCUS technology (ADB) - LNG Production Expansion Project (Tangguh) (ADB) - Strengthening capacity within PT.PERTAMINA and the Government of Indonesia to design and plan CCS pilots and pilot activities (ADB) - ADB and CIF support for early retirement of coal-fired power plants - Technology and Human Resource Development Project on Carbon Dioxide Capture and Storage (CCS) (JICA) - Support for Emission Trading Scheme at coal-fired power plants (promoting carbon pricing introduction in the energy sector using Partnership for Market Implementation (grant), infrastructure development) (WB)

Table 227 Analysis of Renewable Energy Installation

Current status	Issues	Possible measures	Support by development partners
- In 2003, a geothermal law was enacted to establish a system that is primarily for development by private developers. In 2014, the Geothermal Law was amended to remove the upper limit of the field area for which the government can grant project rights to developers, which is expected to promote geothermal development in the areas with strict environmental regulations and increase the number of large-scale projects. - Development target: 3.4 GW in 2021-2030 (RUPTL 2021-2030)	- Addressing environmental, social, or financial problems in privately owned concession areas - Mobilization of private investment ➢ Increase in purchase prices ➢ Mitigation of resource risk (drilling risk) ➢ Reduction of initial investment ➢ Supply of long-term financing	- Grants/blended finance scheme for prospecting risk reduction - Capacity building for assessment and management of social and environmental impacts	- Geothermal development of 55 MW in Dieng, Central Java and 55 MW in Patuha, West Java (ADB) - 90 MW of geothermal development in South Sumatra (ADB) - Muara Lab development (ADB) - Supporting the implementing regulations of the revised Geothermal Law, which provides guidance on the bidding system, revenue sharing with local governments, and access to forests for geothermal power development (ADB) - Establishment of risk mitigation facilities for geothermal resource drilling (WB, GCF, CTF), capacity building on geothermal exploration and management of environmental and social/environmental measures (e.g., ESMAP) - Demonstration test of technology for diagnosing problems in geothermal power plants (NEDO) - Project to Support the Design of Medium- and Long-Term Promotion System for Geothermal Development (JICA) - Geothermal Development Promotion Program (Tulef Geothermal Power Project (JICA)) and many others
- Although Indonesia has abundant hydro resources, the development has not progressed consistently due to the differences in the distribution of resources and areas of high demand, as well as the environmental and social impacts of development (adverse effects on forests and ecosystems, resettlement due to development, etc.), resulting in a development rate of about 7% relative to the amount of resources. - Development target: 10.4 GW in 2021-2030 (RUPTL 2021-2030)	- Mobilization of private investment ➢ Increase in purchase prices ➢ Correct hydropower capacity estimation	- Technical cooperation on electricity generation capacity estimation, water volume forecasting, etc.	- Asahan No.3 Hydro Power Plant Construction Project (JICA) - Pusangan Hydro Power Plant Construction Project (JICA) - Project for dissemination and demonstration to solve the power shortage by introducing the small hydro power generation system for waterways (JICA)

Current status	Issues	Possible measures	Support by development partners
- In 2003, a geothermal law was enacted to establish a system that is primarily for development by private developers. In 2014, the Geothermal Law was amended to remove the upper limit of the field area for which the government can grant project rights to developers, which is expected to promote geothermal development in the areas with strict environmental regulations and increase the number of large-scale projects. - Development target: 3.4 GW in 2021-2030 (RUPTL 2021-2030)	- Addressing environmental, social, or financial problems in privately owned concession areas - Mobilization of private investment ➢ Increase in purchase prices ➢ Mitigation of resource risk (drilling risk) ➢ Reduction of initial investment ➢ Supply of long-term financing	- Grants/blended finance scheme for prospecting risk reduction - Capacity building for assessment and management of social and environmental impacts	- Geothermal development of 55 MW in Dieng, Central Java and 55 MW in Patuha, West Java (ADB) - 90 MW of geothermal development in South Sumatra (ADB) - Muara Lab development (ADB) - Supporting the implementing regulations of the revised Geothermal Law, which provides guidance on the bidding system, revenue sharing with local governments, and access to forests for geothermal power development (ADB) - Establishment of risk mitigation facilities for geothermal resource drilling (WB, GCF, CTF), capacity building on geothermal exploration and management of environmental and social/environmental measures (e.g., ESMAP) - Demonstration test of technology for diagnosing problems in geothermal power plants (NEDO) - Project to Support the Design of Medium- and Long-Term Promotion System for Geothermal Development (JICA) - Geothermal Development Promotion Program (Tulef Geothermal Power Project (JICA)) and many others
- Although Indonesia has abundant hydro resources, the development has not progressed consistently due to the differences in the distribution of resources and areas of high demand, as well as the environmental and social impacts of development (adverse effects on forests and ecosystems, resettlement due to development, etc.), resulting in a development rate of about 7% relative to the amount of resources. - Development target: 10.4 GW in 2021-2030 (RUPTL 2021-2030)	- Mobilization of private investment ➢ Increase in purchase prices ➢ Correct hydropower capacity estimation	- Technical cooperation on electricity generation capacity estimation, water volume forecasting, etc.	- Asahan No.3 Hydro Power Plant Construction Project (JICA) - Pusangan Hydro Power Plant Construction Project (JICA) - Project for dissemination and demonstration to solve the power shortage by introducing the small hydro power generation system for waterways (JICA)

Table 228 Analysis of Bioenergy

Current status	Issues	Possible measures	Support by development partners
- In order to reduce fossil fuel consumption and increase energy self-sufficiency, as well as to combat poverty and unemployment, Indonesia is working to promote the use of biofuels made from indigenous palm oil. - The use of biodiesel for transportation is relatively widespread. - A biofuel blending mandate was enacted in 2008 (MEMR Regulation 32/2008) and revised in March 2015 (MEMR Regulation 12/2015). - In September 2018, the government mandated the use of "B20" biodiesel, a blend of 20% biofuel with diesel oil; in January 2020, the government will begin mandating the use of "B30	- Financial support for bioethanol - Reduction in the cost of raw materials for bioethanol - Expansion of the production capacity for bioethanol	- Implementation of a Demonstration Project (B100) - Establishment of a value chain for bioethanol - Expansion of economic incentives for biofuel promotion (subsidies, taxation)	

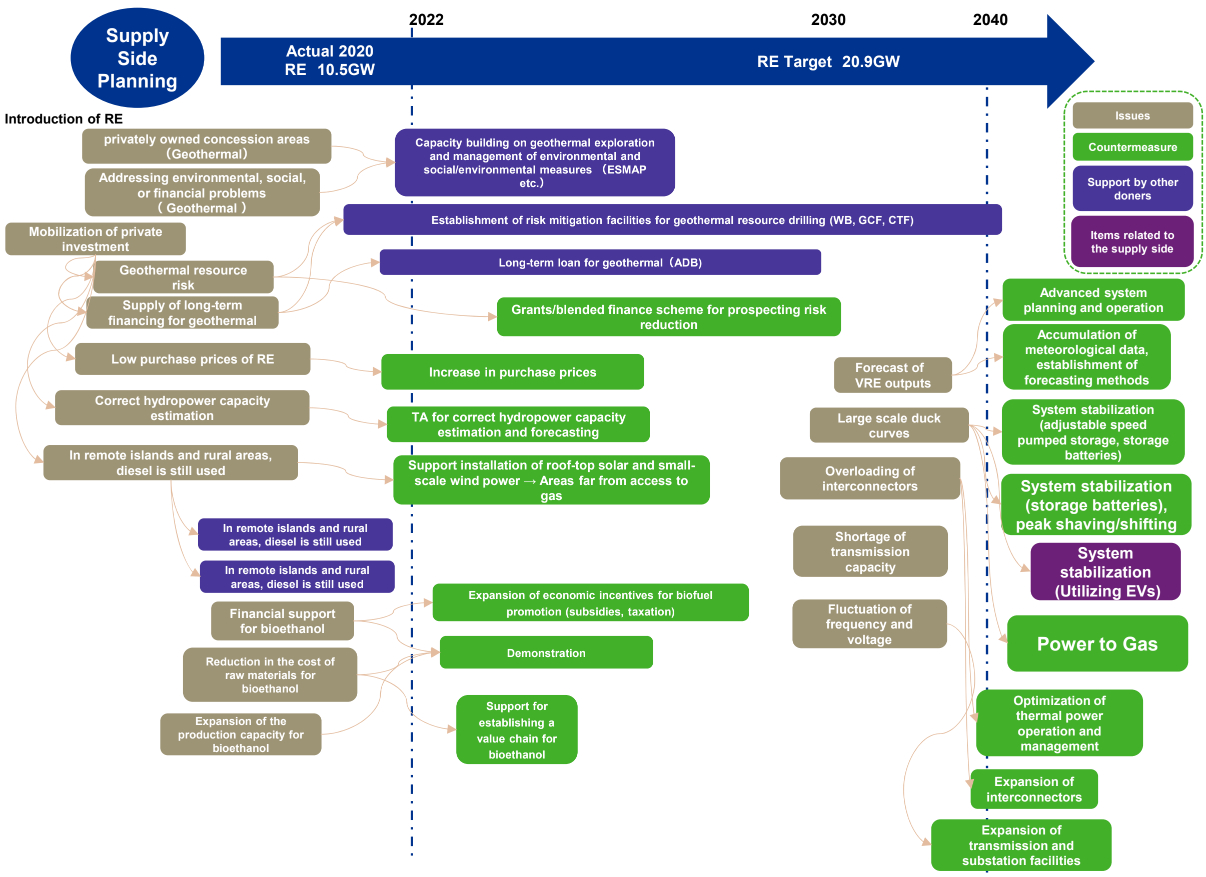

Figure 299 Roadmap of Renewable Energy Installation and Bioenergy

The demand side of Indonesia is divided into three categories: industrial and commercial sector, transport sector, and urban development. Each of the current status, challenges, and measures in each, as well as other donor support are summarized on the following table. Roadmaps were compiled based on the results of the analysis.

Table 229 Analysis of Industrial and Commercial Sector

Current status	Issues	Possible measures	Support by development partners
- The manufacturing sector (excluding oil and gas), which includes eight priority industries: cement, metals (iron and steel), pulp and paper, ammonium fertilizer, petrochemicals, ceramics, textiles and fiber products, and food and beverages, is projected to grow at 10.5% (RIPIN 2015-2035)	- Balancing manufacturing growth and emissions reduction	- Replacement of fossil fuel combustion boilers to heat pumps (electrification) - Use of heat pumps in light industries where the required heat temperatures are relatively low - Improvement of efficiency of equipment, cogeneration using unutilized heat, waste heat, heat storage, FEMS, etc.	- Global Climate Partnership Fund (GCPF) to be established with other donors to invest in RE and EE (ADB and others). - Subsidies for HCFC reduction (GEF)
- Electricity consumption in the industrial, residential and building sectors is large. - High share of the commercial sector (hotels, restaurants, etc.) with the demand for heating and cooling and hot water supply).	- Reduction of electricity consumption (lighting, heating and cooling, hot water supply, etc.) in the industrial, commercial, residential, and building sectors (energy conservation) - Increase the penetration rate of inverter air conditioners for heating and cooling	- Promotion of the introduction of more efficient equipment for air conditioning, hot water supply, lighting, etc. in buildings through the diffusion and tightening of existing regulations - Incentive measures (taxation, subsidies) for the introduction of inverter air conditioners	- Global Climate Partnership Fund (GCPF) to be established with other donors to invest in RE and EE (ADB and others). - Subsidies for HCFC reduction (GEF)
- In the commercial sector, the Energy Conservation Decree (Government Regulation No. 70/2009) establishes the energy management system, including the appointment of energy managers, and the detailed implementation rules are provided in the Regulations on Energy Management. In addition, national competency standards for energy managers and energy auditors have been established.	- Low rate of submission of energy usage status reports - Training of qualified energy managers	- Support for training of qualified energy managers	
- Various systems are being developed under the Energy Conservation Law. In order to spread and tighten each regulation, it is necessary to expand the scope of regulation from companies with large energy consumption to companies with small and medium consumption.	- Nurturing awareness of EE among micro, small and medium-sized enterprises (MSME) - Encouraging EE investments by MSME	- Support for the introduction of energy-saving equipment (introduction of equipment) - Education for targeted enterprises (e.g., free energy efficiency diagnosis, dispatch of lecturers),audit of energy efficiency approaches, provision of guidance summarizing Best Practice - Creation of facilities and funds for EE-related loans - Capacity building for financial institutions	

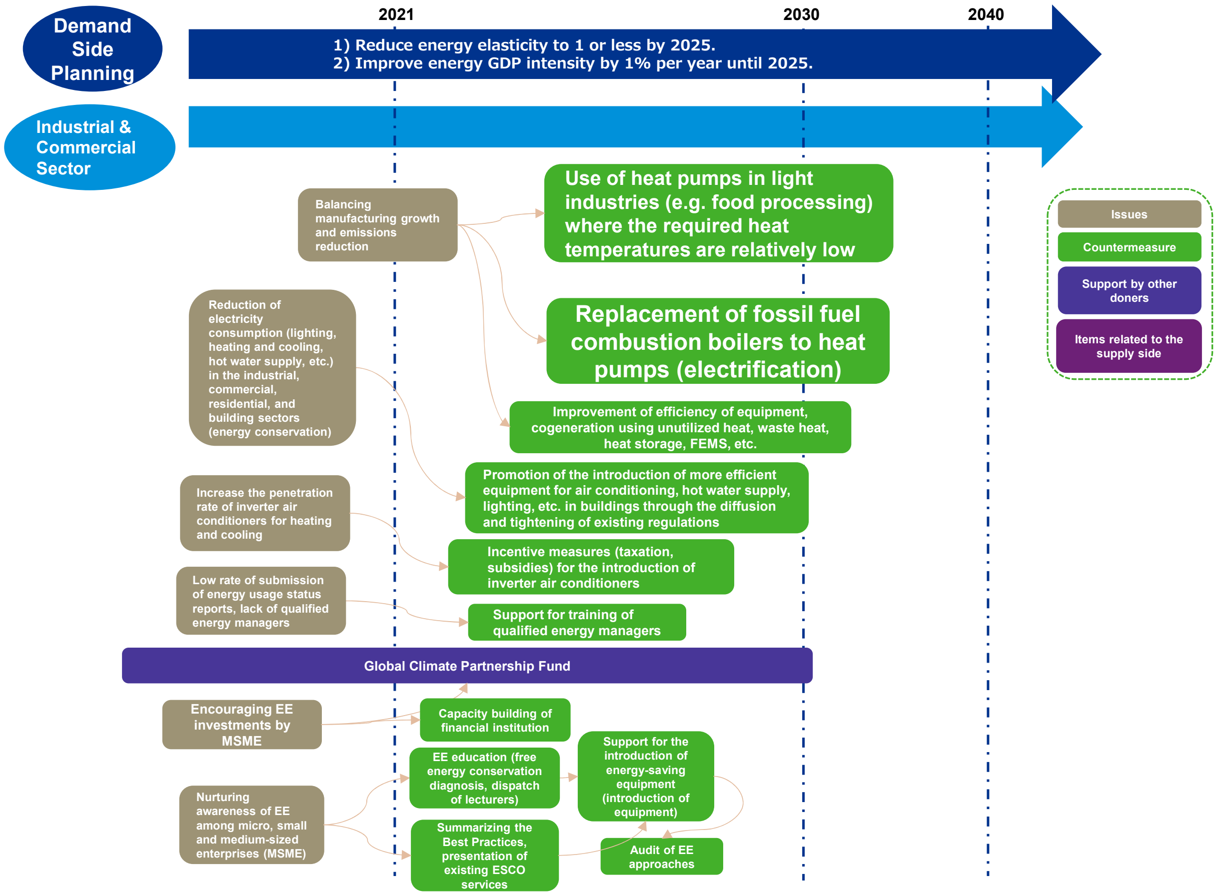

Figure 300 Roadmap of Industrial and Commercial Sector

Table 230 Analysis of Transport Sector

Current status	Issues	Possible measures	Support by development partners
- According to the Indonesian Automobile Association, there were 0 BEVs and 20 PHEVs sold as of 2019. In addition, from January to October 2020, only 250 BEVs were sold. - RUEN provides an action plan for the transport sector with target years of 2019, 2025 and 2050. However, the Indonesian government's efforts in developing a necessary roadmap and regulations have not been fully implemented.	- Reduction in the prices of imported EVs - Development of a roadmap and regulations required for the achievement of the RUEN goals	- Promotion of EV utilization (purchase subsidies, incentive taxation)	Support the implementation of roadmaps, feasibility studies, and regulations for charging infrastructure to facilitate EV deployment (ADB)
	- Promotion of EV-related technology development	- Creation of manufacturing eco-systems and promotion of domestic production - Domestic sales of EVs supporting rapid charging	

Current status	Issues	Possible measures	Support by development partners
- RUEN provides an action plan for the transport sector with target years of 2019, 2025 and 2050. However, the Indonesian government's efforts in developing the necessary roadmap and regulations have not been fully implemented.	- Improving the production capacity of storage batteries and promoting their reuse	- Domestic production of lithium-ion batteries - Construction of battery testing centers - Securing the supply of raw materials for storage batteries - Establishment of recycling technologies for cost reduction - Reuse of storage batteries, formation of a storage battery swapping business, and establishment of standards for storage batteries	Demonstration study of battery sharing system for electric mobility(NEDO,Japan)(2019-2021)
	- Introduction of EVs in public transportation	- Electrification of buses, cabs, motorcycle cabs and ride-hailing cars	
- PLN has developed a roadmap for the proliferation of charging stations for the period 2020 to 2030. The number of charging stations is expected to increase from 180 to 7,146. - In September 2020, MEMR issued Regulation No. 13/2020 on charging infrastructure for BEVs.	- Installation and expansion of charging infrastructure	- Expansion of EV charging stations - Policy support for workplace charging - Optimization of installation locations to account for increased load	
- No specific undertakings with respect to V2X can be confirmed.	- Grid connection	- Establishment of the regulations and guidelines for managing load increases in electricity T&D network for both T&D and charging infrastructure - Planning and securing financial resources for infrastructure updating and expansion	
		- Market design to enable EV participation in the electricity market (demand response)	
- Indonesia has no regulations on fuel efficiency standards.		- Formulation of regulations on fuel efficiency standards	-

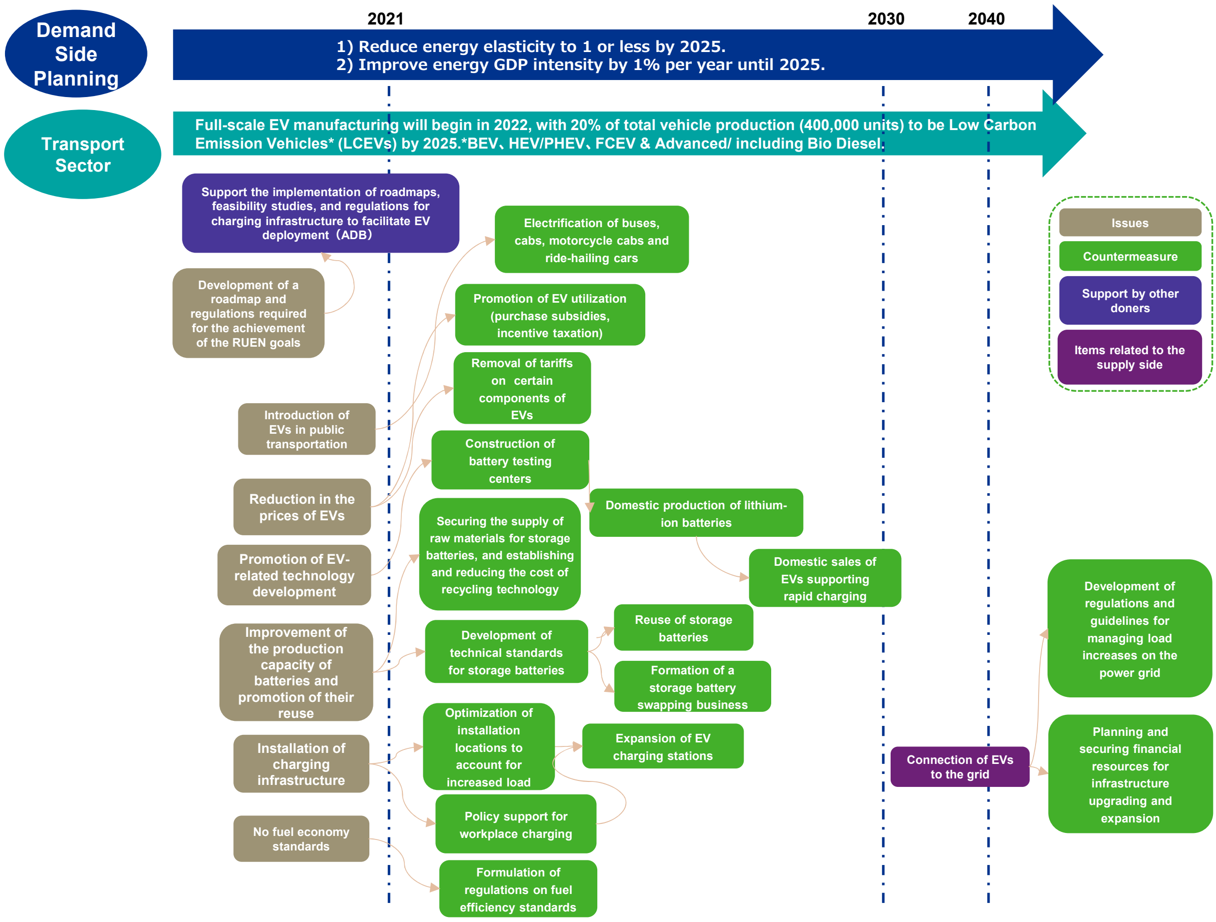

Figure 301 Roadmap of Transport Sector

Table 231 Analysis of Urban Development

Current status	Issues	Possible measures	Support by development partners
(Housing) - In the household sector, an energy-saving labeling system for home appliances has been introduced. The energy-saving labeling system for fluorescent light bulbs was launched in October 2011, and has since become mandatory for lighting lamps and air conditioners, while the rest are voluntary. - Voluntary energy audits standards have been established for home insulation, air conditioning, lighting, and building , but the standards have not yet been made mandatory.	- Enhancement of the existing energy conservation labeling system - Increased awareness of the labeling system	- Expansion of mandatory targets for the labeling system - Mandatory energy audit standards for insulation performance for houses, air conditioning, lighting, and building - Education on the labeling system - Strengthening and dissemination of energy conservation management and energy conservation standards in buildings (residential and office buildings)	
(Housing) - In terms of energy efficiency standards for equipment, MEPS has been introduced for fluorescent light bulbs and air conditioners, but energy efficiency standards for other equipment are voluntary. - MEPS will be expanded to include refrigerators, fans, electronic ballasts, electric motors, LED light bulbs, washing machines, pumps used to pump up wells, irons, and televisions.	- Expansion of MEPS coverage - Increased awareness of MEPS	- Expanding the scope of mandatory MEPS - Education on MEPS	
- Jalarta, Banyuwangi, and Makassar have been selected as pilots for ASCN.	*(The action plans of the three cities indicated on the left do not include anything related to energy)*		Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Ministry of Economy, Trade and Industry (METI), and other organizations are providing support for smart cities in Indonesia. Japanese companies are also moving into the country.
–	General issues surrounding the development of data-oriented smart cities: - Development and application of standardized architectures for smart cities - Addressing information security issues (e.g., utilization and protection of personal information, cyber attacks, information leakage) - Harmonization with existing laws and regulations, and deregulation	• Development and application of standardized architectures for smart cities: (1) Summarizing common ideas and methodologies for smart city initiatives, and making this summary a reference for municipalities that want to start or expand the initiatives when they think about what and how to decide, (2) Defining the city operation system (hereinafter referred to as "OS") as the basic platform of smart cities, and defining the minimum necessary rules for data and authentication exchange in the city OS, so that services and data can be interconnected and distributed efficiently among smart cities. • Issues related to information security: utilization and protection of personal information, cyber attacks, information leakage • Harmonization with existing laws and regulations, and deregulation	

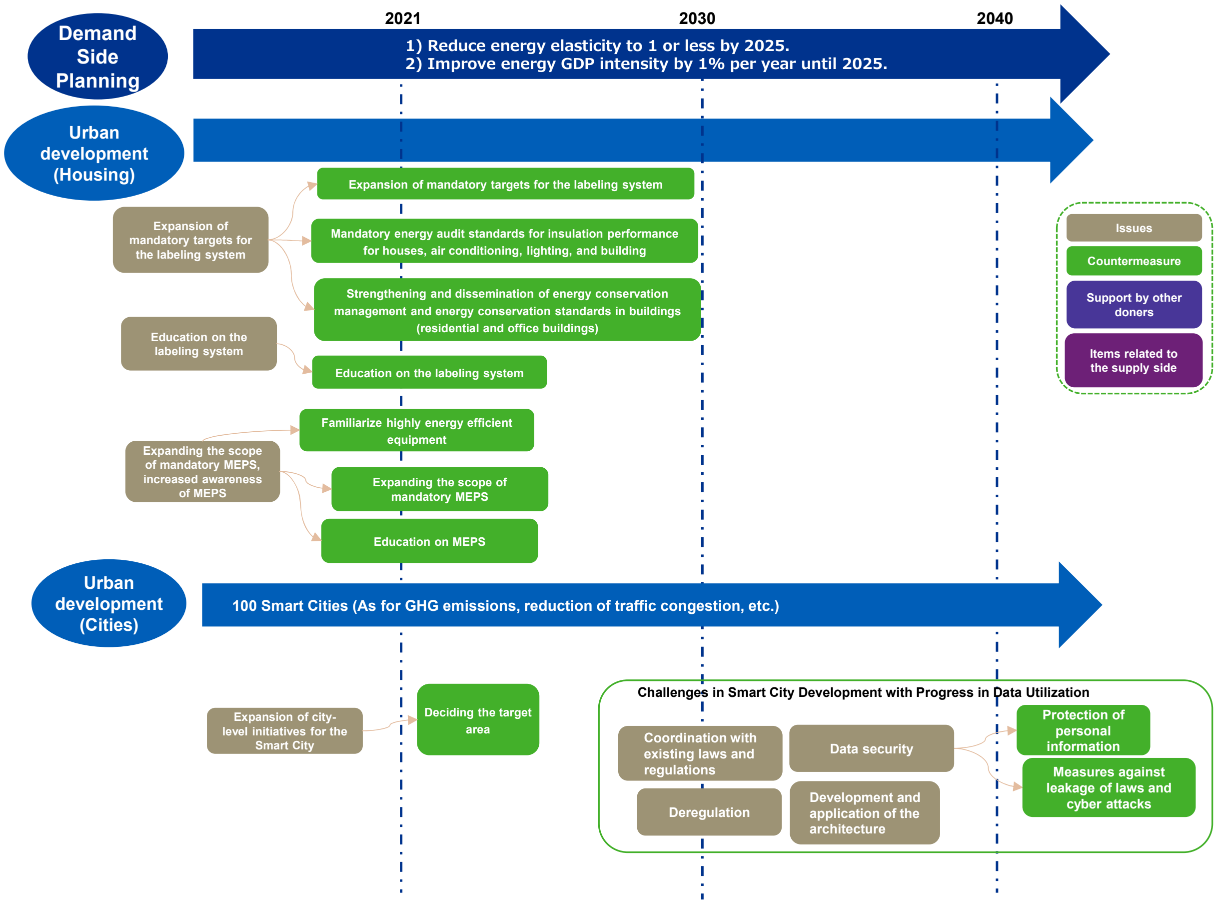

Figure 302 Roadmap of Urban Development

3.2 Field Survey Report

3.2.1 Conducting of Local Interviews

(1) India

Online interview surveys targeting related agencies in India were conducted from November 2021 until February 2022. The current status, needs and other related information obtained from the survey of each agency are described below.

(1) Ministry of Power (MoP) (Conducted on January 19, 2022)

Current Status

- MoP is in charge of large-scale power stations, transmission facilities and system interconnection.
- There is a goal of 310GW of total coal fired fossil fuel power generation by 2030, with plans calling for 6.5GW of coal fired power generation to be decommissioned.
- CCS demonstration projects are being conducted, but the objective is to bring down GHG emissions down to the same level as a gas turbine rather than aim for a GHG zero emissions level.
- Biomass co-combustion is becoming mandatory for coal fired power generation. Co-combustion will be started at 5%, with the co-combustion level to be increased to 20% ultimately.

- Currently, sliding pressure operations[747] is being implemented at thermal power generation plants.

Needs

- Transition to low carbon/decarbonization for coal fired power generation: Ammonia or hydrogen co-combustion, transition to gas combustion, introduction of CCUS or other such means are recognized as methods to facilitate transition to low carbon/decarbonization, but this is considered to be difficult when this involves refurbishment of facilities. The MoP can propose power station candidates for ammonia co-combustion demonstration projects.
- Biomass co-combustion: Collecting rice straw and using it for biomass co-combustion will help increase the income of farms, but support for biomass co-combustion has not been implemented at this point in time.
- Introduction of Automatic Generation Control (AGC): A goal has been set to achieve a minimum load ratio of 55% for thermal power generation, which will necessitate the introduction of AGC.
- Support for supply of bioenergy: An approach has been taken of converting residue (rice straw, etc.) generated by farms into pellets through the National Mission on Use of Biomass, and support is expected to achieve methods with higher cost effectiveness than the current approach.

Other Information

- Two or three projects can be implemented.
- Making the use of hydrogen mandatory for petroleum refining and other such operations is being discussed to popularize green hydrogen.

(2) Ministry of New & Renewable Energy (MNRE) (Conducted on January 25, 2022)

Current Status

- MNRE is in charge of formulating introduction plans for renewable energy.
- The share of renewable energy currently stands at 15%, with a goal of increasing this to 50% by 2030.
- The Indian government and the NITI Aayong are creating a roadmap to achieve energy self-sufficiency by 2050.
- The roadmap concerning the utilization of green hydrogen is being discussed within the government. Hydrogen is being used for fertilizer and at refineries on the demand side, and plans call for the implementation of a pilot project using hydrogen for the steel industry. The shipping industry is considering the use of hydrogen ammonia fuel. In addition, it is recognized that the capacity of industrial organizations in India needs to be strengthened.
- Electric buses have been introduced for short-distance travel in cities.

Needs

- Introduction of system interconnection and storage batteries: Robust system interconnection is required for the large-scale introduction of renewable energy, as well as the introduction of storage batteries and other facilities. In addition, the use of existing dams is an issue.
- Introduction of diverse renewable energy: Diversification of energy and the introduction of effective technology are needed in order to achieve energy self-sufficiency by 2050.
- Hydrogen introduction cost, development of production technology: The main issues consist of the cost for hydrogen introduction and the insufficient amount of natural gas for hydrogen production.
- Infrastructure development for introduction of fuel cell vehicles: There are plans to introduce fuel cell buses for long-distance travel, in historical tourist areas and other regions requiring adequate consideration of the ecosystem by 2025, and implement programs to educate citizens.

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747 During partial load operation when not at full power, lowering boiler pressure to enable efficient operation.

Other Information

- The production of blue hydrogen by using brown coal is being considered.
- Since railways consume a large amount of energy, a goal to achieve carbon neutrality in the railway sector by 2030 has been established.
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(3) Bureau of Energy Efficiency, Ministry of Power (BEE) (Conducted on December 9, 2021)

Current Status

- It appears that progress in achieving energy efficiency requirements is slow due to the fact that efforts succeed when implemented on a small scale, but not as much at a large scale because of difficulties with financing.
- Targets and benchmarks need to be set and the current status needs to be evaluated in order to facilitate the transition to low carbon/decarbonization, but the targets have not been clarified at this point in time.
- The number of coal-fired power stations needs to be reduced, but the cost during the process of shifting to another energy source from coal is an issue.

Needs

- Introduction of heat pumps: The utilization of heat pumps in the industrial sector is beneficial over the long term, but the investment climate is not prepared at this point in time for corporations.
- There is a high priority for the use of hydrogen, introduction of renewable energy, system interconnection, stabilization and other such measures.

Other Information

- Energy conservation is a problem that involves the transportation and various other sectors, but there is insufficient cooperation by the related agencies.
- Consideration is required on how to make the transition of existing modes of transportation to EVs.

(4) Ministry of Steel (Conducted on December 22, 2021)

Current Status

- There are plans to install solar panels at steel plants by 2025.
- The introduction of hydrogen reduction technology using blast furnaces is being considered.
- The need for the use of scrap and breakthroughs to transition to low carbon during the steel making process are recognized.
- When introducing CCUS, it is thought that work should start with small-scale demonstration projects.
- It is recognized that energy consumption needs to be reduced for steelmaking processes and the construction of new steel plants, and that promotion of energy conservation is needed. There are some steel plants that have introduced LED.

Needs

- Introduction of hydrogen co-combustion or ammonia co-combustion: The introduction of hydrogen co-combustion or ammonia co-combustion is being considered to reduce dependence on fossil fuels, and interest has been expressing in cooperation proposals.
- Introduction of energy efficiency technology: The Steel Authority of India Limited (SAIL) is considering the introduction of low carbon/decarbonization technology in order to achieve 50% energy conservation.
- Hydrogen use: There is a desire to introduce hydrogen use if there are success cases for a transition to low carbon/decarbonization.
- In addition, interest has been expressed in the introduction of DX technology, introduction of waste heat recovery/use technology, use of renewable energy, reduction of fossil fuel use by utilizing hydrogen and the use of CCUS.

Other Information

- Tata has announced a net zero plan achieved by introducing low carbon/decarbonization technology.
- JFE is utilizing recycled used plastic for steelmaking, and interest has been expressed based on the thought that this technology is very effective.

(5) Ministry of Road, Transport and Highways (MoRTH) (Conducted on January 5, 2022)

Current Status

- MoRTH has jurisdiction over technical regulations for motor vehicles (public transport agencies and personal vehicles). It is in charge of the technical safety of battery performance and other such areas, regulations concerning EV tax-qualified requirement procedures, and safety requirement definitions to prevent accidents by EVs and other such vehicles.
- MoRTH creates provisions for electric vehicle green license plates to promote the use of EVs, the priority use of expressways / general roads / parking lots, establishes a system to modify transport vehicle regulations to permit the use of EVs, and regulations to relax EV import restrictions.
- There are plans to install charging stations along green highways that are being constructed.
- Work is proceeding on creating vehicle disposal policies complying with the BS-IV standard, and regulations have been formulated concerning the construction of scrapping facilities. There is a plan to construct large-scale facilities for the scrapping of batteries for motorcycles/tricycles.
- Demonstration experiments are being conducted for hydrogen and CNG mixed fuel (18% hydrogen mixed) for public buses. MoRTH has requested manufacturers to produce flex fuel vehicles that can use fuels with diverse mixing ratios (ethanol / gasoline mixed fuel).

Needs

- EV infrastructure development: The high cost of batteries and charging, and the inadequacy of the charging infrastructure are recognized as the foremost issues.
- Electrification of public transport modes: The Indian government is aggressively pursuing the electrification of public transport modes.
- Standards / regulations concerning fuel cell vehicles: The Department of Delhi Transport Corporation is considering the use of hydrogen for fuel cells and with other methods, but the standards / regulations for high-pressure hydrogen tanks for fuel cell vehicles need to be revised. In addition, global standards / regulations need to be adopted in India.

Other Information

- A medium / long-term strategy for the popularization of EVs in the transportation sector as a whole has not been formulated at this point in time.
- The Automotive Research Association of India (ARAI), International Centre for Automotive Technology (ICAT), Global Automotive Research Centre (GARC) and other agencies are conducting battery performance tests under a wide variety of conditions.
- The Central Pollution Control Board under the umbrella of the Ministry of Environment, Forests and Climate Change is working on measures for EVs, battery disposal and reuse, and has formulated regulations concerning the purchasing of used batteries for motorcycles and tricycles.

(6) Ministry of Housing and Urban Affairs (MoHUA) (Conducted on January 27, 2022)

Current Status

- A wide variety of projects have been implemented in 100 cities under the “Smart city mission”. The plan called for implementation between 2015 and 2020, but this schedule was extended to June 2023. Approximately 40% of the “Smart city mission” budget was used in the urban transportation sector (electric buses, CNG buses, development of parking lots, development of railway networks, etc.).
- The MoHUA has established a number of initiatives. These include the “India Cycles4Change Challenge” initiative that supports activities to promote cycling in cities (started June 2020),

the "Streets for People Challenge" initiative that supports the development of pedestrian friendly streets in each city (started September 2020) and the "Transport for all" initiative that focuses on the promotion of public buses as the most popular and convenient mode of transportation in urban cities.

- States are working on the implementation of the "Smart city mission" in line with the Energy Conservation Building Code (ECBC) formulated by the Indian government.
- The installation of LEDs in each region has made progress under the "Smart city mission". There is a focus on the utilization of renewable energy and reduction of fossil fuel use, and construction of solar parks, installation of solar panels on roofs of state-owned buildings (government buildings, school buildings, etc.) and other such work are being implemented.
- In order to promote the approach to the development of smart cities at the regional level, a Climate Center was established under the National Institute of Urban Affairs (NIUA) in 2021.

<u>Needs</u>

- Financial support for smart city development: It is assumed that each city has spent almost all funds allocated for the Smart city mission and is currently exploring future fundraising options. Even small-scale cities that have not received fund assistance from the Smart city mission has support needs.

<u>Other Information</u>

- Since many solar photovoltaic power generation projects are not connected to the distribution network, cooperation with power companies when expanding renewable energy in cities is a serious issue.

(7) NTPC Limited. (Conducted on December 24, 2021)

<u>Current Status</u>

- Work has proceeded on introducing supercritical pressure units in order to improve the efficiency of existing thermal power stations.
- The life of equipment at coal fired power stations is an issue, but budgets for the early abolishment of facilities have been secured.

<u>Needs</u>

- Power system stabilization: The stabilization of systems will be the main challenge for the time being. After the introduction of renewable energy, stabilization of electrical grids that connect India with Bhutan and Bangladesh will be a challenge.
- Support for biofuel: The supply chain for biofuel is insufficient. The NTPC is striving to achieve a biomass combustion ratio of 5% or more, but there is the problem of the boiler temperature increasing when co-combustion is performed, which lowers the efficiency.
- Technical cooperation concerning power system flexibility and storage batteries: At this point in time, storage batteries have not been introduced, but there is a desire to introduce them in the future to store excess power generation and discharge this power when needed. It is expected that secondary ancillary services that use storage batteries will be required in order to respond to the introduction of renewable energy on a large scale.

<u>Other Information</u>

- Ammonia co-combustion and the utilization of green hydrogen are recognized as technologies that will be needed in the future.
- There are plans to start ammonia co-combustion at coal-fired power stations in two or three years. Surveys are currently underway in cooperation with other international organizations.

(8) The Energy and Resources Institute (TERI) (Conducted on November 30, 2021)

<u>Current Status</u>

- Industries that have a demand for hydrogen are spread in a wide area around mines, but since the price of land where power stations are located is low and facilities are installed where there is a high potential for renewable energy, the geographic distribution of supply and demand facilities is an issue.

- The Indian government is considering the introduction of regulations for the mandatory use of green hydrogen. This includes a goal of achieving 5 – 10% green hydrogen out of all hydrogen used in the industrial sector.
- At the Indian Institute of Technology Madras, a hydrogen storage system has been developed for motorcycles and tricycles, and a demonstration project are being conducted on the campus. In addition, Tata Motors is conducting a demonstration project for public buses that are equipped with fuel cells developed by the Indian Institute of Space Science (IIST).
- The Indian government has established a goal of the country becoming a global hydrogen production hub, and has announced that it will strive to become a major exporter of hydrogen in the short to long term. There are plans to implement advanced research on hydrogen in the future.
- The amount of CO_2 that can be stored in oil wells and gas wells in India is extremely limited, and the cost is high when the geological distribution is taken into consideration.

<u>Needs</u>

- Technical support / demonstration projects for hydrogen: Infrastructure development for the production of green hydrogen is a challenge. CCUS demonstration experiments are only being conducted by private sector companies. In addition, the hydrogen production, storage, transport and infrastructure technologies of Japan are highly evaluated, and it is expected that these technologies will be of service to India in the future.
- Use of hydrogen in steelmaking industry: New steelmaking processes using green hydrogen need to be adopted by steel plants in order to facilitate the transition to low carbon/decarbonization, but there are technical issues and investment issues. There is a high level of interest in the electrolysis equipment, hydrogen production, fuel cell and other such technology of Japan.
- Fuel cell production and electrolysis equipment research and development: R&D is being conducted on fuel cell production and electrolysis equipment, and there is interest in the technology of Japan. It is thought that research on materials for storage tanks will be needed in the future.

<u>Other Information</u>

- Hydrogen co-combustion and ammonia co-combustion in the power generation sector are not being considered. Since the cost of renewable energy is extremely low in India, the cost effectiveness of using hydrogen in the power generation sector decreases the higher the share of renewable energy in total energy consumption.
- The operating rate of coal fired power was 80% or higher in the past, but this has decreased to between 50% - 60% in recent years.

(9) Power System Operation Corporation Limited. (POSOCO) (Conducted on February 10, 2022)

<u>Current Status</u>

- POSOCO is a system management company with a national system and five regional systems and is involved with system interconnection of renewable energy.
- It has implemented pilot projects concerning interconnection of solar parks using AGC, as well as a wide range of other projects that include power dispatching management for existing power generation facilities.
- It has also implemented a pilot project that incorporates solar inverters to perform control during the night.

<u>Needs</u>

- Transfer of power storage and other technology: Currently, power storage is primarily performed at the power dispatching level, and the challenge being that there is limited technology to handle system-scale storage. Since *Tokyo* Electric Power Company (*TEPCO*), and other power companies in Japan own many water pumping power stations, there is a desire locally to learn this technology.
- Power system stabilization: An ambitious goal for renewable energy facilities of 500GW by 2030 has been established, but there is the issue of power system stabilization control after the

introduction of solar PV power generation. In addition, voltage and reactive power are deemed to be important to achieve the transition to decarbonization, and there is interest in learning the control methods.

- Power demand prediction: Demand estimates are an issue for rooftop solar installations. A capacity of 7GW has currently been installed nationally, but it is expected that installations will rapidly increase in the future, requiring demand estimates for rooftop solar panels to facilitate power dispatching, resulting in the desire to learn technology from Japan.
- Formation of standards for grid connections: Technical standards for grid connections are being studied in order to respond to system issues that occur when introducing renewable energy on a large scale. Ongoing studies on grid interconnection, including maintenance of inertia force and other problems, are recognized as being necessary, and the desire to learn the experience and technology of Japan has been expressed.

Other Information

- Power system operation within the state is under the jurisdiction of the power dispatching office installed in each state. Five regional power dispatching centers are situated above these, which manage the operation of systems that go across different states. Furthermore, there is the National Load Despatch Center (NLDC) which is above the regional power dispatching centers.

(10) Energy Efficiency Services Limited. (EESL)

Current Status

- The World Bank is working on a project for air conditioning system that targets new and existing buildings in cities and rural areas.
- The ADB is providing support to EESL for the introduction of high-efficiency air conditioning systems.
- It is hoped that pilot projects between JICA and EESL will proceed to the implementation stage.
- USAID is providing various types of ZEB support to facilitate the transition to Net ZEB in India. It has been a partner of EESL for many years.

Needs

- Financing for the introduction of ZEB for the private sector, technical support and other work: Blended financing, technical input, capacity-building, popularization of the ZEB concept, dissemination of ISO and other items are needed.

（2） Thailand

Online interview surveys targeting institutional stakeholders in Thailand were conducted between January and March 2022. The current status, needs and other related information obtained from the survey of each institution are described below.

(1) Department of Alternative Energy Development and Efficiency (DEDE) (Conducted on January 5 and March 3, 2022)

Current Status

- DEDE is in charge of renewal energy and energy efficiency. It formulated the “Energy Efficiency Plan 2018-2037”, has established a goal of reducing energy intensity by 30% in 2037 compared to 2010, but there is the possibility that the target value may be increased in the future.
- South Korea (government or companies) is implementing energy projects concerning biofuel and the supply chain.
- A solar photovoltaic power generation installation business has been implemented for houses. This business is striving to enable prosumers to freely access solar power generation. Work will proceed in the future on the use of solar photovoltaic power generation in PV trading systems, block chain, building and transportation.

- The Building Energy Code obligates new buildings (with a floor area of 2,000m^2 or more) to satisfy the code before building permits are issued (came into effect in 2020). However, this code is only the minimum standard that is needed.
- Research and development is being conducted on technology to boost energy efficiency in cooperation with universities. Academia is being requested to provide energy auditors for energy management programs and trainers for training programs in order to implement energy efficiency programs.
- Consideration of efforts to drive the use of hydrogen across many sectors in addition to the industrial sector has begun.
- Approximately 40 standards have been created for HEPS, and approximately 20 standards have been created for MEPS, and a 5-stage energy labeling scheme has been applied. The labeling scheme program is being implemented with the Electricity Generation Authority for *Thailand* (*EGAT*).
- An EV introduction program has been started with the objective of reducing dependence on fossil fuels. A 30@30 goal has been established, which has become an important pillar of policy for the transportation sector. There is the possibility that introduction goals may be further increased in the future.

<u>Needs</u>

- Provision of information on the introduction of EVs: An EV introduction program has been started to reduce dependence on fossil fuels. A desire was expressed to use Japan's commercial EV introduction targets, market forecasts, etc., as a reference.
- Support concerning storage battery introduction/disposal: The introduction and disposal of storage batteries for solar power plants is a challenge.
- Strengthening of capacity related to ZEB: There is interest in training on energy conservation. It is necessary to formulate Thailand's unique ZEB guidelines that meet international standards, and to implement ZEB support projects (demonstration projects and subsidized projects) for building owners and developers to promote the ZEB concept, and it is hoped that there will be support from Japan. In addition, there is a desire to exchange information with Japan.
- Regulations concerning heat pumps: Consideration is taking place on regulations concerning heat pumps. Currently, there are only low-temperature-compatible products in the country, but there is a need for high-temperature-compatible products for the industrial sector. There is also interest in high efficiency heat pumps.
- Transition to low carbon/decarbonization in industrial sector: Work needs to proceed on reducing the use of coal and fuel oil in the industrial sector, and to drive the transition to renewable energy and low carbon fuels. There is a desire to introduce ultra-high-performance electric boilers and as well as solutions and technologies to replace fossil fuel-based devices for electric furnaces.
- Industrial use of biofuels and promoting production of raw materials: Biofuel is being used in the transportation sector, but use in the transportation sector needs to be promoted in the future. In addition, agriculture needs to be pushed forward to produce raw materials in preparation for the increase in demand for biofuel.
- Preparation of energy transition plan: In addition to the preparation of an energy transition plan, low carbon/decarbonization goals need to be established for bio-jets and other such products.
- Development of technology for power system stabilization, introduction of smart grids and storage batteries: The stabilization of power systems that have an impact on the introduction of renewable energy on a large scale is a challenge, and the development of technology is needed. In addition, the introduction of smart grids and storage batteries is also needed. There is interest in the optimization of automated control.
- Effective MEPS and HEPS: In addition to household appliances for which the scheme is to be applied, consideration of new target devices that are introduced in the construction sector and industrial sector needs to proceed and standards need to be formulated. The ideal situation would be to have the market dominated by energy efficient devices through the more effective

promotion of MEPS and HEPS, and there is a desire to use the experience and knowledge of Japan as reference.

- Improvement of energy efficiency in transportation sector: In the same manner as the industrial sector, the transportation sector consumes a large volume of energy, and there are plans to promote electrification during the transition period. Consideration is taking place on introducing smart and other technologies for logistics in the transportation sector, promoting increased efficiency, training energy efficient drivers and implementing training programs. Technologies and software to manage logistics are also of interest as future initiatives.
- It is thought that the focal points will be the dispersion of energy supply sources, prosumers and energy storage.
- It will also be worthwhile to propose pilot activities for hydrogen co-combustion and ammonia co-combustion.

Other Information

- Movement in Thailand towards the use of hydrogen is still in the initial stage. EPPO started the preparation of a medium to long-term strategy for hydrogen last year, and is considering hydrogen production, its use for the industrial and transportation sectors, and for power generation and other applications. The use of hydrogen has just started, and there are no regulations. The decision has been made to prepare a hydrogen roadmap with the cooperation of METI, but it has not been completed.

(2) Office of Transport and Traffic Policy and Planning, Ministry of Transport (OTP, MoT) (Conducted on February 14, 2022)

Current Status

- There are multiple plans in the transportation sector, including the "Environmentally Sustainable Transport Master Plan", "20 Years Thailand Transport System Development Strategy", and the "ITS Master Plan", but the lack of detail is an issue.
- The MoT plans to formulate the "EV Development Plan (2022-2037)" by the end of 2022. Since the government has clarified that it intends to promote EVs, the MoT is creating a detailed plan to facilitate implementation. The fact that this effort will integrate the electrification of shipping and railways and other such work into a master plan for related facilities differs from plans up until this point in time.

(3) Banpu Public Company Limited. (Conducted on February 15, 2022)

Current Status

- The company has invested in Japan (176GW) and China (177GW) to promote green energy, and it has announced that it will invest in wind power generation and solar photovoltaic power generation (160GW) in Vietnam as well.
- In the fields of E mobility, solar photovoltaic power generation and other such fields, the company is considering the implementation of investment and cooperation projects in Japan and other countries.
- The company is mainly working on five themes: Renewable energy, batteries and energy storage, E mobility, smart cities and electricity transactions.

Needs

- Renewable energy: There is a desire to promote initiatives and the development of energy technology in the future. Investment in regional electrification is also being considered.
- Batteries / energy storage: An investment has been made in a company in Singapore that is producing batteries used in the transportation sector as part of the efforts to develop technology.
- E mobility digital platform: The building of a digital platform is being considered.
- Smart cities: Surveys on demand side energy consumption trends are being conducted in order to achieve a transition to high efficiency energy consumption. Collecting information using IoT is thought to be effective.

- Electricity transactions: Japan was one of the first countries in Asia to begin electricity transactions, and there is a desire to garner the experience and knowledge of Japan in electricity transactions. An investment has been made in a Japanese company (Global Engineering) for this purpose. Currently, electricity transactions are prohibited in Thailand, and there are no regulations or rules.
- Hydrogen co-combustion, ammonia co-combustion, CCUS: In order to make the transition to low carbon possible, it is thought that there should be a transition from coal to gas, and technologies such as co-combustion should be introduced, which is reflected in research on hydrogen, ammonia and CCUS.
- Demand side authentication scheme: A pilot project has been implemented, but work has not reached the level of introduction in the entire country.

Other Information

- When using IoT in order to obtain a grasp of energy consumption by people and trends in preparation for the building of a smart city, the cooperation of the Digital Economy Promotion Agency (DEPA) and related agencies is required.

(4) Electricity Generating Authority of Thailand (EGAT) (Conducted on February 17, 2022)

Current Status

- EGAT currently has plans for two pilot projects. One of these is the first EOR project in Thailand, and the other is an EGR project for a power station that has gas resources in the surrounding area.
- The partner companies for the EOR project and EGR project are currently under consideration, and there are plans in the future to evaluate cooperating companies.

Needs

- DR, VPP: A VPP draft model has been prepared, and there is a desire to learn from the experience of Japan in preparation for VPP implementation. There is a desire for information on technical problems, regulations and market models, as well as customer profitability and financial support models. Interest in the approach to DR has also been expressed.
- Renewable energy power generation output prediction: An output prediction model has already been introduced in some regions in Thailand, but a more accurate and suitable model is needed, and there is a desire to learn the technology from Japan.

(5) PTT Public Company Limited (PTT) (Conducted on February 17, 2022)

Current Status

- Natural gas is the main energy source, accounting for 70 percent of power generation. It is thought that it will continue to be the major source for power generation for the next 15 years, with the share gradually decreasing after then as the amount of renewable energy that is introduced increases. Natural gas resources are drying up in Thailand, necessitating an increase in LNG imports.
- PTT is conducting research and other work concerning batteries with private sector companies and other organizations in order to accumulate knowledge and knowhow.

Needs

- Renewable energy technology and investment: The main challenges concerning renewable energy consist of the technology and investment cost.
- Battery technology development: Batteries are recognized as a key technology for the effective use of renewable energy and EVs, necessitating the development of technology.
- Hydrogen related cooperation: Hydrogen is an alternative to fossil fuels, and is recognized as a technology that will be needed in the future. There is a desire to implement hydrogen demonstration projects in cooperation with Japan.

Other Information

- PTT is proceeding with research on CCUS in bay areas. (information from interview of EGAT).

(6) ESCO Association (Conducted on February 18, 2022)

Current Status

- Since electricity rates are kept at a low level in Thailand, it takes time to recover investments for ESCO projects. Companies would like to recover their investment within five years, but the payback period for many projects is five years or more. Work needs to be done to foster an image of the CO_2 payback period rather than a monetary payback period.
- The main energy efficiency techniques used by ESCO in plants consist of air compressors, energy management systems and voltage regulators. Lights, heat pumps for air conditioning and air conditioning systems (chillers) are used in buildings.
- ESCO projects are being implemented for buildings owned by central government agencies and local governments. When a project is implemented with a government budget, since payment cannot be made directly to ESCO, ESCO devices are purchased, and electricity rates are reduced or other measures are used to offset this amount.
- One problem with policies to promote energy conservation consists of an inability to facilitate cooperation between energy conservation and climate change measures which is caused by the differing of the agency that has jurisdiction over energy savings and climate change measures. It is thought that the implementation of an international protocol (IPMVP) concerning energy efficiency will enable the promotion of energy conservation in Thailand.
- There is a scheme called EERS (Energy Efficiency Resources Standard) in Thailand. This scheme requests electric power companies to provide support to customers to help reduce energy consumption. However, the government, EGAT and companies like PTT are the target of energy conservation policies.

Needs

- Regulations concerning ESCO: Since ESCO is implementing a private sector business model, there are not very many regulations that have been formulated at this point in time.
- Evaluation of energy efficiency projects, introduction of new technology (demonstration projects etc.): The implementation of energy conservation is not proceeding since it is not clear whether large scale energy efficiency projects are functioning or whether they can continue.
- Boosting efficiency of power consumption: Since the energy efficiency market is small at this point in time, there are no incentives to boost the efficiency of power consumption, and the ESCO Association is not working on the establishment of these measures.

Other Information

- ESCO can receive financial assistance from the government by proposing project details to the ENCON Fund (Energy Conservation Promotion Fund). The budget is funded by the government. In addition, the majority of financial resources come from contributions from the Petroleum Fund (Petroleum Fund).

(7) Energy Regulatory Commission (ERC) (Conducted on February 21, 2022)

Current Status

- The main issue is power transmission rather than power generation.
- There is no structure that allows users to select renewable energy sources.
- The pace of liberalization is slow, and no initiatives are being implemented to help new entrants.

Needs

- EV development and related regulations: Regulations, EV charging fees, payment locations, etc. need to be set for EV development, pricing, and EV promotion.
- Introduction of DR: There is interest in the status of DR implementation, payment methods and incentives in Japan.
- Renewable energy related regulations and other measures: There is interest in innovations to maintain the competitiveness of renewable energy, regulations concerning solar power generation, the introduction of batteries and other such measures.
- Liberalization and open access regulations: There is interest in the approach used in Japan for regulations to facilitate open access. In addition, rules need to be created for the popularization

of renewable energy and the stabilization of power to facilitate the liberalization of renewable energy. There is also a desire to consult on response methods and other measures for new entrants into the power sector.

- Technology is important, but it is recognized that work on regulations and related areas should have the maximum priority. There is a wish that persons from the authority in charge of regulations be dispatched or otherwise made available if possible.

(8) Electric Vehicle Association of Thailand (EVAT) (Conducted on February 24, 2022)

Current Status

- A goal of producing 225 000 EVs (passenger cars) by 2025 has been established. Furthermore, the goals have also been established of having 100% of passenger cars used be EVs, and raising the ratio of EVs produced to 50% of the total production volume.
- The government has formulated a policy to reduce the EV import tariffs in 2022 – 2023 with the objective of promoting EVs. In addition, importers must build a local EV production line by the year 2025.
- In addition to solar photovoltaic power generation for industry and housing, the reuse of EV batteries is also being considered. It is recognized that reuse should be considered, rather than the recycling of batteries.
- The Department of Land Transport and V2G are having discussions concerning safety, and there are plans to have discussions with automobile manufacturers from this point in time. It is expected that the government will implement a reduction in taxes and support schemes for automobile companies that implement V2G in the future.
- There are multiple companies that are involved in the EV charging infrastructure, which are called a "charging consortium" as a group. The largest company is Energy Absolute, and there are other electrical distribution companies such as PEA.

Needs

- Formulation of waste management plan for used EV batteries: The popularization of EVs is still in the initial stage, and since almost all of these vehicles are PHEVs, the reuse of EV batteries is not being considered. However, since the battery replacement period is about 10 years, consideration is needed in the future.
- System design and other measures for V2G technology development and commercialization: The number of EVs being currently used is not that high, but discussions need to be held on system design to facilitate V2G technology development and commercialization.
- Electrification by public transport agencies (pilot projects, etc.): Currently, only the taxis that connect airports with cities have been electrified, and is not the general rule. Old diesel buses are still being used in Thailand, and these need to be replaced with electric buses.

Other Information

- EVAT has a strong relationship with The Office of Industrial Economics (OIE) and the Ministry of Energy.
- EVAT is coordinating closely with the Department of Land Transport concerning the support and safety of land transport.
- Supattanapong Punmeechaow, Deputy Prime Minister and Minister of Energy, is deeply involved in expanding the popularization of EVs, and the Excise Department is strongly involved in the overall support scheme. The Excise Department is cooperating to facilitate discussions with private sector companies on the support scheme concerning OEM and other items.
- EVAT is closely cooperating on various input at the initial stage of support scheme consideration in order to create a National Electric Vehicle Policy Committee (NEVPC). In addition, it has a proactive approach to promoting EVs with Mercedes-Benz, BMW, Japanese and other carmakers.

(9) Thai Bankers' Association (TBA) (Conducted on February 28, 2022)

Current Status

- There is a recognition that it is necessary to phase out coal-fired power stations within 10 years. The GHG emissions by each industry and the risks faced by users need to be evaluated and the required countermeasures prepared.
- Efforts are being made to reduce dependence on coal-fired thermal power to zero by 2030, and the discontinuation of financing for new coal-fired power plants is being considered.
- The introduction of renewable energy is proceeding as a result of the many returns that can be obtained because of the incentives for the introduction of renewable energy in recent years.
- Pilot initiatives toward smart industrial parks are proceeding in Thailand.
- A taxonomy system has not yet been established in Thailand.
- The government of Thailand is attempting to reduce coal-fired power generation in order to achieve an energy transition. LNG will be used in the transportation sector in the future.
- Discussions on Power Development are proceeding in Thailand in preparation for the energy transition, and talks are being held concerning the 2022 New Power Plant Construction Project. The Ministry of Energy deems that the setting of an optimum energy mix is necessary.
- At this point in time, there is a focus on the grid, but information on the introduction cost, effects and other details associated with the introduction of CCUS for gas-fired power stations is needed.

Needs

- Transition to low carbon/decarbonization in heavy industry sector: Financing is particularly needed in the heavy industry and other such sectors in order to promote more green activities and projects, and the association wants to receive subsidies and financial support from JICA and other agencies to facilitate the transition of the industry to low carbon/decarbonization. Since some companies and institutions want to achieve sustainability at a low cost and the transition to low carbon/ decarbonization, there should be the possibility of cooperation being implemented between TBA and the Japanese government for projects targeting these companies and institutions.
- Formulation of taxonomy, development of financial products for climate change adaptation measures/ mitigation measures: Financial products (green bonds, sustainability bonds, sustainability linked loans, etc.) are needed in Thailand that can be used for climate change adaptation measures and mitigation measures.
- Introduction of CCUS: The technology and cost are challenges for the introduction of CCUS, but introduction needs to be promoted by providing relevant stakeholders with knowledge on how to install CCUS in existing facilities.
- There is a desire to receive support for the introduction of new technology to facilitate the heavy industry low carbon transition.
- Hydrogen co-combustion: The government of Thailand has the intention to reduce the number of gas-fired power plants and proceed with an energy transition in the future. In addition, financing is possible for hydrogen co-combustion if the technology has an established track record.
- Knowledge sharing and capacity building among stakeholders are needed to avoid risks.

(10) Ministry of Industry (MoI) (Conducted on March 1, 2022)

Current Status

- There are cases in which storage batteries for solar photovoltaic power generation are installed on industrial sites. Plants can generate electricity, but permits are required for charging.
- There is a perception that EVs are not suited to heavy equipment such as forklifts. However, EVs are being used at the U-Tapao International Airport. In addition, pilot projects are being implemented for the transition of trucks for the transport of ore at mines from ICE vehicles to EVs.

Needs

- Transition of heavy equipment used for construction and other such work to low carbon, introduction of hydrogen vehicle technology: It is thought that hydrogen energy (fuel cell technology) is suited to heavy equipment and vehicles, including construction related equipment. There is a desire to learn about any other new technology.
- Recycling / reuse of used batteries: Since it is expected that there will be a rapid popularization of battery packs in the same manner as for electric vehicles, the recycling and reuse of used batteries needs to be considered. There is a desire to ask Japan for support with battery testing and management methods. Secondary use of batteries installed in vehicles as an Inverter Energy System (IES) to power homes and plants would be good, but a survey of whether or not EV battery modules that have already been sold can be used as an IES first needs to be conducted.

Other Information

- The Office of Industrial Economics (OIE) under the Ministry of Industry handles matters related to the installation of storage batteries in plants.
- Discussions among stakeholders related to the power supply have not been held concerning V2G (Vehicle to Grid). The only imported vehicle that can provide a V2G system is the Toyota Prius, but it does not conform to the power system in Thailand

(3) Morocco

Online interview surveys targeting related agencies in Morocco were conducted between March and April 2022. The current status, needs and other related information obtained from the survey of each institution are described below.

(1) Moroccan Agency for Sustainable Energy (MASEN) (Conducted on March 11, 2022)

Current Status

- Since a volume of energy that exceeds demand can be produced in Morocco, there are plans to export renewable energy to the southern part of Europe and western part of Africa. A roadmap for sustainable power transactions (Sustainable Electricity Trade: SET) was formulated together with four countries in Europe (France, Germany, Portugal and Spain) in 2016, and a joint declaration was announced.
- A main issue concerning the promotion of renewable energy consists of a stable supply. Another issue consists of the balance of the desire to promote investments by private sector companies with investments by public institutions. It is recognized that a balance needs to be achieved between the transition speed, investments and revenue.
- When producing energy, it is necessary to create added value in Morocco, such as job creation, domestic production rate (local content), etc. A blade production plant was built in Tangier with the goal of producing sixty percent of the parts for wind turbines domestically, and efforts are being made to achieve the domestic production of the towers for wind turbines. The domestic production ratio of components for solar photovoltaic power generation is only 30 percent.
- MASEN has built a research and development pilot platform in Ouarzazate, and an experimental research center for the production, storage and use of energy in Ben Guerir.
- Since there is high potential for renewable energy in Morocco, it is expected that the country will be able to produce inexpensive green hydrogen in the future along with Chile and Australia. This is particularly effective for countries in which a carbon tax is imposed. Surveys are currently being conducted on the impact that investments in infrastructure facilities will have on the price of hydrogen.
- MASEN and ACWA Power (Saudi Arabian company) are in the process of jointly implementing a CSP thermal energy storage project. MASEN is the guarantor for the country, and loans have been received from the World Bank, KfW, African Bank and EIB.
- Research and development is being conducted on fuel cells. Technology for the storage of hydrogen in underground spaces is still under development.

- Germany has made a plan to produce and import 100MW of green hydrogen in Morocco, and KfW is providing funds to Morocco for technological and economic surveys.
- Since the price of fuel cell vehicles is high, a roadmap for the use of hydrogen in the transportation sector has not been prepared. It is expected that ammonia fuel ships will be introduced for the shipping sector.
- In order to facilitate public-private partnerships in technological development and capacity building concerning hydrogen and solar power, GreenH2 Maroc which is a hydrogen platform and Cluster Solaire which is a solar power platform have been established.

Needs

- Production of green hydrogen: The current issues consist of the lack of data on the production of green hydrogen required to evaluate project risk, the fact that the domestic equipment manufacturers do not produce the needed machinery, the fact that long-term energy procurement that takes into consideration competition between green hydrogen and gray hydrogen as well as carbon tax and other tax systems is required in addition to long-term hydrogen sales contracts, the lack of infrastructure for energy storage and transportation, and insufficient investment by the private sector in the production/export of green hydrogen.
- Support for export of green hydrogen: Dakhla Atlantic Port is currently being constructed for exports to the United States, South Korea and Japan. Since Japan is also planning to focus on green energy, including hydrogen, it is hoped that there will be cooperation from Japan.
- Transport / storage / use of energy: It is hoped that technical cooperation will be received from JICA. Sumitomo Electric Industries, Ltd. has conducted a 1MW CPV experiment at the research and development demonstration test site in Ouarzazate. In addition, Sumitomo Electric Industries, Ltd. is also cooperating with a pilot project for redox flow batteries.

Other Information

- The sudden rise in the prices of resources was used as an opportunity to draw up laws concerning renewable energy (Bill No. 5816, Bill No. 1309), and the introduction of renewable energy was started in 2009.
- Desalinated seawater is used for the production of green hydrogen, but there is not enough water for daily life and agriculture in Morocco. As of March 2022, the largest desalination plant in Africa is under construction in Agadir.
- Due to the status of economic interchange, it is expected that the main export destinations for green hydrogen and green ammonia will be nations in Europe which are geographically close. Currently, green hydrogen is recognized as an export product.
- IFMEREE was established as an education institution for engineers in order to promote research and development. The education facilities at Ouarzazate, Tangier and Oujda can each accept 1000 students to be educated as engineers.

(2) Société d'investissement énergétique (SIE: Energy investment company) (Conducted on March 15, 2022)

Current Status

- SIE is a public corporation that provides energy services in Morocco. It is the agency which performs practical operation for national projects in cooperation with ministries and agencies, serves the role of driving the domestic market to boost energy efficiency, and conducts activities as a facilitator for the public and private sectors. In addition, it performs auditing, preparation and implementation of energy performance projects, as well as measurement and monitoring services during contract periods.
- When private sector companies implement energy efficiency projects, either through BtoB contracts or raising funds, SIE is remunerated by providing technical assistance, financing solutions, and other information to the companies. It is not in charge of financing.
- SIE is focused on boosting energy efficiency at public facilities, for public lighting, decarbonizing industry and clean mobility (reducing consumption of fossil fuels).
- At COP26, the Ministry of Energy Transition and Sustainable Development relaunched the “National Energy Strategy” which has a goal of reducing energy consumption by 20% by 2030.

SIE has introduced a national MRV (Measurement, Reporting and Verification) system in order to achieve this reduction goal.

- SIE has established a goal of balancing the budget in the energy efficiency field by 2026.
- Due to the fact that domestic energy conditions are impacted by the rapid increase in the cost of coal and petroleum, the SIE plans to give priority to the support of efforts to boost energy efficiency with the cooperation of the electricity section of the National Office of Electricity and Drinking Water (Office National de l'Electricité et de l'Eau: ONEE).
- SIE implements short-term, medium-term and long-term energy efficiency projects. Projects being implemented include energy conservation for public lighting in Marrakesh city urban area, energy rate optimization, and an energy improvement in the social sector in the RSK region. It has been demonstrated with these projects that support is needed to facilitate a reduction in power consumption by small to medium sized companies.
- The implementation of an equipment supply program (e.g. support for introduction of LEDs) for ordinary citizens with the cooperation of the ONEE is being considered.
- The SIE conducts training on energy conservation and energy management for the staff at partner ministries and agencies. In addition, it is conducting an education campaign in the short term together with the Ministry of Energy Transition and Sustainable Development. For example, the Friday worship channel is being utilized in the framework of the "Green Mosques" program in an effort to raise awareness of the general public concerning the savings of energy with a goal of improving energy performance at 5 000 Mosques in 2022.
- Work is proceeding to enhance the efficiency of energy use in the industrial sector, transportation sector and urban development sector. Projects are being conducted in the urban development sector to enhance the energy efficiency of lighting. The SIE is working to build the capacity to propose manual-based energy efficiency measure packages for each industrial sector.
- Protective measures are being prepared for the rapid increase in the price of raw materials to enable the kWh unit price of power supplied to be stably maintained at a low level.
- There are various standards to enhance the energy efficiency of buildings, including standards for the heat insulation effects, standards concerning hot water supply and standards related to electrical systems. Regarding air conditioning, there are standards for the external portion of buildings (for facilities, structures, etc.) to retain heat, and standards concerning the devices that actually consume energy.
- SIE is concluding contracts to boost energy efficiency and provide services to international companies and domestic companies. There is a focus on the expansion of markets and the opening up of international markets.
- Support is being implemented for the conversion of plastic into fuel, the development of low fluorine concentration fuel utilizing garbage that contains carbon and other such efforts in order to enable public transportation services to achieve clean mobility.
- Heat pumps are being used to supply 5GW of hot water to mosques in Casablanca, as well as for the supply of 12 000m^3 hot water at hammams (public baths). Solar water heaters have become common for the supply of hot water in private houses.

<u>Needs</u>

- Creation of laws and pilot projects concerning clean mobility: Demonstration projects for electric buses are being conducted in Marrakesh, chief city of central Morocco, but due to the fact that the transportation infrastructure for electric vehicles is inadequate, the Ministry of Energy Transition and Sustainable Development is proceeding with the creation of laws. Pilot projects first need to be implemented at the community level in order to identify challenges concerning infrastructure and users.
- Financial support for energy efficiency investments by small to medium sized companies: ESCO projects are mainly being conducted for small to medium sized companies, but these companies are experiencing difficulty with financing due to the rapid increase in the price of raw materials and the economic impact of the new coronavirus pandemic. In this regard, the

government is responsible for providing support for financing and measures to boost energy efficiency.
- Popularization of heat pumps in industrial sector: SIE is considering promoting the use of heat pumps in the industrial sector. SIE has the desire to implement methods to supply heat to multiple clients with one heat pump and enhance the efficiency of hot water supply by installing a heat pump with solar panels.
- Energy conservation for air conditioning: Energy efficiency measures during the summer when the demand for air conditioning increases and facility investments are challenges. In addition, energy efficiency technology for cold air production and electric motors need to be developed.

<u>Other Information</u>

- The Ministry of Industry and Trade is in charge of boosting the energy efficiency of shopping centers, factories and bay areas, and the Ministry of National Territory Planning, Land Planning, Housing and City Policy is in charge of establishing standards and criteria for increasing the energy efficiency of new housing when it is constructed.
- A survey on Morocco Energy efficiency Standards (for measurement, checking and other work) is being jointly implemented with funding from the United Kingdom. In addition, cooperation is taking place with insurance companies to establish a structure (Performance Bond) to make it easier for companies to receive financing which are involved in boosting energy efficiency.
- Technological exchange is being conducted with Germany, France, Italy, Spain, Israel and the United States.

(3) Research Institute for Solar Energy and New Energies (IRESEN) (Conducted on March 16, 2022)

<u>Current Status</u>

- IRESEN is conducting activities thanks to investments by the Ministry of Energy Transition and Sustainable Development as well as by multiple organizations/companies in the public and private sectors. These mainly consist of activities to promote cooperation between universities and companies, and funding support for research and development by universities and companies.
- A variety of activities are being conducted as part of the approach to research & development and innovation, including advice to ministries and agencies, support for regional strategies, cooperation with the industrial world, and support for educational research.
- Demonstration projects are being implemented for green energy parks (solar power, solar heat, electricity/heat energy storage), green & smart building parks (building materials, mobility, micro grids), green energy parks (green hydrogen, ammonia), green H2A (research and development/ decision making support, technology transfer) and in other areas.
- Research and development projects are being implemented for lightweight E-mobility, direct use of solar heat for industry, validation of new construction materials, chemical storage of electricity, research and development grid energy parks (Cote d'Ivoire) and other such areas.
- The challenge of green hydrogen production is recognized as an integral part of the strategy to increase the production volume of various types of renewable energy. First, it is necessary that green hydrogen be produced in a stable and efficient manner on a small scale, with the production volume increased subsequently.
- Contracts for three projects were concluded with Germany in 2020. The first one was a pilot project for the production of green hydrogen etc., the second was a joint survey project with MASEN, and the third was a project supporting the creation of laws. Furthermore, scientific research is proceeding on 50 – 100MW green ammonia projects and scale expansion.
- There is still not a focus on CCS/CCU and green hydrogen transportation in Morocco, but IRESEN thinks that it is necessary to consider these areas in the future.
- Teams of experts from Mohammed VI Polytechnic University and other educational institutions have been formed and are currently proceeding with research concerning batteries. In addition, the Managem mining company is providing recycling units. Furthermore, there are plans to conduct agenda surveys at the laboratory that is under construction in the green park.

Plans call for the reuse of batteries to be considered first, followed by consideration concerning the recycling of batteries.

<u>Needs</u>

- Cooperation on promotion of E-mobility: There is a desire to focus efforts on reinforcing the electrical system since the power system infrastructure is not adequately developed. The construction of stations that combine rapid charging and normal charging is being considered. In addition, under the current legal system, only companies that have a special license are allowed to sell electricity, and it is illegal to operate charging stations.
- Production and recycling of batteries: Morocco produces 200 000 automobiles per year, but it does not have the knowhow to produce batteries. It would be possible to reduce the price of EVs by building a battery plant in the country in partnership with Japan, to produce batteries. In addition, since the country does not have recycling technology, industrial development can be facilitated through cooperation.

(4) Agence Marocaine pour l'Efficacité Energétique (AMEE: Moroccan Agency for Energy Efficiency) (Conducted on March 23, 2022)

<u>Current Status</u>

- The following policies are currently being implemented in Morocco under its National Energy Strategy.
    - ➢ Establish structure to quickly recover costs (reduce taxes) when investments are made in high efficiency energy facilities.
    - ➢ Provide support for new pilot projects.
    - ➢ Transition to gas as fuel. Since butane and heavy fuel oil which are the main sources of energy in Morocco have a high level of CO_2 emissions, it is necessary to promote modification of the fuel infrastructure in order to reduce energy consumption and the cost.
    - ➢ The government conducts audits under the energy consumption volume disclosure obligation for operators of facilities when annual consumption exceeds 15 000 tons (heavy oil equivalent), but the necessity of the audit could be avoided if ISO50001 certification is obtained.
    - ➢ Promote research concerning energy efficiency.
    - ➢ Set minimum energy efficiency values (minimum energy performance standard). Currently, there are only standards for transformers, motors, refrigerators, air conditioners and lights, and there are cases in which products cannot be imported if they do not satisfy the standard.
    - ➢ Other efforts in addition to the above are being made, including the optimization of industrial facilities and industrial processes, energy efficiency measures for facilities other than those used for production, and energy efficiency education.
- Since there are large temperature differences in the country between the desert, mountains and other regions, the energy conservation standard for buildings differs depending upon the region. And while there are standards for energy conservation when buildings are constructed, laws concerning the introduction of labeling to further privilege higher efficiency buildings have yet to be put into force.
- Butane is the main energy source in Morocco for heating and the supply of hot water. Butane is the most popular energy source because there are subsidies for its use and it is the easiest to transport.
- Energy consumption by buildings in Morocco accounts for 33% of final energy consumption, making it a demand sector with the second highest energy consumption. It is expected that an energy conservation of approximately 1.1% can be made in the field of buildings and public lighting.
- AMEE has formulated MEPS (Minimal Energy Performance) which is a performance standard for the construction field and four types of energy devices (transformers, air conditioners, refrigerators, motors) with the receipt of support from the European Bank for Reconstruction and Development (EBRD). In addition, the "Eco-Binayate" energy performance label for

buildings was developed. These labels were developed to create an environment that facilitates investment by foreign companies etc. Currently, public institutions are verifying laws concerning the energy performance of appliances and devices sold in the country and energy labeling.

- The dissemination rate of household heat pumps is low due to the high initial investment. There is the possibility these products can be introduced in the industrial sector because of the expected return. However, in addition to the fact that the usage rate of fossil fuels is high in the industrial sector, since there are no heat pump production facilities in Morocco, this would be an area in which import subsidies would be applied, presenting the concern that high income households alone would be the target of this subsidy.
- AMEE is jointly working with the Ministry of Energy Transition and Sustainable Development to train Energy Managers and Energy Auditors. A training center has been established, and training on energy conservation is being conducted for workers in the construction, industrial, transportation, agriculture and other fields. Training related to energy auditing is conducted by private sector organizations that can obtain ISO50001 or other certification. The program content concerning energy management that is provided by AMEE includes solar photovoltaic power generation and insulation of buildings to save energy. The World Bank and other investment related agencies serve as partners to conduct this work.
- The transportation sector accounts for 40% of energy consumption. Fuel consumption standards have not currently been set, but work is proceeding on the design of a labeling system for tires. Energy efficiency auditing assistance and eco-driving training are being implemented at taxi and other such companies. In addition, car sharing apps are being created for state agencies, and demonstration experiments are be conducted, such as one in which 100 charging stations for electric vehicles are being installed.
- Low priced diesel vehicles are popular in Morocco, with hybrid vehicles being treated as luxury cars.

<u>Needs</u>

- Energy efficiency for air conditioning: The penetration ratio of air conditioners is approximately 10%, and it is expected that the number of new buildings will increase, but energy efficiency measures are needed since it is expected that the penetration ratio of air conditioners will be 40% in 2030.
- Establishment of MEPS: There are only labels for four types of devices at this point in time, but there are movements towards expansion to other devices, and a need for cooperation. In addition, AMEE needs an additional budget from the government to implement energy conservation activities, and the fact that a judgment must be made on whether or not labeling is adopted for real estate developers from various countries is recognized as an issue.
- Establishment of MEPS monitoring system: The Ministry of Energy Transition and Sustainable Development is preparing laws related to MEPS monitoring, but since there is not an agency that specializes in monitoring, there is the possibility that a request may be made for the cooperation of Japan to establish this type of agency. The Ministry of Industry and Trade, which already has a dedicated department, will be in charge of checking the facilities and equipment.

(5) National Office of Electricity and Drinking Water (ONEE) (Conducted on April 15, 2022)

<u>Current Status</u>

- The current share of renewable energy in Morocco is approximately 40%, but there is a goal of increasing this to at least 52% by 2030.
- Last year, the government of Morocco announced a halt to construction of new coal-fired power plants. Plans call for the coal-fired power plant that was newly built in 2018 to be operated until 2045.
- Inexpensive coal-fired power plants handle approximately 70% of energy consumption as the base load, and are recognized as being important for the stable supply of power. The introduction of renewable energy at a national level for the power supply sector and

transportation sector is being considered, and plans are being formulated for the storage of power.

- Two lines are connected between Morocco and Spain, with a power transmission capacity of 700MW. The direction interconnection of a third line with Spain and Portugal is under consideration.
- It is thought that progress on the introduction of renewable energy in Europe will enable the stability of the system in Morocco to be maintained.
- There is an energy storage capacity of 7 hours for solar photovoltaic power generation by MASEN. In the past, renewable energy generation has never exceeded electricity demand. It is possible for the abundant volume of renewable energy to be utilized to produce green hydrogen.
- The power companies can sell electricity in the extra-high voltage system (400kV / 225kV) to ONEE. Furthermore, a bill has been passed to expand to a medium voltage system, but measures have been implemented to prevent reverse flow to the high voltage side through the regional substation facilities.
- ONEE had a monopoly on the operation of power generation facilities until 1996, but IPPs have increased since with the liberalization of the power generation sector.
- Long-term power purchase agreements with IPPs do not contain requests concerning the transition to low carbon/decarbonization such as output limits or ammonia co-combustion, and making additional requests at the current point in time is difficult.

Needs

- Cooperation concerning offshore pumped power generation: There is interest in offshore pumped power generation, a field in which Japan has experience
- Preparation of thermal power generation roadmap in preparation for net zero goal: ONEE currently has coal-fired power plants at Mohammedia, Kénitra and Jerada. These plants are old, but they continue to be operated in order to respond to peak demand periods. In addition, there are also gas-fired power plants. Consequently, there is a need to prepare a roadmap for these thermal power plants. New technologies can be verified at ONEE facilities.
- Introduction of new technology such as hydrogen co-combustion/dedicated combustion: Currently, operation has been suspended for two units at gas-fired power plants in the country, and the use of alternative fuels to restart operation is being considered. In addition, the cooperation of Japan is needed in order to conduct a study about stable operation of thermal power plants in the future.
- Ammonia co-combustion: Due to the rapid increase in the price of fuel, it is recognized that there needs to be a transition from coal to a different energy source over the long term. There are hopes that workshops will be held in order to share the technology and experience of Japan concerning ammonia co-combustion.

(4) Indonesia

An online interview survey was conducted with the World Bank in Indonesia in July, 2022. On the day of the visit, an environmental specialist from the World Bank participated in the interview, explaining the status of target setting by the Indonesian government and introducing the projects being implemented by the World Bank.

(1) World Bank, Indonesia (conducted on July 21, 2022)

Current Situation

- Indonesia has set NDC targets, and has also set various targets within the government, such as aiming for negative emissions in the forestry sector by 2030.

Projects being implemented by the World Bank

- An analytical study on the relationship between climate change and economic growth is being conducted and is scheduled to be completed in September.

- A survey of donor cooperation by ministry is being conducted. This is a survey to enable the Ministry of Finance to understand the projects that each ministry and agency is implementing with support, the amount of money involved, and the need for additional grants.
- The Ministry is supporting emissions trading (ETS) at coal-fired power plants through a grant called Partnership for Market Implementation to promote the introduction of carbon pricing in the energy sector and to develop infrastructure.

3.2.2 Cooperation Program Drafting

(1) India

Based on the analysis of the current situation in the field survey target countries and the field survey, proposals were made to the MOP on the following four cooperation proposals,

Proposal #1 Grid Stabilization Measures for Mass Introduction of VRE

1. Upgrading of grid operation
   (a) Controller and software modification for flexible operation of existing coal-fired power generation
   (b) Capacity building for grid operation (T/C)
      i) Transfer of capabilities/services for forecasting of weather and VRE outputs
      ii) Technical cooperation to operate VQC and AGC referred to in (a).
   (c) Capacity building for grid operation rules and regulations<To be confirmed if there is a need on the Indian side>
2. Introduction of AGC and VQC systems (LOAN)
3. Expansion of the use of BESS
   (a) Technical cooperation for Expansion of the use of BESS
   (b) Financial assistance for Expansion of the use of BESS

Proposal #2 Optimization of Power Distribution System Operation to Achieve Carbon Neutrality

1. Technical cooperation concerning system flexibility, relevant regulations, DR and VPP
   (a) Development of regulations (technical assistance)
   (b) Training concerning DR/VPP and grid codes (invitation program)
   (c) Pilot projects for DR and EMS
2. Financing smart meter installation (yen loan)
3. Financing DAS and MCMD installation (yen loan)

Proposal #3 Introducing Heat Pumps in the Industrial Sector

1. Technical cooperation to promote the introduction of industrial heat pumps
   (a) Develop a roadmap for the promotion of industrial heat pumps, and organize necessary policies and regulations
   (b) Capacity building of the Indian authorities for necessary policies and regulations (through seminars, expert dispatching, etc.)
2. Financial assistance to promote investment to industrial heat pumps

Proposal #4 Introducing ZEB

1. Capacity building on understanding the ZEB concept to policy makers, Indian companies, and financial institutions; introduction of Japanese case studies (technical cooperation)
2. Financial assistance for companies introducing ZEB

- **Proposed Cooperation Program #1 Grid Stabilization Measures for Mass Introduction of VRE**

Program Objective

With the aim of promoting the introduction of VRE, technical cooperation will be provided for the stabilization of the power system under the mass introduction of VRE, including the enhancement of output regulation capability for existing coal-fired generation and the expansion of the use of BESS .

Component Projects

1. Upgrading of grid operation
   (a) Controller and software modification for flexible operation of existing coal-fired power generation
   (b) Capacity building for grid operation (T/C)
      i) Transfer of capabilities/services for forecasting of weather and VRE outputs
      ii) Technical cooperation to operate VQC and AGC referred to in (a).
   (c) Capacity building for grid operation rules and regulations<To be confirmed if there is a need on the Indian side>

2. Introduction of AGC and VQC systems (LOAN)

3. Expansion of the use of BESS
   (a) Technical cooperation for Expansion of the use of BESS
   (b) Financial assistance for Expansion of the use of BESS

Table 232 Upgrading of grid operation

Background	One of the grid stabilization measures to be taken in conjunction with the mass introduction of VRE is to strengthen the frequency control capability of coal-fired power plants. Along with the expansion of the minimum output of coal-fired generating units, the employment of AGC system equipped with the economic load dispatch (marginal cost dispatch) function will be a key measure for the efficient operation of fossil power plants. It will also be important to take measures to suppress voltage fluctuations caused by fluctuations in power flow on the transmission network and to enhance the automatic voltage control capability using VQC systems from the perspective of improving the reliability of the power system. When large amounts of VRE are integrated with the grid, changes in weather will have a greater impact on the stability of the grid. Forecasting of VRE outputs in accordance with weather forecasts will be necessary for as a power system stabilization measure. In addition, there will be a risk of large fluctuations in power flow and overloading on the interstate transmission lines due to the factors such as geographical dispersion of VRE resources, which could impede the stable power system operation. In addition, depending on the progress of the electricity market development, congestion management may be necessary. To address these issues, it is necessary to develop proper VRE grid connection requirements and rules for congestion management of interconnections, etc.
Contents	(a) In order to introduce AGC and VQC system, thermal power generators (e.g., NTPC) to retrofit controllers and programs to reduce the minimum generator output from 55% to 30% of the current output and to increase the ramp rate from 1%/min to 3%/min. (b) i) Since the output of VRE fluctuates significantly depending on weather conditions, precise weather and VRE output forecasting and generation planning based on such data are necessary to expand the installed capacity of renewable energy resources while maintaining the grid stability. A meteorological service company that has highly-accurate weather

	forecasting technology and is expanding its business overseas and a Japanese electric power company (system operation division) that procures weather forecasts from such a company and uses it for system operation, will jointly be able to assist the load dispatch centres in India with more accurate forecasting of weather and VRE outputs. In this Project, the possibility of such the collaboration among the load dispatch centres in India and Japanese entities will be examined. (It is necessary to check the regulations and business development constraints for providing weather data in India beforehand.) ii) Provide technical cooperation on how to operate the equipment and software installed in a). (c) * *To be confirmed if there is a need on the Indian side* Review of the existing VRE grid connection requirements and the congestion management rules, Proposals for the modifications for those will be conducted.
Expected Impacts	Contribute to achieving the VRE installation target while ensuring the grid stability and efficient operation of the power transmission sector (grid operation).
Target State(s)s	TBD
Counterparts (C/P)	(a) ・ Thermal power generators (e.g., NTPC) (b) i) Renewable Energy Management Center: REMC ii)TBD (c) TBD（To be checked if there is a need on the Indian side）
Expert Composition	(a) ・ Thermal power generators expert (b) ・ Meteorological forecasting service organizations such as meteorological associations, experts in supply and demand operation systems of medium feeders (c) ・ Experts in grid interconnection and interconnection line operation rules of OCTTOs and electric utilities
Implementation period (approx. duration)	From FY2023 onward (1 to 2years)

Table 233 Introduction of AGC and VQC systems (LOAN)

Background	One of the grid stabilization measures to be taken in conjunction with the mass introduction of VRE is to strengthen the frequency control capability of coal-fired power plants. Along with the expansion of the minimum output of coal-fired generating units, the employment of AGC system equipped with the economic load dispatch (marginal cost dispatch) function will be a key measure for the efficient operation of fossil power plants. It will also be important to take measures to suppress voltage fluctuations caused by fluctuations in power flow on the

	transmission network and to enhance the automatic voltage control capability using VQC systems from the perspective of improving the reliability of the power system.
Contents	In order for assist the National Load Dispatch Centre (NLDC), the Regional Load Dispatch Centres (RLDC) and the State Load Dispatch Centres (SLDC)with the introduction of VGC and AGC (LFC & EDC), the following tasks will be conducted: - Cost estimation and financial and economic analysis; - Examination of appropriate financing means; and - Funding under the JICA's instruments (assuming yen loans).
Expected Impacts	Contribute to achieving the VRE installation target while ensuring the grid stability and efficient operation of the power transmission sector (grid operation).
Target State(s)s	TBD
Counterparts (C/P)	・ MOP ・ AGC: POSOCO（NLDC、RLDC or SLDC） ・ VQC: RLDC or SLDC
Expert Composition	・ AGC: Expert in supply and demand systems ・ VQC: Grid Control System Expert ・ Economic and financial expert
Implementation period (approx. duration)	From FY2023 onward (3 to 5 years)

Table 234 Expansion of the use of BESS

Background	In India, the awareness of the business model and the energy (electricity) storage technologies (mainly BESS) is expanding, and in the state of Rajasthan, a tender for 1 GWh of BESS has already been held. In addition, the Government of India is in the process of developing an ancillary services market. However, the BESS business is still at its early stage, and there can be institutional and financial issues to be addressed for sustaining its viability. In this project, JICA will identify those issues and examine financing measures including the blended financing for the BESS business, and finance the introduction of grid-scale BESS.
Contents	(a)Review of the ancillary services market rules ・ Review of regulations and policies associated with energy storage in Target State(s)s, and technical cooperation for regulatory development as needed ・ Examination of favorable financing schemes (including the blended financing) for battery storage projects (b) ・ Use of JICA's financial instruments such as yen loans (including VGF yen loans, etc.), two-step loans and the Private Sector Investment Fund (PSIF) for clean energy funds in India to mobilize private investment in the BESS business.
Expected Impacts	Creation of an investment environment for the expansion of BESS installations in states where VRE is being introduced, and expansion of private investment in storage batteries.
Target State(s)	TBD（the states with a relatively high VRE penetration ratio; Tamil Nadu, Maharashtra, Gujarat, Karnataka, etc..）
Counterparts	・ CEA

(C/P)	· SECI · State Nodal Agencies in the states with a high VRE penetration ratio such as Tamil Nadu, Maharashtra, Gujarat, Karnataka, State Nodal Agency
Expert Composition	· Financial specialist (Examination of blended financing schemes) · Economic and financial analysis experts · Power systems engineering experts · Energy storage experts
Implementation period (approx. duration)	From FY2023 onward (a:1 to 2years, b:3 to 5 years)

- **Proposed Cooperation #2 Optimization of Power Distribution System Operation to Achieve Carbon Neutrality**

Program Objective

Support distribution network design and optimal system operation to promote decarbonization at the distribution level by combining VRE, DR, EMS, etc.

Component Projects

1. Technical cooperation concerning system flexibility, relevant regulations, DR and VPP
   (a) Formulation/upgradation of regulations and rules (technical assistance)
   (b) Training concerning DR/VPP and grid codes (invitation program)
   (c) Pilot projects for DR and EMS
2. Financing smart meter installation (LOAN)
3. Financing DAS and MCMD installation (LOAN)

Table 235 Technical cooperation concerning system flexibility, various regulations, DR and VPP

Background	The Government of India is in the process of the introduction of retail competition in the electricity market through the amendment to the Electricity Utilities Act. (a) ➢ Once The Electricity (Amendment) Bill, (2020) currently under discussion is passed, DR-VPP projects could be established. Aside from the obstacles to the liberalization (electricity pilferage, unauthorized connection, low electricity tariffs below the cost of supply), it is necessary to formulate proper rules and regulations to promote DR. ➢ Reduction of distribution losses is essential as a technical prerequisite for the retail competition. The magnitude of each element of the technical losses (physical losses, pilferage, breakdowns of meters, errors in meter readings) and the commercial losses (unpaid bills) shall be identified and reduced respectively. (b) The rules and regulations governing the DR-VPP businesses and their current status in Japan will be useful to their effective implementation in India. (c) In the states that are (or are likely to be) in a tight electricity supply-demand condition and where retail competition is set in place, in particular, the implementation of pilot projects for DR and EMS will be useful.

Contents	(a) <u>Surveys on DR and VPP</u> ・ Confirmation of the current status and the future outlook of electricity supply-demand balance and the curtailments of thermal generation due to the massive renewable energy integration, and examination of the necessity for interruptible load contracts and VPP projects. When the large necessity is observed, issues for financing DR-VPP projects will also be identified. ・ Confirmation of the existence of large electricity consumers and potential VPP business operators who are likely to accept DR programs ・ Examination of institutional arrangements such as the development of a trading market to enable the participation of DR and VPP projects ・ Identification of technical issues for the introduction of DR and VPP in India ・ Estimation of low-carbon benefits of DR and VPP <u>Reduction of distribution losses as a precondition for DR and VPP</u> ・ Estimation of distribution system losses (estimation of load demand) ・ Identification of transformers suspected of electricity pilferage, etc. ・ Deliberation of measures to eliminate/mitigate pilferage and meter breakdowns (such as broader installation of smart meters) (b) ・ Training at several Japanese electric utilities on their respective DR systems, VPP systems and the technical standards for these systems ・ Discussions with the Japanese electricity regulatory agencies ・ Discussions with Japanese private companies engaged in DR and VPP ** Through these activities, participants will be able to understand the issues of DR and VPP and evaluate the possibility of their implementation in India.* (c) Upon the installation of smart meters by selected DISCOMs (both state-owned and private) in the target states in specific pilot areas, ・ Setting and applying tariffs for interruptible load contracts enforceable in the event of tight supply-demand conditions ・ Demonstration of VPP by aggregators ・ Measurement of effectiveness (frequency and duration of activation, degree of resolution of tight supply-demand conditions, and evaluation of economic efficiency), including a comparison of VPP costs and expansion of generation facilities
Expected Impacts	Ensure the stability of distribution network with massive VRE integration
Target State(s)	*TBD* ** Haryana can be a good candidate for a pilot project because both a tight electricity supply-demand condition and the steady progress of power sector reform are observed and the distribution network is relatively well-developed.*
Counterparts (C/P)	(a) ・ State owned power corporation ・ CEA

	・ CERC ・ SERC ・ State Grid Operator (b) ・ CEA ・ PGCIL (CTUIL) or POSOCO ・ State owned power corporation ・ SLDC ・ State owned DISCOM (c) ・ State owned power corporation ・ SLDC ・ State owned DISCOM
Expert Composition	(a) ・ Distribution experts ・ Power systems operation experts ・ DR/VPP business experts (including financing) (b) ・ Power systems operation expert from Japanese electric power companies ・ Contracting experts (in the electricity industry) ・ Government officials in charge of the electricity industry ・ Experts from private DR companies (c) ・ Professionals responsible for DR at Japanese electric power companies (power systems operation, sales, and electricity tariff setting/monitoring)
Implementation period (approx. duration)	Second half of FY2023 or later (1 to 2 years)

Table 236 Financing smart meter installation (LOAN)

Background	Based on the result of Project 1 above, provide financial assistance, such as yen loans, for the installation of smart meters.
Contents	・ Assistance in organizing technical requirements and preparing specifications for procurement (engineering services) ・ Cost estimation ・ Economic benefits of smart meter installation, financial analysis of distribution companies
Expected Impacts	Broder deployment of smart meters enabling DR and VPP
Target State(s)	Haryana（TBD）
Counterparts (C/P)	・ CEA ・ SERC ・ State owned power corporation ・ State owned DISCOM
Expert Composition	・ Distribution experts ・ Economic & financial experts
Implementation period (approx. duration)	After the implementation of the pilot project set out in Project 1 above (3 to 5 years)

Table 237 Financing DAS & MCMD installation (LOAN)

Background	Based on the results of Project 1 above, provide yen loans for the implementation of DAS and MCMD.
Contents	・ Assistance in organizing technical requirements and preparing specifications for procurement (engineering services) ・ Cost calculation ・ Economic benefits of DAS and MCMD implementation, financial analysis of distribution companies
Expected Impacts	Implementation DAS、MCMD
Target State(s)	Haryana（TBD）
Counterparts (C/P)	・ CEA ・ SERC ・ State owned power corporation ・ State owned DISCOM
Expert Composition	・ Power Distribution Specialist ・ Economic & Financial Expert
Implementation period (approx. duration)	After the implementation of the pilot project set out in Project 1 above (3 to 5 years)

■ **Proposal #3 Introducing Heat Pumps in the Industrial Sector**

Program Objective

While the introduction of industrial heat pumps is deemed to be one of the promising solutions for the promotion of decarbonization in the industrial sector, in India, the investment environment for that technology, including regulatory and institutional arrangements, has not yet been established. Therefore, in order to encourage future investments in the industrial heat pumps in India, a roadmap for their introduction will be developed together with a proposal on necessary policies and regulations and applicable financing schemes.

Component Projects

1. Technical cooperation to promote the introduction of industrial heat pumps
   (a) Develop a roadmap for the promotion of industrial heat pumps, and organize necessary policies and regulations
   (b) Capacity building of the Indian authorities for necessary policies and regulations (through seminars, expert dispatching, etc.)

2. Financial assistance to promote investment to industrial heat pumps
   (a) Technical cooperation to expand investment in industrial heat pumps
   (b) Financial assistance to expand investment in industrial heat pumps

Table 238 Technical cooperation to promote the introduction of industrial heat pumps

Background	In India, today the industrial sector accounts for 39% of the national final energy consumption, the highest share among all sectors. In order to improve energy efficiency in India and to establish a low-carbon economy, it is very important to improve energy efficiency in the industrial sector. Large enterprises in India have been taking energy efficiency efforts through the PAT Scheme and other programs, however, in order to improve energy efficiency in the Indian industrial sector further, it is necessary to strengthen similar efforts for small and medium-sized enterprises (SMEs). While electricity, such as motors, is already covered by BEE's Standards & Labeling program, but heat, such as boilers, is not. Heat use in SMEs may be at relatively low temperatures, and in such cases

	IEA recommends high-efficiency electric heat pumps rather than fossil fuels to improve efficiency. Japan has an advantage in heat pump technologies and can contribute to the expansion of heat pump adoption in India.
Contents	(a) ・ Investigation and confirmation of potential demand for upgrading old fossil fuel boilers operated at relatively low temperatures (~400°C, IEA) to high-efficiency heat pumps (assuming mainly industrial SMEs; the examples in Japan: food, textiles, plastic processing, rubber products), and a simplified forecasting of the effectiveness of the upgrading.) ・ India has the "Indian Boiler Regulations, 1950 (most recent revision is 2022)," but it is unclear what regulations electric heat pump boilers will be subject to. The regulations needed for this purpose will be sorted out. Specifically, as follows. ➢ Confirm whether electric heat pump boilers are within the framework of existing regulations. Identify what new regulations need to be developed for electric heat pump boilers. ➢ Have electric heat pump boilers added to BEE's Standards & Labeling program. ・ Share the experience of Japan and other countries in heat pumps promotion ・ Based on the above consideration, develop a roadmap for each of the possible target industries by organizing the necessary regulations and possible promotion measures in chronological order. (b) ・ Electric heat pump boilers have not been widely employed and have low recognition. Therefore, policy makers are required to deepen their understanding of the features of electric heat pumps, energy-efficient performance, safety (installation and operation), and regulations on electric heat pump safety. (Short-term dispatch or invitation of experts is envisioned) ・ Conduct seminars for equipment designers in order to promote their understanding of the features of electric heat pumps, their energy-efficient performance, etc., and to help them understand the contents of the relevant regulations when new regulations are introduced for electric heat pump boilers. (Holding seminars)
Expected Impacts	By replacing old fossil fuel boilers by heat pumps for heat demand, energy efficiency will be improved. It will also help improve air pollution in India by eliminating emissions of air pollutants.
Target State(s)s	(Candidate) States with relatively stable electricity supply States with no shortfalls in both electricity and peak power during April 2021-February 2022: Maharashtra
Counterparts (C/P)	(a) ・ BEE ・ State Designated Agency ・ Central Boilers Board, Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry https://dpiit.gov.in/sites/default/files/boiler_rules_updated/about.htm (b) ・ BEE ・ State Designated Agency ・ Central Boilers Board, Department for Promotion of Industry and

	Internal Trade, Ministry of Commerce and Industry ・ ESCO companies
Expert Composition	・ Energy efficiency (industrial sector) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.)
Implementation period (approx. duration)	From FY2023 onward (2 to 3 years)

Table 239 Financial assistance to promote investment in industrial heat pumps

Background	In order for Indian domestic companies to introduce industrial heat pumps, it is necessary to facilitate financing for their investments. This project will promote the supply of funds for investment in industrial heat pumps through blended financing using JICA's assistance instruments, mainly by examining financing issues of companies and risk mitigation measures for loans from financial institutions.
Contents	(a) ・ Identify challenges in financing industrial heat pumps in India and risks from the perspective of financial institutions. ・ Consideration of favorable financing schemes to address the issues identified such as two-step loans for the installation of energy-efficient equipment ・ Implementation of pilot projects based on the financing schemes examined above ・ Detailed design of the financing scheme reflecting the results of the pilot project. ・ Seminars for financial institutions through the Energy Efficiency Financing Platform (EEFP)[748] to foster their understanding of industrial heat pumps among financial institutions. (b) ・ Financial assistance to promote industrial heat pumps through the scheme above. ・ Consulting services for ESCOs when following the approach through ESCO services (e.g., promotion of project implementation including fund management, technical support for financing to promote the introduction of renewable energy and energy-efficient equipment, etc.)
Expected Impacts	The project will encourage investments in heat pumps and improve energy efficiency. It will also help improve air pollution in India by eliminating emissions of air pollutants.
Target State(s)	TBD
Counterparts (C/P)	・ BEE ・ ESCO, e.g. EESL
Expert Composition	・ Energy efficiency (industrial sector) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.) ・ Finance experts (including blended financing) ・ Economic and financial analysis experts
Implementation period (approx. duration)	From FY2023 onward (5 years) * To be implemented in parallel with Project 1 above

748 https://beeindia.gov.in/content/eefp

■ **Proposal #4 Introducing ZEB**

Program Objective

Promote the introduction of ZEB in India and promote the introduction of renewable energy in combination with energy efficiency.

Component Projects

1. Capacity building on understanding the ZEB concept to policy makers, Indian companies, and financial institutions; introduction of Japanese case studies (technical cooperation)
2. Financial assistance for companies introducing ZEB

Table 240 1. Capacity building on understanding the ZEB concept to policy makers, Indian companies, and financial institutions; introduction of Japanese case studies (technical cooperation)

Background	In India, although efforts are being made in the field of urban development (office buildings, residences, etc.) to address renewable energy and energy efficiency respectively, efforts to achieve zero-energy buildings by combining them have not yet been fully implemented. On the other hand, local needs for energy conservation and decarbonization are increasing year by year, and Indian government agencies have begun to consider specific approaches toward the realization of zero-energy buildings as part of their policy. In order to conduct further energy efficiency promotion activities for the introduction of ZEB in India, human resource development, institutional design for promotion, and awareness-raising for energy-efficiency will be conducted.
Contents	・ Formulation of a framework for ZEB promotion ➢ Formulation of ZEB-related standards (support for establishment of ZEB ISO/TS in India) ➢ Support for the formation of incentive mechanisms ・ Sharing information (by holding seminars, etc.) on measures to support the promotion of ZEB in Japan (policy, finance, construction, and design) based on the status of ZEB introduction in India ・ Pilot projects ・ Site visits to ZEB in Japan (invitation), dispatch of Japanese experts ➢ Capacity building for policy makers, Indian companies, and financial institutions on ZEB concept
Expected Impacts	Establishment of ZEB standards Better understanding of the ZEB concept by policy makers, companies, and financial institutions.
Target State(s)	Nationwide
Counterparts (C/P)	・ Bureau of Energy Efficiency, Ministry of Power ・ Ministry of Housing and Urban Development ・ Energy Efficiency Services Limited （EESL） ・ Convergence Energy Services Limited（CESL）
Expert Composition	・ Energy efficiency and renewable energy (ZEB) policy experts ・ Energy efficiency and renewable energy (ZEB) promotion experts ・ Energy-efficiency technology experts ・ Renewable energy technology and grid interconnection experts ・ Finance experts

Implementation period (approx. duration)	From FY2023 (1 year)

Table 241 2. Financial assistance for companies introducing ZEB

Background	In India, the need for energy efficiency and conservation is even stronger than before, however, the lack of support and measures to promote the spread of energy efficiency has prevented concrete efforts from being made. This project aims improve energy use efficiency by promoting the introduction of ZEB (renewable energy and energy efficiency) related equipment in India through concessional financing by means of a two-step loan, thereby contributing to stabilization of energy supply and demand and achieving low carbon society.
Contents	・ Provide financing for ZEB installation to end-user companies through a two-step loan or provide ESCO services through yen loans to the Government of India and EESL. ➢ Two Step Loan (concessional loan for private companies to install energy-efficient equipment) ・ Consulting services (promotion of project implementation including financial management, technical support for loans to promote the introduction of renewable energy and energy-efficient equipment, etc.)
Expected Impacts	Increased private investment in ZEB
Target State(s)	Nationwide
Counterparts (C/P)	・ The Government of India (BEE or MoHUA) (Implementing agency) Indian Renewable Energy Development Agency, Energy Efficiency Services Limited (EESL), Convergence Energy Services Limited (CESL)
Expert Composition	・ Financial management experts ・ Energy efficiency and renewable energy (ZEB) technical experts
Implementation period (approx. duration)	From FY2024 (5 years)

For proposal 2.3. above ”Expansion of the use of BESS', the main counterpart is considered to be the Solar Energy Corporation of India (SECI), considering the needs of the counterpart, a support proposal targeting green hydrogen project procurement was proposed.

<Proposed green hydrogen support to SECI>.

Proposals were made for the provision of Viability Gap Funding through the Government of India, technical cooperation such as assistance in the preparation of tender documents and assistance in the selection of operators, and support for demonstration projects.

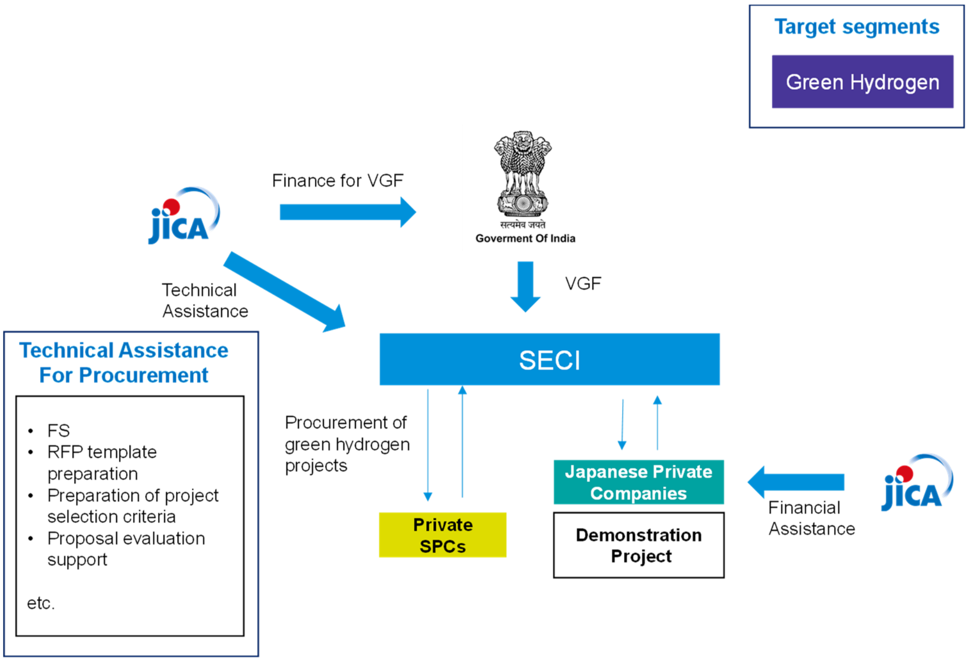

Figure 303 Roles of each organization, etc.

The project on green hydrogen is at a very early stage. Based on the direction given by the National Hydrogen Mission, it was said that off-takers are envisaged as operators in two industries, oil refining and fertilisers, and that PPAs are envisaged for the short term. It was also mentioned that some technical cooperation from the UK is also being received. Given the high cost of producing green hydrogen and the lack of a large scale of demand, it will be difficult for the private sector alone to establish a green hydrogen value chain on a commercial basis, and government and donor support will play an important role. Discussions should continue in the light of future announcements of the National Hydrogen Mission by the Government of India.

(2) Thailand

Based on the analysis of the current situation in the field survey target countries and the field survey, proposals were made to the DEDE on the following four cooperation proposals.

Proposed Cooperation #1
Assistance in Introducing Hydrogen Co-firing at Gas-fired Power Plants

Proposed Cooperation #2
Grid Stabilization Measures for Large-Scale Introduction of Renewable Energies

Proposed Cooperation #3
DR Introduction

Proposed Cooperation #4
Promoting Conversion of Boilers to Heat Pumps for the Industrial and Building Sectors

Proposed Cooperation #5
ZEB Introduction

■ **Proposed Cooperation #1 Assistance in Introducing Hydrogen Co-firing at Gas-fired Power Plants**

Program Objectives

Although gas-fired power generation produces less GHG emissions than coal-fired power generation, the promotion of its transition to zero emission is very important to accomplish the carbon neutrality. As a measure to reduce GHG emissions from gas-fired power generation, which accounts for a large share of Thailand's entire power generation, in this Program, an action plan for the introduction of hydrogen co-firing will be developed, and feasibility studies and demonstration projects in accordance with the action plan will be conducted. In the long term, support for the introduction of hydrogen co-firing turbines and the development of hydrogen supply chain infrastructure will be provided through yen loans.

Component Projects

1. Preparation of an action plan and other technical assistance for the introduction of hydrogen co-firing
   (a) Select potential target gas-fired power plants and conduct technical & economic financial feasibility studies (F/Ss).
   (b) Survey for hydrogen supply chain
   (c) Survey for laws and regulations that will need to be developed, followed by technical assistance for their introduction.
   (d) Conduct trainings in Japan (on relevant Japanese policies and regulations, technologies, etc.).
2. Demonstration project of hydrogen co-firing
   Conduct a demonstration project(s) using actual equipment, including hydrogen supply chain.
3. (Long-term) Based on the results of the above activities concerning the action plan and the demonstration projects, consider how co-firing technologies and other necessary infrastructure will be financed using yen loans, etc., and provide technical assistance for the operation of co-firing technologies to be employed.

Table 242 1. Preparation of action plan and Technical assistance for introduction of hydrogen co-firing

Background	In Thailand, the ratio of gas-fired power generation is high. Although gas-fired power generation produces a relatively low GHG emission, lowering its emissions further is also an issue for achieving the carbon neutrality. Hydrogen co-firing at gas-fired power plants is deemed to be a promising mean to achieve low carbon emissions, and several demonstration projects are in operation around the world to increase the co-firing rate. On the other hand, the procurement of clean hydrogen as a fuel for power generation and the development of necessary regulations are also important issues to be addressed in order to implement hydrogen co-firing. In this Project, F/Ss for hydrogen co-firing will be conducted, and an action plan for the introduction of hydrogen co-firing/100%hydrogen-fed, including the hydrogen supply chain, will be developed. As well, technical assistance will be provided for the development of the necessary regulations.
Contents	(a) ・ Gas-fired power plants eligible for the Project will be selected considering the information such as COD, turbine type and ownership of each plant.

	** In order to enable long-term demonstration and operation, the power plants with a relatively new turbine type and an operational record less than 10 years are desirable. IPPs can hardly be a candidate because of their contractual restrictions. Considering the expansion of target plants as well, the power plants owned by EGAT units are desirable.* ・ F/S for the demonstration of a low co-firing ratio that does not require facility modifications. ・ F/S for the demonstration of a high co-firing ratio with certain facility modifications. ・ Economic and financial analysis of the above-mentioned co-firing methods. (b) ・ With a view to eventually introducing 100% hydrogen-fed, the means for procuring clean hydrogen (blue and green hydrogen), such as domestic hydrogen production and importing hydrogen, will be examined, including economic analysis. (Reference will also be made to the study on hydrogen production and utilization using offshore wind power, being conducted by ADB.) ・ Based on the above study, develop an action plan for the introduction of hydrogen co-firing/100% hydrogen-fed in Thailand, including the development of a necessary hydrogen supply chain plan. (c) ・ Concurrently with the preparation of the action plan, regulations necessary for the use, transportation and storage of hydrogen as a fuel will be identified, and those that can be covered by the existing laws and regulations and those that need to be newly developed will be sorted out. (Utilize the results of JICA's hydrogen study being conducted separately). ・ Provide technical assistance (dispatch of experts, etc.) for the development of necessary regulations.
Expected Impacts	Develop a low-carbonization plan for gas-fired power generation from a long-term perspective that contributes to the accomplishment of the carbon neutrality by 2070.
Target Areas (if any)	-
Counterparts (C/P)	・ EGAT ・ DEDE
Expert Composition	・ Gas-fired power generation specialists ・ Hydrogen technology (production, transport, storage) experts ・ Experts in hydrogen-related policies and regulations ・ Economic and financial analysis Experts
Implementation period (approx. duration)	From the second half of FY2022 onward (2 years)

Table 243 2. Demonstration project of hydrogen co-firing

Background	A demonstration project including the supply chain will be implemented using hydrogen gas turbines that are commercially-available as of 2025 or later. (The project will be implemented using available programs such as NEDO's "Program to Facilitate Private-Sector-Led Promotion of Low Carbon Technology Overseas" and

	"International Demonstration Project on Japan's Energy Efficiency Technologies") https://www.nedo.go.jp/english/activities/international.html
Contents	・ Based on the master plan prepared in Project 1 above, a demonstration of hydrogen co-firing with actual equipment and a hydrogen supply chain demonstration for hydrogen procurement will be conducted. ・ When using NEDO's "Program to Facilitate Private-Sector-Led Promotion of Low Carbon Technology Overseas" to promote the diffusion of low-carbon technologies, the demonstration will be conducted in accordance with the following steps: (1) pre-demonstration surveys, (2) demonstration research, and (3) follow-up activities
Expected Impacts	Develop a low-carbonization plan for gas-fired power generation from a long-term perspective that contributes to the accomplishment of the carbon neutrality by 2070.
Target Areas (if any)	—
Counterparts (C/P)	・ DEDE ・ EGAT
Expert Composition	・ Japanese companies with advanced hydrogen co-firing technologies
Implementation period (approx. duration)	From FY2025 onward

Table 244 3. Necessary financial support and technical assistance

Background	Based on the action plan developed in Project 1 above and the results of the demonstration project in Project 2, provide financing for the implementation of hydrogen co-firing and associated technical assistance.
Contents	・ Financing, including yen loans, for the development of hydrogen supply chain infrastructure, such as hydrogen co-firing combustors, etc. ・ Technical assistance (engineering services) for the introduction of necessary technologies such as hydrogen co-firing combustors, and cost estimation ・ Technical assistance for the operation of hydrogen co-firing power generation (dispatch of experts, etc.) ・ Technical assistance for the operation of hydrogen supply chain infrastructure (dispatch of experts, etc.)
Expected Impacts	Low-carbon gas-fired power generation will contribute to the accomplishment of the carbon neutrality by 2070.
Target Areas (if any)	-
Counterparts (C/P)	・ DEDE ・ EGAT ・ Banpu Public Company Limited
Expert Composition	・ Experts in hydrogen technologies (production, transport, storage) ・ Experts in gas-fired power generation, hydrogen co-firing/exclusive combustion ・ Economic and financial analysis experts
Implementation	Around FY2030 (After the completion of the demonstration project in

period (approx. duration)	Project 2) ** Implementation support will be provided from a long-term perspective.*

■ **Proposed Cooperation #2 Grid Stabilization Measures for Massive Introduction of Renewable Energy Resources**

Program Objectives

In order to ensure steady capacity additions of renewable energy resources in Thailand, technical assistance (including long- and short-term dispatch of experts) on a proper open access systems, regional system operation and forecasting models for VRE output that guarantee, which are all required for ensuring the power system stability under the massive renewable energy integration.

Component Projects

1. Dispatch of experts for the introduction of an open access system
2. Technical assistance for network integration of renewable energy resources
   (a) Simulation and capacity building to optimize weather forecasting and output limitation
   (b) Capacity building for power system operation rules in Thailand

Table 245 1. Dispatch of experts for the introduction of an open access system

Background	According to the ERC, the improvement of TPA and the revision of the Grid Code will be included in its next 5-yer plan. In addition, there was a request from ERC to dispatch an expert on grid interconnection of renewable energy, which will be discussed continuously during the ongoing JICA survey on the carbon neutrality.
Contents	Experts will be dispatched on institutional, regulatory, and grid code issues to ensure renewable energy grid interconnection. Details have already been presented to the ERC on April 18, 2022.
Expected Impacts	Stable and reliable implementation of grid interconnection of renewable energy resources and the promotion of capacity additions of renewable energy resources.
Target Areas (if any)	-
Counterparts (C/P)	ERC、EGAT
Expert Composition	Experts from relevant ministries, agencies, academia, and electric utilities
Implementation period (approx. duration)	From the second half of FY2023 (2 years)

Table 246 2. Technical assistance for network integration of renewable energy resources

Background	As the installed capacity of renewable energy resources increases, output fluctuations due to changes in weather will have a greater impact on the grid. More accurate forecasting of VRE output associated with weather forecasts will be necessary for ensuring the stability of the power system. In addition, when a large amount of renewable energy resources are introduced, there is a risk of large fluctuations in the amount of power flow and overloading of facilities due to the factors such as the dispersed installations of renewable energy resources, which could hinder the stable operation of the power system. In addition, depending on the development of the electricity market, congestion management may be necessary. In order to address these issues, VRE grid connection requirements and congestion management rules for the interconnected

	systems need to be developed.
Contents	(a) ・ Review of weather forecasting systems ・ Verification of weather forecasting accuracy and review of improvement plans ・ Verification of correlation between weather forecasts and actual VRE output (b) ・ To train participants to review VRE grid interconnection requirements, congestion management rules, etc., identify issues, study proposed countermeasures, and prepare drafts, under the guidance of experts. Trainings in Japan will also be provided.
Expected Impacts	Stable and reliable implementation of grid interconnection of renewable energy resources and the promotion of capacity additions of renewable energy resources.
Target Areas (if any)	-
Counterparts (C/P)	EGAT (System Operation Department)
Expert Composition	(a) ・ Experts from meteorological forecasting service organizations, such as the Japan Weather Association ・ Power system specialists familiar with central load dispatching operations (b) ・ Experts in the grid connection and the operation of interconnectors, from the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO) and Japanese electric power companies
Implementation period (approx. duration)	From FY2023 onward (2 years)

■ **Proposed Cooperation #3 DR Introduction**

Program Objectives

In order to promote the stable expansion of the installed capacity of renewable energy resources in Thailand, the effective mobilization of demand response (DR) is quite important. At this end, in this Program, the implementation of demonstration projects for DR and Vehicle-to-Grid (V2G) and other associated technical assistance will be provided.

Component Projects

4. Assistance for DR implementation
   (a) Technical assistance on various regulations for effective use of DR (including those related to V2G)
   (b) Capacity building for institutional design (dispatch of experts, workshops, invitation trainings)
5. Assistance for V2G introduction
   (a) V2G demonstration
   (b) Financing for infrastructure development necessary for V2G introduction

Table 247 1. Assistance for DR implementation

Background	EPPO has listed the promotion of DR (creation of standards and development of regulations for Auto DR) at the beginning of its mid-term plan until 2031. In anticipation of the liberalization of the electricity market, it will be necessary to identify DR needs and develop rules and regulations for it. In addition, in order to consider the future application of DR in Thailand, it will be useful to learn about the rules and regulations and the actual projects concerning DR and VPP in Japan.
Contents	(a) DR experts are scheduled to be dispatched in July 2024 under the Expert Dispatch program for ERC. The following activities will be carried out in advance: ・ Confirmation of preconditions for promoting DR (degree of supply-demand tightness in Thailand, status of diffusion of existing supply-demand adjustment contracts, etc.) ・ Confirmation of the benefits of DR for customers ・ Examination of the necessity and the contents of DR contracts (interruptible load contracts) ・ Consideration of the introduction of automatic DR ・ Examination of the roles of aggregators and the business feasibility ・ Examination of the establishment of a (Central) DR control center ・ Examination of the use of storage batteries, etc. in DR to raise the supply of renewable energy when there is a surplus ・ Review of the existing grid code and distribution code and the proposals for their improvements (b) ・ Training on the respective DR systems, VPP systems, and their technical standards at Japanese electric power companies ・ Discussions with the Japanese electricity regulatory agencies and the ERAB (Energy Resource Aggregation Business) study groups ・ Through these activities, issues related to promotion in Japan will be identified and the possibility of deployment in Thailand will be evaluated.
Expected Impacts	Achieve EPPO's mid-term plan. Stable expansion of renewable energy deployment through effective DR implementation; creation of business opportunities and employment through DR; and creation of new jobs through DR.
Target Areas (if any)	-
Counterparts (C/P)	(a) ERC、EGAT、EPPO (MOE) (b) EPPO (policy officer), ERC (regulatory development), EGAT (grid code, grid management)
Expert Composition	(a) Japanese companies participating in the Energy Resource Aggregation Business (ERAB) Study Group (b) Japanese companies participating in the Energy Resource Aggregation Business (ERAB) Study Group, electric power companies, local governments engaged in DR demonstrations, etc.

Implementation period (approx. duration)	(a) Mostly completed by June 2024. (DR experts are scheduled to be dispatched in July 2024 under the concept of dispatching experts to ERC. (DR experts are scheduled to be dispatched in July 2024 under the concept of dispatching experts to the ERC.) (b) Timing to coincide with the dispatch of short-term experts to promote DR projects scheduled for July 2024 (a component of the proposal to dispatch experts to the ERC).

Table 248 2. Assistance for V2G introduction

Background	The last item in EPPO's mid-term plan is the grid connection of EVs, and the plan calls for the nationwide diffusion of EVs over the next five years, followed by the diffusion of EV aggregators and a V2G pilot project by around 2031.
Contents	(a) ・ The location for the pilot project will be determined after consultation with EGAT and other related organizations. ・ A small number of local governments, companies (offices), recharging facilities, EV manufacturers, and others will conduct demonstration projects in which EVs function as storage batteries and are connected to the grid through aggregation. (b) ・ Investigate financing methods using JICA instruments, such as two-step loans, to develop the necessary infrastructure. ・ Finance will be provided for the implementation after the completion of the demonstration project.
Expected Impacts	Achievement of EPPO mid-term plan; contribution to EV penetration and the expansion of renewable energy.
Target Areas (if any)	(a) -（Select pilot sites prior to the implementation.） (b) -
Counterparts (C/P)	(a) EGAT (promotion of smart chargers, grid-connected parties, revision of grid codes), ERC (regulatory development to promote V2G), EV and charger manufacturers, etc. (b) EGAT
Expert Composition	(a), (b) ・ EV charger experts, experienced in working on V2G demonstration projects (power companies) ・ Economic and financial analysis experts
Implementation period (approx. duration)	FY2027 - FY2030 (following the timeline of the EPPO mid-term plan.)

■ **Proposed Cooperation #4 Promoting Conversion of Boilers to Heat Pumps for the Industrial and Building Sectors**

Program Objective

The Government of Thailand has developed an Energy Efficiency Plan (EEP) 2018-2037, which aims to enhance the economic efficiency of energy (to reduce energy intensity) by 30% in 2037 compared to 2010, with the goal of increasing the reduction target to 40% or 50%, which is currently under review. Heat pumps are attracting attention as a means of energy efficiency in the industrial and the commercial and residential sectors (i.e., replacement of boilers), and their introduction in Thailand stull has rooms. The Promotion of heat pump technologies in industries (for low-temperature applications) and buildings would be a great opportunity for cooperation from Japan.

Component Projects

3. Technical cooperation to promote the introduction of heat pumps
   (a) Develop a roadmap for the introduction of heat pumps for the industrial (for low-temperature applications) and building sectors and organize necessary policies and regulations.
   (b) Capacity building of the Thailand authorities for necessary policies and regulations (through seminars, expert dispatching etc.)
4. Financial assistance to promote investments in heat pumps

Table 249 1. Technical cooperation to promote the introduction of heat pumps

Background	The industrial and the commercial and residential sectors account for about 50% of the national primary energy consumption, and these sectors need to be improved in order to increase energy efficiency of Thailand and to establish a low-carbon economy. Although the Energy Conservation Promotion Act has already been enacted and various energy efficiency efforts are being taken, energy efficiency needs to be further improved. The primary energy consumption per GDP (in toe/ 2015 US$) in Thailand was 0.30 while its average of OECD countries was 0.11. In addition, energy efficiency is mandated by the Energy Conservation Promotion Act for energy-consuming factories above a certain scale, and efforts to further improve energy efficiency in the industrial sector will need to be strengthened for small and medium-sized enterprises (SMEs). Heat use in the industrial and building sectors takes place at relatively low temperatures, in this case, IEA recommends high-efficiency electric heat pumps rather than fossil fuels to improve efficiency. In Thailand, EEP 2018-2037 has been formulated and various studies and preparations are currently underway to make energy efficiency mandatory for all factories. This is a good opportunity to incorporate the use of heat pumps into the Energy Conservation Promotion Act and the Factory Act. In addition, assistance from Japan in this area to date includes the introduction of heat pumps in factories under Public-Private Partnerships Scheme by JICA in 2019, and the exchange of information between the Heat Pump & Thermal Storage Technology Center of Japan and King Mongkut's Institute of Technology to promote the introduction of heat pumps in the building sector. The future assistance program is expected to be structured in conjunction with the results of those existing projects.
Contents	(a) ・ In the industrial sector, investigate and confirm potential demand for replacing old fossil fuel boilers operated at relatively low temperatures (below 400°C) with high-efficiency electric heat pumps (the examples in Japan: food, textiles, plastic processing, rubber products), and make simplified forecasting of the effectiveness of such replacement. For the building sector, the adoption of high-efficiency electric heat pumps for new buildings will be encouraged.

	・ In the Factory Act 2535 of 1992, which stipulates requirements for boiler design, construction, testing, installation, and safety testing and inspection, it is still unclear what regulations electric heat pump boilers will be subject to. Therefore, in this Project, the range of existing regulations framework and whether electric heat pump boilers are within the range or not will be confirmed. In addition, this Project aims to incorporate electric heat pump boilers into laws and ministerial ordinances in order to make energy conservation mandatory for all factories and new buildings in 2030. ・ Conduct research and share experiences of Japan and other countries in heat pumps promotion (e.g., taxation systems). ・ Based on the above study, for the industrial sector, necessary regulations and possible promotion measures will be organized in chronological order for each possible target industry, and a roadmap will be created. (b) ・ Electric heat pump boilers have not been widely employed and have low recognition. Therefore, policy makers are required to deepen their understanding of the features of electric heat pumps, energy-efficient performance, safety (installation and operation), and regulations on electric heat pump safety. (Assuming short-term dispatch or invitation of experts). (Industrial and building sectors, respectively) ・ Conduct seminars for facility designers to promote their understanding of the features of electric heat pumps, their energy-efficient performance, etc. and, if new regulations are introduced for electric heat pump boilers, to have them understand the contents of such regulations (through seminars). (Industrial and building sectors, respectively)
Expected Impact	Energy efficiency will be improved by replacing old fossil fuel boilers by heat pumps for heat demand.
Target State(s)	Nationwide
Counterparts (C/P)	(a) ・ Department of Alternative Energy Development and Efficiency (DEDE) ・ Industrial Estate Authority of Thailand (IEAT) ・ Association of Boiler and Pressure Vessel ・ Thai ESCO Association (b) ・ Department of Alternative Energy Development and Efficiency (DEDE) ・ Industrial Estate Authority of Thailand (IEAT) ・ Association of Boiler and Pressure Vessel ・ Thai ESCO Association and ESCO companies
Expert Composition	(a), (b) ・ Energy efficiency (industrial sector and building sector) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.) (c) ・ Energy efficiency (industrial sector and building sectors) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.)
Implementation	From FY2023 onward (2 to 3 years)

period (approx. duration)	

Table 250 2. Financial assistance to promote investments in heat pumps

Background	To introduce heat pumps (for industrial and building use) to companies in Thailand, it is necessary to facilitate financing of corporate investment. This project will mainly focus on corporate financing issues and measures to mitigate the risk of financing from financial institutions.
Contents	・ Investigate and organize issues in heat pump financing and risks from the perspective of financial institutions. ・ Consideration of blended financing schemes (two-step loans, investments and loans in energy efficiency funds, etc.) to address the identified issues. ・ Implement pilot projects based on the financing schemes examined above. ・ Provide financing for the introduction of heat pumps by companies through two-step loans and JICA investments and/or loans to funds investing in energy efficiency (e.g., EE Revolving Fund[749]). Also, hold seminars for financial institutions to promote their understanding of industrial heat pumps.
Expected Impact	Increase investments in heat pumps by the private sector.
Target State(s)	Nationwide
Counterparts （C/P）	・ Department of Alternative Energy Development and Efficiency (DEDE)
Expert Composition	・ Energy efficiency (industrial sector) experts (experts from the Heat Pump & Thermal Storage Technology Center of Japan, etc.) ・ Finance experts (including blended financing) ・ Economic and financial analysis experts
Implementation period (approx. duration)	To be implemented in parallel with developing the roadmap referred to in Project 1 above (5years).

■ **Proposed Cooperation #5 ZEB Introduction**

Program Objective

Promote the introduction of ZEB and renewable energy resources installed in combination with energy efficiency.

Component Projects

1. Technical and financial cooperation for ZEB introduction
    (a) Technical cooperation to assist ZEB introduction
    (b) Financial assistance to expand ZEB investment

Table 251 1. Technical and financial cooperation for ZEB introduction

Background	The Government of Thailand has formulated the Energy Efficiency Plan (EEP) 2018-2037, which aims to enhance the economic efficiency of energy (to reduce energy intensity) by 30% by 2037, compared to 2010. In the building sector, the Building Energy Code is mandatory for new buildings (floor area of 2,000 m^2 or more), and it is required to meet the code before obtaining a construction permit (effective in 2020), however, it remains at the minimum required level. DEDE recognizes

749 https://unece.org/fileadmin/DAM/energy/se/pp/eneff/5th_Forum_Tunisia_Nov.14/4_November/Prasert_Sinsukprasert.pdf

	the necessity to develop Thailand's own ZEB guidelines that meet international standards. DEDE also recognizes the necessity of governmental ZEB supporting programs (demonstration programs and subsidy programs) for building owners and developers to promote the ZEB concept.
Contents	(a) ・ Review of building energy efficiency design standards and assist with the formulation of Thailand's own ZEB guidelines that meet international standards (including long-term and short-term expert dispatch) ・ Assist in the establishment of ZEB ISO/TS in Thailand ・ Provision of information to policy makers on measures to support the spread of ZEB and ZEH in Japan (finance, policy goals, construction, and design company support network, etc.) ・ Implementation of pilot projects to observe ZEB and ZEH in Japan (including renewable energy, energy efficiency, storage batteries, EVs) (b) ・ Finance for the expansion of ZEB investment by the private sector in Thailand, using JICA instruments such as two-step loans and overseas investments and loans, and considering the employment of blended financing schemes. ・ Capacity building for companies and financial institutions in Thailand on deepen their understanding of the ZEB concept (through online or offline seminars) and share experiences of Japan.
Expected Impact	Expanding investments in ZEBs equipped with renewable energy and EVs in Thailand and increasing private investment.
Target State(s)	Nationwide
Counterparts （C/P）	・ DEDE
Expert Composition	・ Energy efficiency and renewable energy (ZEB) policy experts (a) ・ Energy efficiency and renewable energy (ZEB) promotion experts (a) ・ Energy efficient technology experts (a), (b) ・ Renewable energy technology and grid interconnection expert (a) (b) ・ Finance expert (including blended financing) (b) ・ Economics and finance analysis experts (b)
Implementation period (approx. duration)	From FY2023 onward (5 years)

(3) Morocco

Based on the desktop study and interviews, the following five cooperation proposals were drafted and then the drafts were sent to the interviewed organisations for comments; comments were received from AMEE and SIE, which were reflected in the draft cooperation programmes below. ONEE did not comment on the content, but responded that it was interested in Proposal 1: Support for the introduction of ammonia co-firing “Introduction of Ammonia Co-Firing” and Proposal 2: “Grid Stabilisation Measures for Mass Introduction of VRE (battery storage and adjustable speed pumped storage)”.

Proposal #1
Introduction of Ammonia Co-Firing

Proposal #2
Grid Stabilisation Measures for Mass Introduction of VRE (battery storage and adjustable speed pumped storage)

Proposal #3
Development of a favourable legal system to promote EV (technical cooperation), E-bus demonstration, financing for power distribution system, charging infrastructure, and E-bus introduction (yen loans)

Proposal #4
Promoting Conversion of Boilers to Heat Pumps for the Industrial and Building Sectors

Proposal #5
ZEB Introduction

■ Proposal #1 Introduction of Ammonia Co-Firing

Program Objective

In Morocco, the coal-fired power generation accounts for around 40% of the total electricity supply, and the energy transitions for this coal-fired generation will be necessary toward the carbon neutrality. On the other hand, the key challenge is how to ensure grid flexibility in order to increase the ratio of VRE. The introduction of ammonia co-firing technology will be considered as a solution that can utilize the regulating capability of thermal power generation while enabling its low-carbonisation.

*The power plants to be examined in this project are those that can be retrofitted with denitration equipment (increased capacity) to cope with the increase in NOx and can continue demonstration tests for 10 years or more.

Component Projects

1. Workshop on ammonia co-firing/mono-firing
2. Feasibility study (F/S) for the introduction of ammonia co-firing into the coal-fired power generating units of the National Office of Electricity and Drinking Water (ONEE)
3. Demonstration project for the introduction of ammonia co-firing to ONEE's coal-fired power generation
4. Preparation of an ammonia supply chain master plan
5. Yen loan for the introduction of ammonia co-firing

Table 252 1. Workshop on ammonia co-firing/mono-firing

Background	The ammonia co-firing/mono-firing technologies are not still known well in Morocco. In order to nurture better understandings of government officials and ONEE concerning those technologies, in this project, their characteristics and potentials for their deployment in Morocco will be discussed through a workshop.
Contents	・ Introduction of the ammonia co-firing demonstration project in Japan ・ Explanation about the prerequisites for the implementation of co-firing demonstration projects ・ Confirmation of the availability of coal-fired generating plants in Morocco suitable for the demonstration ・ Identification of potential challenges (generating cost, supply chain, PPA contractual constraints, etc.)

Expected Impacts	Selection of suitable coal-fired generating units for demonstration projects
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ National Office of Electricity and Drinking Water (ONEE) ・ IPP
Expert Composition	Coal-fired generation experts such as engineers from Japanese generating companies with an expertise in ammonia co-firing technologies
Implementation period (approx. duration)	From FY2024 onward

Table 253 2. Feasibility study (F/S) for the introduction of ammonia co-firing into the coal-fired generating units of ONEE

Background	Conduct a F/S to introduce ammonia co-combustion technologies to coal-fired generating plants operated by ONEE. *Candidate plants are those that can be retrofitted with denitration equipment (increased capacity) to cope with increased NOx and can continue demonstration tests for 10 years or more.
Contents	・ Selection of specific coal-fired generating units suitable for ammonia co-firing ・ Consideration of necessary remodeling of denitration equipment and burners ・ Estimation of CO_2 reduction benefits ・ Examination of the construction of an ammonia supply chain ・ Examination of economic viability
Expected Impacts	Energy transition of coal-fired power generation (evaluation of CO_2 emission reduction effects and the economic viability of introducing ammonia co-firing)
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ ONEE
Expert Composition	・ Coal-fired generation experts such as engineers from Japanese generating companies with an expertise in ammonia co-firing technologies ・ Environmental experts (denitrification) ・ Experts in financial and economic analysis
Implementation period (approx. duration)	After the workshop above onward

Table 254 3. Demonstration project for the introduction of ammonia co-firing to ONEE's coal-fired power generation

Background	Demonstration project of ammonia co-firing technologies at ONEE's subcritical coal-fired generating plant(s)
Contents	Based on the above workshop and the F/S, if a suitable plant for ammonia co-firing is found, a demonstration project will be conducted. Description: Facility modification, co-firing demonstration, data measurement and verification, and evaluation for ammonia co-firing.
Expected Impacts	Energy transition of coal-fired power generation
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ ONEE

Expert Composition	・ Coal-fired generation experts such as engineers from Japanese generating companies with an expertise in ammonia co-firing technologies ・ Environmental experts (denitrification)
Implementation period (approx. duration)	After F/S implementation (considering the progress of the demonstration project in Japan)

Table 255 4. Preparation of an ammonia supply chain master plan

Background	Assist in developing a master plan for the fuel ammonia supply chain with a view to introducing ammonia co-firing technologies into ONEE's coal-fired generating plants.
Contents	Support the development of a master plan for the fuel ammonia supply chain by conducting the following studies and analyses; ・ Demand forecasting for ammonia for electricity generation ・ Estimation of the procurement cost of ammonia (green and blue ammonia) ・ Review of the availability of supply chain from production, through storage and transportation, to consumption at the power plants. ・ Examination of the expansion of ammonia supply (including the expansion of the existing ammonia production capability and the construction of new production facilities) ・ Examination of the favorable regulatory framework for the expanded use of ammonia: management of toxic material etc. ・ Examination of storage and transportation: Ammonia is considered as a carrier of hydrogen.
Expected Impacts	Energy transition of coal-fired power generation
Counterparts (C/P)	• Ministry of Energy Transition and Sustainable Development • ONEE
Expert Composition	Coal-fired generation engineers, co-firing equipment manufacturers, ammonia producers, ammonia transporters (for both import and export), hazardous materials management experts
Implementation period (approx. duration)	Same period as the project 3. above

Table 256 5. Yen loan for the introduction of ammonia co-firing

Background	Assist in developing a master plan for the fuel ammonia supply chain with a view to introducing ammonia co-firing technology into ONEE's coal-fired power generation plants.
Contents	Provide financing for the installation of ammonia co-firing and supply chain equipment based on the project 1 to 3 above. • Cost estimation and financial and economic analysis; • Examination of appropriate financing means; and • Funding under the JICA's instruments (assuming yen loans).
Expected Impacts	Energy transition of coal-fired power generation
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ ONEE
Expert Composition	・ Coal-fired generation engineers ・ Mixed combustion equipment engineers ・ Economic & financial experts
Implementation	Late 2020's (3~5 years)

period (approx. duration)	

■ **Proposal #2 Grid Stabilisation Measures for Mass Introduction of VRE (battery storage and adjustable speed pumped storage)**

Program Objective

Morocco plans to build 10.1 GW (4,560 MW solar PV, 4,200 MW wind, and 1,330 MW hydro) of renewable energy resources with an investment of about $40 billion between 2016-2030. In order to introduce a large amount of VRE, it is necessary to consider how to stabilize the grid at the same time. This program will propose and support the integration of storage batteries into the power system in order to stabilize the grid and accommodate a large amount of VRE including PVs under the self-consumption regime.

Projects

1. Study for the introduction of storage batteries for the grid and adjustable speed pumped storage plants
   (a) Planning for appropriate placement and efficient operation of storage batteries
      (i) Study on the installation plan of storage batteries
      (ii) Detailed study (basic design) for the introduction of storage batteries
   (b) Formulation of a plan to secure a certain amount of inertial hydropower (adjustable speed pumped storage)
2. Yen loan for the introduction of storage batteries for the grid
3. Yen loan for the introduction of adjustable speed pumped storage plants
4. Financing industrial installations of storage batteries connected to PVs under the self-consumption through yen loans (two-step loans) and/or blended finance schemes

Table 257 1. Study for the introduction of storage batteries for the grid and adjustable speed pumped storage plants

Background	Morocco has a great potential for solar generation and is developing not only solar PV but also CSP, which has a buffer of several hours after sunset. The primary objective is to directly supply solar power by building a hydrogen production plant near the existing power plants, but expanding solar power generation as grid power, which has day-night disparities, could have a negative impact on the grid stability. To avoid this, the appropriate placement and the efficient operation of grid storage batteries and the construction of hydroelectric power plants with inertia (including adjustable speed pumped storage) will be required.
Contents	(a) Planning for appropriate placement and efficient operation of grid storage batteries i) Develop a long-term supply, demand & grid plan. Grid analysis will be conducted under certain assumptions such as European interconnection and stand-alone grid, and a plan for the installation of storage batteries on the grid will be examined. ii) Then, a detailed study will be conducted to investigate specific plans (capacity and timing) and priorities for the installation of storage batteries. (b) Formulation of a plan to secure a certain amount of inertial hydropower (adjustable speed pumped storage) Conduct a study of water resources and develop a medium- to long-term hydropower generation plan. Given the constraints on water resources, the study will mainly focus on the introduction of variable-speed

	pumping.
Expected Impacts	Contributing to achieving the goal of mass introduction of VRE while maintaining grid stability.
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ ONEE ・ Moroccan Agency of Sustainable Energy (MASEN)
Expert Composition	(a) ・ Electricity demand forecasting experts ・ Grid planning experts ・ Grid analysis experts ・ Economic evaluation experts ・ Renewable energy experts (in particular, those familiar with solar operating conditions) (b) ・ Electricity demand forecasting experts ・ Hydropower experts
Implementation period (approx. duration)	(a) From FY2024 onward (2 years) (Investigate according to the trend of development and expansion of renewable energy resources, including the development of solar generation for hydrogen production. For the time being, the grid continues to be stable due to the European grid interconnection. Since a master planning element will be included in the regular F/S, the period is expected to be around 2 years). (b) From FY2023 onward

Table 258 2. Yen loan for the introduction of storage batteries for the grid

Background	Assist with the installation of storage batteries for the grid to promote the mass introduction of VRE while balancing electricity supply and demand.
Contents	Finance the installation of storage batteries in accordance with the storage battery installation plan prepared in the project 1. ・ Cost estimation and financial and economic analysis; ・ Examination of appropriate financing means; and ・ Funding under the JICA's instruments (assuming yen loans).
Expected Impacts	Contributing to achieving the goal of mass introduction of VRE while maintaining the grid stability.
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ ONEE
Expert Composition	・ Energy storage facility planning/operation specialists ・ Economic & financial experts
Implementation period (approx. duration)	After the planning of the project 1 (3~5 years)

Table 259 3. Yen loan for the introduction of adjustable speed pumped storage

Background	Assist with the installation of adjustable speed pumped storage plants to promote the mass introduction of VRE while balancing electricity supply and demand.
Contents	Finance the installation of adjustable speed pumped storage plants in accordance with the inertial hydropower installation plan prepared in the project 1. ・ Cost estimation and financial and economic analysis;

	・ Examination of appropriate financing means; and ・ Funding under the JICA's instruments (assuming yen loans).
Expected Impacts	Contributing to achieving the goal of mass introduction of VRE while maintaining grid stability.
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ ONEE
Expert Composition	・ Adjustable speed pumped storage planning/operation specialists ・ Economic & financial experts
Implementation period (approx. duration)	After the planning of the project 1 (3~5 years)

Table 260 4. Financing industrial installations of storage batteries connected to PVs under the self-consumption through yen loans (2-step loans) and/or blended finance schemes

Background	Due to the high concentration of population and industry in the north-western Atlas Mountains, there are many constraints to the introduction of large-scale, centralised solar PVs. Therefore, the promotion of decentralised electricity self-consumption systems in the industrial sector in this region will contribute to the transition to renewable energy sources by introducing PVs and storage batteries.
Contents	(a) Study for mobilizing private finance for industrial installations of storage batteries connected to PVs under the self-consumption ・ Conduct a study on sub-sectors where the promotion of self-consumption regimes in the industrial sector through the introduction of renewable energy and batteries is suitable, including barriers. ・ Based on the above study, consider blended finance schemes (e.g. using JICA's 2-step loan) to promote battery investment in the sector concerned. (b) Mobilise private investments in batteries using two-step loans based on the scheme discussed in (a).
Expected Impacts	Improve industrial sector's energy autonomy.
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ SIE
Expert Composition	・ Batteries experts ・ Economic & financial experts
Implementation period (approx. duration)	FY2023 onward (3~5 years)

Proposal #3 Development of a favourable legal system to promote EV (technical cooperation), E-bus demonstration, financing electricity distribution system, charging infrastructure, and E-bus introduction (yen loans)

Program Objective

The proposed program will be conducted in accordance with the roadmap developed by Confédération Générale des Entreprises du Maroc (CGEM) and will contribute to the low-carbonisation of the transportation sector.

Component Projects

1. Technical cooperation to develop a charging infrastructure development plan and training

programs
2. E-bus demonstration
3. Development of electricity distribution and charging infrastructure, and introduction of E-bus (yen loans)

Table 261 1. Technical cooperation to develop a charging infrastructure development plan

Background	The EV roadmap has been developed by CGEM to promote EVs in Morocco. The roadmap includes the plans to carry out the mapping of charging demand, the study of power system expansion and the strategic planning of the charging infrastructure layout in each major city during Phase 1 (2022-2025). This technical cooperation will provide support for the formulation of these plans.
Contents	Experts will be dispatched to provide the following technical cooperation (a) Develop a charging infrastructure development plan ・ Mapping of charging demand and consideration of distribution system expansion ・ Formulation of strategic charging infrastructure installation planning (b) Develop training programs ・ Support for developing training programs on proper use and maintenance of EVs and their charging stations ・ Support for developing awareness for local governments to include EV infrastructure concepts their plan
Expected Impacts	EV charging infrastructure development in line with the EV roadmap
Counterparts (C/P)	・ Ministry of Transport and Logistics ・ Moroccan Agency for Energy Efficiency (AMEE) ・ Research Institute for Solar Energy and New Energies (IRESEN) ・ ONEE ・ Société d'Ingénierie Énergétique (SIE)
Expert Composition	・ Distribution system experts ・ Charging infrastructure experts
Implementation period (approx. duration)	Latter half of FY2023 onward (1 to 3 years)

Table 262 2. E-bus Demonstration

Background	The EV roadmap indicates at least 3 E-bus demonstration projects will be conducted in cities with different climate condition (temperatures) and topographies (elevation and terrain) such as Rabat and Casablanca. The data to be collected during the demonstration will be incorporated in the planning written in the Project 1 above. The SIE has already carried out the electric bus pilot project in Marrakech on the occasion of COP22. 7 electric buses and a catenary charging network have been set up for this purpose. In implementation of this component, component, cooperation with the SIE and results of previous projects by the SIE should be considered.
Contents	・ Collection and analysis of data on recharge volume and recharge time, etc., and verification of equipment layout and operability for E-bus depot charging, opportunity charging and hydrogen. ・ Collection and analysis of remaining storage battery capacity and travel data for E-buses ・ Evaluation of the impact of recharging and discharging the storage

	batteries of E-buses on the power system ・ Study for the possibility of using EVs for balancing electricity supply and demand, etc. ・ Survey for building proper business models
Expected Impacts	Promoting E-mobility in line with the EV roadmap
Target State(s)s	City of Oujda where it has an ongoing energy development program (Smart Eco Region)
Counterparts (C/P)	・ Ministry of Transport and Logistics ・ IRESEN ・ ONEE ・ SIE
Expert Composition	・ EV experts from automobile companies ・ Distribution system experts ・ Charging infrastructure experts etc.
Implementation period (approx. duration)	Same period as the Project 1 (3 to 4 years)

Table 263 3. Development of electricity distribution and charging infrastructure, and introduction of E-bus (yen loan)

Background	The power system will be developed based on the plan produced in the Project 1 above.
Contents	Financing (yen loans, two-step loans) the development of the electricity distribution and charging infrastructure and the introduction of E-buses, in line with the plans referred to in the Project 1 and the results of the demonstration projects in the Project 2. ・ Cost estimation, financial and economic analysis ・ Study of appropriate financing instruments ・ Financing using JICA scheme (yen loans, two-step loan)
Expected Impacts	Increased penetration of E-mobility renewable energy through advanced electricity distribution
Counterparts (C/P)	・ Ministry of Transport and Logistics ・ IRESEN ・ ONEE ・ SIE
Expert Composition	・ E-bus experts from automotive companies, etc. ・ Distribution system experts ・ Economics and financial analysis experts
Implementation period (approx. duration)	After the completion of the Project 1 and 2 (3 to 5 years)

■ **Proposal #4 Promoting Conversion of Boilers to Heat Pumps for the Industrial and Building Sectors**

Program Objective

At COP26 in 2021, the Ministry of Energy Transition and Sustainable Development announced the "National Strategy for Energy Efficiency" with the goal of reducing 20% of energy consumption by 2030 as an intermediate step by 2050. Morocco has already installed heat pump boilers in mosques and hammams, and SIE is considering the use of heat pumps in the industrial sector. SIE has an idea to combine heat pumps with solar hot water to increase efficiency. However, since energy demand for cooling is expected to increase significantly in the future, SIE is considering of expanding to private residences, prioritizing cooling demand over boiler applications.

In Morocco, there are few obstacles to deploying heat pump boilers in the industrial and building sectors. For private residences, it is considered that the promotion of inverter air conditioners within ZEB will be effective.

Projects

1. Technical cooperation to promote the introduction of heat pumps
   - (a) Develop a roadmap for the introduction of heat pumps for the industrial (for low-temperature applications) and building sectors (all types of buildings including commercial and residential sector) and organize necessary policies and regulations.
   - (b) Capacity building of the Moroccan authorities for necessary policies and regulations (through seminars, expert dispatching, etc.)
2. Financial assistance to promote investments in heat pumps
   - (a) Capacity building and financing scheme study to expand heat pump investments
   - (b) Financial assistance with the heat pump installation

Table 264 1. Technical cooperation to promote the introduction of heat pumps

Background	In Morocco, the industrial and consumer sectors account for a high share of final energy consumption. In 2018, final energy consumption was 20% and 32% respectively for industry and buildings sector (both residential and commercial). Energy efficiency in these sectors need to be improved to establish a low carbon economy in Morocco. Morocco enacted the energy efficiency law in 2011 and various energy efficiency efforts are being made. However, there is a room for improvement when comparing the primary energy consumption per GDP (toe/ 2015 US$), one of the major energy efficiency indicators, with that of OECD countries (in 2019, 0.11 for OECD and 0.20 for Morocco). Morocco has set a target to reduce 20% of energy consumption by 2030. The Moroccan industry is dominated by small-to-medium enterprises (SMEs), and the efforts to further improve energy efficiency in the SMEs' in Morocco should be expedited. Heat use in industries and buildings can be made at relatively low temperature, and in these cases the IEA recommends high-efficiency electric heat pumps rather than fossil fuels to improve efficiency. The benefits of electric heat pump boilers in buildings are well-recognized in Morocco, as evidenced by the fact that electric heat pump boilers have already been installed in mosques and hammams and SIE is also considering deployment in the industrial sector.
Contents	(a) ・ Survey and evaluation the impact of introducing heat pumps in Morocco both economically and technically if this kind of survey has not done before (Working with SIE). ・ For the industrial sector, investigate and confirm potential demand for replacing old fossil fuel boilers operated at relatively low temperatures (below 400°C) with high-efficiency electric heat pumps (the examples in Japan: food, textiles, plastic processing, rubber products), and make simplified forecasting of the effectiveness of such replacement. For the building sector, the adoption of high-efficiency electric heat pumps for new buildings will be encouraged. ・ Conduct research and share the experiences of Japan and other countries in the promotion of heat pumps (e.g., taxation systems). ・ Based on the above study, for the industrial sector, necessary

	regulations and possible promotion measures will be organized in chronological order for each possible target industry, and a roadmap will be created. (b) ・ According to SIE, the Government of Morocco has established some regulations for the boiler installation. It is necessary to investigate what kinds of regulations are in place for the deployment of Japanese high-efficiency electric heat pumps in Morocco in the future, and in some cases, it may be necessary to amend the regulations. ・ Although electric heat pump boilers have already been introduced in Morocco, they are not widely used and are not well-recognized. Therefore, policy makers need to be more familiar with the features of electric heat pumps, energy-saving performance, safety (installation and operation), and regulations on electric heat pump safety. (Short-term dispatch or invitation of experts is envisioned). (for each of the industrial and building sectors) ・ Hold seminars for facility designers to facilitate their understanding of the features of electric heat pumps, their energy-efficient performance, etc. and, if new regulations are introduced for electric heat pump boilers, to have them understand the contents of such regulations (through seminars). (for each of the industrial and building sectors)
Expected Impacts	Energy efficiency will be improved by replacing old fossil fuel boilers by heat pumps for heat demand.
Target State(s)s	Nationwide
Counterparts (C/P)	(a) ・ Ministry of Energy Transition and Sustainable Development ・ AMEE ・ SIE (b) ・ Ministry of Energy Transition and Sustainable Development ・ AMEE ・ SIE
Expert Composition	(a)(b) ・ Energy efficiency (industrial sector and building sector) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.) (c) ・ Energy efficiency (industrial sector and building sectors) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.)
Implementation period (approx. duration)	From FY2023 onward (2 to 3 years)

Table 265 2. Financial assistance to promote investments in heat pumps

Background	In order to increase the installations of heat pumps (for the industrial and building sectors) at companies' premises in Morocco, it is necessary to facilitate the financing of corporate investments. This project will mainly focus on the financing issues of enterprises and measures to reduce the risk of financing from financial institutions.
Contents	(a)

	・ Investigate and organize issues in heat pump financing and risks from the perspective of financial institutions. ・ Consideration of suitable financing schemes (two-step loans, investments and loans in energy efficiency funds, etc.) to address the identified issues. ・ Implement pilot projects based on the financing schemes examined above. ・ Hold seminars, etc. for financial institutions to promote their understanding of industrial heat pumps. (b) ・ Provide financing for the introduction of heat pumps by companies through two-step loans and JICA investments and/or loans to funds investing in energy efficiency. ・ When it is the case that the installation of heat pumps be made by ESCOs, provide consulting services to them (e.g., the promotion of project implementation including financial management, and technical assistance with their financing to the introduction of renewable energy and energy-efficient equipment).
Expected Impacts	Increase investments in heat pumps by the private sector.
Target State(s)s	Nationwide
Counterparts (C/P)	・ Ministry of Energy Transition and Sustainable Development ・ AMEE ・ SIE
Expert Composition	・ Energy efficiency (industrial sector) experts (from the Heat Pump & Thermal Storage Technology Center of Japan, etc.) ・ Financial experts (including blended financing) ・ Economic and financial analysis experts
Implementation period (approx. duration)	To be implemented in parallel with developing the roadmap referred to in Project 1 above.

■ **Proposal #5 Zero Energy Building Introduction**

<u>Program Objective</u>

Morocco is implementing various energy efficiency policies under the "National Strategy for Energy Efficiency (Stratégie Nationale de L'efficacité Énergétique à L'horizon)," which aims to reduce 20 % of energy consumption by 2030. In particular, as energy consumption in buildings accounts for 33% of final energy consumption (the second largest consumption by sector), there is a high need for technologies that contribute to energy efficiency in buildings.

Promote the introduction of Zero Energy Building and renewable energy resources installed in combination with energy efficiency.

<u>Projects</u>

Technical and financial cooperation for Zero Energy Building introduction

(a) Technical cooperation to assist Zero Energy Building introduction

(b) Financial assistance to expand Zero Energy Building investment

Table 266 1. Technical and financial cooperation for Zero Energy Building **introduction**

Background	Morocco has already promulgated a legislation which is establishing minimum technical requirements for thermal performance in new buildings according to the six Moroccan climate zones, and AMEE has developed a building labeling system called "Eco-Binayate." A labeling system has also been introduced for the equipment to encourage energy efficiency, but cooling energy is recognized as an

	issue for the time being. The current penetration rate of air conditioners is in the 10% range, but it is expected to reach 40% by 2030, therefore capital investment including energy efficiency measures, will be necessary to be taken to meet the increasing demand for cooling energy in summer which also achieve suppressing the energy consumption. As indicated above, while certain efforts are being actively made to improve energy efficiency, adequate actions have not yet been made to achieve zero energy consumption by combining renewable energy sources. On the other hand, since local needs for energy efficiency and decarbonisation are increasing, institutional design for promoting capacity development, and awareness building of energy efficiency will be conducted in order to promote energy efficiency, including the introduction of Zero Energy Building.
Contents	(a) ・ Review the energy efficiency design standards (including the thermal regulation buildings code (RTCM)) for buildings and assist with the formulation of Morocco's own Zero Energy Building guidelines that meet international standards (through long-term and short-term expert dispatch). ・ Assist with the establishment of Zero Energy Building ISO/TS in Morocco ・ Provide the information on the measures to support the spread of Zero Energy Building and Zero Energy House in Japan (finance, policy goals, supporting networks for construction and design company support network, etc.) to policy makers ・ Implement pilot projects (including renewable energy, energy efficiency, storage batteries, and EV linkage) for public buildings. Electricity from installed renewable energy sources can be used to charge EVs, which can then be used as moving storage batteries in the event of a disaster etc. If surplus electricity is generated, it is supplied to the grid. ・ Support the diffusion of inverter air conditioners with superior energy-saving performance (providing information through online seminars and publicity videos, etc.) ・ Implement pilot projects to observe Zero Energy Building, Zero Energy House and inverter air conditioners in Japan (b) ・ Finance the expansion of Zero Energy Building investments by the private sector in Morocco, taking advantage of JICA instruments such as two-step loans and overseas investments and loans, and considering the employment of blended financing schemes. ・ Capacity building for companies and financial institutions in Morocco on deepen their understanding of the Zero Energy Building concept (through online or offline seminars) and share experiences of Japan.
Expected Impacts	Expanding investments in Zero Energy Building equipped with renewable energy and EVs in Morocco and increasing private investment.
Target State(s)s	Nationwide
Counterparts	・ Ministry of Energy Transition and Sustainable Development

(C/P)	・ AMEE ・ SIE
Expert Composition	・ Energy efficiency and renewable energy (Zero Energy Building) policy experts (a) ・ Energy efficiency and renewable energy (Zero Energy Building) promotion experts (a) ・ Energy efficient technology experts (a), (b) ・ Renewable energy technology and grid interconnection expert (a) (b) ・ Finance expert (including blended financing) (b) ・ Economics and financial analysis experts (b)
Implementation period (approx. duration)	From FY2022 onward (5 years)

(4) Indonesia

In the 'Data Collection Survey on Power Sector in Indonesia for Decarbonization', the following five masterplanning measures are proposed as priority support measures.

In response to this proposal, the following details of support for cooperation in masterplanning are being considered.

Proposal #1 Formulation of the Entire Ammonia Supply Chain (Master Plan)
Proposal #2 Formulation of LNG Master Plan
Proposal #3 Development of Master Plan for Introduction of CCS (CCUS) in Indonesia
Proposal #4 Study on Detailed Long-Term Vision for Power Development
Proposal #5 Formulation of Power System Master Plan

■ **Proposal #1 Formulation of the Entire Ammonia Supply Chain (Master Plan)**

<u>Program Objective</u>

To establish a supply chain of ammonia for massive consumption for power generation

Background	In the power sector, the fuel switching from coal to ammonia can contribute to following paths towards the accomplishment of carbon neutrality by 2060 according to “Decarbonization of ASEAN Energy System: The Optimum Technology Selection Model Analysis up to 2060” released by ERIA and IEEJ (presented at Asia Green Growth Partnership Ministerial Meeting (AGGPM) held on 25th April 2022.) IHI and PJB plan to jointly conduct technical studies on boilers at some locations including PJB’s Gresik Thermal Power Plant with a view to ammonia co-firing down the track. In order to expand the use of ammonia as fuel, it is necessary to build a large-scale supply chain by developing the technologies to reduce supply costs, while the technology for high-ammonia co-firing of 50% or more needs to be developed. Ammonia has already been used commonly as a raw material for chemical fertilizer, and Indonesia is the third largest exporter of ammonia in the world. With these backgrounds, JICA proposes to develop a master plan to formulate the entire ammonia supply chain
Contents	- Demand forecasting for ammonia for electricity generation - Estimation of procurement cost of ammonia (green ammonia and

	blue ammonia) - Review of the availability of supply chain from production, through storage and transportation, to consumption at the power plants. - Examination of the expansion of ammonia supply (including the expansion of existing ammonia production capability and the construction of new production facilities) - Examination of the favorable regulatory framework for the expanded use of ammonia: management of toxic material etc. - Examination of storage and transportation: Ammonia is considered as a carrier of hydrogen.
Expected Impacts	With the master plan of the entire supply chain, the governmental authorities and the industry will be able to consider critical issues to be resolved and plan specific projects.
Counterparts (C/P)	• Ministry of Industry, MEMR • PLN
Expert Composition	- Thermal (coal-fired) engineer, manufacturer of co-firing units, producer of ammonia, transporter (including export/import) of ammonia, toxic material management, regulators, etc.
Implementation period (approx. duration)	2023 or later (as early as possible)

■ **Proposal #2 Formulation of LNG Master Plan**

<u>Program Objective</u>

To establish a long-term plan for the expansion of LNG projects in Indonesia

Background	As a conclusion of "Data Collection Survey on Power Sector in Indonesia for Decarbonization" (JICA, March 2022), it is recognized that LNG-fired power plants (including CCS implementation) will be necessary as a part of power supply mix in 2060 and as a bridge toward the goal of carbon neutrality in 2060. While LNG has already been introduced in Indonesia, most of the receiving terminals are floating storage and regasification units (FSRU), and it is necessary to consider the introduction of onshore LNG receiving terminals with excellent scalability and the construction of peripheral infrastructure such as pipelines. In particular, port and storage facilities are very costly and it may be more economical to build them as shared facilities (among multiple power plants) rather than to build them at each plant. Considering these issues, it is important to formulate a master plan for the development of LNG receiving terminals and pipelines, and to proceed with the construction of facilities in accordance with the masterplan.
Contents	- Selection of candidate sites for LNG receiving terminals (considering the location of the existing power plants and future power plant locations) - Consideration of proper scale of LNG receiving terminals (number of berth, capacity and number of storage facilities and vaporizers

	etc.) - Development plan of pipeline network connecting LNG terminals and power plants - Consideration of the utilization of LNG for the purposes other than power generation
Expected Impacts	With the nationwide long-term master plan, the governmental authorities for the energy industry and PLN will be able to determine the priority of LNG terminal development in accordance with the development of power plants.
Counterparts (C/P)	・ MEMR ・ PLN
Expert Composition	
Implementation period (approx. duration)	From 2023 onward. It is desirable this LNG master plan study will be implemented in parallel with the creation of the power development master plan (Proposal# 4). If implemented separately, the study for the LNG master plan shall be implemented in advance of Proposal#4.

Proposal #3 Development of Master Plan for Introduction of CCS (CCUS) in Indonesia

Program Objective

To establish a long-term plan for the development of CCS (CCUS) in Indonesia

Background	According to RUPTL 2021-2030, thermal power generation will be operated during this period and they may continue to be utilized beyond 2030 as they can provide the flexibility to the power system. In order to accomplish the carbon neutrality, the introduction of CCS (CCUS) will be quite important as far as thermal power generation continues to be operational. Different types of technologies for CO2 capture/sequestration and their conformity to each type of thermal plants were already briefly examined in "Data Collection Survey on Power Sector in Indonesia for Decarbonization" (JICA, March 2022) Five CCS projects are being developed in Indonesia: Gundih CCUS, Sukowati Co2-EOR, Tangguh CCUS, Sakakemang CCS, and PAU Central Sulawesi Clean Ammonia project. The Government of Indonesian has been preparing laws and regulations on CCS. A presidential decree on CCS was drafted in March 2019 and is now in the process for governmental approval. The CCS approval process will deal with 1) Definition of CCS and its regulation, 2) establishment of committees, 3) required documents for permit application, 4) post-injection monitoring period, and 5) transfer of long-term liability after the CCS site is closed .
Contents	- Survey of suitable sites for CO_2 storage in Indonesia; - Study on CO_2 emissions from thermal power plants (Estimation of CO_2 emissions during the period when thermal power generation is used) - Study on configuration of CO_2 transport pipeline network/shipping scheme; and - Selection of sites for demonstration tests of the combination of thermal power plants and CCS, based on the feasible CO_2 storage

	sites and the current status of the existing thermal power plants (coal and gas)
Expected Impacts	Based on the result of this master plan, it is proposed to implement a feasibility study and demonstration tests of CCS at specific locations with technical assistance from a third country with adequate expertise such as Japan.
Counterparts (C/P)	• MEMR • PLN
Expert Composition	-
Implementation period (approx. duration)	From 2023 onward

■ **Proposal #4 Study on Detailed Long-Term Vision for Power Development**

Program Objective

To establish a long-term power development plan taking account of various components such as renewable energy and other decarbonization technologies.

Background	In "Data Collection Survey on Power Sector in Indonesia for Decarbonization" (JICA, March 2022), simplified demand forecasting was conducted with limitation of time and data availability. While the Survey overviewed the electricity demand and generation capacity for four major grids, i.e., Sumatra, Java-Bali, Kalimantan, and Sulawesi were overviewed, a more detailed examination is expected. As a result of the discussions during the above survey, it was recognized that the detailed demand forecasting needs to be implemented based on economic indicators and the accumulation of major electricity-consuming equipment, and that the power development plan should be revised based on the updated demand forecasts.
Contents	- Detailed demand forecasting: Forecasting based on economic indicators and the accumulation of major electricity-consuming equipment etc. - Study on changes in load curves based on the introduction trend of EVs and intermittent renewables - Detailed study on future generation mix based on estimated hourly changes in demand in each grid (peak load time, midnight rate, daily load factors, etc.) considering fluctuating VRE. - Formulation of a long-term power development plan reflecting a fuel conversion plan (including co-firing) and a retirement plan for the existing coal-fired power plants in consideration of their respective COD date. - Study on potential locations and generating capacity for each type of generation such as hydro, PV, wind and thermal plants with CCS, etc. - For this study, the following professionals will need to be deployed: Demand forecasting engineer, (macro-) economist, engineers of each type of generation (thermal, various renewables), power system engineer, etc.

	Note: In order to formulate a consistent plan, it is better to implement an integrated master plan study including LNG (Proposal# 2) and power system (Proposal# 5) in the same project. However, if they are carried out separately, the master plan study of LNG should come first, followed by the power system master plan which will require the result of the LNG study. In this regard, the power development plan may need to be modified due to possible restrictions on power system development plan (Proposal# 5) as they are closely corelated.
Expected Impacts	- With this master plan study, PLN will be able to identify the priority of power development projects. - The result of the power development plan will be the basis of the following power system master plan (Proposal# 5).
Counterparts (C/P)	・ MEMR ・ PLN
Expert Composition	-
Implementation period (approx. duration)	Ideally in parallel with LNG master plan (Proposal# 2) or thereafter. Prior to the power system master plan (Proposal# 5)

■ **Proposal #5 Formulation of Power System Master Plan**

Program Objective

To establish a transmission master plan enabling the prioritization of electricity transmission facilities (transmission lines and substations) to be constructed in consistence with the power development plan.

Background	Since the generating capability of PVs depends on climate conditions, it is highly likely that locations suitable for the installation of PVs will be dispersed across the country, and in case those locations are concentrated in a specific area without transmission facilities which can accommodate the generating capacity fully, a shortage of transmission capacity may occur, which may lead to the curtailment of generation outputs. Therefore, it is necessary to periodically confirm the consistency between the generation development plan and the transmission network expansion plan from a viewpoint of both middle- and long-term, and it is important to extend the period covered by the master plan, shorten the planning cycle and improve the accuracy of the plan. While “Data Collection Survey on Power Sector in Indonesia for Decarbonization” (JICA, March 2022) overviewed the power system in four main grid, i.e., Sumatra, Java-Bali, Kalimantan, and Sulawesi, a more detailed examination is expected.
Contents	- Overview of the long-term (30 to 40 years) power system situation based on the power development plan - Power flow analysis based on power development plan; - Examination of fault current; - Ensuring system stability, ; - Plan of transmission and substation facilities; and - Examination of priority projects (including possible modification of the preceding power development plan based on the result of

	power flow analysis)
Expected Impacts	- With this master plan study, PLN will identify the priority of transmission projects to be developed. - PLN will recognize the importance of periodical review of generation and system studies.
Counterparts (C/P)	• PLN
Expert Composition	System planning engineers, transmission and distribution engineers, demand forecasting engineers, power generation engineers for each generation technology, etc.
Implementation period (approx. duration)	Following the power development master plan study (Proposal# 4). It is ideal to update the study periodically with a few years' interval.

3.3 Consideration of Pilot Project Implementation

3.3.1 Project Selection and Overview

Consideration was given to implementing pilot projects in the target countries that would be effective for the formation of projects designed to achieve a low-carbon/decarbonized society.

The government policy in India will be increasingly oriented towards a carbon neutral approach in the future, and introduction of renewable energy, energy conservation measures, etc. are being promoted. On the other hand, while interest in zero energy buildings (ZEB) is growing in the field of buildings, it has not reached the stage of concrete projects.

In this survey, it was decided to conduct a pilot project which will help promote the popularization of ZEB in India through the identification of issues/challenges that need to be addressed to achieve ZEB by combining renewable energy and energy efficiency, and with proposals for solutions based on examples from Japan.

An overview of the pilot project is described below.

Table 267 Overview of Pilot Projects in India

Objective	Perform demonstration of package that integrates energy efficiency and renewable energy in order to promote Zero Energy Building concepts in India, with the objective of reducing energy demand, accelerating the introduction of renewable energy, reducing reliance on fossil fuels, thus contributing to the reduction of greenhouse gas (GHG) emissions.
Implementing Agency	Convergence Efficiency Services Limited (CESL) * A portion will be performed in cooperation with The Confederation of Indian Industry (CII), and technical advice from Japan will be provided by Advantec Co., Ltd.
Implementation Period	November 2021 – July 2022
Content	a) Selection of Target Building A medium scale building will be selected as the target for this demonstration. Before the final selection is performed, a walk through energy audit will be conducted for about 10 buildings. b) Implementation of Energy Audit A detailed energy audit will be implemented by an authorized energy auditor according to the protocol defined by the Bureau of Energy Efficiency. c) Design of Energy Efficiency Measures/ Solar photovoltaic power generation / Control System Design of the energy efficiency measures/ solar photovoltaic power

	generation / control system will be performed while receiving technical advice from Japan. d) Measurement, Reporting and Verification of Energy Efficiency Surveys will be conducted in India and Japan using the MRV (Measurement, Reporting and Verification) methodology, and the suitable method for evaluation of the ZEB performance in India will be identified. e) Consideration of Challenges, Issues and Solutions Challenges/Issues that need to be addressed in order to make the target projects commercially viable shall be identified and appropriate considerations will be given to solutions to these challenges/issues, including financial assistance and technical assistance for the introduction or revision of relevant policies, rules, and regulations. Furthermore, when challenges/issues and solutions are discussed, the need for technical and financial assistance will be confirmed through discussion with the BEE (Bureau of Energy Efficiency) and MoHUA (Ministry of Housing and Urban Affairs). f) Organization of Knowledge Concerning ZEB Implementation in India A report will be made on the lessons learned through the implementation of the project, including ZEB evaluation, ZEB ISO, glass selection, insulation, battery design, and cleaning of air conditioners and other activities. g) Study of EV as ZEB Configuration Element Policies, regulations and procedures concerning the promotion of EVs in India will be summarized, current and potential challenges/issues and solutions will be discussed in order to verify the possibility of adopting EVs in the future as a ZEB component. h) Submission of Final Report

3.3.2 Results of project implementation

Walkthrough audits had been conducted for 10 building projects to explore present energy efficiency and renewable energy generation status. Also, estimation made to identify additional capacity of Renewable Energy system which can be installed to off-set grid energy use to the maximum extent. Detailed related to building components such as building envelope, lighting system, air-conditioning, equipment, motors, renewable system etc were collected through the site visit.

Table 268 Results of pilot project

Building Name	Energy Performance Index (kWh/m2/year)		EEC Ratio (%)		RE Ratio (%)		ZEB Ratio (%)	
	Existing	Potential	Existing	Potential	Existing	Potential	Existing	Potential
India International Institute of Democracy and Election management	52	47	26	29	15.8	26.4	41.6	55
National Investigation Agency (NIA)	-	-	6	38	0	13.5	5.8	51.4
Steel Authority of India Limited (SAIL)	169	123	-16	27	2.8	31.2	-13.6	57.9

Western Printing Group	60	57	48.3	50	0	44.8	48.3	94.5
Central Revenues Control Laboratory (CRCL)	71	68	20	21	0	78.4	19.9	99.3
State Bank Academy	110	51	9	54	17	21	26	75
Gas Authority of India Limited (GAIL) Jubilee Tower	207	166	42	45	1.1	2.2	43.5	48
National Institute of Food Technology Entrepreneurship and Management (NIFTEM)	29	27	32	32	93.8	93.8	126	100
Oil and Natural Gas Corporation (ONGC)	169	136	6	30	7.2	10.5	12.8	40.6
Northern Railways Hazrat Nizamuddin Railway Station (NZM)	56	48	9	23	48.3	56.2	57.8	79.4

Detailed energy audit carried out for two projects – CRCL and WPG. Both the building projects have potential in improving energy efficiency at least by 10-15% and adequate spaces are available to add renewable energy capacity. These RE system capacity can enable the projects to become Net Zero or ZEB ratio can be more than 80% which shows projects are Near Net Zero.

Since solar panels are inexpensive in India, at about 1/3 of the price level in Japan, it was confirmed that the economic rationale for ZEB introduction is high compared to Japan. Therefore, it is expected that Japan's ZEB introduction support measures will be introduced to India through technical cooperation, and various types of financial cooperation will be provided in the future.

3.4 Exchange of views with relevant organizations on infrastructure system exports

Prior to conducting the field survey, in addition to the Ministry of Economy, Trade and Industry (METI) and the Ministry of the Environment, we held meetings with the Tokyo Metropolitan Government, Yokohama City, and Kitakyushu City to exchange opinions and confirm the possibility of collaboration and future policies.

Furthermore, after conducting interviews with relevant local organizations in India, we exchanged opinions with the Japan Iron and Steel Federation (JISF) as a related organization in Japan. We shared local needs and discussed possible cooperation with Japan. The status of cooperation between the Japan Iron and Steel Federation and the Indian side is as follows.

- The Japan-India meeting was held in 2011 and has been held annually since then, with the exception of FY 2019 and FY 2020. The FY2021 meeting was held online in January.
- So far, diagnostics of steel mills in India have been conducted. After diagnosing the operation status of facilities and energy use, we conducted diagnostics for energy conservation and CO2 reduction based on international standards, and introduced the required technologies to the local market.
- In addition, an Indian version of the customized list of technologies was created and shared with the Indian side, and the local side has requested that this activity be continued in the future. Although it is difficult to link this to the actual introduction of the technology, the local side is considering the introduction of the technology.

4. Analysis, Compilation, and Dissemination of Information Related to Low-carbon and Decarbonization Energy

4.1 Cluster Discussions

In February 2022, we proposed the following as a draft of the cooperation program in India at that time as a material for the JICA cluster discussion.

Table 269 Candidate for Cooperation Program in India

No.	Project Name	Outline
1	Feasibility study on ammonia co-firing	To investigate the feasibility of introducing ammonia co-firing as a measure to reduce carbon dioxide emissions from coal-fired power plants, which account for a large share of power generation in India.
2	Grid stabilization measures for mass introduction of VRE	Technical cooperation on output adjustment of existing coal-fired power generation for the purpose of promoting mass introduction of VRE.
3	Biofuel production or biomass co-firing using rice straw	Demonstration project of biofuel production or biomass co-firing using rice straw as a response to the problem of incineration of agricultural residues (rice straw), one of the causes of air pollution in India, and as a contribution to low-carbon society.
4	Optimization of distribution system operations	Support for grid design and operational optimization to promote decarbonization at the distribution level, combining VRE, DR, EMS, etc.
5	Support for the introduction of heat pumps in the industrial sector	Although the introduction of industrial heat pumps is promising for the future, the current investment environment in India, including regulatory development, is not yet in place. Therefore, a roadmap for the introduction of industrial heat pumps will be developed, necessary regulations and policies will be organized, and a blended finance scheme will be studied to promote corporate investment.
6	Support for ZEB implementation	To promote the introduction of renewable energy combined with energy conservation for the introduction of ZEB in India.
7	Support for the Steel Sector	India is the world's second largest producer of steel and its associated CO2 emissions account for about 5% of the country's total emissions. India's interest in Japan's low-carbon technology (in the steel sector) is very high.

4.2 Study Materials for BBL

At the BBL (study meeting) held inside JICA in June 2022, an overview of the quantitative energy analysis model, model analysis in Europe, model analysis in Japan, and model analysis of carbon neutrality targeting ASEAN were explained.

Table 270 BBL Overview

Theme	Introduction to Quantitative Energy Analysis Models
Date and Time	June 2, 2022 12:30pm - 1:30pm
Type of event	Online Conference
Speaker	Yuji Matsuo, Institute of Energy Economics, Japan
Participants	JICA staff related to low-/de-carbonization projects and members of this study team.

4.3 Collection of Updates and Regular Summary Information in Technology, Policy, Institutions and Business on Low and Decarbonisation

From January 2021 to June 2022, monthly updates related to low-/de-carbonisation were collected and reports were prepared on specific themes. For updates, information was collected and summarised on developments in the Japanese Government, manufacturers, energy companies and financial institutions, developments in other governments and donors, and a list of reports published by international organisations for that month. For the preparation of reports on specific themes, the following themes were compiled.

Table 271 Specific themes

	Specific Themes
Jan.2021	I Key points of the IEA "Energy Efficiency 2020" - COVID-19 and low-/de-carbonisation
Feb.2021	Overview of hydrogen strategies in Japan, Germany and the EU
Mar.2021	Sustainable finance and information disclosure
Apr.2021	Start-ups contributing to low and decarbonisation in developing countries
May.2021	German energy cooperation policy for Africa from IRENA "The Renewable Energy Transition in Africa"
Jun&Jul.2021	Comparison of decarbonisation strategies of Japanese electricity and gas companies
Aug.2021	Overview of IRENA ”Integrating low-temperature renewables in district energy systems: Guidelines for policy makers2021”
Sep.2021	Carbon pricing overview and latest developments
Oct.2021	Discussion points for COP26
Nov.2021	Latest trends in transition finance in ASEAN and EU
Dec.2021	Trends in low-carbon technologies for thermal power generation
Jan.2022	Decarbonisation trends in the maritime and aviation sectors
Feb&Mar.2022	Trends in other donor support in the decarbonisation sector
Apr.2022	Energy Transition in ASEAN" by Japan and Europe and Japanese version of 'transition finance' trends
May.2022	Trends in accounting and reporting of GHG emissions from business activities and product distribution
Jun.2022	International relations around hydrogen

5. Future Cooperation Policy in the Hydrogen Sector

5.1 Cooperation Patterns in the Hydrogen Sector

This section summarizes the cooperation patterns in the hydrogen sector for developing countries around the world, intending to provide a reference when considering future hydrogen-related cooperation projects for developing countries.

According to the IEA (2021)[750], global hydrogen demand under the NZE scenario will increase from less than 90 Mt H_2 in 2020 to more than 200 Mt H_2 in 2030. Furthermore, hydrogen demand is expected to reach 530 Mt H_2 by 2050, with the industrial and transportation sectors accounting for half of this demand.

The industrial sector accounts for more than 50 Mt H_2 of hydrogen demand in 2020; under the NZE scenario, industrial sector hydrogen demand grows from about 50 Mt H_2 in 2020 to about 140 Mt H_2 in 2050, and transportation sector demand increases from less than 20 kt H_2 in 2020 to 100 Mt H_2 in 2050. The use of hydrogen in the power generation sector is also expected to expand. For example, hydrogen co-firing in gas-fired power plants and the use of stationary fuel cells to balance the large introduction of variable renewable energy and seasonal fluctuations are possible applications. Currently, hydrogen use in the power generation sector is less than 0.2%.

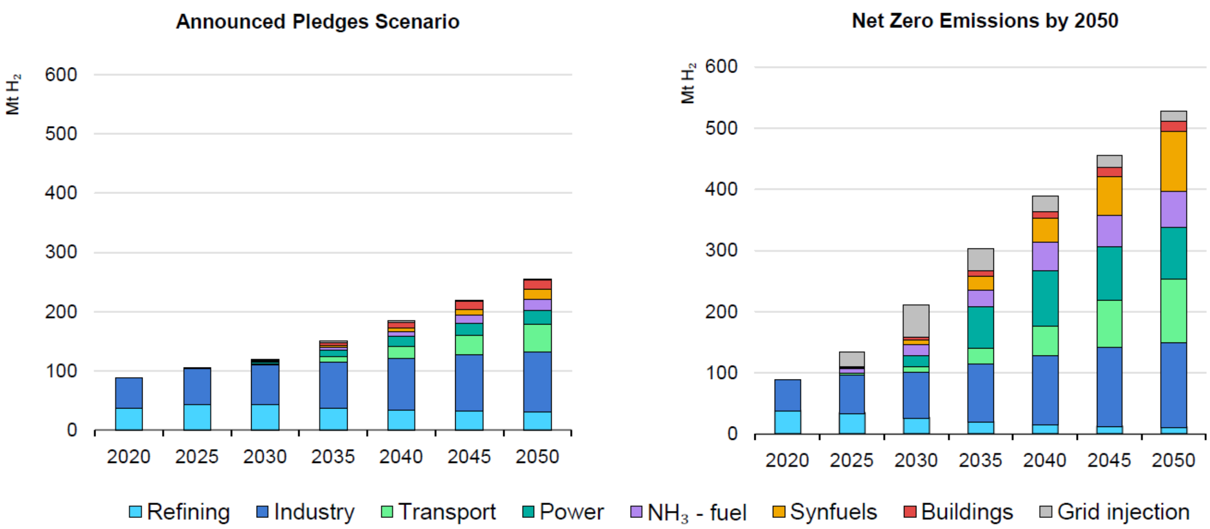

Figure 304 Global hydrogen demand by sectors in APS and NZE (2020-2050)

Source: IEA, Global Hydrogen Review 2021

5.1.1 Grouping of Target Countries

Developing countries are grouped according to the following procedures:

(1) Select countries in the income bracket that are potentially eligible for JICA assistance from the World Bank's income bracket classification.

(2) Classify countries into four quadrants based on hydrogen production potential and the ratio of the industrial sector to final energy consumption.

(3) Examine the potential for hydrogen production and use in the country by referring to additional indicators.

(1) Select countries in the income bracket that are potentially eligible for JICA assistance from the World Bank's income bracket classification

[750] IEA (2021), "Global Hydrogen Review 2021", https://www.iea.org/reports/global-hydrogen-review-2021.

We applied the same procedure for selecting developing countries among target countries described in Section 1.2 here. Countries are selected from the World Bank's income bracket classification (Upper-middle income, Lower-middle income, and Low income) that could be eligible for JICA assistance. However, countries without IEA energy balance table, such as small island countries and conflict areas, are excluded.

(2) Classify countries into four quadrants based on hydrogen production potential and the ratio of the industrial sector to final energy consumption

First, we estimate "green hydrogen production potential" of each country based on IRENA (2022)[751]. Here, green hydrogen is taken up as hydrogen production, which has the potential to be used as a domestically produced resource along with the expansion of renewable energy. In countries which can produce blue hydrogen, CCS can be feasible domestically. In that case, the combination of fossil fuel-fired power generation and CCS is considered to be efficient. Therefore, blue hydrogen production is excluded from consideration. The hydrogen production potential is estimated based on the hydrogen technical potential under optimistic assumptions of IRENA (2022). The potential amount shown for each region is divided by the area of each country in the region.

We also calculate "share of the industrial sector in final energy consumption" based on the IEA energy balance table. Here, we pick up the industrial sector's share of final energy consumption since the industrial sector's demand for high-temperature heat is one of the representative hydrogen demands. Below are the four quadrant classifications and the distribution of countries by income bracket.

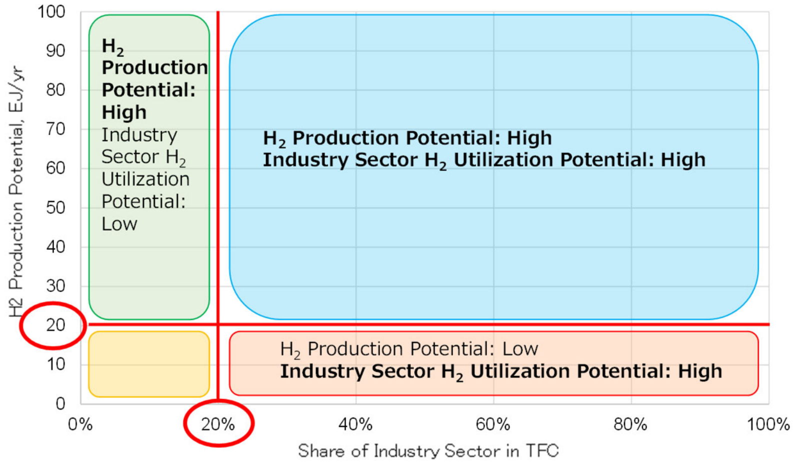

Figure 305 Four-quadrant classification based on green hydrogen production potential and industrial sector share of final energy consumption

Note 1: The reference values for dividing the quadrants (green hydrogen production potential of 20 EJ/yr, industrial sector ratio of 20%) are set with reference to the median values for the target.

Note 2: The third quadrant is "H_2 Production Potential: Low, Industry Sector H_2 Utilization Potential: Low".

Source: Author

751 IRENA (2022), "Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Part III Green Hydrogen Cost and Potential", https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost.

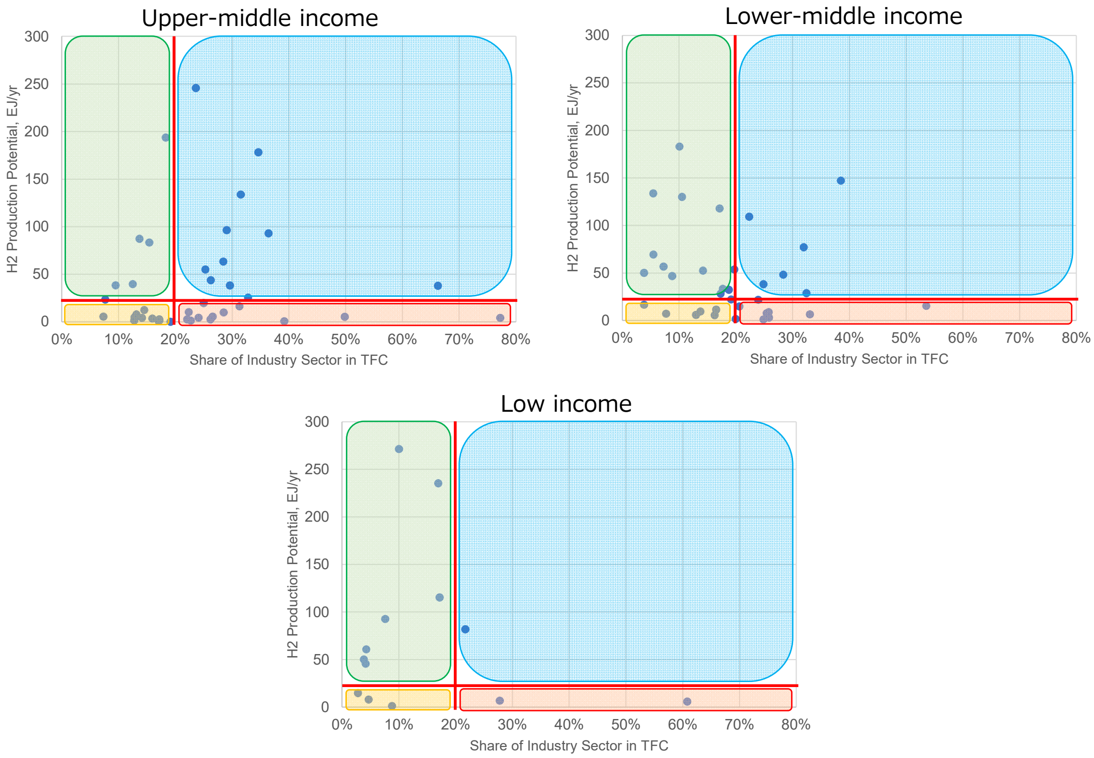

Figure 306　Four-quadrant classification by income bracket

Source: Author

(3)　Examine the potential for hydrogen production and use in the country by referring to additional indicators

We propose to refer to the following four items as additional indicators on a country-by-country basis when examining the hydrogen demand and supply potential of the target countries.

First, the share of variable renewable energy in the current electricity generation, based on the IEA energy balance table. Here, variable renewable energy refers to solar photovoltaic and wind. If the share of variable renewables is high, the country can be said to have a high priority for grid stabilization needs. This may be helpful in considering individual demonstrations such as the use of hydrogen for grid balancing.

Second is the share of diesel in final energy consumption of the transportation sector (road), based on the IEA energy balance table. It should be noted that diesel is considered here as heavy-duty vehicle (and public transport) use. If the share of diesel is high, it can be said that there is potential for hydrogen use in heavy-duty vehicles and others in the transportation sector.

Another indicator that can be used as a reference is the cost of green hydrogen production in a country or region. Here, levelized cost of hydrogen (LCOH) at the national and regional level are estimated with reference to IRENA (2022). However, it should be noted that the data is limited to some countries and regions.

Finally, it is also necessary to take into account the status of hydrogen strategy development in each country: according to the World Energy Council (2021)[752], upper-middle income and lower-middle income countries are in the stages of “Strategy in preparation”, “Policy discussions”, and “Initial demonstration projects. discussions, official statements, and initial demonstration projects”.

[752] World Energy Council (2021), “Working Paper National Hydrogen Strategies”, https://www.worldenergy.org/publications/entry/working-paper-hydrogen-on-the-horizon-national-hydrogen-strategies.

5.1.2 Concepts for Analyzing Cooperation Patterns

This section summarizes the concept for analyzing cooperation patterns based on the four-quadrant classification presented in 5.1.1, further taking into account the status of the development of hydrogen strategies.

Table 272 Concepts for analyzing cooperation patterns

Group	Hydrogen Strategy: In Consideration	Hydrogen Strategy: No Consideration
Green H_2 Production Potential: High Industry Sector H_2 Utilization Potential: High	・ Hydrogen production: Demonstration of optimal system operation, including maximum use of VRE and balancing grid. Technical cooperation on institutional design for optimal system operation. Yen loans and other financings for the implementation of electrolysis equipment and control systems for optimal operation and management. ・ Domestic hydrogen transportation and storage: Demonstration of related technologies and technical cooperation. Technical cooperation on safety standards and legal system design. ・ Demonstration of hydrogen and synthetic fuel utilization methods in the industry, transportation, and power sectors. Technical cooperation on related safety standards and legal system design (see long list for specific demonstration project proposals). ・ In case of high VRE ratio in power generation: Yen loans and other financings for deploying stationary fuel cells. ・ In case of high diesel share in transportation (road) energy consumption: Yen loans and other financings for the development of hydrogen refueling infrastructure to promote the spread of fuel cell vehicles.	・ Support for the formulation of a hydrogen strategy based on the country's industrial structure. ・ Technical cooperation for reducing the cost of hydrogen production.
Green H_2 Production Potential: Low Industry Sector H_2 Utilization Potential: High	・ Likely to consider (green or blue) hydrogen imports. Technical cooperation on legal and institutional design related to hydrogen imports and storage. ・ Development of facilities for import, domestic transportation, and storage. Demonstration of actual operation. Technical cooperation on the development of safety standards for facilities and operations. Provision of yen loans and other financings for infrastructure development. ・ In case of high diesel share in transportation (road) energy consumption: Yen loans and other financings for the development of hydrogen refueling infrastructure to promote the spread of fuel cell vehicles.	・ May consider future (green or blue) hydrogen imports. ・ Support the development of a phased hydrogen strategy based on a study of hydrogen demand and the timing of the establishment of international hydrogen trade.

	• Hydrogen co-firing in the power sector: Master planning, technical cooperation, and demonstration for the introduction of co-firing. Yen loans and other financings for co-firing equipment and infrastructure development.	
Green H_2 Production Potential: High Industry Sector H_2 Utilization Potential: Low	• Likely to consider (green or blue) hydrogen exports. Development of manufacturing facilities for hydrogen export carriers and related equipment for export and demonstration of actual operations. Yen loans and other financings for infrastructure development. • Domestic hydrogen transportation and storage: Demonstration of related technologies and technical cooperation. Technical cooperation on safety standards and legal system design. • In case of high VRE ratio in power generation: Yen loans and other financings for deploying stationary fuel cells. • In case of high diesel share in transportation (road) energy consumption: Yen loans and other financings for the development of hydrogen refueling infrastructure to promote the spread of fuel cell vehicles.	• Support for conducting a study of hydrogen demand. • Technical cooperation for reducing the cost of hydrogen production.
Green H_2 Production Potential: Low Industry Sector H_2 Utilization Potential: Low	• Support for conducting a study on potential for hydrogen demand in a country in order to prepare materials for future hydrogen strategy development.	

Source: Author

5.2 Organizing Basic Information for Hydrogen-related Support in Priority Study Target Countries

This section makes an analysis for the purpose of stimulating discussion on hydrogen utilization and its relevant support in the priority study target countries of Thailand, Indonesia, Morocco, and India. The following sections 5.2.1 and 5.2.3 are common to all four countries, while only 5.2.2 is organized by each country. The time horizon of the analysis is the period up to 2050.

5.2.1 Properties of Hydrogen and Various Synthetic Energies

Table 273 List of properties of hydrogen and synthetic fuels

	Hydrogen	Synthetic methane	Synthetic methanol	Ammonia
Energy per unit weight (LHV) (MJ/kg)	120 MJ/kg	48.6 MJ/kg (LNG)	19.9 MJ/kg	18.6 MJ/kg
Energy per unit volume (LHV) (GJ/m^3)	8.5 GJ/m^3 (liquid)	20.8 GJ/m^3 (LNG)	15.8 GJ/m^3	11.5 GJ/m^3 (liquid)

Energy loss during production	Present: 25% – 35% Future: 18%	Present: 40% – 45% Future: 15%	Present: 40% – 48% Of which - Water electrolysis of hydrogen: 25% – 35% - Methanol synthesis: approximately 20%	Present: 36% – 45% Of which - Water electrolysis of hydrogen: 25% – 35% - Ammonia synthesis: approximately 15%
Precautions in handling	Non-toxic Highly flammable, explosive	Non-toxic Same as natural gas	Toxic (Humans naturally generate methanol in their bodies, but because methanol is toxic, increasing the methanol load in the body causes toxic symptoms)	Acute toxicity
Advantages and disadvantages of the supply infrastructure	No maritime transport infrastructure; Domestic supply infrastructure available	Existing infrastructure available	Existing infrastructure available; Requiring new infrastructure investment for large-scale use	Existing infrastructure available; Requiring new infrastructure investment for large-scale use

Source: IEA[753]; IRENA[754]; the Ministry of Economy, Trade and Industry[755]

Green hydrogen and synthetic fuels derived from green hydrogen (synthetic methane, synthetic methanol, ammonia, etc.) can contribute to decarbonization in various business sectors. Although hydrogen can be produced from a variety of raw materials, projects of hydrogen production through water electrolysis using power from renewables are underway all over the world. The energy loss rate of hydrogen production through water electrolysis currently remains at 25% to 35%, but it is expected to be reduced to 18% in the future. Hydrogen has a large calorific value per unit mass, but has a small calorific value per unit volume, which makes storing and transporting hydrogen at high densities challenging. The method of transporting hydrogen in the form of high-pressure gas is widely used. Pipelines are the most economical means to transport large amounts of hydrogen. In Japan, hydrogen pipeline development is limited to demonstration, but in Europe, plans are underway to form a hydrogen pipeline network in the future by utilizing the existing network of natural gas. Although hydrogen is non-toxic it is highly flammable and explosive, measures must be taken to ensure safety when handling it.

Synthetic methane and synthetic methanol are typical synthetic fuels produced from green hydrogen and captured CO_2. These are hydrogen carriers that can effectively utilize existing infrastructure. In the

[753] IEA, Technology Collaboration Programme on Advanced Motor Fuel, https://www.iea-amf.org/content/fuel_information/ammonia#properties

[754] IRENA (2021), "Innovation Outlook Renewable Methanol", https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jan/IRENA_Innovation_Renewable_Methanol_2021.pdf

[755] Material for the first meeting of Subcommittee on Hydrogen Policy, the Ministry of Economy, Trade and Industry, "Current Situation Surrounding Hydrogen and Ammonia and Future Direction of Study" (March 29, 2022), https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/001_03_00.pdf

case of synthetic fuels, CO_2 emitted during combustion is the captured CO_2, so that there are no additional CO_2 emissions over the whole lifecycle. For the transportation and storage of synthetic methane, existing infrastructure for LNG/natural gas and existing facilities for city gas can be used as they are. For the production of synthetic methane (methanation) energy loss happens in two steps: water electrolysis and Sabatier reaction. Currently, the overall thermal efficiency of methanation (including water electrolysis of hydrogen) remains at approximately 55% to 60% (energy loss of 40% to 45%), but the overall efficiency of innovative methanation technologies under development, such as SOEC co-electrolysis, can reach as high as approximately 85% [756](energy loss of 15%)[757].

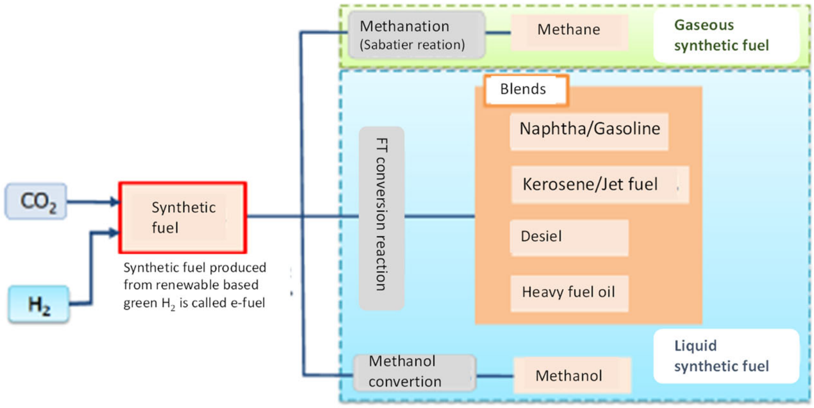

Figure 307 Overview of synthetic fuels produced from hydrogen and CO_2

Source: Synthetic Fuel Study Group[758]

Methanol can be a raw material for the production of various chemicals. In addition, since it is in liquid form at ordinary temperature and normal pressure, it can be used as fuel for automobiles and ships. Methanol currently used is derived from fossil fuels, but methanol produced from green hydrogen and captured CO_2 is also called e-methanol. Methanol is easy to transport because it is a liquid form at ordinary temperature and normal pressure, and it is already widely used in the chemical industry. Therefore, the transport/storage infrastructure and relevant regulations are in place. Methanol is classified as a hazardous substance because of its toxicity. Energy loss in the production of e-methanol happens in two steps: water electrolysis and methanol synthesis. The overall energy loss is approximately 40% to 48%.

Ammonia is also a hydrogen carrier. The main usage of ammonia at present is the use as a raw material for fertilizers and the use for denitrification in thermal power plants. On the other hand, ammonia can also be used as fuel and green ammonia derived from green hydrogen is expected to serve as a green fuel since it emits almost no CO_2 throughout its life cycle from production to combustion. Technology development and demonstrations are being promoted for using ammonia for power generation and fuel for marine engines (ammonia engine). While the supply chain of ammonia is already in place, new infrastructure investments are required for the large-scale use of ammonia as a green fuel in the future. Since ammonia is highly toxic, it is ideal to intensively control it when used as fuel. For ammonia production, the Haber-Bosch method using hydrogen and nitrogen as feedstocks has been established. Energy loss in production of green ammonia happens in two steps: water electrolysis and ammonia conversion. Although the overall energy loss is 36% to 45% at present, technology development has been promoted to improve efficiency.

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[756] Example: Methanation using the collaboration reaction of SOEC/methane synthesis

[757] https://www.meti.go.jp/shingikai/energy_environment/methanation_suishin/pdf/007_03_01.pdf

[758] Synthetic Fuel Study Group, "Synthetic Fuel Study Group Interim Report (April 2021)," https://www.meti.go.jp/shingikai/energy_environment/gosei_nenryo/pdf/20210422_1.pdf

5.2.2 Analysis of Hydrogen Availability by Consuming Sector

In this section, sector-specific hydrogen demand potential is estimated as sector-specific hydrogen availability in four priority study target countries.

(1) Introduction

In principle, hydrogen demand in this study is based on the assumption that hydrogen is used as energy (combustion) on the premise of offsite hydrogen supply. In other words, hydrogen produced on-site and consumed as a raw material in the process of manufacturing industrial products is not in the scope.

The figure below shows the hydrogen utilization status in Japan. Currently, the majority of hydrogen utilization is for on-site hydrogen production and supply, and large-scale off-site hydrogen supply is extremely limited.

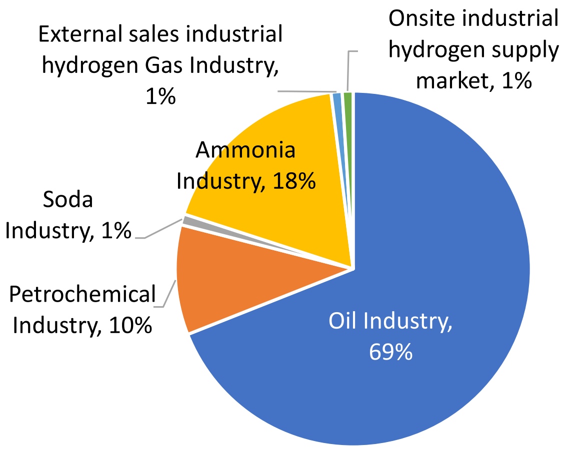

Figure 308 Current situation of hydrogen utilization in Japan

Source: Hydrogen Energy Utilization System Vol. 33, No.2 (2008)

At present, because there is almost no demand for hydrogen to be used as energy, it is difficult to estimate hydrogen demand using the model used for general demand estimation. In addition, since there are many uncertain factors about hydrogen, such as its utilization promotion policy, utilization technology, transport, and costs, it is quite difficult to predict future hydrogen demand.

Therefore, in this section, scenarios in which hydrogen is utilized are created, and the hydrogen demand potential based on the scenarios is estimated. Therefore, it should be noted that the hydrogen demand potential estimated in this section is an academic analysis instead of a demand outlook.

(2) Assumptions for estimation of hydrogen demand potential

Assumptions for estimating hydrogen demand potential are as follows.

1) Definition of hydrogen demand

The hydrogen demand potential in this study is limited to the usage as energy (combustion) and does not include the use as a raw material. However, the following new demand for ammonia is estimated.

- Direct combustion: Estimated by regarding it as hydrogen combustion
- Net imports: Estimated on the assumption that net imports are converted to domestic production

2) Points to note on estimation results

It is necessary to pay attention to the following points regarding the estimation results.

- Supply capacity and supply cost of hydrogen are not considered.

- Results are not linked with the other section on hydrogen in this study.
- Results are not reflecting the energy policies of each country including those for hydrogen.

3) Major premise of scenario creation

The major premise for the creation of scenarios is as follows.

- Strong policies exist for the promotion of hydrogen utilization
- However, even in 2050, hydrogen pipeline infrastructure will remain limited.
- The scenarios image the hydrogen demand potential on the scale of the advent of a hydrogen society.

4) Energy assumed to be replaced by hydrogen

- Power generation sector: Natural gas and coal
- Industrial sector: Natural gas,

  For ammonia, the amount of hydrogen contained in ammonia is estimated on the assumption that net import volume (import - export) is replaced by domestic production.
- Transport sector: Motor Gasoline and Diesel (Gas oil)

5) Baseline of the estimation

The baseline for estimating the hydrogen demand potential is as follows.

A) India, Indonesia, and Thailand

BAU Scenarios for 2040 and 2050 in "Energy Outlook 2021" of the Economic Research Institute for ASEAN and East Asia (ERIA)

Sector-specific data not included in the "Energy Outlook" of the ERIA are estimated for 2040 and 2050 with the sector-specific annual rates of the "Energy Outlook 2021" of the ERIA based on the numbers in "World Energy Balances 2021" of the IEA.

B) Morocco

Based on the "World Energy Balances 2021" of the IEA, the sector-specific growth rate in Africa in the "World Energy Outlook 2021" (Stated Policy Scenario) of the IEA is estimated for 2040 and 2050.

(3) Scenario

1) Classification of priority study countries

The following figure shows the classification of priority study target countries based on "5.1.1 Grouping of target countries." Indonesia and Thailand are classified as "upper-middle income," while India and Morocco are classified as "lower-middle income." The hydrogen demand potential in the industrial sector in Morocco is low.

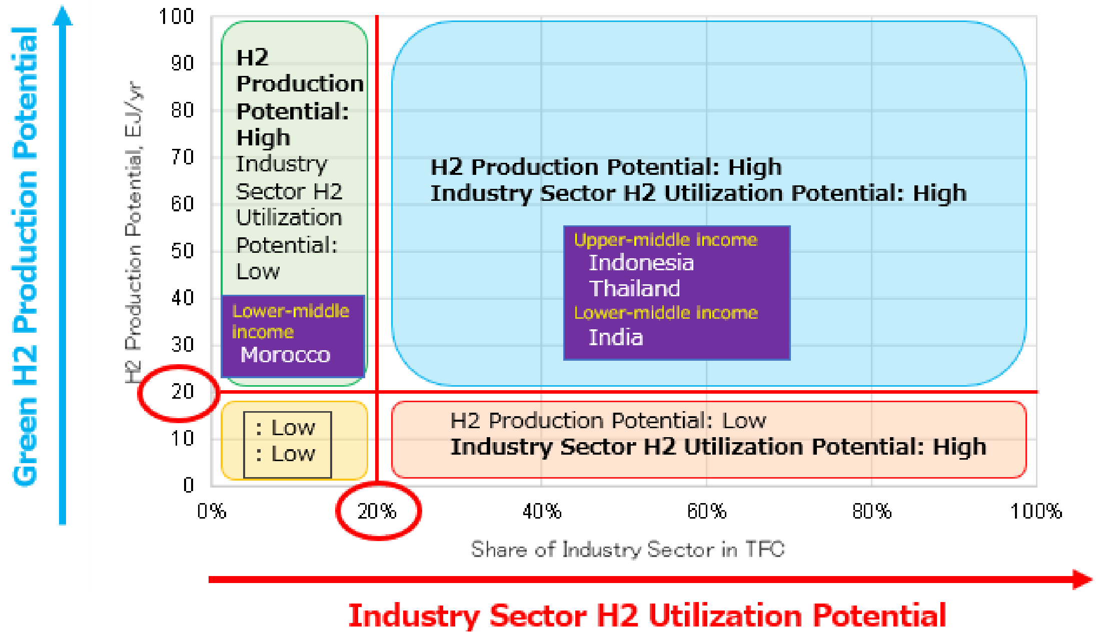

Figure 309 Classification of priority study countries

Source: JICA Team

The table below shows the target sectors for hydrogen demand potential by priority study countries in formulating scenarios. The hydrogen demand potential of industrial natural gas in Morocco is not expected. As for ammonia, since Indonesia is a net exporter, there is no potential on hydrogen demand for ammonia production.

Table 274 Target sectors of hydrogen demand potential by country

Country	H_2 Generation	Industry	FCV	Ammonia
India	✓	✓	✓	✓
Indonesia	✓	✓	✓	(Net exporter)
Morocco	✓		✓	✓
Thailand	✓	✓	✓	✓

Source: Author

Table 275 Exports and imports of ammonia

Unit: ton

Country	Year	Imports	Exports	Net Imports
India	FY2021	2,307,245	2,877	2,304,368
Indonesia	2018	21,584	1,395,560	-1,373,976
Morocco	2018	1,445,040	0	1,445,040
Thailand	2018	481,643	0	481,643

Note: Indonesia is a net exporter of ammonia

Source: Department of Commerce, Ministry of Commerce and Industry, India

Others: World Integrated Trade Solution

2) Scenario

The table below shows the scenarios (draft) for the power generation, industrial (including ammonia), and transport sectors.

Table 276 Scenarios for calculating hydrogen demand potential

Sector	Assumption (draft)	Scenario (2040, 2050)
Power generation	Natural gas ● Full-scale hydrogen utilization will commence in 2040 (10 years is assumed to be required to construct a large-scale hydrogen production plant, domestic supply infrastructure, and hydrogen-fired power plant (CCGT)) ● Hydrogen will be supplied to power plants through newly constructed pipelines. ● Among the existing natural gas-fired power plants as of 2040 (TWh), some of them will be converted to power plants using a mixed fuel of 30% hydrogen and 70% natural gas through the replacement of combustors. ● Among the new natural gas-fired power plants as of 2050 (2050–2040, TWh) some of them will be converted to power plants fueled by 100% hydrogen through the replacement of combustors.	Conversion ratio to mixed fuels Scenario 1: 30% Scenario 2: 50% Scenario 3: 70%
	Coal ● Among the existing coal-fired power plants as of 2040 (TWh), some of them will be converted to power plants using a mixed fuel of 30% hydrogen and 70% natural gas. ● Among the new coal-fired power plants as of 2050 (2050–2040, TWh), some of them will be converted to power plants fueled by 100% hydrogen. ● (Charts for Morocco in 2050 are the same as those for 2040)	Conversion ratio to mixed-fuel power plants Scenario 1: 10% Scenario 2: 20% Scenario 3: 30%
Industry	Heat demand ● Mini-grids using mixed fuels of hydrogen and natural gas will be installed around hydrogen-fired power plants in 2040, and part of the natural gas used for boilers in the manufacturing industry will be converted to mixed fuels. ● Mini-grids using 100% hydrogen fuels will be installed around power plants fueled by 100% hydrogen in 2050, and part of the natural gas used for new boilers in the manufacturing industry will be converted to 100% hydrogen fuels. ● (It will be halved in India, and it will be none in Morocco)	Conversion ratio to mixed fuels Scenario 1: 30% Scenario 2: 50% Scenario 3: 70%
	Ammonia ● Part of imported ammonia will be converted to domestically produced ammonia using green hydrogen (2040, 2050) ● (It will be none in Indonesia as it is a net exporter)	Conversion ratio to domestic production (2040→2050) Scenario 1: 10% --> 20% Scenario 2: 20% --> 40% Scenario 3: 30% --> 60%

Transport	Motor Gasoline ● A certain ratio of gasoline-powered vehicles will switch to ZEVs (2040, 2050) ● The ratio of FCVs that accounts for ZEVs is 10% ● (It will be halved in India and Morocco)	Ratio of ZEVs (2040→2050) Scenario 1: 10% --> 20% Scenario 2: 20% --> 40% Scenario 3: 30% --> 60%
	Diesel (Gas oil) ● A certain ratio of diesel-powered vehicles will switch to ZEVs (2040, 2050) ● The ratio of FCVs that accounts for ZEVs is 20% ● (It will be halved in India and Morocco)	

Note: CCGT = Combined Cycle Gas Turbine, ZEV = Zero Emission Vehicle
Source: Author

The figure below shows the scenario for the power generation sector in an easy-to-understand manner.

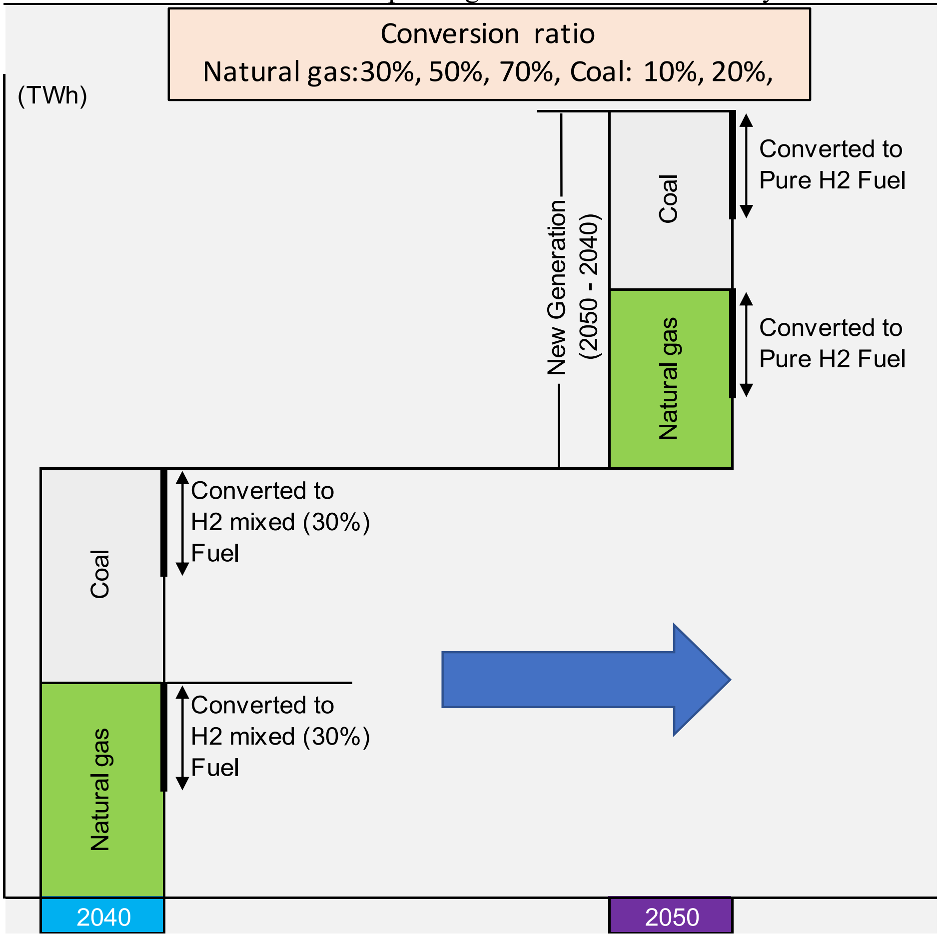

Figure 310 Scenario image for the power generation sector
Source: Author

The table below summarizes the numbers for the 2040 and 2050 scenarios.

Table 277 Scenario summary

Sector	Electricity Generation				Indisurt				Transport			
Energy	Natural gas		Coal		Natiral gas		Ammonia		Gasoline		Diesel	
Year	2040	2050	2040	2050	2040	2050	2040	2050	2040	2050	2040	2050
India	H2 30% fuel Conversioin ration of existing 30% 50% 70%	H2 100% fuel Conversuin ratio of new 30% 50% 70%	H2 30% fuel Conversion ratio of exsisting 10% 20% 30%	H2 100% fuel Conversion ration of new 10% 20% 30%	H2 30% fuel Conversion ration of exsisting 15% 25% 35%	H2 100% fuel Conversion ratio of new 15% 25% 35%	Imports→ Domestic production 10% 20% 30%	Imports→ Domestic production 20% 40% 60%	FCV share 10% within ZEV Conversuion ratio to ZEV 5% 10% 15%	FCV share 10% within ZEV Conversuion ratio to ZEV 10% 20% 30%	FCV share 20% within ZEV Comnversion ration to ZEV 5% 10% 15%	FCV share 20% within ZEV Comnversion ration to ZEV 10% 20% 30%
Indonesia	H2 30% fuel Conversioin ration of existing 30% 50% 70%	H2 100% fuel Conversuin ratio of new 30% 50% 70%	H2 30% fuel Conversion ratio of exsisting 10% 20% 30%	H2 100% fuel Conversion ration of new 10% 20% 30%	H2 30% fuel Conversion ration of exsisting 30% 50% 70%	H2 100% fuel Conversion ratio of new 30% 50% 70%	Imports→ Domestic production No potential	Imports→ Domestic production No potential	FCV share 10% within ZEV Conversuion ratio to ZEV 10% 20% 30%	FCV share 10% within ZEV Conversuion ratio to ZEV 20% 40% 60%	FCV share 20% within ZEV Comnversion ration to ZEV 10% 20% 30%	FCV share 20% within ZEV Comnversion ration to ZEV 20% 40% 60%
Morocco	H2 30% fuel Conversioin ration of existing 30% 50% 70%	H2 100% fuel Conversuin ratio of new 30% 50% 70%	H2 30% fuel Conversion ratio of exsisting (2040) 10% 20% 30%		No potential	No potential	Imports→ Domestic production 10% 20% 30%	Imports→ Domestic production 20% 40% 60%	FCV share 10% within ZEV Conversuion ratio to ZEV 5% 10% 15%	FCV share 10% within ZEV Conversuion ratio to ZEV 10% 20% 30%	FCV share 20% within ZEV Comnversion ration to ZEV 5% 10% 15%	FCV share 20% within ZEV Comnversion ration to ZEV 10% 20% 30%
Thailand	H2 30% fuel Conversioin ration of existing 30% 50% 70%	H2 100% fuel Conversuin ratio of new 30% 50% 70%	H2 30% fuel Conversion ratio of exsisting 10% 20% 30%	H2 100% fuel Conversion ration of new 10% 20% 30%	H2 30% fuel Conversion ration of exsisting 30% 50% 70%	H2 100% fuel Conversion ratio of new 30% 50% 70%	Imports→ Domestic production 10% 20% 30%	Imports→ Domestic production 20% 40% 60%	FCV share 10% within ZEV Conversuion ratio to ZEV 10% 20% 30%	FCV share 10% within ZEV Conversuion ratio to ZEV 20% 40% 60%	FCV share 20% within ZEV Comnversion ration to ZEV 10% 20% 30%	FCV share 20% within ZEV Comnversion ration to ZEV 20% 40% 60%

Source: Author

The hydrogen demand potential for power generation is calculated by assuming a virtual mixed-fuel power plant shown in the figure below.

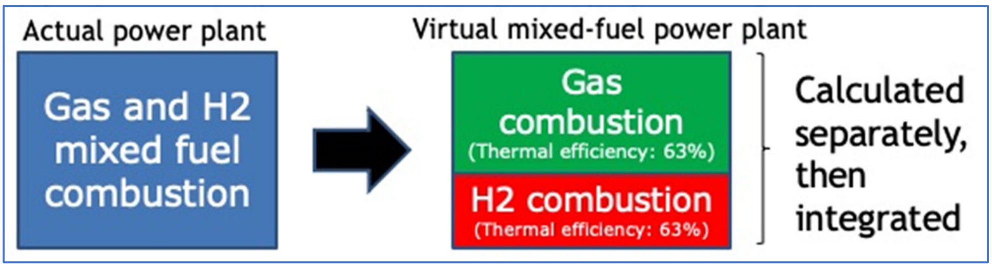

Figure 311 Virtual mixed-fuel power plant

Source: Author

In the transport sector, some of the conventional gasoline-powered vehicles and diesel-powered vehicles are assumed to be converted to fuel cell vehicles (FCVs). It is necessary to consider the fuel mileage between conventional gasoline-powered vehicles and FCVs. Since sufficient data are not available for comparison at present, the fuel mileage was calculated by comparing two models with similar vehicle sizes shown in The table below. For diesel-powered vehicles, since no comparable data are available, a calculation was made by assuming that the fuel mileage between conventional diesel-powered vehicles and FCVs is the same as that between conventional gasoline-powered vehicles and FCVs.

Table 278 Comparison of TOYOTA CROWN and TOYOTA MIRAI

	CROWN	MIRAI
Appearance		
Size (cm)	4,910×1,800×1,455	4,890×1,815×1,535
Weight (kg)	1,590 - 1,650	1,850
Exhaust volume	2,000 cc	-

Fuel consumption (JC08)	12.8 km/L *1	7.59 km/m3 *2
Fuel consumption per 100 km	7.84 L	13.81 m3
Comparison	Energy consumption per 100 km (FCVs are 1.8 times more efficient)	

Note: Fuel tank capacity of MIRAI: 122.4 L, pressure: 70 MPa --> 85.68 m^3-H_2/full tank
MIRAI can travel for up to 650 km with a full tank of H_2.
Source: Toyota Motor Corporation

The table below shows various assumptions for calculating hydrogen demand potential.

Table 279 Various assumptions for calculating hydrogen demand potential

Carbon content	Coal: 25.8 kg-C/ GJ (= 3.961 ton-CO_2/toe-input) Natural gas: 15.3 kg-C/GJ (=2.349 ton-CO_2/toe-input) Gasoline: 18.9 kg-C/GJ (=2.902 ton-CO_2/toe) (=2.269 ton-CO_2/KL Gas oil: 20.2 kg-C/GJ (=3.102 ton-CO_2/toe) (=2.648 kg-CO_2/KL)	Source: 2006 IPCC Guidelines
Net Calorific Value (NCV)	Other Bituminous Coal (Australian export coal) 0.6138 toe/ton	Source: World Energy Balances 2021 database, IEA
H_2 specification	Gas density: 0.0835 kg/m3 NCV: 10,780 kJ/ m3 = 2,575 kcal/ m3 = 30,834 kcal/ kg = 3,884 m3/ toe	Source: Iwatani Corporation
Thermal efficiency (Electricity generation)	Coal: 55% Natural gas: 63% H_2: 63%	Source: Improvement in the efficiency of thermal power generation, Agency for Natural Resources and Energy, November 2017
Conversion factor	1 GJ = 0.02388 toe 1 cal = 4.187 J 1 Gcal = 0.1 toe 1 MWh = 0.086 toe 1 MMBtu = 0.0252 toe	

Source: Author

(4) Hydrogen demand potential based on the scenarios

The following figures show the hydrogen demand potential based on the scenarios of four countries.

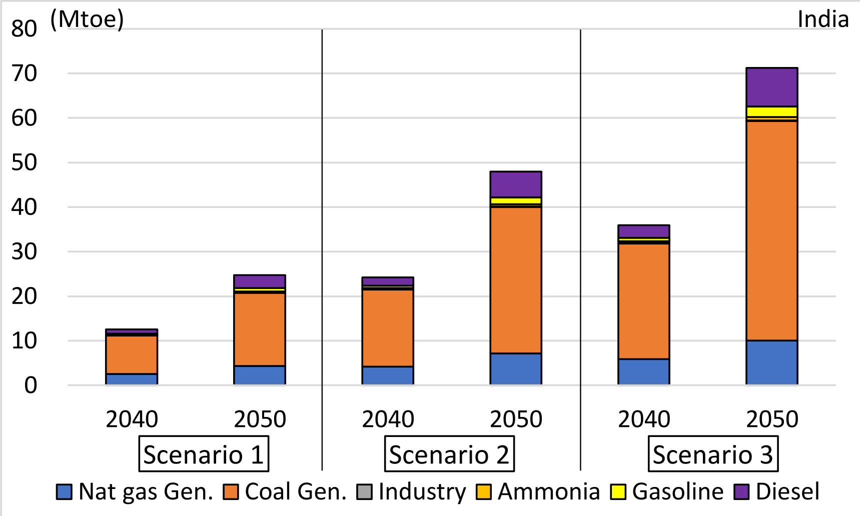

Figure 312 Hydrogen demand potential in India

Source: Author

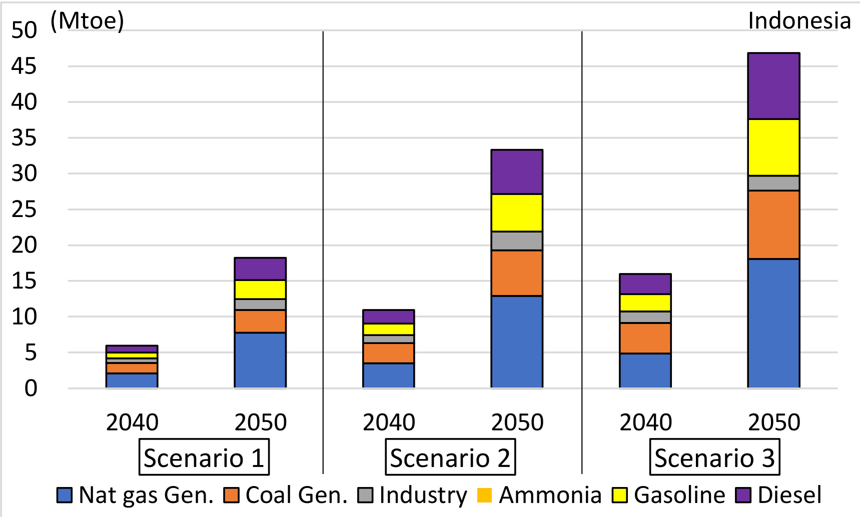

Figure 313 Hydrogen demand potential in Indonesia

Source: Author

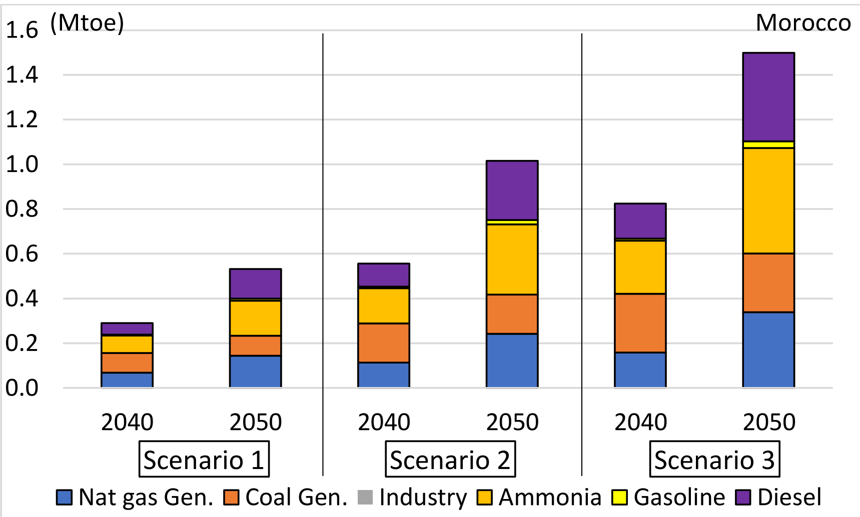

Figure 314 Hydrogen demand potential in Morocco

Source: Author

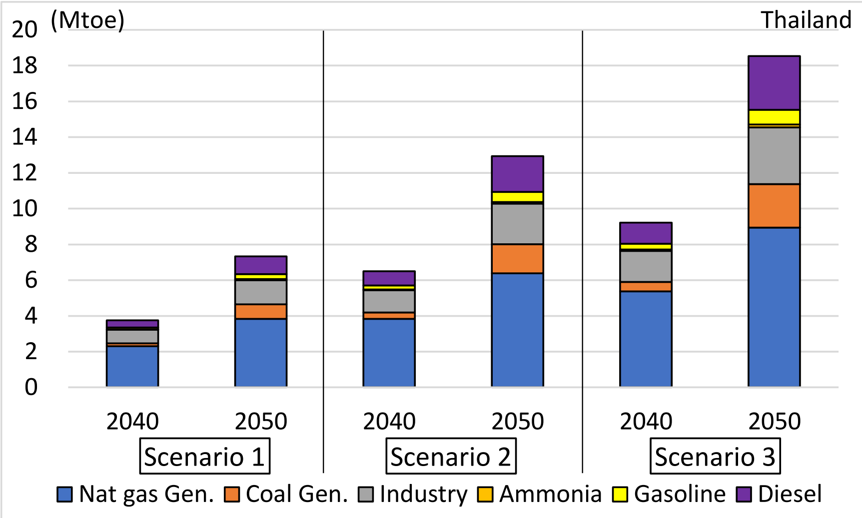

Figure 315 Hydrogen demand potential in Thailand

Source: Author

The table below shows the summary of the hydrogen demand potential by dividing the units into energy (Mtoe), volume (1 million m^3, NCV base), and weight (1,000 tons, NCV base).

Table 280 Summary of hydrogen demand potential

Unit: Mtoe

Country	Scenario 1		Scenario 2		Scenario 3	
	2040	2050	2040	2050	2040	2050
India	12.5	24.7	24.2	48.0	35.9	71.2
Indonesia	5.9	18.2	10.9	33.3	16.0	46.8
Morocco	0.3	0.5	0.6	1.0	0.8	1.5
Thailand	3.8	7.3	6.5	12.9	9.2	18.5

Unit: 1 million m^3 (NCV basis)

Country	Scenario 1		Scenario 2		Scenario 3	
	2040	2050	2040	2050	2040	2050
India	386,754	762,087	747,232	1,479,178	1,107,710	2,196,268
Indonesia	182,858	561,191	337,370	1,026,905	491,881	1,444,052
Morocco	8,934	16,409	17,170	31,328	25,406	46,248
Thailand	115,680	226,039	200,039	398,715	284,398	571,392

Unit: 1,000 tons (NCV basis)

Country	Scenario 1		Scenario 2		Scenario 3	
	2040	2050	2040	2050	2040	2050
India	32,294	63,634	62,394	123,511	92,494	183,388
Indonesia	15,269	46,859	28,170	85,747	41,072	120,578
Morocco	746	1,370	1,434	2,616	2,121	3,862
Thailand	9,659	18,874	16,703	33,293	23,747	47,711

Note: Conversion factor 30,834 m^3/toe, 0.0835 kg/m^3

Source: Survey team

(5) Impact of hydrogen demand potential

In order to examine the impact of hydrogen demand potential based on the scenarios, the amount of electricity required is estimated for the case with the assumption that all hydrogen demand potential is produced by water electrolysis. With the current technologies, 5 kWh of electricity is required to produce 1 m^3 of hydrogen, but estimation is made by using 4 kWh/m^3 in anticipation of technological progress.

The table below shows the amount of electricity required to produce the hydrogen demand potential. It is not realistic to produce all hydrogen demand potential by water electrolysis, and it is assumed that a considerable amount of blue hydrogen will be required.

Table 281 Required amount of electricity generation

Unit: TWh

Country	Scenario 1		Scenario 2		Scenario 3		(Reference) Total power generation
	2040	2050	2040	2050	2040	2050	2019
India	1,547	3,048	2,989	5,917	4,431	8,785	1,611
Indonesia	731	2,245	1,349	4,108	1,968	5,776	288
Morocco	36	66	69	125	102	185	40
Thailand	463	904	800	1,595	1,138	2,286	186

Source: Author

5.2.3 Analysis of Hydrogen Price Reduction Targets

In this section, the competitive price of hydrogen is estimated from the viewpoint of the demand side. As for the price, it is also estimated for the case where the price of CO_2 is added to the price of fossil fuels in consideration of the CO_2 price. Pricing is based on the outlook for future pricing written on the "World Energy Outlook 2021" (WEO 2021) of the IEA. Prices not listed in the "WEO 2021" are compared with current prices available in statistics, etc.

(1) Price to be the precondition for comparison

The table below shows the price assumptions used to estimate the prices at which hydrogen has competitiveness.

Table 282 Price assumptions

Sector	Fuel	Price	Source
Power generation	Natural gas	\$8.9/ MMBtu	Stated Policy, WEO 2021 2050 price, Japan
	Coal	\$70/ ton	
Industry	Natural gas	\$40.6/ MWh	Energy Prices and Taxes 2021, IEA, 2020 price, Japan
Transport	Motor Gasoline (Indonesia)	\$78/ BOE (\$0.491/ L)	Handbook of Energy & Economic Statistics of Indonesia 2021 price
	Diesel (Gas Oil) (Indonesia)	\$56/ BOE (\$0.352/ L)	
Common in all sectors	CO_2	Scenario 1: \$50/ton Scenario 2: \$100/ ton Scenario 3: \$200/ ton	\$200 = Stated Policy, WEO 2021 2050 price, BRICS

Source: Author

(2) Competitive price of hydrogen

1) Power generation sector

(A) Natural gas

Price assumption: \$8.9/MMBtu (\$352.2/toe)

Power generation efficiency: Natural gas 63%, hydrogen 63%

The table below shows the estimated prices at which hydrogen has competitiveness.

Competitive fuel: Natural gas (input base)

Table 283 Prices at which hydrogen has competitiveness (power generation sector: natural gas)

Unit	CO_2 price ($/ton)			
	0	50	100	200
(Energy) Price	($/toe) 353.2	($/toe) 470.6	($/toe) 588.1	($/toe) 823.0
(Volume) Price	($/m3) 0.091	($/m3) 0.121	($/m3) 0.151	($/m3) 0.212
(Weight) Price	($/kg) 1.089	($/kg) 1.451	($/kg) 1.813	($/kg) 2.538

Source: Author

(B) Coal

Price assumption: $70/ton ($114.0/toe)

Power generation efficiency: Coal 55%, hydrogen 63%

The table below shows the estimated prices at which hydrogen has competitiveness.

Competitive fuel: Coal (input base)

Table 284 Prices at which hydrogen has competitiveness (power generation sector: coal)

Unit	CO_2 price ($/ton)			
	0	50	100	200
(Energy) Price	($/toe) 130.6	($/toe) 312.1	($/toe) 510.2	($/toe) 906.3
(Volume) Price	($/m3) 0.034	($/m3) 0.080	($/m3) 0.131	($/m3) 0.233
(Weight) Price	($/kg) 0.403	($/kg) 0.962	($/kg) 1.573	($/kg) 2.795

Source: Author

2) Industrial sector (Heat demand, mainly for boiler)

(A) Natural gas

Price assumption: $40.6/MWh ($472.1/toe)

The table below shows the estimated prices at which hydrogen has competitiveness.

Competitive fuel: Natural gas

Table 285 Prices at which hydrogen has competitiveness (industrial sector: natural gas)

Unit	CO_2 price ($/ton)			
	0	50	100	200
(Energy) Price	($/toe) 353.2	($/toe) 470.6	($/toe) 588.1	($/toe) 823.0
(Volume) Price	($/m3) 0.091	($/m3) 0.121	($/m3) 0.151	($/m3) 0.212
(Weight) Price	($/kg) 1.089	($/kg) 1.451	($/kg) 1.813	($/kg) 2.538

Source: Author

3) Transport sector

(A) Gasoline

Price assumption: $78/BOE ($0.491/L, $1,129/toe)

Fuel consumption difference: FCVs are 1.8 times more efficient than conventional gasoline-powered vehicles

Competitive fuel: Gasoline

Table 286 Prices at which hydrogen has competitiveness (transport sector: gasoline)

Unit	CO_2 price ($/ton)			
	0	50	100	200
(Energy) Price	($/ toe) 1,129	($/ toe) 1,391	($/ toe) 1,652	($/ toe) 2,174
(Volume) Price	($/ m3) 0.291	($/ m3) 0.358	($/ m3) 0.425	($/ m3) 0.560
(Weight) Price	($/ kg) 3.482	($/ kg) 4.288	($/ kg) 5.093	($/ kg) 6.703

Source: Author

(B) Diesel oil (gas oil)

Price assumption: $56/BOE ($0.352/L, $811/toe)

Fuel consumption difference: FCVs are 1.8 times more efficient than conventional diesel-powered vehicles

Competitive fuel: Diesel oil (gas oil)

Table 287 Prices at which hydrogen has competitiveness (transport sector: diesel oil (gas oil))

Unit	CO_2 price ($/ton)			
	0	50	100	200
(Energy) Price	($/ toe) 811	($/ toe) 2,856	($/ toe) 3,117	($/ toe) 3,639
(Volume) Price	($/ m3) 0.209	($/ m3) 0.735	($/ m3) 0.803	($/ m3) 0.937
(Weight) Price	($/ kg) 2.500	($/ kg) 8.806	($/ kg) 9.611	($/ kg) 11.221

Source: Author

5.3 Basic survey for the Formulation of A Demonstration Project Proposal and the Guidelines for Promoting Green Hydrogen Utilization

A basic survey will be conducted for Thailand, Indonesia, Morocco, and India for the formulation of a demonstration project proposal and the guidelines for promoting green hydrogen utilization.

5.3.1 Proposal of Demonstration Project (draft) and cooperation possibilities.

(1) Long list of demonstration projects

Table 288 Long List of demonstration projects

No.	Sector		Overview	Technology readiness
	Hydrogen production			
1		Hydrogen production from renewable electricity	Green hydrogen production with electricity from solar PV, wind, or solar PV and wind hybrid system. The hydrogen produced can be supplied to domestic users or be exported. ※Refer to (7)~(18) for applications of domestic produced hydrogen	Still at demonstration stage in Japan。 How to reduce CAPEX・OPEX of water electrolyzer system is important.
2		Hydrogen production from excessive electricity	Large amount of solar PV or wind in the electricity grid can result to electricity that can not be absorbed by the	Still at demonstration stage in Japan。 How to reduce CAPEX・OPEX of water electrolyzer

			grid (excessive electricity) and the excessive electricity can be used to produce hydrogen, which can help reduce curtailment of solar PV/wind. The hydrogen produced can be supplied to domestic users or be exported. ※Refer to (7)~(18) for applications of domestic produced hydrogen	system is important.
3		Optimization of the use of variable renewable electricity	Demonstration of the optimization of best use of variable renewable electricity such as solar PV and wind, and supply of hydrogen depending on the demand change, as well as providing grid service. The system can be like that used in FH2R@Fukushima or demonstration project in Yamanashi prefecture in Japan. Main components of the system include variable renewable power generation plant, onsite electrolyzing system, and control system. Produced greeen hydrogen can be supplied to the demand sites nearby.	Still at demonstration stage in Japan (FH2R@Fukushima). How to reduce CAPEX and OPEX of water electrolyzer system is important.
	Domestic hydrogen delivery and hydrogen storage system			
4		High pressured hydrogen trailer for domestic delivery	The purpose of the demonstration is to support the development of domestic hydrogen delivery system (hydrogen delivery from hydrogen prduction site to domestic demand sites such as industrial plants, or hydrogen refueling stations) by using high pressured hydrogen trailers. In addition to delivery system, development of relevant safety standards and operation regulations can also be considered.	Already commercialized in Japan. Further technology development for loosing safty standards/regulation to reduce cost is an important issue.
5		Liquefied hydrogen trailer for domestic delivery	The purpose of the demonstration is to support the development of domestic hydrogen delivery system (hydrogen delivery from hydrogen prduction site to domestic demand sites such as industrial plants, or hydrogen refueling stations)	Demonstration stage in Japan. Technology development for cost reduction of hydrogen liquefication is important.

			by using liquefied hydrogen trailers. In addition to delivery system, development of relevant safety standards and operation regulations can also be considered.	
6		Hydrogen pipeline	In the case of large amount hydrogen delivery or hydrogen town hydrogen pipeline will be needed. Demonstration of hydrogen pipeline can be disgned in accordence to the specific needs of the country. Converting existing natural gas network to hydrogen pipeline can also be considered.	It is confirmed that polyethylene pipe (PE pipe) is hydrogen ready. Although new steel pipe is not problem, whether sxisting steel pipe can be used for transport of high pressure hydrogen is yet to be confirmed.
	Application of hydrogen and hydrogen synthetic fuels			
7	Power Sector	Local-production-local-cunsumption energy supply system with hydrogen	The demonstration system is designed to comprise of renewable power generation, electrolyzers, fuel cells, hydrogen tank, etc. to supply 100% renewable electricity and heat to nearby areas (factories, buildings, etc.). Since much energy is lost in the renewable electricity ⇒ hydrogen ⇒ electriciy conversion process, how to improve value of the system (energy supply from local resource, system resilience, stable supply) in an important issue.	There are similar demonstrations in Japan (Kita Kyushu). It is important to verify the optimal equipment configuration and optimal operation that captures the entire hydrogen production, transportation, storage system.
8	Transportation	Hydrogen refueling station+fuel cell vehicle/bus/truck	Demonstration of hydrogen's application in the on-road transportation (fuel cell vehicles/buses/trucks) as well as associated infrastructure (e.g. construction and operation of hydrogen refueling station). The demonstration may also include the development of relevant safety standards and regulations.	Heavy fuel cell trucks is still at demonstration stage in Japan. And new regulation for hydrogen refueling stations to deal with heavy fuel cell trucks is under development.
9	Transportation	Hydrogen engin for ships	"Demonstration of using hydrogen engin for ships. The hydrogen fuel is supposed to be from domestic produced green hydrogen. ※It should be noted that hydrogen engins for ships is still at development/demonstration stage in Japan"	Development and demonstration stage in Japan. Cost reduction is key.

10	Transportation	Ammonia engin for ships	Demonstration of using ammonia engin for ships. The ammonia fuel is supposed to be from domestic produced green ammonia. ※It should be noted that ammonia engins for ships is still at development/demonstration stage in Japan	Development and demonstration stage in Japan. Cost reduction is key.
11	Transportation	Fuel cells for ships	Demonstration of fuel cell's applition for ships (domestic vessels). The hydrogen fuel is supposed to be from domestic produced green hydrogen. ※It should be noted that fuel cell's application for ships is still at development/demonstration stage in Japan	Development and demonstration stage in Japan. Cost reduction is key.
12	Industry	Replace grey hydrogen with green hydrogen, for example, ammonia production plant	Demontration of replacing grey hyddrogen used in industrial processes with green hydrogen. Industries including ammonia production, oil refinery, mathanol production, fertilizer production, etc.. The green hydrogen is supposed to be domestic produced green hydrogen.	Replace grey hdyrogen with green hydrogen and no additional R&D is needed.
13	Industry	Replace grey hydrogen with green hydrogen, for example, oil refinery		Replace grey hdyrogen with green hydrogen and no additional R&D is needed.
14	Industry	Hydrogen boiler for steam supply	Demonstration of supplying low temperature steam produced by hydrogen boilers to factories (such as food processing factories). The hydrogen fuel for the boilers comes from domestic produced green hydrogen.	Although boilers with 100% hydrogen is already developed, as an transsitional measure how to deal with hydrogen blended gas need to be considered.
15	Industry	Hydrogen burner for direct industry heating	Demonstration of replacing fossil fuel burner boiler with hydrogen burner to supply heat to industril heating process. The hydrogen fuel is supposed to be from domestic produced green hydrogen.	Still at development stage in Japan.
16	Industry	Hydrogen direct reduction (Iron & Steel)	Hydrogen direct reduction is percieved as an important measure for the decarbonization of the iron & steel sector. Large European steel makers is at the front line of the demonstration of HDR ※It should be noted that hydrogen direct reduction is still at development stage in	HDR is still at R&D stage in Japan. HDR is an endothermic reaction and large volume of hydrogen is required.

			Japan	
17	Synthetic fuels (e-fuels)	Synthetic methane	Demonstration of e-fuel (synthetic methane, synthetic jet fuel) production from captured CO2 (thermal power plant, industrial plant, biomass power generation plants, cement production, etc.) and domestic produced green hydrogen. The e-fuels can be used in blending with city gas (synthetic methane), CNG cars (synthetic methane), and domestic air port (synthetic jet fuel).	Demonstration stage in Japan.
18	Synthetic fuels (e-fuels)	Synthetic jet fuel		Technology development stage in Japan.
	Hyrogen export			
19		Hydrogen export: ammonia	The demonstration is designed for hydrogen export, major elements including ammonia conversion facilities, ammonia tanks, port facilities for export, etc.	Ammonia international supply chain is under demonstration. Technology development of green ammonia production is the key element.
20		Hydrogen export: MCH	The demonstration is designed for hydrogen export, major elements including MCH conversion facilities, MCH tanks, toluene tanks, port facilities for export, etc.	MCH international supply chain is under demonstration.
21		Hydrogen export: liquefied hydrogen	The demonstration is designed for hydrogen export, major elements including hydrogen liquification facilities , liquefied hydrogen tanks, port facilities for export, etc.	Liquefied hydrogen international supply chain is under demonstration.

Source: Author

5.3.2 Narrowing Down Projects with High Feasibility

(1) India

As previously mentioned, India is classified as a "lower-middle income" and a class with high green hydrogen production potential and industrial sector hydrogen use potential. The Indian government has a "National Hydrogen Mission" and a specific plan is currently in the draft approval stage (see below).

Based on a desktop survey of hydrogen-related trends in India, a short list of six hydrogen demonstration projects was presented to MNRE and needs were interviewed. While all of the areas were welcomed, the need for research and demonstration projects to optimize hydrogen production and transportation was considered to be particularly high. Below is an analysis based on the results of the desktop survey and interviews.

(a) Trends of hydrogen-related policies, companies, and government support from other countries in India

The following is a summary of domestic hydrogen-related policies and activities of Indian and foreign companies, foreign governments, and donors. The major industries in India are agriculture, industry, mining, and IT. agriculture, forestry, and fisheries account for 16.3% of GDP, while manufacturing accounts for 15.3%. The steel industry is one of the main industries. Fertilizer plants and petroleum refining are considered priority sectors in the national hydrogen mission.

■ Hydrogen related policies

In India, the hydrogen-related policies listed in the table below have been formulated. The Action Plan for Hydrogen is currently being developed, and the draft budget and support details for creating demand for green hydrogen, incentives for green hydrogen production, and incentives for domestic manufacturing of related equipment are in the final approval stage. This draft was developed through discussions among stakeholders, industry, and government officials in India. The budget and plans for R&D support projects, infrastructure, and export-related matters will also be finalized in the same manner.

Table 289 Hydrogen Policy in India

Policies	Summary
National Hydrogen Mission	The plan aims to increase the annual production of green hydrogen to 5 million tons by 2030 (2021.8). To promote the use of green hydrogen, the Government of India has a plan to mandate that 10% of the hydrogen used in fertilizer plants and oil refineries be green hydrogen by 2024. The mission will result in demonstrations, research and development, policy support, and the development of hydrogen technology standards and regulations and frameworks in the infrastructure building, transportation, and industrial sectors. It also aims to become a global hub for hydrogen production.
Green Hydrogen/ Green Ammonia Policy	It outlines provisions to support and promote the supply of renewable energy to green hydrogen and green ammonia producers (2022.2). The provisions include allowing green hydrogen and green ammonia producers to freely purchase renewable electricity and expand their renewable energy capacity, and to deposit renewable electricity with distribution companies for up to 30 days. It also states that green hydrogen and green ammonia producers will be allowed to install bunkers at ports to store green ammonia for export.

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Hydrogen-Related Trends in Indian Domestic Companies

Domestic Indian companies are also involved in hydrogen production and utilization, either on their own or in collaboration with other companies. The table below shows the hydrogen-related businesses of Indian companies.

Table 290 Hydrogen-related businesses of Indian companies

Name of company	Summary
Adani Power Ltd (APL)	Adani has announced plans to invest $20 billion over the next 10 years in the renewable energy sector and has set a goal of becoming the world's largest green hydrogen producer using its own renewable energy. In addition, the company plans to produce methanol, ammonia, and fertilizer from green hydrogen. Currently, the company is conducting pilot projects and studies on co-firing green hydrogen and green ammonia.
Adani New Industries Ltd. (ANIL)	ANIL aims to invest more than US$50 billion over the next 10 years in green hydrogen production and related ecosystems. ANIL aims to produce 1 million tons of green hydrogen per year by 2030. (2022.6)
Reliance	Reliance is working to realize clean and affordable energy supply using hydrogen, wind, solar, fuel cells, and batteries in its new energy business Reliance is implementing green energy and other projects in Gujarat, investing Rs. 59.5 billion in the establishment of a 100 GW renewable energy power plant and the development of a green Rs. 59.5 billion investment in hydrogen ecosystem development. (2020)

ACME Solar	It announced plans to produce green hydrogen in India and Europe in partnership with Lhyfe Labs of France (2021.2). It also announced plans to invest $3.5 billion in 4 GW of green hydrogen and ammonia settlement in Oman (2021.8). In addition, the company signed a memorandum of understanding to secure a site for green ammonia production in Oman's Duqm Port Special Economic Zone.
ReNew Power	Indian renewable energy company. Announced a JV with L&T, an engineering company, and Indian Oil, a major fossil fuel retailer, for the production of electrolyzers for green hydrogen production (2022.4) Announced Mitsui & Co.'s equity participation in Renew in April 2022.
The Tata Power Company Limited	Conducted a research study on the use of green hydrogen as a fuel (2020).
Ohmium	Opened India's first large-scale green hydrogen electrolyzer production facility (2021.8). Initial production capacity is 500 MW per year, with plans to expand to 2 GW per year. Export of Indian-made electrolyzers to the U.S. began (2021.11).
Indian Oil	Indian Oil is conducting a demonstration of fuel cell buses in collaboration with Tata Motors. (2021.6) In addition, it announced the construction of the country's first green hydrogen plant at the Mathura refinery, which will be powered by wind power generation in Rajasthan. (2021.7) The company is also working with foreign companies and announced its intention to establish a hydrogen research center with Greenstat Hydrogen India, a Norwegian company. (2021.2) It has also announced a collaboration with the Italian company Snam to develop a hydrogen and gas value chain. (Adani group and Greenko are also participating) (2020.11)
BGR Enegry	MOU signed with Irish company FusionFuel for cooperation in green hydrogen development in India. (2021.3)
JSW	The company has begun discussions with the Australian company Fortescue Future Industries regarding green hydrogen production. (2021.7)

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Support from other donors

In India, the World Bank, ADB, and USAID are in the process of implementing or considering projects related to hydrogen. The figure below shows support from other donors in India.

Table 291 Support by other donors in India

Name of donor	Summary
WB	A hydrogen roadmap was developed for MNRE (2021). In addition, assistance is being provided in Himachal Pradesh and Madhya Pradesh for green hydrogen production and use, utilizing the potential of renewable energy, and a study is being conducted in Kerala to introduce green hydrogen in the transportation and transport sector. It is also providing assistance to Damondar Vally Corp (Power Corporation) to add green hydrogen to its renewable energy plan.
ADB	Technical cooperation for clean energy development (2021~2024). The project will evaluate each sector, develop new business models, prepare FS reports, discuss necessary policies, and design project investment pipelines. In the mid- to long-term, the project aims to achieve a transition to clean energy through the use of green hydrogen in the industrial sector. ADB also proposed a technical cooperation project to support the introduction of new technologies and the preparation of a specific development roadmap to accelerate the energy transition from fossil fuels to green hydrogen in India (2021.11).
USAID	In collaboration with MNRE, DOE, and the US-India Strategic Partnership Forum, a Hydrogen Task Force has been established (2020). The Task Force will assess the state of the technology, study policy options, and make recommendations to support scaling up

	and reducing the cost of hydrogen technology development to reduce emissions and enhance energy security and resiliency.

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Hydrogen-related trends in the Japanese government and Japanese companies

The table below shows the cooperation and projects related to hydrogen that Japanese ministries and companies are working on in India.

Table 292 Hydrogen-related cooperation and implementation projects by the Japanese government and Japanese companies in India

Name of agency/company	概要
Ministry of Economy, Trade and Industry	The Japan-India Clean Energy Partnership (CEP) was signed (2022.3) to promote energy cooperation between Japan and India. Areas of cooperation include EVs, energy storage systems including storage batteries, EV charging infrastructure, and clean hydrogen and clean ammonia including green.
Embassy of Japan in India	The Embassy of Japan in India held the Japan-India Hydrogen Business Matting Event, Japan-India Hydrogen Seminar, and Japan-India Hydrogen Fuel Cell Workshop for related organizations from February to April 2022 as "Japan-India Clean Hydrogen Month" to promote Japan-India public-private partnership in hydrogen to further investment and solve issues in the utilization of hydrogen.
The Japan Iron and Steel Federation	Since FY2013, the Japan-India Steel Public-Private Partnership Meeting has been held. In January 2022, the meeting was held with the aim of proposing energy conservation and environmental conservation policies to the Indian steel industry and promoting the transfer of energy conservation and environmental conservation technologies from Japan. Currently, technical assistance is being provided to introduce various technologies, including hydrogen-reduced steelmaking.
IHI	IHI, Kowa Company, Ltd. and APL signed a MoU for the implementation of joint verification of ammonia co-firing technology (2022).
Kowa Company, Ltd.	Kowa Company, Ltd. and APL are conducting technological research and development of hydrogen and ammonia utilization in thermal power plants.
Yamanashi Hydrogen Company, Inc., Suzuki Motor Co Ltd.	Yamanashi Hydrogen Company Inc., and Suzuki Motor Co Ltd. have submitted a proposal to the NEDO's "FY2022 International Demonstration Project for Japanese Technologies Contributing to Efficient Energy Consumption (Study on Conformity with Demonstration Requirements, etc.)" for the "Study on Conformity with Demonstration Requirements of Hydrogen Technology for Efficient Heat Management at a Factory in India (Haryana, India). This project was adopted. This project is to study the feasibility of establishing an optimal heat operation system in a factory by using surplus electricity from variable renewable energy sources in India to produce hydrogen through a P2G system. The project period is scheduled to end in March 2023. The project period is until March 2023.

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Foreign governments and companies

The table below shows the status of hydrogen-related cooperation by foreign governments and companies in India. An agreement on electrolyzer production has been concluded between a European company and an Indian company, but no concrete progress has been made yet.

Table 293 Hydrogen-related Trends in India by Foreign Governments and Foreign Companies

Name of company	Summary
Stiesdal A/S	Styesdal A/S of Denmark and RNEL have signed a cooperation agreement on the technological development and production of the HydroGen electrolyser with the goal of producing green hydrogen in India at low cost (2021.10).
TotalEnergies	French energy company that on June 14, 2022 entered into a partnership with Adani to co-create a green hydrogen ecosystem. The strategic partnership resulted in TotalEnergies acquiring a 25% minority interest in Adani New Industries Ltd (ANIL) from Adani Enterprises Ltd (AEL).
Maire Tecnimont	Italian engineering firm, planning to partner with APL to create a value chain for ammonia and green hydrogen (2021.3).
Government of United States of America	Strategic Clean Energy Partnership (SCRP) (2018); in April 2021, the Climate and Clean Energy Agenda 2030 Partnership; and in September of the same year, the Hydrogen and Biofuels Task Force, a joint public-private partnership to expand clean energy technologies Launched.
EU	They signed the "Clean Energy and Climate Partnership" (2016). They agreed to strengthen their efforts in the environmental field and are promoting cooperation on clean hydrogen production and application technologies (2021.12).
Government of Australia	A basic agreement was signed at the India-Australia Energy Dialogue (2022.2) to promote low-cost and deployment of technologies related to renewable energy. It is planned to promote clean hydrogen production incorporating least-cost solar power and CCS.
Government of the Netherlands	The Dutch government and TERI conducted two stakeholder meetings on hydrogen utilization (2022.3), the first between business and government officials and the second between researchers and government officials. Proposals for cooperation with India that the Dutch government considers effective include the establishment of a joint research platform and feasibility studies in the transportation sector and the port and transport sector, technical cooperation on electrolyzer technology from Dutch domestic companies to Indian companies, cooperation on the production of blue hydrogen, cooperation on green hydrogen Cooperation in the development of infrastructure for export of green hydrogen, cooperation in hydrogen co-firing and utilization of natural gas pipelines, and technical cooperation and investment in hydrogen-fueled vessels. The Netherlands expects a potential investment of $160 billion in India's hydrogen sector by 2030.

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

(b) Potential of Hydrogen Demonstration Project in India

On August 2, 2022, an interview was conducted with MNRE to determine the needs for hydrogen demonstration projects in India. In the interview, a short list of six demonstration projects shown in the table below was presented, along with their case studies, to ascertain the level of interest.

Table 294 Potential hydrogen demonstration projects and expected counterparts in India

No.	Possible demonstration projects	Summary	Expected counterparts
1	Hydrogen production from renewable energy	Green hydrogen will be produced from electricity sourced from solar, wind and hybrid solar/wind generating units, and the hydrogen will be supplied to domestic hydrogen utilizing facilities or to the premises for hydrogen export.	- MoP - MNRE

2	Maximize the use of output-variable renewable energy sources	The objective of the demonstration is to optimize the operation of the power system to maximize the utilization of electricity from VREs to supply hydrogen in response to hydrogen demand, and to provide flexibility to the grid. The system configuration will be based on the FH2R system in Namie-cho, Fukushima and the Yamanashi demonstration, and will include VREs and on-site water electrolysis equipment, as well as a control system to manage the optimal energy operation. The produced green hydrogen will be supplied to adjacent hydrogen consuming facilities.	- MoP - MNRE
3	Domestic Transportation	Depending on the location of hydrogen production and demand, the demonstration will include consideration of transporting hydrogen domestically using a high-pressure hydrogen trailer, domestic hydrogen transportation using a liquefied hydrogen trailer, or a hydrogen pipeline. In addition to the demonstration of related technologies, support for safety standards and the creation of related regulations will also be considered.	- Ministry of Road Transport and Highways
4	Hydrogen stations + fuel cell vehicles, fuel cell buses, fuel cell trucks, etc.	The project aims to develop hydrogen utilization and related infrastructure in the road sector, including the establishment and operation of hydrogen stations, and the demonstration of fuel cell vehicles, fuel cell buses and fuel cell trucks. In addition to technology demonstrations, support for the development of related safety standards and regulations will also be considered.	- Ministry of Road Transport and Highways - MNRE - Ministry of Heavy Industries
5	Substitution of hydrogen derived from fossil fuels: Green hydrogen supply to oil refineries and chemical plants, ammonia plants, etc.	The objective is to replace fossil fuel-derived hydrogen used in industrial fields with green hydrogen. For example, the project will demonstrate the replacement of fossil fuel-derived hydrogen supplied to ammonia production plants, oil refining facilities, methanol production plants, fertilizer plants, etc. with green hydrogen. It is also envisioned that domestic green hydrogen supply will be included in the demonstration project.	- Ministry of Heavy Industries
6	Hydrogen export carriers: ammonia, MCH, liquefied hydrogen	In order for India to enable exporting hydrogen, a necessary FS will be conducted at first, and it is envisioned	- Ministry of Road Transport and Highways

	that related facilities for hydrogen export at synthesis or liquefaction facilities, tanks and ports of carriers identified as optimal in the FS will be developed and demonstrated for actual operation. In addition to the technical demonstration, support for the preparation of related safety standards and regulations will also be considered.	-	MNRE

*The numbers of the demonstration projects in which MNRE has shown interest and for which there is a high need in India are marked with zeros. (Red zeros indicate demonstration projects that are considered to have particularly high needs.

(Source: Compiled by JICA Survey Team)

MNRE stated that it is interested in all of the demonstration projects mentioned above and that they are consistent with Indian government policy. At this time, none of these demonstration projects are currently being implemented by other donors. In addition to the above, MNRE is also interested in hydrogen production from biomass. In India, where the rural population is larger than the urban population, there is much political interest in using biomass to increase rural incomes. A description of each of the needs related to the demonstration projects in the table above is as follows.

With respect to "1. Hydrogen production from renewable energy sources," there is a clear need for research on the most cost-effective way to produce green hydrogen in each region. The Government of India has established clusters in various regions and is studying various models for effective combinations of renewable energy and batteries, electrolyzer capacity, battery capacity, etc., so that green hydrogen can be produced in large quantities at the lowest possible cost in each of these clusters. This study is being conducted because India is a large country and the technology and cost of transporting green hydrogen from production sites to utilization sites is a challenge. However, the optimal model for each region differs, so it is necessary to create an optimal model for each region.

Regarding "3. Domestic Hydrogen Transportation," there is likely to be a high need for cooperation regarding a feasibility study on the utilization of existing infrastructure and the introduction of transport trailers and other equipment. Since India has not accumulated experience in domestic hydrogen transportation and storage, there is a need for cooperation by private companies and other countries regarding the infrastructure and estimation necessary for hydrogen transportation and storage. In the initial stage of domestic hydrogen transportation, it is expected that transportation using high-pressure hydrogen trailers will be the mainstream, and the introduction of high-pressure hydrogen trailers that have been commercialized in Japan is considered to be a promising cooperation proposal. The Indian government plans to provide support for demonstration tests of domestic transportation, but details have not been disclosed. According to MNRE, a project to mix clean hydrogen into gas pipelines is currently underway with direct support from the Indian government[759].

The most promising demand sector for green hydrogen in India is "5. Substitution of hydrogen from fossil fuels: green hydrogen supply to ammonia production plants, green hydrogen supply to oil refineries and chemical plants. The Government of India's National Hydrogen Mission is considering mandating the use of green hydrogen in the petroleum refining and fertilizer industries, and NITI Aayog has proposed setting the targets shown in the table below for the green hydrogen mandates being considered in the petroleum refining and fertilizer industries[760].

759 The website of the Ministry of Petroleum and Natural Gas also states that there are plans for a pilot of hydrogen blending into the city gas network. (Website of Ministry of Petroleum & Natural Gas: https://mopng.gov.in/en/page/12)

760 Same as above

Table 295 Potential mandates for existing applications

Sector	Target Type	Mandate	Cut-off date for the sector to go 100 % Green
Refinery	Corporate level targets	50% by 2030	2035
Fertilizers	Import substitutions	100% by 2030	2040

(Source: NITI Aayog (2022),"Harnessing Green Hydrogen Opportunities for Deep Decarbonization in India," p.40)

Currently, 6 million tons of gray hydrogen is utilized in India for petrochemical refining, ammonia and methanol generation, and steel production. As shown in the figure below, NITI Aayog continues to anticipate potential hydrogen demand in the petroleum refining industry, chemical industries such as fertilizer production, large long-haul freight transportation, and to a limited extent, the power sector. In the demand forecast below, the petroleum refining industry and ammonia demand for fertilizer will account for the majority of overall hydrogen demand through about 2030.

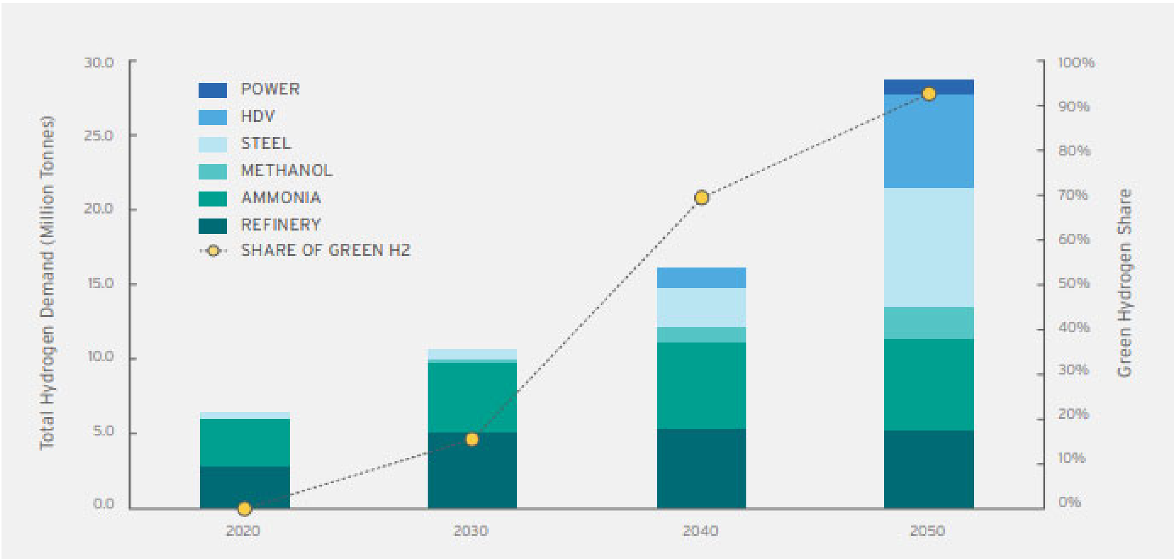

Figure 316 Hydrogen demand outlook and potential green hydrogen share at cost parity (without policy intervention)

(Source: : NITI Aayog (2022),"Harnessing Green Hydrogen Opportunities for Deep Decarbonization in India," p.37)

*The demand forecasts are based on demand forecasts by the Indian Ministry of Steel, Ministry of Consumer Affairs, Food and Public Distribution, Ministry of Petroleum and Natural Gas, IEA, Boston Consulting Group, World Bank, and RMI Analytics.

In addition, NITI Aayog forecasts the demand for petroleum-derived hydrogen and green hydrogen in the petroleum refining and fertilizer industries as shown in the figure below. Green hydrogen will account for more than half of the hydrogen demand in both the petroleum refining and fertilizer industries by 2040, and green hydrogen demand will account for most of the hydrogen demand by 2050.

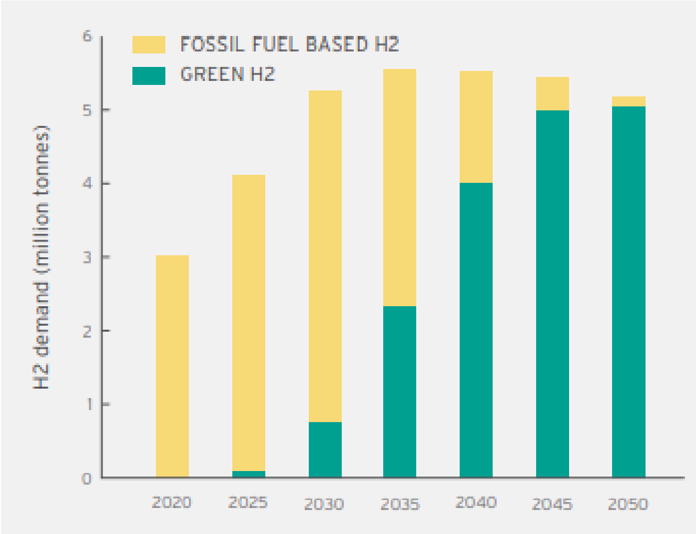

Figure 317 Hydrogen demand from refinery

(Source: NITI Aayog (2022),"Harnessing Green Hydrogen Opportunities for Deep Decarbonization in India," p.74)

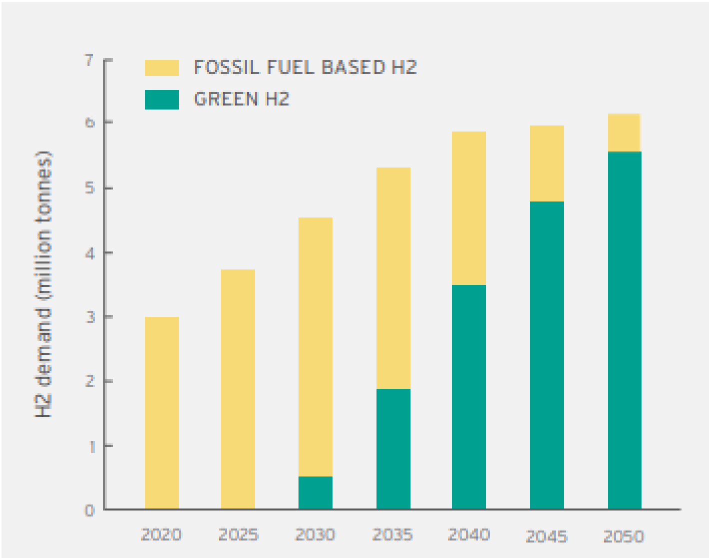

Figure 318 Hydrogen demand from ammonia for fertilizer

(Source: NITI Aayog (2022),"Harnessing Green Hydrogen Opportunities for Deep Decarbonization in India," p.75)

Currently, most fertilizer plants import and utilize ammonia as a raw material, and have technical knowledge of the ammonia supply chain and equipment, etc. Therefore, the fertilizer industry is considered to have an easier time introducing ammonia production facilities utilizing green hydrogen compared to other industries. However, if green hydrogen is produced using variable renewable energy, it may not be produced stably. While this is not a major problem as long as the amount of green hydrogen used is limited, MNRE is of the opinion that a stable supply of green hydrogen is an issue that must be addressed within the next 10 years as the amount of green hydrogen used increases, and that measures need to be considered for this purpose. MNRE is of the opinion that measures need to be taken to address this issue within the next decade.

According to MNRE, any demonstration project related to port infrastructure or to long-distance transportation by ship will be considered. According to MNRE, any demonstration project related to port infrastructure or long-distance transportation by ship is welcome. A demonstration project on maritime hydrogen transportation is already underway, funded by the Indian government.

In addition, the Indian government plans to support the introduction of hydrogen in mobility and demonstration projects of hydrogen in steel production[761]. As mentioned earlier, an action plan for hydrogen is currently being developed, and a draft budget and support details for the creation of demand for green hydrogen, incentives for green hydrogen production, and incentives for domestic manufacturing of related equipment are in the final approval stage. This draft has been developed through discussions among stakeholders, industry, and government officials in India. The budget and plans for R&D support projects, infrastructure, and export-related matters will also be finalized in the same manner.

Based on the above, it is considered that there is a need for research and demonstration projects to optimize green hydrogen production, including optimization of transportation to consumers (assuming the oil refining and fertilizer industries) in the clusters that the Indian government is considering. As for potential cluster sites, NITI Aayog points out that the west coast of India, with its abundance of renewable energy and concentration of fertilizer plants and oil refineries, and the steel industry in the eastern belt have potential for early hydrogen industry clusters[762]. Since the use of hydrogen in steel is still in the research and development stage in Japan, and no technology in the world is at the practical stage, it is likely that clusters will first be formed on the west coast with the intention of using hydrogen in the oil refining and fertilizer industries, which do not require any particular new technology.

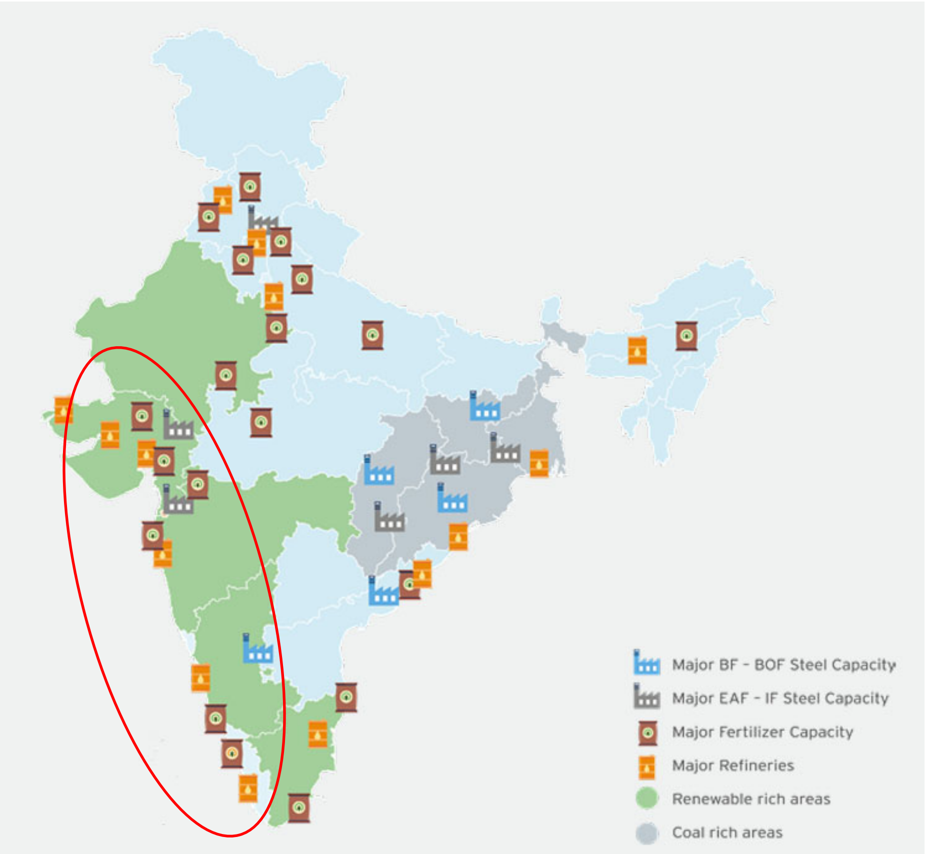

Figure 319　Location of key industrial facilities and potential energy source

(Source: NITI Aayog (2022),"Harnessing Green Hydrogen Opportunities for Deep Decarbonization in India")

761 The result of the interview from MNRE

762 NITI Aayog (2022), "Harnessing Green Hydrogen Opportunities for Deep Decarbonization in India"

(2) Thailand

Thailand is classified as a pattern with high green hydrogen production potential in the Upper-middle income, high hydrogen utilisation potential in the industrial sector and no hydrogen strategy under consideration.

(a) Trends of hydrogen-related policies, companies, and government support from other countries in Thailand

The manufacturing sector accounts for nearly 30% of GDP in Thailand, and the automotive industry is a major industry. Domestic hydrogen-related policies and developments in Thai domestic companies, foreign companies, foreign governments, donors, etc. are described below.

■ Hydrogen-related policies

No hydrogen-specific strategies, roadmaps, etc. have been developed

Table 296 Hydrogen-related policies

Policy	Overview
National Energy Planning Framework	The Ministry of Energy has identified increasing clean energy generation as one of the most urgent tasks for the next decade (2021-2030). (The Japanese Ministry of Economy, Trade and Industry is involved in this plan.)
Hydrogen Thailand	Public-private partnership initiatives on hydrogen.

■ Hydrogen-related trends among companies in Thailand

Table 297 Hydrogen-related trends among companies in Thailand

Company	Overview
EGAT	Wind power combined with a 300 kW fuel cell to supply the Ramtacon Learning Centre. Equipment is from Europe and China.（2018.4)
ThaiOilPlc（TOP）	Thailand's largest oil refiner. Acquired US hydrogen production start-up(2022.6).
BIG	Thai subsidiary of US industrial gas giant Air Products and Chemicals. Installed Thailand's first hydrogen filling station for fuel cell vehicles on a trial basis in collaboration with Thai National Oil PTT (2013).A Member of Hydrogen Thailand.
PTT	state-owned oil company. A Member of Hydrogen Thailand.

■ Support by the World Bank and ADB

Table 298 Support by ADB

Entity	Overview
ADB	Technical cooperation to promote clean energy development in Southeast Asia. The project will conduct country and sector-specific assessments, develop new business models, prepare FS reports, discuss necessary policies and design project investment pipelines. The first step will be the electrification of transport, followed in the medium to long term by the use of green hydrogen in the industrial sector to achieve the transition to clean energy.

ADB	Hydrogen will be generated using offshore wind power as an energy source and utilised in large trucks travelling along the coast. Eventually, the hydrogen will be used for electricity and ships. As this is a large-scale project involving the construction of a wind farm and the laying of submarine cables, a PPP is envisaged. (*From interview.)

■ Hydrogen-related trends in the Japanese Government and Japanese companies

Table 299 Hydrogen-related trends in the Japanese Government and Japanese companies

Entity	Overview
METI,Japan	Energy partnership in connection with AETI (2022.1). Hydrogen and ammonia are included in the cooperation.
Toyota, Kansai Electric Power Company, Osaka Gas, Toyota Tsusho.	A 'carbon neutral' industrial park is planned in the eastern province of Rayong with the aim of achieving virtually zero carbon dioxide emissions. The aim is to build an integrated system for the development, production, use and storage of renewable energy, including hydrogen. The first feasibility study for the project will be compiled by the end of this year and a recommendation made to the Thai government, with a view to opening the park in 2025. The first feasibility study will be compiled by the end of this year and recommendations made to the Thai Government. As an advanced industrial park initiative for decarbonisation, the project will also be considered for expansion to other South-East Asian countries. (2021.11) From the Japanese side, TMT, Toyota Tsusho (Thailand), Osaka Gas and Kansai Electric Power Co. From the Thai side are the Industrial Estate Authority of Thailand (IEAT), PTT, PTT's petrochemical subsidiary PTT Global Chemical (PTTGC) and US-based Bangkok Industrial Gas (BIG), a major industrial gas company.

■ Foreign governments and companies

Table 300 Foreign governments and companies

Entity	Overview
DOE, USA	Memorandum of Understanding signed with Bloom Energy, ATE, EGAT and EGCO Group for investment opportunities in fuel cell and electrolyser technology to support Thailand's decarbonisation and energy transition to hydrogen and towards carbon neutral goals.（2021.12）
Federal Ministry of Economic Affairs and Energy	Launched a project called H2-Uppp. Implemented in cooperation with the German-Thai Chamber of Commerce (GTCC). Supports green hydrogen and Power-to-X policies and market development. Also conducts market analysis（2022.1）.
Enapter (Start-up from Europe）	Agreement signed with EGAT in August 2019. Showcase for a building at Chiang Mai University that is 100% energy powered by renewable energy + hydrogen energy storage. One of the flagship projects of the European Commission's Hydrogen Valley Mission Innovation Platform.
Saudi Aramco	MoU signed with PTT on cooperation in the field of blue and green hydrogen and various clean energy-related initiatives (2022.5).

(b) Potential of Hydrogen Demonstration Project in Thailand

5.2.2 The hydrogen demand potential in Thailand as indicated in the "Analysis of hydrogen availability by consuming sector" is as follows. As a reference for a sense of the scale of the figures, hydrogen consumption (industrial use) in Japan in 2021 is approximately 403 million m^3[763].

Table 301 Summary of hydrogen demand potential

Unit: Mtoe

Country	Scenario 1		Scenario 2		Scenario 3	
	2040	2050	2040	2050	2040	2050
India	12.5	24.7	24.2	48.0	35.9	71.2
Indonesia	5.9	18.2	10.9	33.3	16.0	46.8
Morocco	0.3	0.5	0.6	1.0	0.8	1.5
Thailand	3.8	7.3	6.5	12.9	9.2	18.5

Unit: 1 million m^3 (NCV basis)

Country	Scenario 1		Scenario 2		Scenario 3	
	2040	2050	2040	2050	2040	2050
India	386,754	762,087	747,232	1,479,178	1,107,710	2,196,268
Indonesia	182,858	561,191	337,370	1,026,905	491,881	1,444,052
Morocco	8,934	16,409	17,170	31,328	25,406	46,248
Thailand	115,680	226,039	200,039	398,715	284,398	571,392

Unit: 1,000 tons (NCV basis)

Country	Scenario 1		Scenario 2		Scenario 3	
	2040	2050	2040	2050	2040	2050
India	32,294	63,634	62,394	123,511	92,494	183,388
Indonesia	15,269	46,859	28,170	85,747	41,072	120,578
Morocco	746	1,370	1,434	2,616	2,121	3,862
Thailand	9,659	18,874	16,703	33,293	23,747	47,711

Note: Conversion factor 30,834 m^3/toe, 0.0835 kg/m^3
Source: Survey team

Assuming that all of the above hydrogen demand potential is obtained from water electrolysis, the table below shows that, compared to the total electricity generation in 2019, it is unlikely to be realistic to produce all of the hydrogen demand potential from water electrolysis in the country, indicating that imports and domestic production of blue hydrogen could also be considered.

Table 302 Required amount of electricity generation

Unit: TWh

Country	Scenario 1		Scenario 2		Scenario 3		(Reference) Total power generation
	2040	2050	2040	2050	2040	2050	2019
India	1,547	3,048	2,989	5,917	4,431	8,785	1,611
Indonesia	731	2,245	1,349	4,108	1,968	5,776	288
Morocco	36	66	69	125	102	185	40
Thailand	463	904	800	1,595	1,138	2,286	186

763 Ministry of Economy, Trade and Industry Production Dynamics Statistics
https://www.meti.go.jp/statistics/tyo/seidou/result/ichiran/08_seidou.html#menu3

Source: Survey team

As the Thai Government has not yet clearly set out its vision for future hydrogen production and use, such as a hydrogen strategy, support for the formulation of a hydrogen strategy and other hydrogen-specific policy policies could be considered first. A more realistic estimation of hydrogen demand potential and support for the formulation of a long-term action plan/roadmap for the optimisation of domestic hydrogen use and production, consistent with the national energy policy, could be considered first.

(3) Indonesia

Indonesia is classified as a pattern with high green hydrogen production potential in the Upper-middle income, high hydrogen utilisation potential in the industrial sector and no hydrogen strategy under consideration.

(a) Hydrogen-related policies and companies, as well as government support from other countries in Indonesia

The country has fossil fuel resources such as coal, oil and gas. The manufacturing sector accounts for approximately 20% of GDP, mainly in the transport equipment (motorcycles) and food industries.

Domestic hydrogen-related policies and developments by Indonesian and foreign companies, foreign governments, donors and others are as follows.

■ Hydrogen-related policies

No hydrogen-specific strategies, roadmaps, etc. have been developed

Table 303 Hydrogen-related policies

Policy	Overview
MEMR roadmap policy towards net zero emissions (NZE) by 2060.	Plans for new and renewable energy NRE share of 23% in 2025, 42% in 2030, 57% in 2035, 71% in 2040, 71% in 2050 and 100% in 2060.

■ Hydrogen-related trends among companies in Indonesia

Table 304 Hydrogen-related trends among companies in Indonesia

Company	Overview
Pertamina Geothermal Energy (PGE)	Starting a for the development of hydrogen production using geothermal energy in the Ulubelu area (2021.8).

■ Support by ADB

Table 305 Support by ADB

Entity	Overview
ADB	Technical cooperation to promote clean energy development in Southeast Asia. The project will conduct country and sector-specific assessments, develop new business models, prepare FS reports, discuss necessary policies and design project investment pipelines. The first step will be the electrification of transport, followed in the medium to long term by the use of green hydrogen in the industrial sector to achieve the transition to clean energy.

■ Foreign governments and companies

Table 306 Foreign governments and companies

Entity	Overview
Samsung, Hyundai and GGGI.	Green hydrogen production project in Sarulla district, North Sumatra. Investment amount: $1.2 billion (2022.3).
Germangovernment and HDF Energy(France)	Initial feasibility study of a hybrid solar power plant pilot project using green hydrogen in Sumba district, East Nusatungara（2021）.

■ Hydrogen-related trends in the Japanese Government and Japanese companies

Table 307 Hydrogen-related trends in the Japanese Government and Japanese companies

Entity	Overview
METI, Japan	Energy partnership in connection with AETI (2022.1). Hydrogen and ammonia are included in the cooperation.
IHI	An MoU has been signed with PT Pembangkitan Jawa-Bali (PJB), a wholly-owned subsidiary of PLN, for the application of ammonia and biomass co-firing technologies, future application of dedicated firing technologies and verification of their economic viability, with plans to conduct various technical studies for existing boilers at the PJB-owned Gresik thermal power plant and others, assuming co-firing of carbon neutral fuels such as ammonia and future dedicated firing.
Marubeni	A demonstration project has been initiated in South Australia, Australia, on the production of low-cost green hydrogen, its transport to Indonesia using hydrogen storage alloys, and the utilisation of hydrogen through fuel cells(2022.1).
Toyo Engineering	FSs have been initiated with Pupuk Indonesia Holding Company (PIHC), Fertiliser Corporation, on green ammonia production at the fertiliser plant of Pupuk Iskandar Muda (PIM), Aceh (METI FS). A system to produce clean fuel ammonia by introducing green hydrogen to an existing fertiliser plant operated by PIM will be verified to ensure that the project is safe and economically rational, taking into account the selection of renewable energy sources of electricity and how to deal with fluctuations in electricity supply (2022.6).
Mitsubishi Cooperation, JOGMEC	Bandung Institute of Technology (ITB) and PT Panca Amara Utama (PAU) signed a Memorandum of Understanding (MOU) to conduct a joint study on Carbon Capture & Storage (CCS) and carbon dioxide utilisation for clean fuel ammonia production in the province of Central Sulawesi, Indonesia. A Memorandum of Understanding (MOU) was signed between the four parties agreeing to conduct a joint study on Carbon Capture & Storage (CCS) and carbon dioxide utilisation for clean fuel ammonia production in Central Sulawesi, Indonesia (2021.5).
Toshiba	An agreement was reached with PLN to collaborate on the dissemination of the H2One™ stand-alone hydrogen energy supply system in the country, and the signing took place at the Nichi-Ni Energy Forum organised by the Ministry of Economy, Trade and Industry (METI). (2018) *In an interview, H2One™ was described as "not suitable for power generation business in terms of economic efficiency. It can provide hot water and electricity for three to seven days at stations and other places in times of disaster, etc.".

(b) Potential of Hydrogen Demonstration Project in Indonesia

5.2.2 The hydrogen demand potential in Indonesia as indicated in the "Analysis of hydrogen availability by consuming sector" is as follows. As a reference for a sense of the scale of the figures, hydrogen consumption (industrial use) in Japan in 2021 is approximately 403 million m^3[764].

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Assuming that all of the above hydrogen demand potential is obtained from water electrolysis, the table below shows that, compared to the total electricity generation in 2019, it is unlikely to be realistic to produce all of the hydrogen demand potential from water electrolysis in the country, indicating that imports and domestic production of blue hydrogen could also be considered.

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Unit: TWh

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Morocco	36	66	69	125	102	185	40
Thailand	463	904	800	1,595	1,138	2,286	186

Source: Survey team

A modelling analysis of green hydrogen and ammonia trade under the 1.5°C scenario by IRENA indicates that Indonesia's potential demand for hydrogen is large, but due to the high capital cost of renewable energy, it will be one of the major importers, with almost all demand met through imports (Australia, the India are assumed to import from India).

[764] Ministry of Economy, Trade and Industry Production Dynamics Statistics https://www.meti.go.jp/statistics/tyo/seidou/result/ichiran/08_seidou.html#menu3

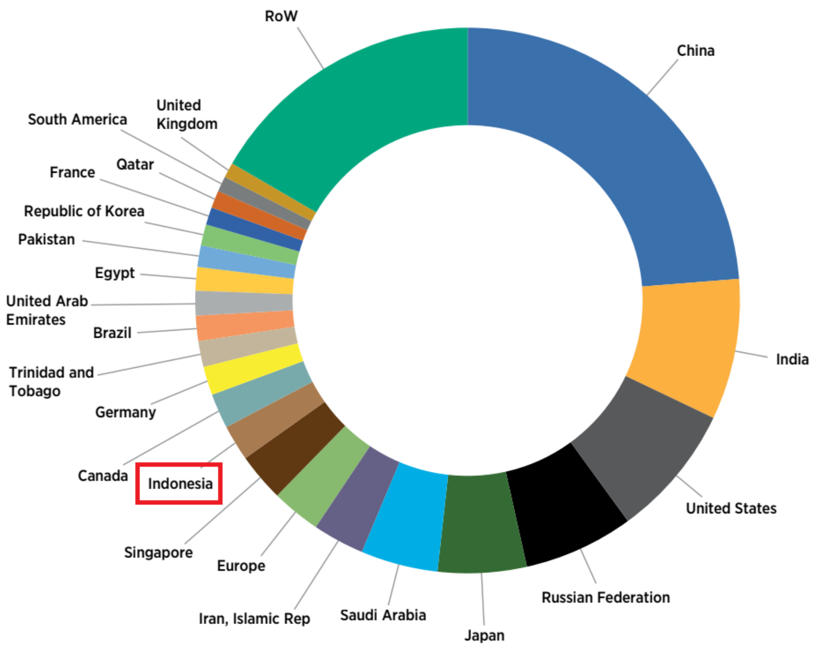
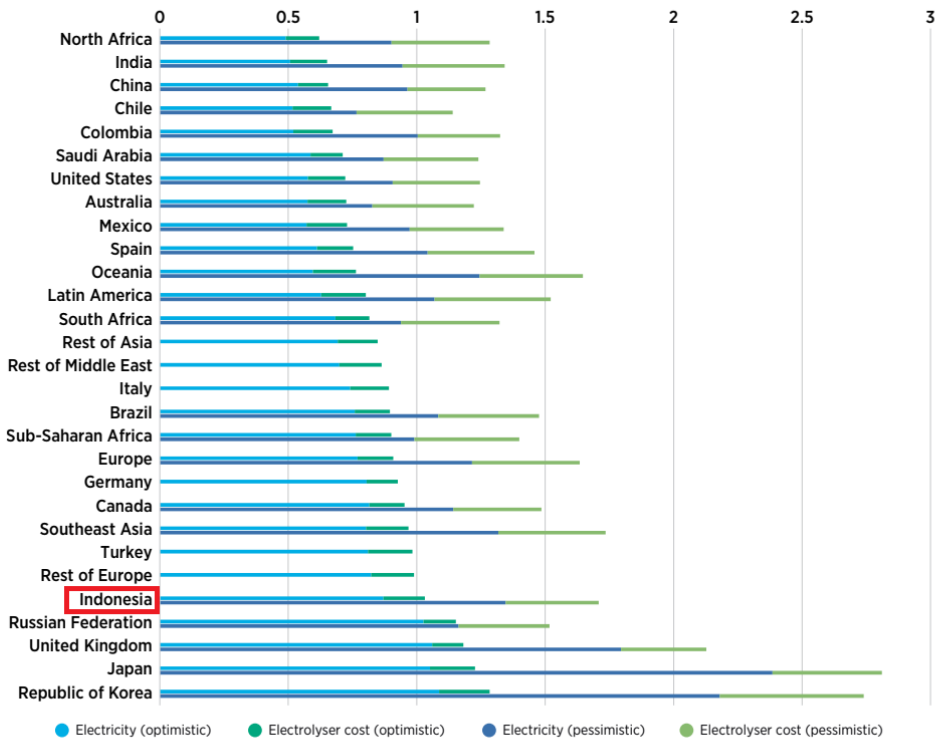


Figure 320　Hydrogen demand by country in 2050 under the 1.5°C scenario

Source：IRENA"GLOBAL HYDROGEN TRADE TO MEET THE 1.5°C CLIMATE GOAL"[765]



Unit：USD/kgH2

Figure 321　Levelised cost of hydrogen by region in 2050 for an optimistic and pessimistic scenario

765 https://www.irena.org/publications/2022/Jul/Global-Hydrogen-Trade-Outlook

Source：IRENA"GLOBAL HYDROGEN TRADE TO MEET THE 1.5°C CLIMATE GOAL"

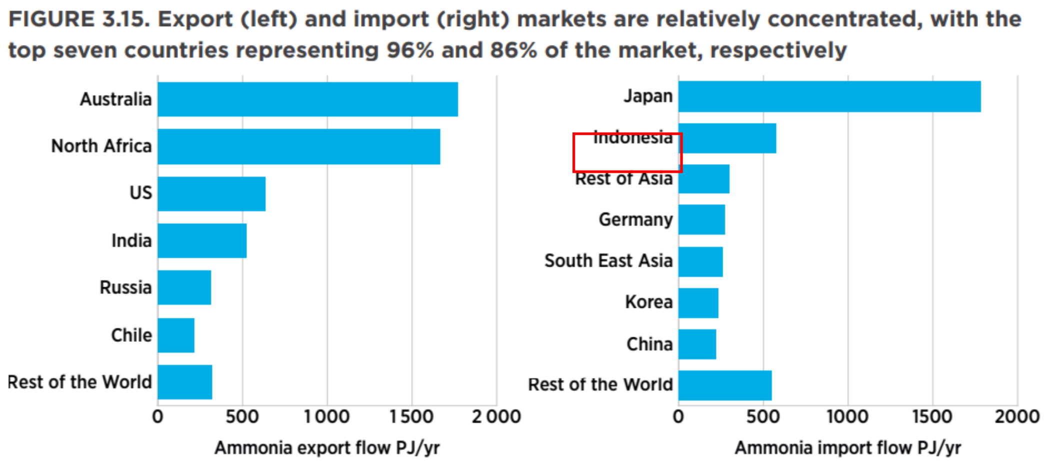


Figure 322 Export (left) and import (right) markets are relatively concentrated, with the top seven countries representing 96% and 86% of the market, respectively

Source：IRENA"GLOBAL HYDROGEN TRADE TO MEET THE 1.5°C CLIMATE GOAL"

In both analyses, the demand potential for hydrogen in Indonesia is significant. However, it is highly likely that a heavy reliance on imports would be considered undesirable by the Indonesian Government from an energy security perspective. It may be possible to support the development of a hydrogen strategy that optimises domestic hydrogen use and production, taking into account the domestic demand potential and production potential, but also from the perspective of energy security.

(i) Estimate the demand potential for hydrogen in Indonesia (based on the analysis of hydrogen availability by consumption sector in Section 5.2.2 of this report, and in consultation with the Indonesian Government).

(ii) Establishment of hydrogen utilisation targets on the demand side and incorporation into policies to achieve the net zero target.

- ➢ Set targets for the introduction of hydrogen in each sector, such as industry (use in fertilisers, oil refining, etc.), transport/transportation (use in buses, trucks, commercial vehicles, etc.) and power generation (ammonia co-firing, etc.) in line with the national net zero target
- ➢ Study policies to create demand

(iii) Set hydrogen price reduction targets and incorporate them into policies to optimise domestic hydrogen production.

- ➢ Setting targets for domestic hydrogen production
- ➢ Reducing the capital cost of electrolysers and renewable energy sources, optimising their location, etc. to reduce the cost of green hydrogen production
- ➢ Optimisation of location, etc. to reduce the cost of blue hydrogen production
- ➢ Optimisation of domestic transport and storage, cost reduction
- ➢ Study of policies for the promotion of hydrogen production

With regard to support for demonstration projects, as the immediate demand for green hydrogen and ammonia is likely to come from coal-fired ammonia co-firing, a demonstration for the establishment of a fuel ammonia supply chain (domestic transport,storage etc.) is considered.

Under the Asian Energy Transition Initiative (AETI) announced by the Ministry of Economy, Trade and Industry (METI) on 24 May 2021, IHI has signed an MoU with PT Pembangkitan Jawa-Bali (PJB), a wholly-owned subsidiary of PLN, as mentioned above. The MoU will involve the application of ammonia and biomass co-firing technologies, the application of future dedicated firing technologies and the verification of their economic feasibility.

The MoU will involve the co-firing of carbon-neutral fuels such as ammonia and various technical studies for the future implementation of dedicated firing, targeting existing boilers at the PJB-owned Gresik thermal power station and other plants. In the case of 20% ammonia co-firing, 500,000 tonnes per 100 MW per year is required, and securing low-carbon fuel ammonia and building a supply chain are considered to be major issues. A demonstration project for hydrogen transport and storage aimed at supplying the target coal-fired power plant could be one of the candidates. This needs to be discussed in consultation with the Ministry of Economy, Trade and Industry and other relevant national authorities.

(4) Morocco

As previously mentioned, Morocco is classified as a "lower-middle income" and a class with high green hydrogen production potential and low hydrogen use potential in the industrial sector. Because of Morocco's high dependence on fossil fuel imports, there is a need for hydrogen-related demonstration projects to reduce the country's dependence on fossil fuels and at the same time reduce the economic burden of imports. Based on a desktop survey of hydrogen-related trends in Morocco, a short list of six hydrogen demonstration projects was presented to MASEN. interviews with MASEN revealed that the projects include "Hydrogen production from renewable energy," "Hydrogen station + fuel cell car, fuel cell bus, fuel cell truck etc.", "Synthetic fuel: synthetic methane", and "Hydrogen export carriers: ammonia, MCH, liquefied hydrogen". Of these, needs for demonstration projects related to the installation of hydrogen stations and the introduction of fuel buses in coastal areas are particularly high. Below is an analysis based on the results of the desktop survey and interviews.

(a) Hydrogen-related policies and companies, as well as government support from other countries in Morocco

Morocco's major industries are agriculture and fisheries, mining, manufacturing, and tourism. Manufacturing and agriculture account for 13.72% and 12.96% of real GDP, respectively, by industry. Automotive-related products are the country's largest export, with finished vehicles being exported to Europe. Morocco also relies on imports for most of its fossil energy supply, with the exception of a small amount of natural gas (less than 10% self-sufficiency). With regard to natural gas, Algeria had been exporting natural gas to Spain via Morocco, but natural gas exports were suspended in November 2021 because the transit contract between Morocco and Spain and the contract for the sale of gas to Morocco expired and no new contract was concluded. From the perspective of energy security, the energy transition from fossil fuels to hydrogen is considered important.

■ Hydrogen related policies

Since the establishment of the Hydrogen Commission in 2019, various hydrogen-related policies have been developed.

Table 310 Hydrogen Policy in Morocco

Policies	Summary
Green Hydrogen Roadmap	It identifies hydrogen as a key growth area in the national economy and lays out an eight-point action plan to promote the development of green hydrogen (2021.8) It envisions a domestic hydrogen market of 4 TWh and an export market of 10 TWh by 2030. To meet this demand, 6 GW of new renewable energy capacity will be needed and more than 15,000 direct and indirect jobs will be created.
National Green Hydrogen Strategy	A national strategy aimed at creating economic and industrial sectors centered on green hydrogen and green ammonia (2021.8).
EV Roadmap (under preparation)	A roadmap is being developed to address legislation, industry integration, and incentives for home industries to promote EVs (2021.12). (In Phase 1, a market study on EVs and charging

	infrastructure will be conducted, and in Phase 2, a roadmap for EVs and charging infrastructure according to international standards will be developed. (using charging stations equipped with EV chargers developed based on hydrogen fuel cell technology).

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Hydrogen-Related Trends of Domestic Companies in Morocco

The table below shows the various initiatives related to hydrogen production and utilization undertaken by domestic companies in Morocco.

Table 311 Hydrogen-related businesses of Moroccan companies

Company name	Summary
OCP Group	OCP Group, a major player in phosphate-related industries, has expressed interest in strengthening and expanding cooperation with UNIDO to produce green hydrogen and ammonia (2022.6). In addition, together with IRESEN and the Mohammed VI University of Technology, a framework agreement for cooperation was signed to launch GREEN H2A, a technology platform for research, development, and innovation in the field of green hydrogen and its applications (PtX) (2021.11).
Nareva holdings	Nareva is a leading wind energy company. It is targeting investment opportunities in various renewable energy sources and was involved in the launch of GREEN H2A (2021.11).
Oxygène	A company that manufactures and sells medical gases; was involved in the launch of GREEN H2A (2021.11).

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Support from other donors etc.

In Morocco, the World Bank and other donors have provided or are planning to provide assistance, as shown in the table below.

Table 312 Support by other donors etc. in Morocco

Name of donor	Summary
WB	Modeling was done using a scenario of approaching net zero by 2050. In the future, we plan to analyze the scenario with the use of green hydrogen as well.
GIZ	The Government of Germany signed an energy partnership with Morocco (2012). Under this partnership, a FS study was conducted on the scope of PtX in Morocco. Cooperation has been established with the goal of producing and exporting green hydrogen. Future R&D projects are planned for the production, export, regional development, and industrial use of green hydrogen.
UNIDO	The Government of Morocco and UNIDO signed a joint declaration on mobilizing green funds for decarbonizing the industrial sector and promoting the use of green hydrogen in the industrial sector (2022.5).
AfDB	A survey is being conducted on opportunities for cooperation on hydrogen.
EBRD	EBRD and IRESEN have signed a MoU for investment promotion for energy transition in Morocco. Scope of cooperation includes green hydrogen (2021.9).

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Hydrogen-related trends in the Japanese government and Japanese companies

The table below shows the hydrogen-related projects being implemented by Japanese companies in Morocco.

Table 313 Hydrogen-related cooperation and implementation projects by the Japanese government and Japanese companies in Morocco

Name of company	Summary
MITSUI & CO., LTD.	As part of METI's FY2021 "Subsidy for Feasibility Study on Overseas Deployment of High-Quality Energy Infrastructure" project, we conducted a phased increase in the co-firing ratio and green ammonia co-firing at a coal-fired power plant in Morocco. In addition, we conducted a feasibility study on the use of DX to upgrade infrastructure operation and maintenance management (2021).

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

■ Foreign governments and companies

The table below shows the status of hydrogen-related cooperation by foreign governments and companies in Morocco.

Table 314 Hydrogen-related Trends in Morocco by Foreign Governments and Foreign Companies

企業名	Summary
Total Eren	Total Eren, an independent power company and subsidiary of French oil company Total Energies, has announced a €10.6 billion investment in a hydrogen and green ammonia project in Morocco (2022.2). The project plans to produce green hydrogen from wind and solar power.
Fusion Fuel	An Irish company involved in green hydrogen technology. announced (2021.7) a green hydrogen and green ammonia production project in Morocco. The project is the largest green hydrogen and green ammonia project announced in Morocco, with a total investment of over 7.5 billion dirhams (approximately USD 850 million), with the goal of producing 183,000 tons of green ammonia by 2026.
Shell	Shell has signed an agreement with Mohammed VI University of Technology and OCP Group to conduct a research and development project on green ammonia production (2022.3). The project will study the feasibility of large-scale production of ammonia using green elements.
Air Liquide	A French industrial gas producer that has committed to invest €8 billion in the low-carbon hydrogen value chain by 2035 and to invest in the development of a 3 GW capacity electrolyser by 2030. It was involved in the launch of GREEN H2A (2021.11).
Government of the Netherlands	The Dutch and Moroccan governments held the World Hydrogen Summit & Exhibition 2022 in Rotterdam, a meeting on cooperation between Morocco and the Netherlands in the field of green hydrogen and confirmed the implementation of a project on green hydrogen (2022. 5). A partnership project between Moroccan and Dutch green hydrogen operators is expected to be implemented.
Government of Portugal	The two countries signed a Declaration of Cooperation aimed at developing a partnership in the field of green hydrogen between the economic stakeholders of the two countries (2021.2).

(Source: Compiled by JICA Survey Team based on desktop research and interviews)

(b) Potential of Hydrogen Demonstration Project in Morocco

On July 21, 2022, an interview was conducted with MASEN's Director of R&D and Industrial Integration (Director of R&D and Industrial Integration) to determine the needs for hydrogen demonstration projects in Morocco. During the interview, six demonstration projects and their case studies shown in the table below were presented to ascertain the level of interest.

Table 315 Potential hydrogen demonstration projects and expected counterparts in Morocco

No.	Possible demonstration projects	Summary	Expected counterparts
1	Hydrogen production from renewable energy	Green hydrogen will be produced from electricity sourced from solar, wind and hybrid solar/wind generating units, and the hydrogen will be supplied to domestic hydrogen utilizing facilities or to the premises for hydrogen export.	- Ministry of Energy Transition and Sustainable Development - MASEN
2	Maximize the use of output-variable renewable energy sources	The objective of the demonstration is to optimize the operation of the power system to maximize the utilization of electricity from VREs to supply hydrogen in response to hydrogen demand, and to provide flexibility to the grid. The system configuration will be based on the FH2R system in Namie-cho, Fukushima and the Yamanashi demonstration, and will include VREs and on-site water electrolysis equipment, as well as a control system to manage the optimal energy operation. The produced green hydrogen will be supplied to adjacent hydrogen consuming facilities.	- Ministry of Energy Transition and Sustainable Development - MASEN - ONEE
3	Domestic Transportation	Depending on the location of hydrogen production and demand, the demonstration will include consideration of transporting hydrogen domestically using a high-pressure hydrogen trailer, domestic hydrogen transportation using a liquefied hydrogen trailer, or a hydrogen pipeline. In addition to the demonstration of related technologies, support for safety standards and the creation of related regulations will also be considered.	- Ministry of Energy Transition and Sustainable Development - MASEN - Ministry of Transport and Logistics
4	Hydrogen stations + fuel cell vehicles, fuel cell buses, fuel cell trucks, etc.	The project aims to develop hydrogen utilization and related infrastructure in the road sector, including the establishment and operation of hydrogen stations, and the demonstration of fuel cell vehicles, fuel cell buses and fuel cell trucks. In addition to technology demonstrations, support for the development of related safety standards and regulations will also be considered.	- Ministry of Energy Transition and Sustainable Development - MASEN - Ministry of Transport and Logistics
5	Synthetic fuels: Synthetic Methane	This is a demonstration project to produce synthetic methane from CO_2 collected from thermal power plants, the industrial sector, biomass electricity generation, cement plants, etc., and domestically produced green hydrogen. Future plans include blending synthetic methane into	- Ministry of Energy Transition and Sustainable Development - MASEN - Ministry of Transport and Logistics

		city gas infrastructure and supplying natural gas vehicles.	
6	Hydrogen export carriers: ammonia, MCH, liquefied hydrogen	In order for Morocco to enable exporting hydrogen, a necessary FS will be conducted at first, and it is envisioned that related facilities for hydrogen export at synthesis or liquefaction facilities, tanks and ports of carriers identified as optimal in the FS will be developed and demonstrated for actual operation. In addition to the technical demonstration, support for the preparation of related safety standards and regulations will also be considered.	- Ministry of Energy Transition and Sustainable Development - MASEN - Ministry of Transport and Logistics

*MASEN has placed a circle in the number of the demonstration project in which MASEN has expressed interest and for which there is a high need in Morocco. (A red circle indicate demonstration projects that are considered to have particularly high needs.

(Source: Compiled by JICA Survey Team)

1. "Hydrogen production from renewable energy sources" was of interest, but "maximum use of renewable energy sources with variable power output" was not a need and feasibility of implementation, as it requires improvements in infrastructure and industrial infrastructure, which are prerequisites for its introduction, and is not consistent with the current vision of Morocco. low. In the case of hydrogen production using renewable energy, it is necessary to improve both the hard aspects, such as installation of renewable energy and water electrolysis equipment, and the soft aspects, such as human resources, securing financial resources, and measures for concluding long-term sales contracts and taxation, but these are not yet in place, and thus there are needs for cooperation in both the hard and soft aspects. However, this is an area where many European governments and companies have already made inroads, as shown in Figure "Hydrogen-related Trends of Foreign Governments and Companies in Morocco".

In the table above, MASEN showed the most interest in the introduction of "4. Fuel Cell Buses. The introduction of fuel cell buses for public transportation and the use of green hydrogen produced in the country as a fuel, which can achieve low-carbon public transportation and reduce dependence on fossil fuels, generated a high level of interest on the part of Morocco. Since there are no hydrogen stations in Morocco, it is expected that the demonstration project will be used for round-trips within a predetermined route where a hydrogen station has been installed. In addition, since water, the raw material for green hydrogen, must be procured from seawater desalination plants, coastal areas such as Rabat and Agadir, where desalination plants have been installed, were identified as candidate sites. Since no country in Africa has yet introduced fuel cell buses, the introduction of fuel cell buses in Morocco will be the first demonstration project on the African continent. The hydrogen roadmap calls for the pilot project to be implemented before 2025.

As for "5. Synthetic fuels," the hydrogen roadmap aims to export synthetic fuels to Europe through pipelines after 2035, and although they expressed interest in this project, there is a need to consider the source of recovery of CO_2, the raw material for synthetic fuels, as well as the need for collaboration with related organizations in the heavy industry sector. However, he expressed concern that institutional issues may arise because of the need to consider the source of CO_2 capture as a raw material for synthetic fuels and the need to collaborate with related organizations in the heavy industry sector. Since the sources of CO_2 emissions that can be used as feedstock are known to some extent, cooperation, including the establishment of a system and institutional structure, will be necessary when conducting a demonstration project related to the production of synthetic fuels. Currently, it is difficult to immediately implement a project related to synthetic methanol, as the necessary legal framework for the use of large amounts of methanol is not yet in place. Since regulations and standards for hydrogen fuel and transportation are not yet in place, there is also a high need for technical cooperation for the development of these regulations and standards. However, the fact that it is considered an export product for Europe also means that it is likely to compete with cooperation from European governments and other organizations.

Based on the above, it is suggested that a demonstration project of fuel cell buses (including installation of hydrogen stations) as a form of hydrogen use be conducted in coastal areas such as Rabat and Agadir, along with a demonstration of hydrogen production. In Japan, the Tokyo Metropolitan Government has already introduced 84 fuel cell buses as of December 2020[766], so this is an area where the experience and knowledge of fuel cell bus operations in Japan can be utilized.

5.3.3 Basic Survey for Establishing Guidelines for Green Hydrogen

(1) Laws and regulations concerning hydrogen supply and utilization in Japan

This section reviews the outline of the laws and regulations in Japan relating to the production, storage, transport, and consumption of hydrogen. With the main focus on regulations under the High Pressure Gas Safety Act, other relevant laws and regulations are studied. It should be noted that, because comparisons with foreign laws and regulations are considered, only the principles are extracted, and conditions and exceptions are not described.

Laws and regulations include laws, cabinet orders, and ministerial ordinances.

From the viewpoint of low carbonization, hydrogen production through water electrolysis using power generation from renewables is considered to be the main focus, but in this study, laws and regulations related to power generation from renewables are excluded from the scope of the study.

1) Summary

Table 316 Supply chain and Relevant laws and regulations

Supply chain	Relevant laws and regulations (what are considered to be important regulations are extracted)
Production and storage	High Pressure Gas Safety Act Subject: Compressed gas, the pressure of which is not less than 1 MPa at its normal operating temperature (hydrogen falls under this category) Major regulations: Permission is required for installation Completion inspection by an external party is required A Safety Chief who holds a certificate for each facility needs to be appointed and assigned (= multiple qualified persons are required per factory) Annual inspection by an external party is required Act on the Prevention of Disasters in Petroleum Industrial Complexes and Other Petroleum Facilities (only in certain areas) Facilities are separated by passages in accordance with usages, such as production and storage (= requiring a larger area than necessary) Industrial Safety and Health Act Airing, ventilation, and dust removal measures are required. Air Pollution Control Act (hydrogen production through fossil fuel reforming) Obligation to measure soot and smoke as well as NOx

766 "Tokyo Metropolitan Government's Efforts to Promote Hydrogen Energy." https://www.kankyo.metro.tokyo.lg.jp/climate/hydrogen/hydrogen_seminar.files/tokyo.pdf

	Noise Regulation Law and Vibration Regulation Law (mainly applicable to compressors) Application for installation is required
Transport	[Transport by vehicles (tank trucks, etc.)] High Pressure Gas Safety Act Tanks are subject to regulations on storage A driver needs to be a certificate holder Two drivers are needed for long hours of transport Road Act Traveling through underwater tunnels is prohibited or restricted [Transport through pipelines] High Pressure Gas Safety Act Regulations on burial depth Pipes require to undergo a pressure resistance test Gas Business Act (in the case of crossing a site) Appointment of a chief gas engineer with a certificate (no compatibility with the High Pressure Gas Safety Act)
Utilization	[General] High Pressure Gas Safety Act It is subject to regulations on storage when gas is purchased and stored Notification is required to be submitted when high-pressure gases are used in the consuming equipment Facilities need to keep distance from schools, hospitals, etc. [Hydrogen station] High Pressure Gas Safety Act Distance regulation between facilities, installation of sprinkling facilities and fire walls, and facilities equipped with safety device Assignment of qualified persons [Power generation] Electricity Business Act (power generation capacity above a certain scale) (Even if the fuels are high-pressure gases, the Electricity Business Act is mainly applied, instead of the High Pressure Gas Safety Act or the Gas Business Act) Assignment of qualified persons with certificates Various safety regulations Fire Service Act It is applied to the storage of MCH which is a hydrogen carrier

2) Purpose of relevant laws and regulations, the scope of regulations

(A) High Pressure Gas Safety Act

A) Purpose of the Act (Article 1, excerpt)

It is to regulate the production, storage, sale, transport, and other matters related to handling and consumption of high-pressure gases, as well as the manufacture and handling of their containers in order to prevent disasters caused by high-pressure gases. In addition, it is to encourage voluntary activities by private businesses for the safety of high-pressure gases. This ensures public safety.

B) Scope of regulations (Article 2, excerpt)

High-pressure gas to which the High Pressure Gas Safety Act is applied means compressed gas, the pressure of which is not less than 1 MPa at its normal operating temperature and which is currently not less than 1 MPa, or compressed gas, the pressure of which is not less than 1 MPa at a temperature of 35°C.

The High Pressure Gas Safety Act is applied to all high-pressure gas supply chains (production, storage, transport, and consumption).

In the case of hydrogen, it is applied to compressed hydrogen and liquid hydrogen of 1 MPa or more. In the case of hydrogen carriers, it is applied to ammonia, but not MCH.

(B) Act on the Prevention of Disasters in Petroleum Industrial Complexes and Other Petroleum Facilities

A) Purpose of the Act (Article 1, excerpt)

Since petroleum industrial complexes are a large group of factories that handle high-pressure gases, highly volatile substances, and poisonous substances, they may bring serious damage in the event of a disaster. For this reason, the purposes of this Act are to establish basic matters concerning the prevention of disasters, to promote various measures for the prevention of the occurrence and spread of disasters at petroleum industrial complexes through synergistic effects with the Fire Service Act, the High Pressure Gas Safety Act, and other laws concerning the prevention of disasters, and to protect the lives, bodies, and property of the citizens from disasters.

B) Scope of regulations

Petroleum that contains hydrogen, and high-pressure gases, are subject to regulations.

Act on the Prevention of Disasters in Petroleum Industrial Complexes and Other Petroleum Facilities is applied to the production, storage, transport (unloading and loading facilities), and consumption of petroleum and high-pressure gases in petroleum industrial complexes.

(C) Industrial Safety and Health Act

A) Purpose of the Act (Article 1, excerpt)

The purposes are to ensure workers' safety and health in the workplace and to facilitate the creation of comfortable work environments, by advancing comprehensive and systematic measures related to industrial injury prevention, such as taking measures to establish standards for hazard prevention, clarifying accountability structures, and promoting autonomous action with a view to preventing industrial injuries.

B) Scope of regulations (Article 2, excerpt)

Construction, equipment, raw material, gas, vapor, dust, or the like that is related to the employment of workers are in the scope.

The Industrial Safety and Health Act is applied to the production, storage, and transport of hydrogen.

(D) Air Pollution Control Act

A) Purpose of the Act (Article 1, excerpt)

The purpose is to protect victims of air pollution. For this reason, the following matters are stipulated.

- Regulation on emissions of soot and smoke, volatile organic compounds, and dust from factories
- Promotion of the implementation of measures against hazardous air pollutants
- Protection of citizens' health
- Preservation of the living environment
- Liability of businesses to compensate for loss and damage if damage to human health arises in connection with air pollution

B) Scope of regulations (Article 2, excerpt)

Sulfur oxides, soot and dust, and volatile organic compounds are subject to regulations.

As for hydrogen, regulations are applied when hydrogen is produced or consumed by reforming fossil fuels with steam.

(E) Noise Regulation Law

A) Purpose of the Act (Article 1, excerpt)

The purposes are to implement necessary regulations on noise generated in factories over a considerable range, to preserve the living environment, and to contribute to the protection of citizens' health.

B) Scope of regulations (Article 2, excerpt)

Among the facilities installed in factories, those that generate significant noise are in the scope. In the case of hydrogen, compressors for the production and storage of compressed hydrogen are the main targets of regulations.

Regulations also cover the areas where housing is concentrated, areas around hospitals or schools, and other areas where it is deemed necessary to protect the living environment of residents by preventing noise.

(F) Vibration Regulation Law

A) Purpose of the Act (Article 1, excerpt)

The purposes are to implement necessary regulations on vibration generated in factories over a considerable range, to preserve the living environment, and to contribute to the protection of citizens' health.

B) Scope of regulations (Article 2, excerpt)

Among facilities installed in factories or workplaces, those that generate significant vibration are in the scope. In the case of hydrogen, compressors for the production and storage of compressed hydrogen are the main targets of regulations.

Regulations also cover the areas where housing is concentrated, areas around hospitals or schools, and other areas where it is deemed necessary to protect the living environment of residents by preventing vibration.

(G) Road Act

A) Purpose of the Act (Article 1)

The purpose is to stipulate matters concerning roads, such as the designation, approval, management, structure, and maintenance of routes, as well as the classification of cost bearing, in order to improve the road network, thereby contributing to the development of traffic and promoting public welfare.

B) Scope of regulations (Article 2, excerpt)

The transport of dangerous goods is in the scope. In the case of hydrogen, transport of compressed hydrogen and liquid hydrogen is subject to regulations.

(H) Fire Service Act

A) Purpose of the Act (Article 1, excerpt)

The purpose of this Act is to prevent, guard against, and suppress fires, to protect the lives, bodies, and property of citizens from fires, to reduce the damage arising from fires or disasters such as earthquakes, and to appropriately transport injured and sick persons due to disasters, thereby maintaining peace and order and contributing to the promotion of social and public welfare.

B) Scope of regulations (Article 2, excerpt)

They are applied to the production, storage, transport, and consumption of liquid fuels.
The MCH, which is a hydrogen carrier, is subject to the Fire Service Act.

(I) Gas Business Act

A) Purpose of the Act (Article 1, excerpt)

The purpose is to ensure public safety and prevent pollution by coordinating the operation of gas business and regulating the construction, maintenance, and operation of gas facilities.

B) Scope of regulations (Article 2, excerpt)

Within the scope of the study in this section, the transport of hydrogen (through pipelines) is covered.

Note that, when supplying city gas mixed with hydrogen, the entire hydrogen supply chain (production, storage, transport, and consumption) is in the scope, but the city gas business is excluded from this study.

(J) Electricity Business Act

A) Purpose of the Act (Article 1, excerpt)

The purpose is to assure public safety and promote environmental preservation by realizing appropriate and reasonable management of electricity business and regulating the construction, maintenance, and operation of electric facilities.

B) Scope of regulations (Article 2, excerpt)

Within the scope of the study in this section, hydrogen consumption (power generation) is in the scope.

In order to increase the hydrogen demand potential, hydrogen-fired power generation is effective. However, because thermal power generation is almost like a multi-year national project with a wide variety of regulations, etc., it is not in the scope of this study, which compares the regulatory differences with foreign countries.

3) Corresponding Articles related to hydrogen (excerpts) and specific regulations on hydrogen

(A) Production and storage of hydrogen

This section summarizes the regulations of the High Pressure Gas Safety Act concerning the production and storage of hydrogen. Regulations on storage may also apply to transport and utilization. The outline of the regulation on hydrogen stations that supply hydrogen to FCVs, which is one of the forms of hydrogen utilization, is compiled in a separate section.

A) High Pressure Gas Safety Act

(a) Definition of high-pressure gas (Article 2, paragraph (1) of the Regulation on Safety of General High Pressure Gas)

Since hydrogen and ammonia (hereinafter referred to as hydrogen) are included in combustible gas described in Article 2, paragraph (1) of the Regulation on Safety of General High Pressure Gas, hydrogen is subject to regulations under the High Pressure Gas Safety Act.

Article 2 of the High Pressure Gas Safety Act defines high-pressure gas as “compressed gas, the pressure of which is not less than 1 MPa at its normal operating temperature.” In foreign countries, the pressures subject to regulation may differ. If a Japanese company that manufactures high-pressure gas-related facilities is to launch its facilities that comply with Japanese regulations in a foreign country, they may not comply with the regulations in the relevant country.

(b) Difference between permission and notification based on production volume (Article 5 of the High Pressure Gas Safety Act)

a) If the daily capacity of hydrogen production (volume of gas that can be processed per day, calculated at 0°C and 0 Pa) is 100 m^3 or more, the manufacturer becomes a Class 1 Producer and needs to obtain permission from the prefectural governor. Upon completion of the construction work for the installation of a production facility, it shall not be used until it undergoes a completion inspection provided by the prefectural governor and is found to be in conformity with the technical standards[767].

b) If the daily capacity of hydrogen production (volume of gas that can be processed per day, calculated at 0°C and 0 Pa) is less than 100 m^3, the manufacturer becomes a Class 2 Producer and needs to submit a notification to the prefectural governor.

(c) Difference between permission and notification based on storage quantity (Article 15 of the High Pressure Gas Safety Act)

a) If a hydrogen storage facility has a daily capacity (volume of gas that can be processed per day, calculated at 0°C and 0 Pa) of at least 1,000 m^3, it becomes a Class 1 Storage Place and needs to obtain permission from the prefectural governor. Upon completion of the construction work for the installation of a storage facility, it shall not be used until it undergoes a completion inspection provided by the prefectural governor and is found to be in conformity with the technical standards.

b) If a hydrogen storage facility has a daily capacity (volume of gas that can be processed per day, calculated at 0°C and 0 Pa) of at least 300 Nm^3 and less than 1,000 m^3, it becomes a Class 2 Storage Place and needs to submit a notification to the prefectural governor.

c) If a hydrogen storage facility has a daily capacity (volume of gas that can be processed per day, calculated at 0°C and 0 Pa) of less than 300 Nm^3, permission and notification are not required.

(d) Import (Article 22 of the High Pressure Gas Safety Act)

If high-pressure gas is imported, the imported high-pressure gas and the container shall undergo import inspection by the prefectural governor and may not remove them until they have been verified as being in conformity with the technical standards specified by an Ordinance of METI. Provided, however, that this shall not apply in the case where the high-pressure gas is imported by unloading through pipelines from a ship.

(e) Safety

a) Hazard Prevention Rule (Article 26 of the High Pressure Gas Safety Act)

A Class 1 Producer shall formulate a Hazard Prevention Rule describing the items specified by an Ordinance of METI and shall submit a notification report thereof to the prefectural governor.

b) Safety training (Article 27 of the High Pressure Gas Safety Act)

A Class 1 Producer needs to prepare a Safety Training Program and conscientiously implement it. Any Class 2 Producer and Class 1 Storage Place shall provide their employees with safety training.

c) Safety Chief (Article 27-2 of the High Pressure Gas Safety Act)

A Class 1 Producer shall appoint a high pressure gas production safety chief who holds a Production Safety Management Certificate for each division of the facilities.

d) Safety inspection (Article 35 of the High Pressure Gas Safety Act)

With respect to facilities for production which may have the possibility of explosion or other disasters due to high-pressure gas, a Class 1 Producer shall annually subject such facilities to a

[767] It is stipulated in the Regulation on Safety of General High Pressure Gas (Ordinance of the Ministry of International Trade and Industry).

safety inspection conducted by the prefectural governor. A Class 2 Producer is required to conduct a periodical self-inspection once a year.

(f) Ventilation measures (Article 6, paragraph (1), item (ix) of the Regulation on Safety of General High Pressure Gas)
According to Article 6, paragraph (1), Item (ix) of the Regulation on Safety of General High Pressure Gas, rooms in which hydrogen production equipment, storage containers, and consuming equipment are installed shall have such a structure that hydrogen does not stay in the rooms when it leaks.
In the case of hydrogen gas, facilities shall have a well-ventilated structure by means of openings having a sufficient area in two or more directions, or by ventilators, or the combination of both, in consideration of the nature of hydrogen, the amount of gas to be processed or stored, the characteristics of the facilities, and the room size.

(g) Filling containers (Article 44 of the High Pressure Gas Safety Act)
No person who has manufactured or imported containers may transfer or deliver such containers unless they have passed the container inspection and bear the mark to indicate that they have successfully passed the said inspection.

Article 6, paragraph (2), item (viii) of the Regulation on Safety of General High Pressure Gas stipulates the standards for storage methods of storage containers as follows (excerpt).

- Within 2 m of the container storage area, the use of fire shall be prohibited, and flammable or ignitable substances shall not be placed. Provided, however, that this shall not apply when measures have been taken to effectively block the space between the container and fire, or flammable or ignitable substances.
- Compressed hydrogen containers for transportation automobiles shall be kept at a temperature of 65°C or less at all times.

(B) Act on the Prevention of Disasters in Petroleum Industrial Complexes and Other Petroleum Facilities
Under Article 3 of the Ministerial Ordinance on the Arrangement of Facility Districts for Newly Established Business Office in Special Disaster Prevention Areas for Petroleum Industrial Complexes and Other Petroleum Facilities, it is stipulated that production facility districts, storage facility districts, unloading and loading facility districts, service facility districts, business management facility districts, or other facility districts shall be classified.

Under Article 11 of the Ministerial Ordinance on the Arrangement of Facility Districts for Newly Established Business Office in Special Disaster Prevention Areas for Petroleum Industrial Complexes and Other Petroleum Facilities, it is stipulated that specified passages shall be provided in accordance with the area of production facility districts and storage facility districts.

Table 317 Width of specified passage

Division of districts	Width of specified passage
1. Production facility district	
a. Having an area of less than 20,000 m^2	6 m
b. Having an area of at least 20,000 m^2 and less than 40,000 m^2	8 m
c. Having an area of at least 40,000 m^2 and less than 60,000 m^2	10 m
d. Having an area of at least 60,000 m^2	12 m
2. Storage facility district	
a. Having an area of less than 10,000 m^2	6 m
b. Having an area of at least 10,000 m^2 and less than 20,000 m^2	8 m
c. Having an area of at least 20,000 m^2 and less than 40,000 m^2	10 m

d. Having an area of at least 40,000 m^2	12 m
3. Unloading and loading facility district, service facility district, or business management facility district	6 m

Source: Ministerial Ordinance on the Arrangement of Facility Districts for Newly Established Business Office in Special Disaster Prevention Areas for Petroleum Industrial Complexes and Other Petroleum Facilities

(C) Industrial Safety and Health Act (Article 261 of the Ordinance on Industrial Safety and Health)
The provision of Article 261 of the Ordinance on Industrial Safety and Health is applied to the handling of hydrogen gas.

"As regards places where there is a risk of explosions or fires due to existing vapor of inflammable substances, flammable gas or flammable dust, the employer must take measures such as ventilation, airing, or removal of dust in order to prevent the explosions or fires. (Work of Gas Welding at a Place Where Ventilation Is Insufficient)"

(D) Air Pollution Control Act (Article 15 of the Regulation for Enforcement of the Air Pollution Control Act)
When hydrogen is produced by reforming fossil fuels, the reformer is regarded as a gas-generating furnace; therefore, the Air Pollution Control Act is applied. Notification to the competent local government is required under Article 9 of the Regulation for Enforcement, and periodic measurements of soot and smoke, as well as NOx, are required under Article 15 of the said Regulation.

Table 318 Measurement frequency of amounts and concentrations of soot and smoke (partly omitted)

Facility condition	Measurement frequency
a. Facilities having a reformer of a steam-reforming type with a hydrogen production capacity of less than 1,000 m^3 at a temperature of 0°C and a pressure of 1 atmosphere (limited to those using only gaseous fuels and raw materials) and reformer for fuel cells	At least once every five years
b. Facilities that emit soot and smoke from the outlet with an exhaust gas volume of less than 40,000 m^3 (excluding a.)	At least twice a year in principle
c. Facilities other than b.	At least once per work period not exceeding 2 months

Source: Article 15 of the Regulation for Enforcement of the Air Pollution Control Act

Table 319 Measurement of the concentration of soot and smoke associated with nitrogen oxides

Facility condition	Measurement frequency
a. Facilities having a reformer of a steam-reforming type with a hydrogen production capacity of less than 1,000 m^3 at a temperature of 0°C and a pressure of 1 atmosphere (limited to those using only gaseous fuels and raw materials) and reformer for fuel cells	At least once every five years
b. Facilities that emit soot and smoke from the outlet with an exhaust gas volume of less than 40,000 m^3 (excluding a.)	At least twice a year in principle
c. Facilities other than b.	At least once per work period not exceeding 2 months

Source: Article 15 of the Regulation for Enforcement of the Air Pollution Control Act

(E) Article 3 of the Noise Regulation Law and Article 3 of the Vibration Regulation Law

Under the Noise Regulation Law and the Vibration Regulation Law, specified facilities are stipulated as those that generate significant noise and vibration among facilities installed in factories or workplaces. In the hydrogen supply chain business, air compressors and blowers with a rated power output of 7.5 kW or more for the prime mover may fall under the category of specified facilities. Therefore, if such facilities have been introduced, applications must be submitted to the competent local government regardless of the level of noise generated. However, each local government has different noise regulation values.

2) Transport of hydrogen

(A) Transport by a container fixed to a vehicle

(Excerpt from Article 49 of the Regulation on Safety of General High Pressure Gas)

- Compressed hydrogen containers for transportation automobiles shall not be used if they are older than 15 years.
- When transporting compressed gas with a volume of 300 m^3 or more and liquefied gas with a mass of 3,000 kg or more, a person who holds a Production Safety Management Certificate shall monitor the transport.
- In the case of continuous operation time exceeding 4 hours or the operation time of the operation team exceeding 9 hours a day, two operators must be assigned.
- Compressed hydrogen containers for transportation automobiles needs to be kept at a temperature of 65°C or less at all times.

(Article 46, paragraph (3) of the Road Act)

Traffic is prohibited or restricted in underwater tunnels or the like by vehicles carrying dangerous substances with explosive or flammable properties.

(B) Transport through pipelines

(Excerpt from Article 6 of the Regulation on Safety of General High Pressure Gas)

- Pipelines must be buried at least 60 cm below the ground level.
- Pipelines must pass the pressure resistance tests at 1.5 atmospheres or more for liquids and 1.25 atmospheres or more for air, nitrogen, etc.

(Article 168 of the Ordinance for Enforcement of the Gas Business Act)

When hydrogen is supplied through pipelines from outside the premises, the Gas Business Act is applied. When installing pipelines exceeding 500 m on the premises, a chief gas engineer who holds a chief gas engineer's license shall be appointed.

3) Utilization of hydrogen

(A) Specific high-pressure gases (Article 24-2 of the High Pressure Gas Safety Act, and Article 7, paragraph (2) of the Order for Enforcement of the High Pressure Gas Safety Act)

If specific high-pressure gases are to be consumed, notification shall be submitted to the prefectural governor no later than 20 days prior to commencement of consumption (Article 24-2 of the High Pressure Gas Safety Act). It is applied to the cases in which compressed hydrogen of 300 m^3 or more and liquefied ammonia of 3,000 kg or more are stored and consumed under Article 7, paragraph (2) of the Order for Enforcement of the High Pressure Gas Safety Act. This may be the case when hydrogen is used as boiler fuel in factories.

Storage facilities in consuming facilities need to secure a distance (facility distance) of no less than Class I facility distance from Class I security properties such as schools and hospitals, and no less than Class II facility distance from Class II security properties such as residences. Facility distances are calculated according to storage capacity.

A distance of more than 8 m is required between the storage facilities in consuming facilities and the fire.

Storage facilities in consuming facilities must pass the pressure resistance tests at 1.5 atmospheres or more for liquids and 1.25 atmospheres or more for air, nitrogen, etc.

(B) Hydrogen station

The table below summarizes the regulations that mainly show numerical standards, as well as the main standards for safety measures, among the Regulation on Safety of General High Pressure Gas and safety regulations on high-pressure gases, which target hydrogen stations.

Table 320 Regulations of the High Pressure Gas Safety Act at hydrogen stations

Item	Regulatory standard	Article
Separation distance	Distance between the boundary surface of the public road and the outer surface of the dispenser body: 8 m or more Distance between fire and high-pressure gas facility: 8 m or more Distance between the site boundary surface and high-pressure gas facility: 8 m or more (however, this does not apply if mitigation measures are taken by barriers)	Article 7-3 (2) Article 7-3 (10) Article 7-3 (2)
Sprinkling	Installation of equipment to automatically prevent temperature rise in storage tanks of combustible gases, etc.	Article 6 (32)
Qualified person	Assignment of at least one security superintendent in the case of a typical hydrogen station Assignment of at least three persons in the case of a hydrogen station equipped with a hydrogen shipping facility: a Safety Controller, a Safety Technical Manager (certificate holder), and a Supervisory Safety Worker	Article 63 (2) Article 65
Barriers and fire walls	Installation of a barrier of not less than 2 cm in height between the compressor/pressure accumulator and the dispenser, as well as a fire wall between the high-pressure gas facility and the site boundary	Article 7-3 (16)
Safety measures	Installation of equipment to detect, alarm, and automatically stop leakage Installation of equipment around the dispenser that detects and alarms fires, automatically stops the operation, and prevents temperature rise	Article 7-3 (10) Article 7-3 (18)

Source: Regulation on Safety of General High Pressure Gas

(C) Power generator (small size, Electricity Business Act)

The regulations under the Electricity Business Act apply to power generators. According to Article 38 of the Electricity Business Act and Article 48, paragraphs (1) and (2) of the Ordinance for Enforcement of the Electricity Business Act, the low-output power generation facilities shown in The table below do not require the notification of safety regulations or the appointment of a chief engineer; therefore, power generators can be easily installed even in ordinary homes. The voltage must be 600 V or less.

Table 321 Standards for small-output power generation facilities

Power generation facility	Small-output power generation facility
1. Solar battery power generation	Less than 50 kW
2. Buoyancy power generation facility	Less than 20 kW
3. Hydropower (less than 1 m^3/s with no dam)	Less than 20 kW
4. Internal combustion thermal power generation	Less than 10 kW
5. Fuel cell	Less than 10 kW
6. Stirling engine	Less than 10 kW

Note: In the case where the total output of the small-output power generation facilities of 1 to 6 is 50 kW or more in the same premises, it is not regarded as a small-output power generation facility.

Source: Electricity Business Act, Ordinance for Enforcement of the Electricity Business Act

5.3.4 Development of Guidelines in Each Country

Regulations related to hydrogen in India, Morocco, Thailand, and Indonesia were classified into the following categories: production stage, storage/distribution stage, and use stage, and the contents of the regulations were summarized.

Table 322 Regulations related to hydrogen in India

#	Regulation	Value Chain Category	Description
1	Electricity Act, 2003 (In Force from June 10, 2003, Electricity (Amendment) Bill, 2014(As introduced in Lok Sabha on 19.12.2014), Corrigendum	Production (Input)	An act to consolidate the laws relating to generation, transmission, distribution, trading, and use of electricity and generally for making measures conducive to development of electricity Industry, promoting competition therein , Protecting interest of consumers and supply of electricity to all areas , rationalization of electricity tariff, ensuring transparent policies, regarding subsidies, promotion of efficient and environmentally benign policies constitution of Central Electricity Authority , Regulatory Commissions and establishment of Appellate Tribunal and for matters connected therewith
2	Energy Conservation Act	Production (Input)	The Energy Conservation Act, 2001 was enacted to provide for efficient use of energy and its conservation and for matters connected therewith. This act provides for the establishment and incorporation of the Bureau of Energy Efficiency (BEE)
3	The Electricity Regulatory Commissions Act, 1998	Production (Input)	An Act to provide for the establishment of a Central Electricity Regulatory Commission and State Electricity Regulatory Commissions, rationalization of electricity tariff, transparent policies regarding subsidies, promotion of efficient and environmentally benign policies and matters connected therewith or incidental thereto.
4	THE Electricity (Supply) Act, 1948	Production (Input)	An Act to provide for the rationalization of the production and Supply of electricity, and generally for taking measures Conducive to electrical development.
5	MINES AND MINERALS (DEVELOPMEN T AND REGULATION) ACT, 1957	Production (Input)	The mines and minerals sector is governed by the Mines and Minerals Act of 1957. This act provides for: The governance of mining leases within the country. The purpose of why the lease is given. How to ensure the wellbeing of the people living in the areas where mines are auctioned.
6	Electricity (Rights of Consumers) Rules, 2020	Production (Input)	The rules cover various aspects of power supply to consumers in the country, including obligations of distribution licensees, metering arrangements, the release of new connections, modifications of existing connections, grievance redressal and compensation mechanisms

#	Regulation	Value Chain Category	Description
7	Reduction in Contract Performance Guarantee (CPG) for Tariff Based Competitive Bidding (TBCB) transmission projects in line with Department of Expenditure's OM dated 30.12.2021	Production (Input)	OM enlisting provisions of Standard Bidding Documents (RFP and TSA) for selection of bidders as Transmission Service Provider through tariff-based competitive bidding process to establish Inter State Transmission Service (ISTS) along with extension in validity of the RFP document regarding computation of CPG @ 3% of required aggregate capital cost of projects/aggregate payments received from 31.12.2021 to 31.03.2023
8	Notification for Electricity (Transmission System Planning, Development and Recovery of Inter-State Transmission Charges) Rules, 2021	Production (Input)	The rules cover the aspects of planning and approval including short-term and perspective plans by institutions like Central Electricity Authority in consultation with stakeholders like Central and State Transmission Utilities, system operators, generating and distribution companies for development of electricity systems and identification of specific transmission projects along with rules on connectivity for distribution companies and ISTS consumers to buy or sell power and recovery of inter-state transmission charges.
9	Establishment of Renewable Energy Management Centre (REMC) at Telangana and Energy Management Centre (EMC) at South Andaman	Production (Input)	Office Order conveying the establishment of Renewable Energy Management Center (REMC) in Telangana with the main functions as forecasting & scheduling and tracking real time RE generation along with provision of forecasting system to help system operators to manage grid operations. An Energy Management Center (EMC) would also be established in south Andaman with the main function of monitoring, operation and management of conventional generation as well as solar generation through deployment of state-of-art monitoring, forecasting and resource management system.
10	Constitution of five Regional Power Committees Transmission Planning RPCTPs	Production (Input)	An Office Offer entailing the constitution of five Regional Power Committees Transmission Planning RPCTPs (Eastern, Western, Northern, Southern and North-Eastern) with the main functions as quarterly review of Transmission Systems in the region, assessment of transmission systems in the near, medium and long term, examination of applications for connectivity etc. under terms of reference along with ensuring that transmission capacity wheels electricity to all regions, quarterly forwarding of reports on assessment to NCT along with their recommendations.
11	Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State	Production (Input)	Provides the regulations on ISTS and General Network Access to facilitate non-discriminatory open access to licensees or generating companies, or consumers through general provisions, connectivity (eligibility and application of grant etc.), General Network Access (eligibility, deemed grant, role of nodal agency etc.), relinquishment of connectivity, allocation of

#	Regulation	Value Chain Category	Description
	Transmission System) Regulations, 2022.		transmission corridor under GNA and T-GNA etc.
12	Central Electricity Regulatory Commission (Terms and Conditions for Renewable Energy Certificates for Renewable Energy Generation) Regulations, 2022	Production (Input)	Regulations by the Central Regulatory Electricity Commission explaining the terms and conditions for Renewable Energy Certificates for Renewable Energy generation covering the role of National Load Dispatch Centre as the Central Agency, eligibility for issuance of certificates, grant of accreditation, revocation of accreditation and registration, exchange and redemption of certificates and denomination of certificates etc.
13	Central Electricity Regulatory Commission (Payment of Fees) (Third Amendment) Regulations, 2022	Production (Input)	Regulations regarding payment of fees by the Central Electricity Regulatory Commission explaining the amendments to various Principal Regulations for licensees and mode of payment.
14	Detailed Procedure on "Methodology of Payment of Certificate Retainer-ship" under Regulation 33 of the Central Electricity Regulatory Commission (Fees and Charges of Regional Load Despatch Centre and other related matters) Regulations, 2019	Production (Input)	Order informing examination and approval of a detailed procedure submitted by NLDC under the head "Detailed procedure on Methodology of Payment of Certificate Retainer-ship 15th March 2022" with applicability from control period of 1.04.2019 to 31.03.2024
15	Central Electricity Regulatory Commission (Deviation Settlement Mechanism and Related Matters) Regulations, 2022	Production (Input)	Notification detailing the regulations seeking to ensure, through a commercial mechanism that users of the grid do not deviate from and adhere to their schedule of drawal and injection of electricity in the interest of security and stability of the grid.

#	Regulation	Value Chain Category	Description
16	Central Electricity Regulatory Commission (Ancillary Services) Regulations, 2022	Production (Input)	Regulations by the Central Regulatory Electricity Commission aimed to provide mechanisms for procurement, through administered as well as market-based mechanisms, deployment and payment of Ancillary Services at the regional and national level for maintaining the grid frequency close to 50 Hz, and restoring the grid frequency within the allowable band as specified in the Grid Code for relieving congestion in the transmission network to ensure smooth operation of the power system, and safety and security of the grid.
17	Central Electricity Regulatory Commission (Terms and Conditions of Tariff) (Second Amendment) Regulations, 2021	Production (Input)	Notification explaining the amendments to regulations of terms and conditions tariff with respect to modifications in various principal regulations. Applicable from control period of 1.04.2019 to 31.03.2024
18	Central Electricity Regulatory Commission (Power Market) Regulations, 2021	Production (Input)	Regulations covering the Power Market extending to Power Exchange, Market Participants other than Power Exchange and the OTC Market applying to various contracts in the Power Exchange and OTC Market covering the features of these contracts, registration under Power Exchange, Market Coupling etc.
19	Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2020	Production (Input)	Regulations regarding terms and conditions for tariff determination from Renewable Energy sources applying to cases where tariff for a grid connecting station or a unit thereof commissioned during the Control Period and based on renewable energy sources is to be determined by the Commission.
20	Central Electricity Regulatory Commission (Sharing of Inter-State Transmission Charges and Losses) Regulations, 2020	Production(Input)	Regulations pertaining to sharing of inter-state transmission charges and losses applicable to all Designated ISTS customers, Inter-State Transmission Licenses, National Load Despatch Centre (NLDC), Regional Load Despatch Centres (RLDCs), State Load Despatch Centres (SLDCs) and Regional Power Committees explaining components and sharing of ISTS charges, accounting, billing and collection of the charges etc.
21	Central Electricity Regulatory Commission (Procedure, Terms and Conditions for grant of trading license and other related matters) (First Amendment)	Production (Input)	Notification enlisting the regulations regarding procedure, terms and conditions for grant of trade license and other related matters covering qualifications and procedure for grant of license, trading margin, terms and conditions of license, contravention and penalties and revocation of license.

#	Regulation	Value Chain Category	Description
	Regulations, 2020		
22	Central Electricity Regulatory Commission (Sharing of Revenue Derived from Utilization of Transmission Assets for Other Business) Regulations, 2020	Production (Input)	Regulations explaining the sharing of revenue derived from utilization of transmission assets for other businesses applicable to inter-state transmission licensees, whose transmission charges are determined by the Commission under Section 62 of the Act.
23	Indian Electricity Grid Code Regulations, 2010 (Sixth Amendment)	Production (Input)	Notification regarding regulations to the Indian Electricity Grid Code explaining amendments to part 6 of the Principal Regulations.
24	Open Access in Interstate Transmission Regulations,2008 (Sixth Amendment)	Production(Input)	Regulations to Open-Access in inter-state Transmission explaining amendments to regulation 2 of Principal Regulations, amendments to regulation 13 explaining the procedure for scheduling of transaction in Real-Time market and amendments to regulation 20 of Principal Regulations.
25	Central Electricity Regulatory Commission (Cross Border Trade of Electricity) Regulations, 2019	Production(Input)	Notification enlisting regulations regarding Cross Border Trade of Electricity applicable to the participating entities in India and the neighbouring countries engaged in trade covering institutional framework, tariff determination, transmission planning, connectivity access and system operation, payment of charges and payment security mechanism.
26	Central Electricity Regulatory Commission (Grant of Connectivity, Long-term Access and Medium-term Open Access in inter-State Transmission and related matters) (Seventh Amendment) Regulations, 2019	Production(Input)	Regulations to Grant of Connectivity, Long-Term Access and Medium term Open Access in the inter-state Transmission and related matters through amendments to regulation 2, 5, 8, 9, 15, 21, 27 and 27 of Principal Regulations.

#	Regulation	Value Chain Category	Description
27	Central Electricity Regulatory Commission (Open Access in inter-State Transmission) (Fifth Amendment) Regulations, 2018	Production(Input)	Regulations covering amendments to Principal regulations regarding Open Access in Inter-State Transmission.
28	Central Electricity Regulatory Commission (Planning, Coordination and Development of Economic and Efficient Inter-State Transmission System by Central Transmission Utility and other related matters) Regulations, 2018	Production(Input)	The regulations lay the principles, procedures and processes for planning and development of an efficient Inter-State Transmission System for smooth flow of electricity, wider participation of stakeholders during the planning process, specific procedures for transparency in the process and demarcation of roles and responsibilities for various organizations to meet the above objectives.
29	Central Electricity Regulatory Commission (Communication System for inter-State transmission of electricity) Regulations, 2017	Production(Input)	The regulations provide for planning, implementation, operation, maintenance and up-gradation of reliable communication system for all communication requirements including exchange of data for integrated operation of national grid applying to the communication infrastructure to be used, all users, SLDCs, RLDCs, NLDC etc.
30	The Central Electricity Regulatory Commission (Terms and Conditions for Dealing in Energy Savings Certificates) Regulations, 2016	Production(Input)	The regulations define a framework for dealing in Energy Savings Certificate through Power exchanges applicable to ESCerts offered for transaction on Power Exchanges including contracts in ESCerts as approved by the Commission in accordance with provisions of power market regulations.
31	Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015	Production(Input)	The regulations aim to restore the frequency at the desired level and relive congestion in the transmission network whill shall be applicable to the regional entities involved in transactions facilitated through short-term open access or medium-term open access or long-term open access in inter-state transmission system.

#	Regulation	Value Chain Category	Description
32	Central Electricity Regulatory Commission (Grant of Regulatory Approval for execution of Inter-State Transmission Scheme to Central Transmission Utility) (First Amendment) Regulations, 2015	Production(Input)	Regulations to Grant of regulatory approval for execution of Inter-State Transmission Scheme to Central Transmission utility covering amendment to Regulation 3 of Principal Regulations.
33	The Central Electricity Regulatory Commission (Standards of Performance of inter-State transmission licensees) Regulations, 2012	Production(Input)	Regulations for inter-state licencees to ensure compliance of the standards of performance by inter-state transmission licencees and to provide for an efficient, reliable, coordinated and economical system of electricity transmission, non-adherance of which would entitle the affected parties to compensation.
34	Central Electricity Regulatory Commission (Unscheduled Interchange charges and related matters) (Second Amendment) Regulations, 2012	Production(Input)	Notification entailing the regulations for unscheduled interchange charges and related matters providing the amendment to various principal regulations for interchange charges.
35	Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Solar PV Power Projects	Production(Input)	Applicable for long term procurement of electricity by the 'Procurers' [the distribution licensees, or the Authorized Representative(s), or an Intermediary Procurer] from grid-connected Solar PV Power Projects ('Projects'), having size of 5 MW and above, through competitive bidding
36	Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022	Production(Input)	According to the new rules, "any entity (obligated or not) may elect to purchase & consume renewable energy as per their requirements", through personal generation directly from RE sources or by procuring RE through open access from any developer, purchase of renewable energy certificates, or by the purchase of green hydrogen. This basically allows any entity to fulfill their RPO obligations through purchase of Green hydrogen

#	Regulation	Value Chain Category	Description
37	Explosives Act, 1884	Storage & Distribution	An Act to regulate the manufacture, possession, use, sale, transport, import and export of Explosives.
38	Petroleum Act, 1934	Storage & Distribution	The Petroleum Act, 1934, is an Act to consolidate and amend the law relating to the import, transport, storage, production, refining and blending of petroleum. Petroleum may be any liquid hydrocarbon or mixture of hydrocarbons, and inflammable mixture (liquid, viscous or solid) containing any hydrocarbon, and includes natural gas and refinery gas
39	Inflammable Substances Act, 1992	Storage & Distribution	An Act to regulate import, storage, transportation and production of certain substances which are inflammable in nature
40	Liquefied Petroleum Gas (Regulation of Supply and Distribution) Order 2000	Storage & Distribution	Provides guidelines on storage and transport of LPG in India, which inlcudes: Restriction on storage and transport of liquefied petroleum gas – (1) No person shall - (a) fill any cylinder with liquefied petroleum gas or transfer liquefied petroleum gas from one cylinder to another cylinder or from one container to another container unless authorised by the Chief Controller of Explosives; (b) transport or store a cylinder filled with liquefied petroleum gas except in an upright position; (c) store or use or cause to be stored or used a cylinder filled with the liquefied petroleum gas except in a cool, dry, well-ventilated and accessible place under cover, away from boilers, open flames, steam pipes or any potential source of heat; (d) remove the seal prior to use of the cylinder: Provided that the distributor or his authorised representative or the delivery person may remove such seal in the presence of the consumer either for testing, checking or installation of the cylinder; (e) use cylinder, pressure regulator and gas cylinder valve other than those specified in Schedules II and III. (2) No transporter or delivery person shall deliver or cause to deliver liquefied petroleum gas either in cylinder or in bulk to any person other than the consumer or distributor
41	Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for LPG Storage, Handling and Bottling Facilities) Regulations, 2019	Storage & Distribution	These regulations cover the minimum requirements for engineering and safety considerations in layout, design, storage, LPG tank trucks, pipelines, bulk handling, operating procedures, bottling operations, maintenance, inspection, safety management system, fire protection facilities, competence assurance, emergency management plan, gas monitoring system of LPG Storage, Handling and Bottling Facilities Apply to all existing and new LPG storage, handling and bottling facilities including at refineries, gas processing plants and LPG pipelines. The process units at refineries and gas processing plants as well as LPG pipelines are not included in these Regulations

#	Regulation	Value Chain Category	Description
42	Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Petroleum and Petroleum Products Pipelines) Regulations, 2016	Storage & Distribution	Requirements of these regulations shall apply to all existing and new petroleum and petroleum products pipelines. These regulations shall cover pipeline design, materials and equipment, piping system components and fabrication, installation, testing, corrosion control, operation and maintenance and safety of petroleum and petroleum products pipelines. The pipelines include dedicated pipelines for specific consumers but excludes offshore crude pipelines, onshore well flow, feeder and collector pipelines
43	Gas Cylinder Rules 2016	Storage & Distribution	The rules specify the general provisions for filling, possession, import and transport of cylinders, specifications of markings on cylinders, general provisions on safety and handling, provisions to obtain import license for cylinders, examination and testing of cylinders
44	Petroleum and Natural Gas Regulatory Board (Determination of Transportation Rate for CGD and Transportation Rate for CNG) Regulations, 2020	Storage & Distribution	Guidelines for determination of transportation rate for CGD and transportation rate for CNG
45	Petroleum and Natural Gas Regulatory Board (Authorizing Entities to Lay, Build, Operate or Expand City or Local Natural Gas Distribution Networks) Regulations, 2008 (as amended)	Storage & Distribution	These regulations apply to an entity which is laying, building, operating or expanding, or which proposes to lay, build, operate or expand a CGD network. A CGD network shall be designed to operate at a pressure as specified in the relevant regulations for technical standards and specifications, including safety standards for maintaining the volumes of supply of natural gas
46	Petroleum and Natural Gas Regulatory Board (Access Code for Common Carrier or Contract Carrier Petroleum and Petroleum Products Pipelines) Regulations, 2016 (as amended)	Storage & Distribution	These regulations apply to all entities operating or proposing to operate petroleum and petroleum products pipeline and shipper who engage or intend to engage in transportation service for petroleum and petroleum products pipeline.

#	Regulation	Value Chain Category	Description
47	Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Petroleum and Petroleum Products Pipelines) Regulations, 2016	Storage & Distribution	These regulations cover pipeline design, materials and equipment, piping system components and fabrication, installation, testing, corrosion control, operation and maintenance and safety of petroleum and petroleum products pipelines
48	Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Regulations, 2018	Storage & Distribution	These regulations lay down minimum requirements of layout within the plant boundary for unloading or loading, storage, regasification, transfer and handling and tank truck loading facilities for LNG facilities. These regulations cover safety in design and operational aspects of process systems, storage tanks, regasification facilities, ship shore interlock, berthing conditions for the ship, receiving facilities including jetty and port
49	Explosive Rules 2008	Storage & Distribution	Rules inline with Explosive Act to regulate the manufacture, possession, use, sale, transport, import and export of Explosives.
50	SMPV Rules,2016	Storage & Distribution	Defines restriction on filling, manufacture and import of pressure vessels including fittings and vaporizer along with guidelines on construction and fitment of pressure vehicles
51	Petroleum Rules,2012	Storage & Distribution	These rules regulate the approvals and restriction required for delivery and dispatch of petroleum products in India
52	Central Motor Vehicles Act,1988	Applications (Utilization)	The Act provides in detail the legislative provisions regarding licensing of drivers/conductors, registration of motor vehicles, control of motor vehicles through permits, special provisions relating to state transport undertakings, traffic regulation, insurance, liability, offences and penalties, etc
53	Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for [dispensing of Automotive Fuels]) Regulations, 2018	Applications (Utilization)	Defines- Definitions, layout, design, operating procedures, maintenance, inspection, safety equipment, competence assurance, emergency management plan, customer safety and awareness for all existing and new Retail Outlets dispensing [Automotive fuels] such as MS, HSD, Auto LPG, CNG, [LNG, LCNG] and their variants.

#	Regulation	Value Chain Category	Description
54	Liquified Petroleum Gas (Regulation of Use in Motor Vehicles) Order 2001	Applications (Utilization)	The regulations entail the restrictions on unauthorized sale of auto LPG, guidelines regarding procurement, storage and sale of auto LPG, assessment and certification rating of parallel marketeers etc.
55	Technical Standards and Specifications including Safety Standards for Dispensing of Compressed Natural Gas (CNG) from Mobile Refueling Unit Regulations, 2021	Applications (Utilization)	The regulations mention the technical standards and specifications including safety standards for Dispensing of Compressed Natural Gas (CNG) from Mobile Refueling Unit which relate to Site Selection, Equipment, Operation & Maintenance, Piping & Control System, Emergency Plan & Procedure, Fire Protection Facilities, Competence Assessment and Training, Power Sourcing, Safety Inspections / Audit, Typical Layout & Safety Distance.
56	The Central Motor Vehicles (Tenth Amendment) Rules, 1989	Applications (Utilization)	Amended the Central Motor Vehicles Act, 1989.Last two amendments incorporate: 1. Safety standards for CNG/Bio-CNG/H-CNG vehicles 2. Requirements for the motor vehicles running on compressed gaseous hydrogen fuel cell
57	Technical Standards for construction of electric plants and electric lines	Applications (Utilization)	Defines standards for power generation plants including gas turbine-based power plants

Table 323 Regulations related to hydrogen in Morocco

#	Regulation	Value Chain Category	Description
1	Law 02-84 on water user associations	Production (Input)	The law lays the emphasis on integrated water resources management, financial instruments under the user pays/polluter pays principle, economic value of water, linked to national and regional solidarity and watershed management principles
2	Law 10-95, (Management of water resources)	Production (Input)	Authorizing the transfer of public enterprises to the private sector and to reform this sector at the institutional and legal levels in order to modernize the management of water resources and provide the public authorities with the tools enabling them to face the multiple challenges posed.

#	Regulation	Value Chain Category	Description
3	Law 06-99 on competition and price freedom, amended by law 30-08	Production (Input)	The regulation governs the organization and operation of local governments, and spells out their responsibilities for potable water supply, sanitation and wastewater treatment.
4	Law 78-00, (Environmental obligations)	Production (Input)	Improve living conditions and protect the environment while achieving a 60% treatment rate for collected wastewater and an 80% rate for connections to the sanitation network in urban areas by 2020
5	Law 36-15, (Use of water)	Production (Input)	The act contains the general provisions, the use and exploitation of the public hydraulic domain, the development and use of rainwater, the valuation and use of unconventional waters, the administration of water and water planning, and water conservation, among others. it aims to put in place planning rules and tools, including wastewater, drinking water seawater and others to increase water potential taking into account climate change in order to to adapt to it
6	Law 16-09, Law 39-16 (Establishment of ADEREE as policy making body)	Production (Input)	Established the Moroccan agency for development of renewable energy and energy efficiency (aderee), as a public agency. Aims to contribute to the implementation of the national policy on renewable energy and energy efficiency. it proposes national, regional and sectoral plans for the development of renewable energy and energy efficiency.

#	Regulation	Value Chain Category	Description
7	Law No. 48-15 (Establishment of the Moroccan Energy Authority (Autorité Nationale de Régulation de l'Energie) (ANRE))	Production (Input)	This law organises the regulation of the electricity sector and the creation of the national electricity regulatory authority. specifically, it sets out the missions of the national transmission grid operator and the electricity distribution system operators; the resources of the national transmission system operator and transmission system operators; access to electricity networks; the settlement of disputes and tariffs
8	Law 13-09, Law 58-15, (Renewable Energy Development Law)	Production (Input)	This law provides a legal framework for the development of renewable energy projects in Morocco. these are defined as all sources of energy that are naturally renewable, particularly solar energy, wind energy, geothermal energy, wave and tidal energy, as well as energy generated through biomass, waste and biogas (but excluding hydraulic energy with installed power above 30mw).law no 58-15 dated 12 January 2016, which amended law 13-09 to allow independent producers to access the low voltage grid, allowing them to sell surplus renewable energy
9	Law 57-09 (Establishment of Moroccan Agency for Sustainable Energy (MASEN)	Production (Input)	Established the Moroccan agency for solar energy, now the Moroccan agency for sustainable energy (Masen) as a public private partnership. Masen was established to ensure the implementation of the Moroccan solar programme. the Masen aims to achieve the development of integrated production of electricity from solar energy, with a minimum total capacity of 2,000 mw.
10	Law 47-09 (Law on Energy Efficiency requirements)	Production (Input)	This law sets the criteria of 'minimum energy performance¥ for appliances and electrical equipment powered by natural gas, liquid or gaseous petroleum products, coal and renewable energies. it makes mandatory energy audits for companies and institutions in the production, transmission and distribution of energy, as well as the performance of an energy impact study for new construction and urban projects.
11	Law No 54-14 (Access to transmission network for captive power plants)	Production (Input)	Allows national electricity self-producers to join the transmission network to carry energy from production sites to consumption sites.

#	Regulation	Value Chain Category	Description
12	Dahir No 1-63-226, Law No 38-16 (Transfer to MASEN of all ONEE real estate assets used for renewable energy installations)	Production (Input)	This gives onee a monopoly on the production, transportation and distribution of electricity
13	Law No 16-08, (Self generation of electricity from Renewables)	Production (Input)	Enables industrial installations to produce up to 50 kw of their own electricity from renewable energies
14	Order setting the model specifications to accompany the application for final authorization for the commissioning of a plant for producing electrical energy from renewable energy source	Production (Input)	The decree fixing the model of the specifications to accompany the application for final authorization, for the commissioning of an installation for the production of electrical energy from a renewable energy source
15	Access to Medium Voltage Grid	Production (Input)	Key objective of the order: to set the terms and conditions of access of the facilities of electric production from renewable sources to the medium voltage grid; to have a smooth and gradual opening of said network ;and to establish a transparent, non-discriminatory and stable framework for investors.
16	Decree No. 2-10-578 of 7 Jumada I 1432 (11 April 2011) adopted in application of Law No. 13-09 on renewable energy	Production (Input)	To establish and arrest procedures related to the terms and conditions of the constitution and the filing of the application for authorization and pursuant to articles 5, 8, 17, 18, 28 and 29 of law no. 13.09 on renewable energy

#	Regulation	Value Chain Category	Description
17	Order No. 3851-21, (Trajectory for next 10 years)	Production (Input)	Joint decree of the minister for energy transition and sustainable development and the minister of the interior no. 3851-21 of 24 rabii ii 1443 (november 30, 2021) setting the trajectory for the next ten years, from 2022 to 2031, made up of envelopes for the injection of electrical energy produced from renewable energy sources into the medium voltage electrical network
18	Dahir no. 1-16-60 of 17 Chaabane 1437 (Application of Law 48-15)	Production (Input)	Application text for law 48-15, which governs regulation of the electricity sector and the creation of the national electricity regulatory authority
19	Order of the Minister of Trade, Industry, Mines, Crafts and the Merchant Navy No. 053-62 of January 2, 1962	Production (Input)	Order of the minister of trade, industry, mines, crafts and the merchant navy no. 053-62 of January 2, 1962 relating to the characteristics of liquefied petroleum gases
20	Order of the Minister of Energy and Mines n°1546-07 of 18 rejeb 1428 (August 3, 2007)	Production (Input)	Order of the minister of energy and mines no. 1546-07 of 18 rejeb 1428 (august 3, 2007) relating to the characteristics of major petroleum products
21	Order of the Minister of Energy, Mines, Water and the Environment No. 143-13 of 24 Safar 1434 (January 7, 2013)	Production (Input)	Order of the minister of energy, mines, water and the environment no. 143-13 of 24 Safar 1434 (January 7, 2013) amending order no. 1546-07 of 18 rejeb 1428 (3 august 2007) relating to the characteristics of major petroleum products
22	Order of the Minister of Trade, Industry, Mines, Crafts and the Merchant Navy No. 053-62 of January 2, 1962	Production (Input)	Order of the minister of trade, industry, mines, crafts and the merchant navy no. 053-62 of january 2, 1962 (bo no. 2571 of february 2, 1962) relating to the characteristics of petroleum gases liquefied, modified and supplemented by order of the minister for energy, mines, water and the environment no. 699-09 of march 25, 2009.
23	Circular no. 236 DCPR of December 14, 2006	Production (Input)	Order of the minister of energy and mines relating to the safety and security measures to be observed at the level of oil and gas installations.

#	Regulation	Value Chain Category	Description
24	Order of the Minister of Energy, Mines, Water and the Environment No. 3349-11	Production (Input)	Relating to the special import authorization by persons, other than explosives manufacturers, of materials or substances that can be used in the manufacture of explosive products.
25	Decree No. 2.09.154	Production (Input)	Relating to the special import authorization by persons other than explosives manufacturers of materials or substances that can be used in the manufacture of explosive products.
26	Joint Order of the Minister of Energy and Mines, the Minister of Public Works, Vocational Training and Executive Training and the Minister of Transport No. 1263-91 of 9 chaoual 1413 (April 1, 1993)	Storage and Distribution	Joint order of the minister of energy and mines, the minister of public works, vocational training and executive training and the minister of transport no. 1263-91 of 9 chaoual 1413 (April 1, 1993) approving the regulation general relating to the safety standards applicable to filling centres, bulk or cylinder depots and fixed storage for industrial or domestic use of liquefied petroleum gases as well as the packaging, handling, transport and use of these products
27	Decree No. 2-72-513 of 3 Rebia I 1393 (April 7, 1973)	Storage and Distribution	Decree no. 2-72-513 of Rebia i 3, 1393 (april 7, 1973) taken for the application of the Dahir bearing law no. 1-72-255 of Moharram 18, 1393 (February 22, 1973) on the import, export, refining, recovery in refineries and filling centers, storage and distribution of hydrocarbons.
28	Dahir carrying law no. 1-72-255 of 18 Moharram 1393 (February 22, 1973)	Storage and Distribution	Dahir laying down law no. 1-72-255 of Moharram 18, 1393 (February 22, 1973) on the import, export, refining, recovery in refineries and filling centers, storage and distribution of hydrocarbons
29	Decree No. 2-95-699 of Moharrem 4, 1417 (May 22, 1996)	Storage and Distribution	Amending and supplementing decree no. 2-72-513 of 3 rabii i 1393 (April 7, 1973) taken for the application of the Dahir carrying law no. 1-72-255 of 18 Moharram 1393 (22 February 1973) on the import, export, refining, recovery in refineries and filling centers, storage and distribution of hydrocarbons. (bo no. 4384 of June 06, 1996)
30	Decree No. 2-72-513 of April 7, 1973	Storage and Distribution	(Bo no. 3155 of April 18, 1973) taken for the application of Dahir no. 1-72-255 of February 22, 1973, amended and supplemented by decree no. 2-95-699 of may 22, 1996 (bo no. o. 4384 of June 06, 1996).

#	Regulation	Value Chain Category	Description
31	Law no. 67-15 amending and supplementing the Dahir carrying law no. 1-72-255 of 18 Moharrem 1393 (February 22, 1973)	Storage and Distribution	On the import, export, refining, recovery in refineries and filling centers, storage and distribution of hydrocarbons. (bo no. 6454 of April 7, 2016).
32	Dahir no. 1-95-141 of 6 rabii I 1416 (August 4, 1995)	Storage and Distribution	Promulgating law no. 4-95 amending and supplementing the Dahir on law no. 1-72-255 of moharrem 18, 1393 (February 22, 1973) on import, export, refining, refining and in the filling center, the storage and distribution of hydrocarbons. (bo no. 4323 of September 6, 1995).
33	Dahir carrying law no. 1-72-255 of February 22, 1973	Storage and Distribution	(Bo no. 3151 of march 21, 1973) on the import, export, refining, recovery in refineries and filling centers, storage and distribution of hydrocarbons, modified and supplemented by Dahir no. 1- 95-141 of august 4, 1995 (bo no. 4323 of September 6, 1995).
34	Circular no. 01 of March 13, 2017	Storage and Distribution	Order from the minister of energy, mines, water and the environment relating to the strengthening of the control of liquefied petroleum gas (lpg) cylinders.
35	Circular no. 01-09 of January 8, 2009	Storage and Distribution	Relating to the strengthening of the control of liquefied petroleum pressure devices.
36	Order of the Director of Industrial Production and Mines of December 29, 1953	Storage and Distribution	Related to certain storage containers for liquefied hydrocarbons, amended and supplemented by decrees of the minister for energy and mines no. 1185-85 of December 9, 1985 (bo no. 3836 of may 07, 1986) and no. 1185-07 of July 25, 2007 (bo no. 5558 of September 06, 2007)
37	Joint Order of the Minister of Energy and Mines, the Minister of Public Works, Vocational Training and Executive Training and the Minister of Transport No. 1263-91 of 9 CHAOUAL 1413 (April 1, 1993)	Storage and Distribution	General regulations relating to the safety standards applicable to filling centres, bulk or cylinder depots and fixed storage for industrial or domestic use of liquefied petroleum gases as well as the packaging, handling, transport and use of these products

#	Regulation	Value Chain Category	Description
38	Circular no. 6359 of October 10, 2018	Storage and Distribution	Order of the minister of energy, mines and sustainable development relating to the obligations of the beneficiaries of approvals for the regulatory control of onshore steam and gas pressure devices.
39	Circular no. 2456 of December 02, 2005	Storage and Distribution	Relating to the approvals of the regulatory control bodies for steam and gas pressure devices
40	Order of the Director of Industrial Production and Mines of January 14, 1955	Storage and Distribution	Relating to regulations on gas pressure devices
41	Order of the Director of Industrial Production and Mines of January 13, 1955	Storage and Distribution	Regulating the construction and use of gas pressure devices, supplemented by the order of the minister of trade, industry, mines and the merchant navy no. 556 -62 of January 18, 1963 (bo no. 2623 of February 1, 1963).
42	Order of the Director of Industrial Production and Mines	Storage and Distribution	Regulating the technical conditions for the storage of explosives, detonators and explosives firing devices. (bo no. 2203 of January 14, 1955).
43	Dahir of March 2, 1938	Storage and Distribution	Regulating the handling and transport by land of dangerous materials, combustible materials, flammable liquids (other than hydrocarbons and liquid fuels), powders, explosives, ammunition and fireworks, compressed, liquefied, solidified and dissolved gases, poisonous, caustic and corrosive materials and toxic or nauseous products, in particular its title iv regulating the handling and transport of powders, explosives, ammunition and fireworks.

Table 324 Regulations related to hydrogen in Thailand

#	**Policy/ Regulation**	**Value Chain Category**	**Description**
1	Energy Industry Act B.E. 2550 (2007)	Production (Input)	The primary legislation governing the electricity sector is the Energy Industry Act B.E. 2550 (2007). The act shall apply to the operation and energy industry in Thailand, including electricity, natural gas, and renewable energy.
2	Power development plan of Thailand 2018-2037	Production (Input)	Thailand's Power Development Plan (PDP) 2018-2037 (Rev. 1) aims to improve energy efficiency and enhance energy security in Thailand. The PDP 2018 focuses on: (1) Energy Security: coping with the increasing power demand to correspond to the National Economic and Social Development Plan and taking into account fuel diversification; (2) Economy: maintaining an

			appropriate cost of power generation for long-term economic competitiveness; and (3) Environment: lessening the carbon dioxide footprint of power generation and focusing on renewable energy sources.
3	The Alternative Energy Development Plan 2018-2037	Production (Input)	The Alternative Energy Development Plan 2018-2037 (AEDP 2018-2037) is an updated version of the AEDP2015 which was developed and focused on promoting energy production within the full potential of domestic renewable energy resources. The AEDP aims to develop appropriate renewable energy production to benefit the social and environmental dimensions of the society.
4	Regulations for the Purchase of Power from Very Small Power Producers	Production (Input)	Regulations for the Purchase of Power from Very Small Power Producers (for the Generation Using Renewable Energy) setting out criteria and conditions for power purchase agreements (PPAs) for very small power producers (VSPPs) under the Community Power Plants for the Local Economy project—part of the Electricity Generating Authority of Thailand's (EGAT) Energy Policy for the Local Economy.
5	Notification on the initiation of an Anti-Dumping Investigation on Flat Hot Rolled Steel in Coils and not in Coils	Production (Input)	Anti-Dumping/ Countervailing Duties/ Safeguard measures to import Hot Rolled Steel in Coils and not in Coils from Malaysia and China: The company that would import hot-rolled and non-rolled steel sheets from Malaysia and China has to pay for duty charged which approximately 23.57 - 42.51% of CIF price (if import from Malaysia) and 30.91% of CIF price (if import from China) *The rate of tax would be changed depend on the origin of the materials. (Please see the detail in the DFT's website) The above regulation is applicable till 22/06/22
6	Notification on the Initiation of an Anti-Dumping Investigation on Certain Hot Dip Plated or Coated with Aluminium Zinc Alloys of Cold Rolled Steel (unofficial translation)	Production (Input)	Anti-Dumping/ Countervailing Duties/ Safeguard measures to import Certain Hot Dip Plated or Coated with Aluminium Zinc Alloys of Cold Rolled Steel: the company that would like to import cold rolled steel plated or coated with an alloy of aluminium and hot-dipped galvanized from China, Korea and Taiwan has to pay duty charged as the list below. - imported from China : 2.65 - 29.50% - imported from Korea : 6.31 - 22.55 - imported from Taiwan : 5.85 - 24.14 *The rate of tax would be changed depend on the origin of the materials. (Please see the detail in the DFT's website) The above regulation is applicable till 09/01/24
7	Water resource act, B.E 2561 (2018)	Production (Input)	This Water resource act, B.E 2561 (2018) aims to the efficiency and effectiveness of the administration of water resources in respect of the allocation, use, development, management, maintenance, rehabilitation and conservation thereof as well as rights in water, thereby benefiting the provision of public utility services and other public interests. The State has the power to use, develop, manage,

			maintain, rehabilitate and conserve water resources to engender common benefits in a balanced and sustainable manner. The rights in water, Public water resources are publicly owned. A person has the right to use or maintain water to the extent necessary for the benefit of activities or land without causing grievance or damage to other persons.
8	PWA Regulation on determining of the water supply tariff, B.E. 2524, and revised edition (No.21) B.E. 2558	Production (Input)	Provincial Waterworks Authority (PWA) Regulation on determining of the water supply tariff, B.E. 2524, and revised edition (No.21) B.E. 2558 provided guidelines for water tariff setting in Thailand. The regulation specifies the rate by the areas (1. The private investment areas and Chonburi 2. Phuket, Koh Samui, and Koh Phangan 3. Other Provincial Waterworks Authority branches (nationwide)) and water user type (1. Private residence 2. Government and Small enterprises 3. State enterprises, Industries and Large size business)
9	Notification of Ministry of Industry No.76/2560	Storage & Distribution	Notification of Ministry of Industry No.76/2560 Re: General Rules for Discharging Wastewater into Public Sewage System in Industrial Estates, B.E.2560 (2017). The main content about this regulation included - The standard of sewage system. - The prohibit about drain substances that affect the drainage of wastewater treatment into the sewer global industrial - Water quality criteria which the operator will drain into the sewage system. - Water quality monitoring method.
10	Regulations of the Board of Directors of the Industrial Estate Authority of Thailand Governing Standards for Utility Systems, Facilities and Services in Industrial Estates	Production (Input)	These regulations of water supply system for industrial estate indicates that the quality of water supply for use in industrial estate shall meet the standard of MWA and PWA.
11	Regulations for hazardous substance	Storage & Distribution	The Hazardous Substance Act B.E.1992 is the most important chemical control law in Thailand. The purpose of the Act is to regulate the importation, production, marketing, and possession of all hazardous chemicals (including industrial chemicals, pesticides, and biocides) used in Thailand.
12	Production and Importation of Hazardous Chemicals in Thailand	Production (Input)	Since 19 Feb 2015, manufacturers and importers of hazardous substances exceeding 1 ton per year are now required to notify their hazardous substances to the Department of Industrial Works (DIW) via DIW's online system.
13	Ministerial regulation on criteria, method	Storage & Distribution	The Ministerial Regulation: a) Criteria, method for hazardous substances production, import, export, or possession permission

	for hazardous production, import and export		b) Duty of a person engaging in hazardous substances production, import, export, or possession
14	Petroleum Act	Production (Input)	The Petroleum Act governs the exploration and production of petroleum (natural gas and oil). It is administered by the Department of Mineral Fuels under the Ministry of Energy.
15	Hazard Classification and Communication System of Hazardous Substances	Storage & Distribution	This notification covers the classification of 16 classes of physical hazard, 10 classes of health hazard, and 2 classes of environmental hazard and communication such as Labelling and preparing a safety data sheet.
16	Manual for Chemical and Hazardous Substances Storage	Storage & Distribution	This manual for Chemical and Hazardous Substances Storage covers the manual of storage facility, Storage classification of chemical and hazardous substances, Preventive Measures, Special requirements and storage outside building.
17	The principle and safety standard of the place using natural gas	Storage & Distribution	This notification defines the principle and safety standard of the place using natural gas such as distance of controlling safety, the construction and installation of station, fire prevention and extinction.
18	Energy Act	Storage & Distribution	The Act established the Energy Regulatory Commission (ERC) to regulate the energy industry, to prevent abuse of power and protect energy consumers and those adversely affected by energy industry operations
19	Regulations of Ministry of Energy; Vol 135, Spec.Vers. 65	Storage & Distribution	Ministerial Regulations on Natural Gas Storage Places, B.E. 2561
20	Regulations of Ministry of Energy; Vol 130, Spec.Vers. 29	Storage & Distribution	Ministerial Regulation: The Transportation System for Natural Gas Through a Pipeline, B.E.2556 (2013)
21	Notification of Ministry of Energy; Vol 130, Spec.Vers. 159	Storage & Distribution	Notification Of the Ministry of Energy: Type and Size of Transportation System for Natural Gas Through a Pipeline, And Criteria, Method, Procedure and Guidelines of Compiling an Environmental Report, B.E.2556 (2013)
22	Determination of Type and Size of Natural Gas Pipeline, and Regulations, Procedures, and Guidelines for the preparation of environmental reports	Storage & Distribution	It is related with the transport operators in the natural gas liquids pipeline to determine the type and size of natural gas pipeline.
23	Notification of Department of Industrial Works Re Training Course of Regular Gas Control,	Storage & Distribution	This regulation stipulated the training course detail; Training course is contained with 4 topics - Control of the delivery and loading gas staff training - Control of use or storage gas staff training - Gas delivery staff - Gas loading staff

	Transport, and Contained Worker in Factory, B.E. 2553 (2010)		
24	Notification of Ministry of Industry Re: Security Protection Measurement for Factory Operation Related to Gas Usage, Storage, Transportation, and Container, B.E. 2548 (2005)	Storage & Distribution	This regulation specifies the condition of the gas building characteristic, gas container, the filling System and safety equipment, the valve and joint of the gas container must follow the international standard, the colour and symbol of gas container and the delivery for safety. In addition, the regulation indicates that the condition of gas container must be inspected by the registration laboratory.
25	Notification of Department of Industrial Works Re: Criteria and Method for Registration as Regular Gas Control, Transport, and Contained Worker in Factory, B.E. 2551 (2008)	Storage & Distribution	This regulation specifies the criteria and method for registration as regular gas control, transport, and contained worker. The applicant must submit the application form for registration to Department of Industrial Works.
26	Regulations of Ministry of Energy; Vol 138, Spec.Vers. 45	Storage & Distribution	Ministerial Regulations: Liquefied Petroleum Gas Terminal B.E. 2564 This is the main regulation regarding to Liquefied Petroleum Gas Terminal Storage in Thailand
27	Regulations of Ministry of Energy; Vol 136, Spec.Vers. 18	Storage & Distribution	Ministerial Regulations: Location of liquefied petroleum gas storage facility B.E. 2562
28	Notification of Ministry of Energy; Vol 128, Spec.Vers. 59D	Storage & Distribution	Notification of Ministry of Energy Subject: Regulations and Methods of Storage, Assignment of Responsible Special Personnel, and Exemption to Follow the Hazardous Substances Act 1992 (B.E.2535) for Areas of Liquefied Petroleum Gas Responsible by the Department of Energy Business 2011 (B.E.2554)
29	Regulations of Ministry of Energy; Vol 138, Spec.Vers. 45	Storage & Distribution	Liquefied Petroleum Gas Transportation by Liquefied Petroleum Gas Tanks, B.E. 2564
30	The principle and safety standard of natural gas service station	Applications (Utilization)	This notification defines safety standard of service station including permit to operate the gas service stations, the safety distance of service stations, installation and the construction of service stations, fire prevention and extinction
31	Regulations of Ministry of Energy; Vol 138,	Applications (Utilization)	Ministerial Regulations on Liquefied Petroleum Gas Storage Places in the Type of Distribution Stores, B.E.2564

	Spec.Vers. 45		
32	Regulations of Ministry of Energy; Vol 134, Spec.Vers. 50	Applications (Utilization)	ministerial regulations Liquefied Petroleum Gas Containers, B.E. 2560
33	The Department of Energy Business; Vol. 125, Spec.Vers. 54 Gnor	Applications (Utilization)	The Department of Energy Business - Notification: Determination of Conditions Governing Exportation of Liquefied Petroleum Gas B.E. 2551 This regulation has the purpose to control the quantitative liquefied petroleum gas within the country in order to prevent the shortage of liquefied petroleum gas fuel. Therefore, the person or the company that would like to export the liquid gas outside the country. It is necessary to meet the condition in this regulation such as they should have a letter of certification from the Director General of the Department of Energy Business before exporting liquid gas.
34	Department of Energy Business, Ministry of Energy notification about the LPG gas facilities compliance.	Applications (Utilization)	Department of Energy Business, Ministry of Energy announce the notification about the LPG gas facilities compliance. This regulation specifies that the company who need to maintain the LPG gas as raw materials for the production process must require a permission from the Department of Energy Business. - The company who possess less than 250 kg. is exempt from this requirement. - The company who possess more than 250-500 kg. must inform the Department of Energy Business about the facts of possession - The company who possess more than 500 kg. must apply for a license to possess.
35	Ministerial Regulations: Guideline, Procedures, and Conditions of Inform Processes, Permission, and Fees about oil business operation, B.E. 2556 (2013)	Applications (Utilization)	Ministerial Regulations: Guideline, Procedures, and Conditions of Inform Processes, Permission, and Fees about oil business operation, B.E. 2556 (2013) is related to oil, petroleum gas and natural gas by type of business operations. The regulation specifies guideline, procedures, and conditions of oil, petroleum gas and natural gas.
36	Notification of the Ministry of Energy: The Place for Inform of Business Operation Permission of Control Product Type 2, and Place for Submission of the Application for the Operate and Control License Types 3, B.E.	Applications (Utilization)	The Notification of the Ministry of Energy provided the procedures and conditions relating to the notification of license fees for oil and other fuels business operation.

	2559 (2016)		
37	Ministerial regulations: Oil station, B.E. 2552 (2009)	Applications (Utilization)	Ministerial regulations: Oil station, B.E. 2552 (2009) set a guideline for the fuel station including LPG, NGV. The regulation prescribes the detail about the lay out, landscape, location, and safety distance area of the fuel station. Moreover, the regulation also stipulates about the quality of the fuel storage, tank system, fuel pumps, fuel dispensers and equipment for fire prevention.
38	Notification from The Department of Energy Business Re: Prescribing Characteristics and Quality of Natural Gas for Motor Vehicles B.E. 2018	Applications (Utilization)	There is the Notification from The Department of Energy Business Re: Prescribing Characteristics and Quality of Natural Gas for Motor Vehicles B.E. 2018 specifies the chemical quality detail of the NGV.
39	Notification of the Ministry of Finance: The reduction of duty rates and exemption of customs duties for all imported battery electric vehicles.	Applications (Utilization)	Ministry of Finance declared the notification about the reduction of duty rates and exemption of customs duties for all imported battery electric vehicles. The definition of the battery electric vehicles (BEV) are the electric vehicles which passenger seats less than ten people and import when completely built up. The above regulation is applicable till 31/12/23
40	Notification of the Department of Land Transport: The rated power of the electric vehicles B.E 2563	Applications (Utilization)	Department of Land Transport support the use of electric vehicles for energy saving by announce the notification which specifies the rated power of the electric motor used for vehicle according to the automobiles law B.E. 2563. The type of the vehicles was divided in to 4 types 1. Taxi car (rated power must more than 15 Kw. and speed limit more than 90 km.hr) 2. Private car (rated power must more than 4 Kw. and speed limit more than 45 Km.hr) 3. Motor tricycle car (rated power must more than 4 Kw. and speed limit more than 45 Km.hr) 4. Motorcycle (rated power must more than 250 W. and speed limit more than 45 Km.hr)

Table 325 Regulations related to hydrogen in Indonesia

♯	Regulation	Value Chain Category	Description
1	Law 30/2009	Production (Input)	Electricity Law No. 30 of 2009 provides the overarching legal framework to govern the power industry in Indonesia. This includes for the development, generation and distribution of electricity. The 2009 Electricity Law and the implementing regulations: - GR No. 14/2012 on Electricity Business Provision (as amended by GR No. 23/2014) - GR No. 42/2012 on Cross-Border Sales and

♯	Regulation	Value Chain Category	Description
			Purchases - GR No. 62/2012 on Electricity Support Business.
2	Law 11/2020	Applications (Utilization)	Job Creation Law No. 11 of 2020 was an omnibus law that amended various laws (including electricity and oil and gas amongst others) to simplify regulation, licensing and provide clarity on the role of state vs. regional government.
3	MEMR 4/2020	Production (Input)	Minister of Energy and Mineral Resources (MEMR) Regulation No. 4 of 2020 on the Utilisation of Renewable Energy for the Provision of Power amends the Government Regulation No. 50/2017 on Utilization of Renewable Energy Sources for Power Supply was intended to make renewable energy sources more competitive, and thus increase their rate of inclusion into the national energy mix. Provide guidance on the required licenses and limitations for development of rooftop solar. Stipulates that tariff for industrial consumers will adjust with macroeconomic conditions.
4	GR 25/2021	Production(Input)	Government Regulation No. 25 of 2021 regarding the Administration of the Energy and Mineral Resources Sector provides guidance on the conditions and requirements to establish a Wilayah Usaha (a business supply area for non-PLN supply). It covers (i) the provision of electric power for the public interest; (ii) the provision of electric power for the party's own use; and (iii) the electric power support services business.
5	MEMR 11/2021	Production (Input)	Minister of Energy and Mineral Resources (MEMR) Regulation No. 11 of 2021 on Implementation of Electricity Business, which require an Electricity Supporting Services Business Licence (IUJPTL) A transmission business entity holding integrated IUPTLU or transmission IUPLTU will not be bound by an electricity business area (Wilayah Usaha) and is obliged to open the opportunity for the collective use of transmission grid in conducting its transmission business.

♯	Regulation	Value Chain Category	Description
6	GR 14/2012	Production (Input)	Government Regulation No. 14 of 2012 regarding Power Supply Business Activities is a key implementing regulation for the Electricity Law on electricity supply activities covering tariff setting and environmental management. It also establishes provisions for energy preservation and management by improving efficiency in energy use and control over its consumption, in order to achieve effective and rational use of energy resources.
7	MoEMR 188.K/HK.02/MEM.L/2021	Production (Input)	MoEMR Ministerial Decree No. 188.K/HK.02/MEM.L/2021 regarding Electricity Supply Business Plan (RUPTL) 2021 - 2030 RUPTL sets out a business plan of the PLN for the incoming period of ten years in terms of electricity development in Indonesia. The RUPTL provides projections relating to the electricity demand growth, energy mix, infrastructure, and available investment sectors for the IPP. The law is reviewed annually (in BAU case) till 2030
8	MoEMR 143K/20/MEM/2019	Production (Input)	MoEMR Ministerial Decree No.143K/20/MEM/2019 regarding National Electricity Plan ("RUKN") 2019 - 2038, amendment of RUKN 2008 - 2027 The National Electricity Master Plan (RUKN) for 2019-2038 (ESDM Decree No. 143K/21/MEM/2019) stipulates the national electricity master plan for year 2019 until 2038. The RUKN sets out the 20-year projection of the supply and demand of electricity, investment policies, and new/renewable energy utilization policy. The RUKN is also used as a basis for local governments in drafting the Regional Electricity Master Plan (or RUKD) as well as for PT PLN (Persero) in preparing its annual Electricity Power Supply Business Plan (RUPTL). The law is applicable till 2038
9	Law 30/2007	Production (Input)	Law No. 30 of 2007 on Energy and the 2014 NEP, as targeted in GR No. 79/2014, in mind President Joko Widodo issued PR No. 22/2017 on the National General Energy Plan (Rencana Umum Energi Nasional - “RUEN”). Under the RUEN the Government seeks to re-emphasise the purpose of energy use as a driver of the national economy. The law is reviewed every 5 years
10	GR 79/2014	Production (Input)	

♯	Regulation	Value Chain Category	Description
11	PR 22/2017	Production (Input)	
12	Law 17/2019	Production (Input)	Law No. 17 of 2019 establishes the basic legislation on Water Resource Management. The scope of Water Resources basic law includes: state control and people's right to water; duties and competent authority for water resources management; water resources management; licensing; water resources information system; empowerment and supervision; funding; rights and obligations; society participation; and coordination. Water Resources are controlled by the state and used for the greatest prosperity of the people. Control on water resources remains with the central and regional government through local water company or Perusahaan Daerah Air Minum ("PDAM")."
13	MEN 3/2010	Production (Input)	Minister of Environment (MEN) regulation No. 3/2010 Concerning Wastewater Quality Standards for Industrial Estate. This Regulation aims to take preventive actions on water pollution by stipulating the standard quality of sewage for industrial zones so as to avoid the contamination on the living environment. Sewage standard quality is also specified in this regulation.
14	MPWH 37/2015	Production (Input)	Minister of Public Work and Public Housing (MPWH) Decree No. 37 of 2015 on Utilization Permits of Water and/or Water Resources. The decree regulates the utilization permits of water resource for commercial activities. It also regulates several aspects, such as application mechanism of water resources utilization, requirements, granting, extension, and revocation of utilization permits, and prohibition related to water resources utilization. Three government institutions that have the authority to grant the permits are: 1) Minister of Public Works and Public Housing or Kementerian Pekerjaan Umum dan Perumahan Rakyat ("PUPR") as licensor to utilize water resources in the cross-provincial river area, cross-national river area, and national strategic river area; 2) Governor as licensor to utilize water resources in the river area of cross-regency/city; 3) Regent/mayor as licensor to utilize water resources in the river area within a regency/city.

♯	Regulation	Value Chain Category	Description
15	MoHA 23/2006	Production (Input)	Ministry of Home Affairs ("MoHA") Decree 23/2006 provided guidelines for water tariff setting in Indonesia. The decree stipulates eight main points related to water tariff setting in Indonesia, which covers: 1) Basic guidance on tariff setting policy, 2) Allocation of consumption block, 3) Determination of the consumer group's classification, 4) Base and operational cost, 5) Local water company's revenue, 6) Classification and tariff structure, 7) Tariff setting mechanism, 8) Adjustment and assessment mechanism on the existing tariff
16	MoI 54/M-IND/PER/3/2012	Production (Input)	The Minister of Industry (MoI) Regulation No. 54/M-IND/PER/3/2012 (as amended by MoI Regulation No. 5/M-IND/PER/2/2017) stipulates the minimum required percentage of local goods and services (by value) that are to be used for the development of electricity infrastructure. Failure to comply with these local content requirements may result in administrative and financial sanctions. Note this does not currently include hydrogen but could be used as some illustration.
17	PMK 41/PMK.010/2022	Production (Input)	Ministry of Finance (PMK) regulation no. 41/PMK.010/2022 provided guidance on withholding tax for import of products including steel, cobalt etc. which are essential in the electrolyser.
18	PMK 26/PMK.010/2022	Production(Input)	Ministry of Finance (PMK) regulation no. 26/PMK.010/2022 provided guidance on tariffs for imports of products including steel, cobalt etc. which are essential in the electrolyser.
19	PR 54/2010	Production(Input)	Presidential Regulation No. 54 of 2010 require entities to maximise local content and specific industries can have levels set.
20	PR 38/2015	Production(Input)	Presidential Regulation No. 38 of 2015 and 16 of 2018 require entities to maximise local content and specific industries can have levels set.
21	PR 16/2018	Production(Input)	Presidential Regulation No. 16 of 2018 require entities to maximise local content and specific industries can have levels set.
22	Law 32/2009	Storage & Distribution	Law No. 32 of 2009 on Environmental Protection and Management provides the legal backbone for implementing regulations on hazardous and toxic chemicals.

♯	Regulation	Value Chain Category	Description
23	GR 74/2001	Storage & Distribution	Chemicals classified under B3 (most risky) are governed under Government Regulation No. 74 of 2001 on Hazardous and Toxic Substances Management which regulates the life cycle of B3 including import, production, transportation, distribution, storage, use, and processing.
24	MOT 7/2022	Storage & Distribution	The Minister of Trade (MOT) Regulation No. 7 of 2022 provides guidelines concerning Distribution and Control of Hazardous Substances of B2 chemicals.
25	Law 22/2001	Storage & Distribution	Law No. 22 of 2001 provides the legal backbone for implementing regulations on oil and gas such as hydrogen (for both upstream and Applications (Utilization)) activities. Businesses must guarantee environmental management, including preventing pollution, restoring damages, and includes post-mining obligations (Art 40).
26	MEMR 4/2018	Storage & Distribution	Gas transportation by pipeline is regulated under Government Regulation No. 36 and Minister of Energy and Mineral Resources (MEMR) Regulation No. 4 of 2018 regarding the Business of Gas in Applications (Utilization) Oil and Gas Business Activities, as amended from MEMR Regulation No. 19 of 2012 and is controlled by BPH Migas.
27	GR 36/2018	Storage & Distribution	
28	MEMR 6/2016	Storage & Distribution	National gas trading is governed under the Oil and Gas Law and specifically in Government Regulation No. 36. It must be conducted by a business entity established in Indonesia. Must adhere to price stipulation under Minister of Energy and Mineral Resources (MEMR) Regulation No. 6 of 2016.
29	MEMR 10/2017	Applications (Utilization)	Minister of Energy and Mineral Resources (MEMR) Regulation No. 10 of 2017 sets the minimum requirements for PPAs to cover in the contract between PLN and seller. It outlines key contract provisions for PPA.
30	GR 14/2012	Applications (Utilization)	Procurement of power in totality is governed by Government Regulation No. 14 of 2012 regarding Power Supply Business Activities, which states that electricity purchase can be procured by open tender; direct selection; or direct appointment.
31	MEMR 50/2017	Applications (Utilization)	Utilisation of Renewable Energy Resources for Electricity to set new tariffs for renewable energy projects. Minister of Energy and Mineral Resources (MEMR) Regulation No. 50 of 2017 regulates the tariff regimes for renewable electricity generation with tariffs still benchmarked to PLN's average electricity generation cost (Biaya Pokok Pembangkitan – "BPP").

♯	Regulation	Value Chain Category	Description
32	MEMR 4/2020	Applications (Utilization)	Minister of Energy and Mineral Resources (MEMR) Regulation No. 4 of 2020, the second amendment of MEMR 50 of 2017 regarding utilization of RE sources for electricity supply. Removal of the BOOT scheme for RE into BOO scheme. This regulation alleviates Developer (e.g. IPP) obligation to transfer assets to the PLN; as was previously required under BOOT scheme (30 years after asset commencement).
33	PR 4/2016	Applications (Utilization)	Presidential Regulation No. 4 of 2016 (as amended by PR No. 14/2017) includes modalities to procure renewable energy. The Government plans to develop a new and renewable energy aggregator to buy electricity generated from new and renewable sources and on-sell to PLN for specific subsidies. Hydro, geothermal and wind power projects, including the transmission lines, can be developed in Natural Reserve Areas and Natural Conservation Areas in accordance with prevailing laws and regulations.
34	MoI 36/2021	Applications (Utilization)	Ministry of Industry (MoI) Regulation No. 36/2021 regarding Four Wheelers Low Carbon Vehicle such as fuel cell electric vehicles (FCEV). This regulation states that is is mandatory for FCEVs to have electric motor, battery, power control unit or inverter, and hydrogen tank as the main components.
35	Law 32/2009	Applications (Utilization)	Law No. 32 of 2009 and Minister of Environment (MEN) Regulation No. 5 of 2012 states that businesses and/or activities other than those stated should have an environmental management/ monitoring effort document (Upaya Pengelolaan Lingkungan Hidup – Upaya Pemantauan Lingkungan Hidup) or letter of intent regarding environmental management/monitoring.
36	MEN 5/2012	Applications (Utilization)	
37	MEMR 13/2020	Applications (Utilization)	Minister of Energy and Mineral Resources No. 13 of 2020 on Battery-based Electric Vehicles Charging Infrastructure. The regulation stipulates a broad range of objectives related to battery-based EV charging infrastructure, which covers charging and battery-swapping infrastructure facility requirements, business schemes, the state-owned electricity company (PLN)'s role, electricity fees/tariffs, and safety installation requirements.
38	PR 55/2019	Applications (Utilization)	Presidential Decree No. 55 of 2019 sets a timeline for ramping up of local content requirements for electrical vehicles in Indonesia.

♯	Regulation	Value Chain Category	Description
39	MOT 44/2020	Applications (Utilization)	Minister of Transportation Regulation No. 44 of 2020 on Physical Examination for Electric Vehicles. All electric vehicle products, including electric cars and motorcycle, are required to conduct a physical examination test to examine its battery condition, charging kit, electrical contact safety, functional safety, and hydrogen emission test.
40		Applications (Utilization)	Other than Pusat Sertifikasi ("Pusertif"), a subsidiary of PT PLN (Persero), PT PLN Pusat Sertifikasi ("PLN Pusertif") now has the authority to provide certification to SPKLU operators as part of the country's plan to accelerate the provision of EV charging station in Indonesia.
41	MEMR press release no. 84. Pers/04/SJI/2022	Applications (Utilization)	Hydrogen is expected to become a contributor to the energy transition, and therefore, plays an important role in decarbonizing the global energy system, Minister of Energy and Mineral Resources (EMR), Arifin Tasrif, has side on the sidelines of a bilateral meeting with the Minister of Trade, Industry and Energy of the Republic of Korea, Moon Sung Wook, in Jakarta on Monday (21/2). Arifin admitted there are a number of challenges to hydrogen use, including how to make hydrogen economically viable, financially attractive, and beneficial to society. "We will continue to follow trends in hydrogen technology and open opportunities to collaborate in hydrogen implementation," added Arifin. On the supply side, hydrogen is one of the government's main strategies in carrying out the road map to carbon neutrality by 2060. "The main strategy to reach carbon neutral from the supply side is by developing renewable energy on a massive scale, with a focus on solar, hydro and geothermal as well as hydrogen," said Arifin. The Director General of New, Renewable Energy and Energy Conservation, Dadan Kusdiana, has on several occasions revealed plans to use hydrogen in the industry and transportation sectors. Hydrogen will not be used with fuel cell technology but will instead use internal combustion technology commonly installed at motor vehicles.