Kingdom of Cambodia
Ministry of Mines and Energy (MME)
Electricity Authority of Cambodia (EAC)

Cambodia
Power Economics and Planning Advisor
Training for Capacity Building on
IPP Project Evaluation

Project Completion Report

June 2022

Japan International Cooperation Agency (JICA)

The Chugoku Electric Power Co., Inc.

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Glossary

Term	Description
C/P	Counter Part
EAC	Electricity Authority of Cambodia
EDC	Electricité du Cambodge
LNG	Liquefied Natural Gas
IPP	Independent Power Producer
JICA	Japan International Cooperation Agency
MEF	Ministry of Economy and Finance
MME	Ministry of Mines and Energy
MP	Master Plan
OJT	On the Job Training
PPA	Power Purchase Agreement
WG	Working Group

Summary

The evaluation of IPP projects is administered by the MME, which is in charge of electric power policy, power generation planning and related issues, and performed by a committee consisting of the Electricite du Cambodge (EDC), the only company in the country with a combined license for generation/transmission (national power system) and distribution of electricity, the Electricity Authority of Cambodia (EAC), an independent regulatory agency in charge of issuing licenses and approving rates related to the electric utility industry, and similar organizations. Each organization of the committee performs evaluations from the perspective of consistency between the government plan and the power plant operation plan, appropriateness of proposed rates, and suitability of the results of studies on environmental and social considerations. However, since each organization conducts their evaluations by referring to cases and precedents of other countries, there are concerns regarding issues with the consistency and reliability of the results of these evaluations.

This project aims to improve the project evaluation abilities of the MME and EAC (members of the committee responsible for IPP evaluation) in regards to IPP project plan proposals by providing them with training and reference documents for IPP evaluation in order to contribute to stable power development in the Cambodian electric power sector.

WG1 Evaluation System

It is customary for the MME, EDC, EAC, and similar organizations to act together in the Cambodian electric power sector by gathering to discuss various issues whenever they arise, with the IPP evaluation system following this same practice. The actual roles, however, change from time to time depending on the capabilities of the selected committee members, such that the roles of each organization are not clearly stipulated. For these reasons, we decided to make recommendations for the IPP evaluation system and a checklist for the evaluation process.

a) Checklist Creation

The role of each organization in the Cambodian IPP evaluation system is liable to change occasionally depending on the capabilities of the committee members and the items to be evaluated are not officially specified, resulting in changes in the contents of the evaluation each time a different project is evaluated. It was decided to prepare a checklist of items that absolutely must be checked in IPP evaluations in order to make sure that required evaluation items are covered every time so as to ensure a stable electric power supply.

b) Recommendations for the IPP Evaluation System

Under current conditions, IPP evaluations are conducted through consultations between committee members appointed individually rather than by organizational units, it is assumed that the quality of evaluations vary depending on the capabilities of the appointed members. We proposed the following as a way to standardize the tasks performed, and perform evaluations efficiently and systematically in order to ensure that evaluations are conducted responsibly with consistent quality.

a. Create a checklist for IPP evaluations that clearly define the evaluation items in order to ensure consistent evaluation quality and fairness of evaluations. The MME is mainly responsible for evaluating this checklist on a periodic basis.
b. Determine the departments responsible for each item of the checklist in order to perform evaluations with organizational responsibility.
c. Each department continuously implements human resources development such as in-house training for their assigned checklist items, and makes efforts to improve the quality of evaluations. For example, it is recommended that the capabilities of each personnel be assessed annually and that training be provided based on the results of this assessment. The training is expected to be led by the C/Ps of this project.
d. As technical skill materials regarding training prepared during this project will be archived so that any member of MME and EAC can refer to them, it is recommended that such a mechanism also be used to share information in the future.

c) Information Sharing

In Cambodia, there is little sense of technical capabilities possessed by organizations, and past training materials are simply retained individually by the training participants with no idea of sharing them. For these reasons, the materials created during this project were shared using Google Drive so that any C/P can access them. In addition, training videos conducted on the web were recorded and shared on YouTube.

WG2 IPP Evaluation Method

A document was prepared describing how the evaluation items in the checklist prepared during WG1 should be checked for use as a reference during an evaluation, and training was conducted based on this document. The following policies were applied to create training materials for common items, and LNG-fired, hydro, and solar power generation.

a) Common Items

Common items consisted of creating training materials for low-level system interconnection. As the trainees consisted of MME and EAC personnel, the emphasis was not on technical study methods, but rather on the contents of items to be evaluated during an IPP evaluation and what information requires verification. Care has been taken to ensure that the contents of each item can be understood by introducing the technical standards of Cambodia and the descriptions in the Grid Code that are the criteria for evaluations.

b) LNG-Fired Power Generation

Given the overall low level in regards to LNG-fired power generation and the lack of experience in Cambodia, training materials on the differences between coal-fired and LNG-fired power generation, such as fuel handling and machinery/facilities, were created in order to provide required knowledge about LNG. We also created materials on what each item represents and what must be checked during an actual evaluation based on this LNG-related knowledge. Each material was created in a manner that is easy to understand using figures and photographs.

c) Hydro Power Generation

We decided to provide training especially for low-level items of hydro power generation based on the experience within Cambodia, and created materials accordingly. As there are technical standards for hydro power in Cambodia, it is necessary to consider whether the requirements of these technical standards are met during the evaluation. This document was designed to explain what points should be examined from items of the technical standards using the example of Japan.

d) Solar Power Generation

We decided to provide training on all items on the checklist related to solar power and created materials accordingly. Emphasis was placed on low-level natural disaster risks in particular by using photographs of case study natural disasters, and data such as typhoon paths and lightning strike distribution in Japan to present the need for countermeasures and what data requires checking in an easy to understand manner.

WG3 Demand Forecast

MME recognizes the need to increase the frequency of updating demand forecasts because of the massive changes in demand over the past few years due to factors such as the rapid increase in electricity demand caused by economic growth and the decrease in demand caused by the impact of the COVID-19. For this reason, the Department of Energy Development of the MME (department in charge of demand forecast) has set a goal of updating demand forecasts every two years from now on. However, as Cambodia has not conducted demand forecasting before, it has not developed personnel who can actually perform such demand forecasting.

The demand forecasts in the revised MP carried out by Chugoku Electric Power in 2019 were made using the Simple-E application that meets the needs of the Cambodian C/Ps. Simple-E is an add-in application for Excel, so it can be used on a PC running Excel, and since the data and correlation functions are clearly shown, the forecasting process is not a black box but rather the relationship between the demand forecast parameters and the forecast results can be easily understood. Based on the above, demand forecasting training was conducted using Simple-E.

WG4 Financial/Tariff Analysis

From the results of interviews with MME personnel, we know that they tend to refer to and follow precedents due to insufficient financial and tariff analysis capabilities, such that they cannot accurately determine the appropriateness of the details of a Power Purchase Agreement (PPA) proposed by an IPP. For example, factors such as "location," "technical content," and "cost structure" differ for each power plant, as these are nearly never the same, making it quite difficult to evaluate the differences with a power plant that has been appropriately evaluated even if referring to precedents.
It is impossible to negotiate PPAs with IPPs in a favorable manner without financial and tariff analysis. For this reason, training was conducted to improve the financial and tariff analysis capabilities.

Chapter 1 Project Overview

1.1 Project Background

Cambodia has experienced remarkable economic growth in recent years by achieving domestic development together with a shift to increased foreign direct investment and diversified industries. As electricity is essential for this development, the country's demand for electricity has increased some 500% in the 10 years since 2010 at an average annual rate of around 19%.

The development of facilities for supplying electricity in the capital city of Phnom Penh, which accounts for 70% of the country's electricity demand, has not kept pace with the growing demand and makes for the largest challenge to the stable supply of electricity. JICA supports the construction of new and additional substations, the expansion of power transmission and distribution networks, and the proper operation and maintenance of power transmission-transformation facilities through yen loan projects ("Japanese ODA Loans").

In addition, in order to maintain and improve the development effectiveness of such facilities, a "Power Economics and Planning Adviser" has been dispatched (the third person was dispatched as of June 2022) to the Ministry of Mines and Energy ("MME" hereinafter) from FY2016 to provide advice on ensuring a balance between the supply and demand of electricity as well as ensuring the continued availability of system capacity, including the expansion of power transmission and distribution facilities.

Within this major issue of responding to the rapidly increasing demand for electricity is the fact that the majority of power generation projects (such as hydro and coal-fired power) in Cambodia are reliant on independent power producers ("IPP" hereinafter). As there are many cases in which the power generation facilities of these IPPs are considered for commercialization based on proposals from the IPP to the government, the relevant government agencies must conduct an appropriate evaluation at the project proposal stage, and approve the project after making necessary changes in order to ensure that the appropriateness of the project in technical and financial aspects, including the electric power purchase price, and that the project is developed and operated as planned.

The evaluation of IPP projects is administered by the MME, which is in charge of electric power policy, power generation planning and related issues, and performed by a committee consisting of the Electricite du Cambodge (Cambodian electric company; "EDC" hereinafter), the only company in the country with a combined license for generation/transmission (national power system) and distribution of electricity, the Electricity Authority of Cambodia ("EAC" hereinafter), an independent regulatory agency in charge of issuing licenses and approving rates related to the electric utility industry, and similar organizations. Each organization of the committee performs evaluations from the perspective of consistency between the government plan and the power plant operation plan, appropriateness of proposed rates, and suitability of the results of studies on environmental and social considerations. However, since each organization conducts their evaluations by referring to cases and precedents of other countries, there are concerns regarding issues with the consistency and reliability of the results of these evaluations.

In view of the importance of these issues, this training was conducted as part of the activities of the Power Economics and Planning Adviser currently dispatched, after selecting items of high priority from among those requested.

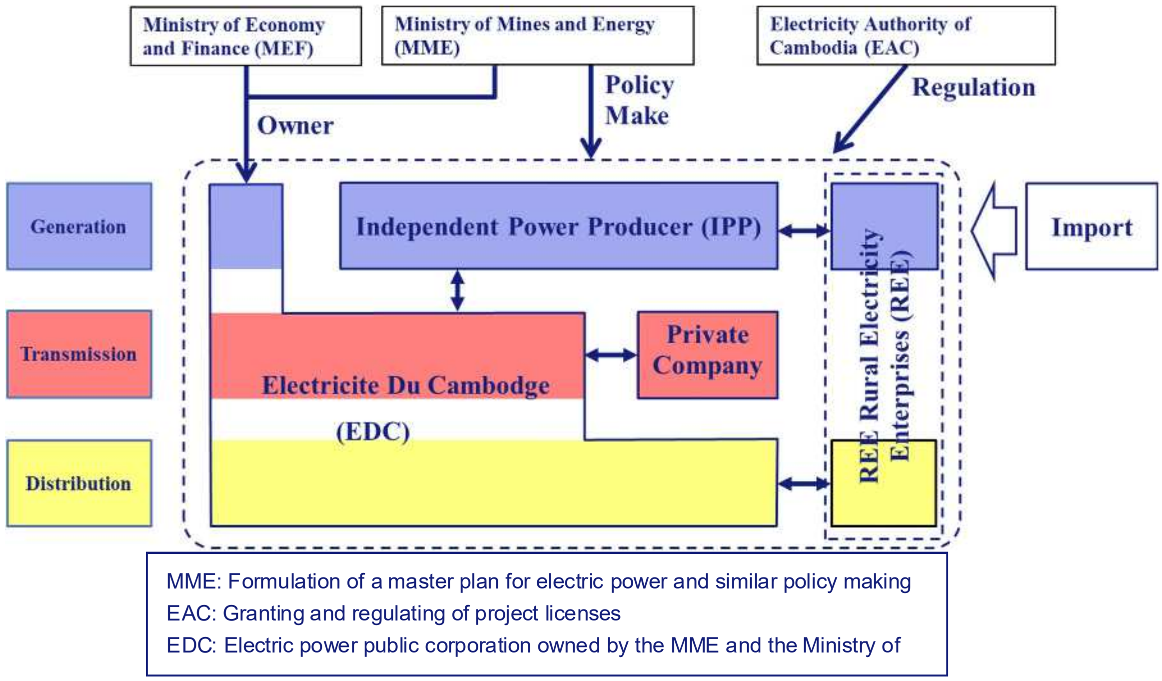
1.2 Project Objectives

This project aims to improve the project evaluation abilities of the MME, EDC and EAC (members of the committee responsible for IPP evaluation) in regards to IPP project plan proposals by providing them with training and reference documents for IPP evaluation in order to contribute to stable power development in the Cambodian electric power sector.

Chapter 2 Description of Activities

2.1 Composition of Counterparts (C/Ps)

Cambodia's electric power sector is composed of organizations as shown in Fig. 2-1.



Source: Created by the Chugoku Electric Power from EAC Annual Reports, etc.

Fig. 2-1 Composition of the Cambodian Electric Power Sector

In this training, it was assumed that all of MME, EAC and EDC, which play a central role in IPP evaluation, would be listed as Counterparts ("C/P" hereinafter), but EDC was reluctant to become a C/P. Therefore, C/Ps for this training were selected from MME and EAC.

2.2 Kick-Off Meeting

A kick-off meeting for this project was held via web conference on Oct. 20, 2021. The project was outlined to H.E. Heng Kunleang, Director-General of the General Department of Energy, Ministry of Mines and Energy, who granted his approval. (Attachment 3)

Fig. 2-2 Kick-Off Meeting

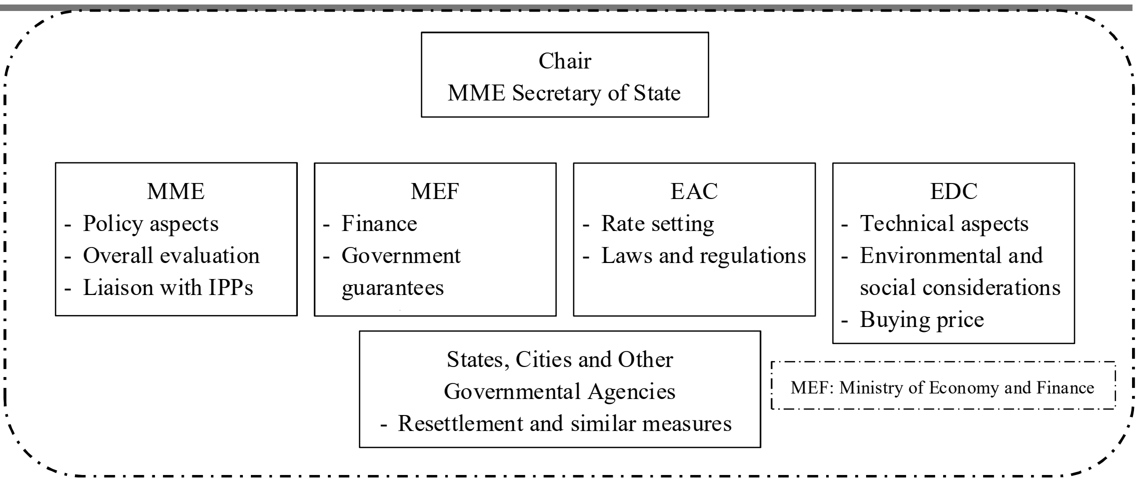
In addition, a kick-off meeting with the C/Ps was held via web conference on Dec. 7, 2021 (Attachment 4).

Fig. 2-3 Kick-Off Meeting with C/Ps

2.3 WG1 Evaluation System

Major hydro and thermal power plants in Cambodia have been developed by IPPs, except for a 400-MW diesel power plant that was installed on an emergency basis during the electricity shortage in 2019. In addition to this, large-scale solar power plants have also been developed by IPPs in recent years, starting with 10MW plants.

The IPP evaluation is conducted by organizing a committee on a case-by-case basis with the basic system and roles as described in. Efforts are made to improve the accuracy of the evaluation process as much as possible by referring to cases in neighboring countries and using external consultants.



Source: Created by the Chugoku Electric Power from interviews with the MME

Fig. 2-4 IPP Evaluation System and Roles

It is customary for the MME, EDC, EAC, and similar organizations to act together in the Cambodian electric power sector by gathering to discuss various issues whenever they arise, with the IPP evaluation system following this same practice. The actual roles, however, change from time to time depending on the capabilities of the selected committee members, such that the roles of each organization are not clearly stipulated. For these reasons, we decided to make recommendations for the IPP evaluation system and a checklist for the evaluation process.

2.3.1 Checklist Creation

The role of each organization in the Cambodian IPP evaluation system is liable to change occasionally depending on the capabilities of the committee members and the items to be evaluated are not officially specified, resulting in changes in the contents of the evaluation each time a different project is evaluated. It was decided to prepare a checklist of items that absolutely must be checked in IPP evaluations in order to make sure that required evaluation items are covered every time so as to ensure a stable electric power supply.

This project is only focused on LNG-fired, hydro and solar power plants with no coverage of coal-fired or wind power plants. These plants are excluded because Cambodia has decided not to develop new coal-fired power plants and the development of wind power plants has made little progress due to the limited amount of promising sites.

We intended to create this checklist based on feasibility study documents from Cambodia in order to meet the actual conditions existing in the country, but since we could not obtain such information from Cambodia, we prepared the checklist for LNG-fired, hydro, and solar power plants by referring to the publicly available feasibility study documents of other countries and the "Guideline and Manual for Hydropower Development" (JICA). The points of each evaluation item that must be focused on are also described so that the contents of the evaluation do not change from project to project.

2.3.2 Recommendations for the IPP Evaluation System

(1) Ascertain the Current Status

IPP power plants that have started operation in Cambodia in recent years are listed in Table 2-1, providing us with experience in several IPP evaluations for hydro, coal-fired and solar power plants.

Table 2-1 IPP Power Plants Started Operation in Recent Years

Power Plant Name	Type	Output [MW]	COD
Kamchay	Hydro	194	2011
Atay	Hydro	120	2013
Tatay	Hydro	246	2014
Russei Chrum	Hydro	338	2015
Lower Sesan 2	Hydro	400	2017
CEL	Coal-Fired	100	2014
CEL2	Coal-Fired	135	2019
CIIDG	Coal-Fired	405	2016
Sunseap	Solar	10	2017
Schneitec (Kampong Speu)	Solar	80	2019
Schneitec (Pursat)	Solar	60	2021
Schneitec (Kampong Chhnang)	Solar	60	2020

Source: Created by the Chugoku Electric Power from EAC Annual Reports, local media reports, etc.

However, the evaluation committee members, who were selected as individuals and not by organization, conducted the evaluation through mutual consultation. In terms of human resources development, it was found that it is insufficient to improve the IPP evaluation skills of young personnel only through on-the-job training because only one or two IPP evaluations are conducted per year in recent years, and due to the variety of power plants, including hydro, thermal, and solar power plants. In addition, although various donors have provided various training programs to the Cambodian electric power sector, we found that the training materials are possessed by individual participants, and there is little basis for knowledge sharing and skill transfer.

(2) Basic Plan

The following basic plan was created as an efficient and systematic manner to conduct the evaluation process:

- Use of the IPP evaluation checklist created by the WG2 of this project
- Create a mechanism for sharing technical skill materials
- Ascertain the technical skill capabilities of each individual
- Trainers nurtured by this project will provide continuing education to others

(3) Recommendations

Under current conditions, IPP evaluations are conducted through consultations between committee members appointed individually rather than by organizational units, it is assumed that the quality of evaluations vary depending on the capabilities of the appointed members. We proposed the following as a way to standardize the tasks performed, and perform evaluations efficiently and systematically (see Attachments 6) in order to ensure that evaluations are conducted responsibly with consistent quality. On May 11th, 2022, we conducted recommendations to H.E. Heng Kunleang, Director General.

a. Create a checklist for IPP evaluations that clearly define the evaluation items in order to ensure consistent evaluation quality and fairness of evaluations. The MME is mainly responsible for evaluating this checklist on a periodic basis.
b. Determine the departments responsible for each item of the checklist in order to perform evaluations with organizational responsibility.
c. Each department continuously implements human resources development such as in-house training for their assigned checklist items, and makes efforts to improve the quality of evaluations. For example, it is recommended that the capabilities of each personnel be assessed annually and that training be provided based on the results of this assessment. The training is expected to be led by the C/Ps of this project.
d. As technical skill materials regarding training prepared during this project will be archived so that any member of MME and EAC can refer to them, it is recommended that such a mechanism

also be used to share information in the future.

2.3.3 Information Sharing

In Cambodia, there is little sense of technical capabilities possessed by organizations, and past training materials are simply retained individually by the training participants with no idea of sharing them. For these reasons, the materials created during this project were shared using Google Drive so that any C/P can access them. In addition, training videos conducted on the web were recorded and shared on YouTube.

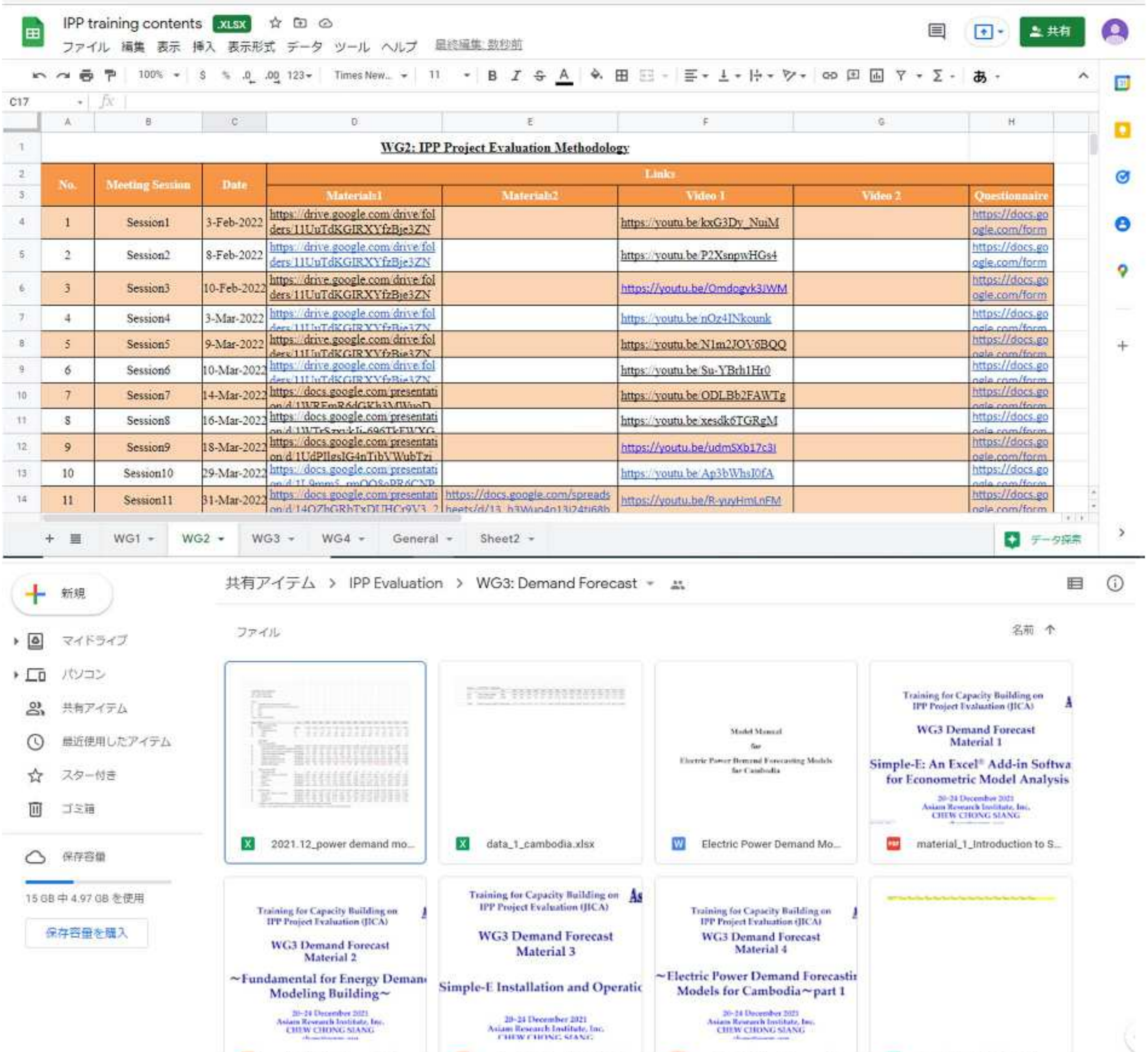


Fig. 2-5 Information Sharing (Example of screenshot of Google Drive)

Fig. 2-6 Information Sharing (Example of screenshot of YouTube channel)

2.4 WG2 IPP Evaluation Method

A document was prepared describing how the evaluation items in the checklist prepared during WG1 should be checked for use as a reference during an evaluation, and training was conducted based on this document.

IPP_Feasibility Study Check List(LNG Thermal)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Fuel Supply					
1.1 Fuel Source	To enable stable supply, check the financial status and fuel supply experience of the fuel supplier. To make sure that the fuel supply contract period matches the IPP project period.	Thermal & Combustion Energy			
1.2 LNG Quality	Confirm Gas calorific value, Gas property, Environmental impact component (nitrogen, sulfur, etc.) Confirm the fuel is suitable for the GT specifications. Confirm the consistency between the amount of exhaust gas components and local environmental regulations	Thermal & Combustion Energy			
1.3 Fuel Handling Facility	-				
1.3.1 Transport Distance	Calculate the LNG consumption at the power plant and confirm that the required amount can be procured by LNG carriers considering the distance to power station, the number and the capacity of carriers	Thermal & Combustion Energy			
1.3.2 Unloading Place and LNG Jetty of Power Plant	Confirm feasibility of pier docking of LNG carriers considering vessel size, water depth of jetty.	Thermal & Combustion Energy			
2.Power Plant Site					
2.1 Conditions of Plant Site	-				
2.1.1 Location	Confirm the distance to transmission lines, the rivers as water source, access roads, obstacles such as unexploded ordnance	Thermal & Combustion Energy			
2.1.2 Natural Conditions of Site	Confirm that annual temperature, coastal wave height, sea water temperature, tidal level, Hydrologic regime and wind condition near the site for the past several decade and site height are collected	Thermal & Combustion Energy			
2.2 Traffic	Confirm availability of air transportation method, sea transportation method, land transportation method, maximum transportable amount.	Thermal & Combustion Energy			
2.3 Engineering Geology	-				
2.3.1 Earthquake	Confirm that earthquake record (e.g. time and scale), existence of active fault and seismic region coefficient around the site are collected	Thermal & Combustion Energy			
2.3.2 Topography	Confirm that topographic data of the site is collected. Confirm that rainfall data around the site are collected and rainfall characteristic of the site is understood.	Thermal & Combustion Energy			
	Confirm that geological survey result near the site by boring survey are collected				

Fig. 2-7 Reference Documents used During Evaluation (Excerpt)

2.4.1 Capability Assessment and Setting of Training Items

In order to provide training to strengthen IPP evaluation capabilities, it was necessary to narrow down the items to be covered in training for which capabilities were lacking so that IPP evaluation capabilities in Cambodia could be effectively improved in a limited amount of time. To do this, we first asked all C/Ps to assign a pre-training level (score from 1 to 5) for each item in the draft checklist prepared by WG1 in order to assess the current IPP evaluation capabilities in Cambodia. The criteria for the scores are as indicated in the table below.

Table 2-2 Criteria for Assessing Capabilities

Score	Level
1	I don't understand any of the items on the checklist.
2	I understand one of the checklist items.
3	I understand half of the checklist items.
4	I understand 75% of the checklist items.
5	I understand all of the items on the checklist.

Evaluation item	Specific elements	average
Purpose of FS Check List	**This list is a compilation of items that should be checked in order to review Feasibility studies fairly and appropriately. Please check each evaluation item with points of interest.**	
1.Power System		
1.1 Situation of Power System	Validity of conditions and results of power flow study	2.37
1.2 Necessity of Power Plant based on power development mast	Type of generator, Capacity, Commercial Operation Date	2.79
1.3 Connection to Power System		
1.3.1 Specification	Voltage, Power factor, Operating frequency range of power generation facilities, etc., Frequency adjustment function※1, Neutral point grounding equipment・Electromagnetic induction hazard・Protection device	2.00
1.3.2 Impact on Power system	Necessity of power system extension (if overloaded), Voltage fluctuation※2, Power plant output (kW, MW) fluctuation※2, Power quality※2, System stability, Automatic load limiter and power generation suppression(only if required)	1.89
1.3.3 Countermeasures for accidents	Short-circuit and ground-fault currents, Fault Ride Through function※3	1.79
1.3.4 Control and communication requirements	Telephone equipment for security of electric facilities, Power Feed Information Transmission Equipment	2.11
2.Transmission Line		
2.1 Transmission line	Interconnection point with power system, Voltage, Route(Over head or under ground), Structures, Wire type, Necessity of Low-loss wire, Number of Circuits, Things crossing transmission lines(e.g. river, railroad, etc.), Matching of power generator and transmission line capacity	2.11
3.License & Permission		
3.1 Land acquisition	Land acquisition, Land use permit conditions, Usable period	1.83
3.2 Construction permission and power generation license	Government permission (the start of construction work and power generation, etc.)	2.11
4.Legal Requirements		
4.1 Related laws and regulations	e.g. Energy Saving, Regulation of vibration and noise at site boundaries and around equipment, etc.	2.17
4.2 Environmental preservation	e.g. Discharge of Pollutants, Environmental Protection, Soil and Water Conservation, etc.	2.05
4.3 Social and Environmental Impact Assessment	Residents, rare animals, remains, etc. at the installation site	2.00
4.4 Health and safety	Occupational health, Labour safety	2.32
5.Power Off-Take		
5.1 Power Off-Take of the project	Power purchase (power generation amount, price, reception point, Commercial Operation Date, etc.)	2.32
5.2 Power Evacuation Options in case of trouble	Penalty conditions in case of trouble	2.11
5.3 Project development schedule and plan	Construction schedule, Construction organization(including ability of EPC), Technical risks(Reflection status of the latest knowledge on power plant components), etc.	3.05
6.Financial analysis		
6.1 Financing cost	Financing costs in project development	1.84
6.2 Financial analysis	IRR, Sensitivity analysis	1.63
6.2.1 Capital expenditures (CAPEX)	EPC cost of power plant and transmission line, Financing cost, Tax, and other related expenses	2.05
6.2.2 Operation and maintenance expenditures (OPEX)	Operation and Mentenance cost after Commercial Operation Date	1.95
6.2.3 Tariff	Confirmation of Tariff (including power generation cost) consideration of CAPEX, OPEX, Power generation amount, Profit, etc.	2.47
7.Risk Analysis		
7.1 Completion risk	Probability of Cost overrun, Commercial Operation Date delay, etc.	1.74
7.2 Operational and Management risk	Reliability of operation / management system	1.79
7.3 Financial risk	Financial arrangements, Repayment, Fluctuation of exchange rate, Bankruptcy, etc.	1.79

Fig. 2-8 Results of Capability Assessment (Common Items)

The results of the C/Ps capability assessment are as follows.

a) LNG-fired Power

As many of the items for LNG-fired power were scored at Level 3 even by the most capable personnel, it was determined that there is a need to improve capabilities in general, including prerequisite knowledge.

b) Hydro Power

As Cambodia has experience with hydro power within the country, it was decided not to provide training on a wide range of topics, but rather to focus on lower-level topics, specifically on seismic, hydrological, and meteorological studies, as well as dam, waterway, and electrical facilities design.

c) Solar Power

As with hydro power, there is Cambodian personnel with experience and high-level capabilities in solar power, but the level was low in regards to natural disasters, PCS, protective devices, and maintenance management. Since there are fewer facilities for solar power than for thermal and hydro power, and fewer items to be evaluated, it was decided that providing general training would contribute to improving capabilities in Cambodia, rather than covering only low-level items in training.

d) Common Items

It was determined that it is necessary to improve capabilities for items common to each project (such as system interconnection and laws/regulations), especially for items related to system interconnection, which are among those for which capabilities are low, but excluding financial and tariff analysis, for which training will be provided during WG4.

2.4.2 Creation and Organization of Training Materials

The following policies were applied to create training materials for common items, and LNG-fired, hydro, and solar power generation.

a) LNG-Fired Power Generation
Given the overall low level in regards to LNG-fired power generation and the lack of experience in Cambodia, training materials on the differences between coal-fired and LNG-fired power generation, such as fuel handling and machinery/facilities, were created in order to provide required knowledge about LNG. We also created materials on what each item represents and what must be checked during an actual evaluation based on this LNG-related knowledge. Each material was created in a manner that is easy to understand using figures and photographs.

b) Hydro Power Generation
We decided to provide training especially for low-level items of hydro power generation based on the experience within Cambodia, and created materials accordingly. As there are technical standards for hydro power in Cambodia, it is necessary to consider whether the requirements of these technical standards are met during the evaluation. This document was designed to explain what points should be examined from items of the technical standards using the example of Japan.

c) Solar Power Generation
We decided to provide training on all items on the checklist related to solar power and created materials accordingly. Emphasis was placed on low-level natural disaster risks in particular by using photographs of case study natural disasters, and data such as typhoon paths and lightning strike distribution in Japan to present the need for countermeasures and what data requires checking in an easy to understand manner.

d) Common Items
Common items consisted of creating training materials for low-level system interconnection. As the trainees consisted of MME and EAC personnel, the emphasis was not on technical study methods, but rather on the contents of items to be evaluated during an IPP evaluation and what information requires verification. Care has been taken to ensure that the contents of each item can be understood by introducing the technical standards of Cambodia and the descriptions in the Grid Code that are the criteria for evaluations.

2.4.3 Training Implementation and Follow-Up

The training was conducted remotely using a web conferencing tool (Zoom) due to the inability to travel to Cambodia because of the COVID-19 pandemic. As training on a wide range of IPP evaluation methods was provided during WG2, the training frequency was set to twice a week from February to May, taking into consideration the tasks of C/Ps. Participants were able to ask questions at any time during each training session and we made every effort to resolve questions whenever asked. A questionnaire was also sent out after the training so that those who could not attend the training in real time could still have their questions resolved.

2.5 WG3 Demand Forecasting

Although medium to long-term demand forecasting used in the Power Development Master Plan ("MP" hereinafter) were conducted by Korea Electric Power in 2006 with the support of the World Bank, and by Chugoku Electric Power in 2013 and 2019, but both were left to the consultants creating the MP. However, interviews with MME personnel indicated that they recognize the need to increase the frequency of updating demand forecasts because of the massive changes in demand over the past few years due to factors such as the rapid increase in electricity demand caused by economic growth and the decrease in demand caused by the impact of the COVID-19. For this reason, the Department of Energy Development of the MME (department in charge of demand forecasting) has set a goal of updating demand forecasts every two years from now on. However, as Cambodia has not conducted demand forecasting before, it has not developed personnel who can actually perform such demand forecasting.
The demand forecasts in the revised MP carried out by Chugoku Electric Power in 2019 were made using the Simple-E application that meets the needs of the Cambodian C/Ps. Simple-E is an add-in application for Excel, so it can be used on a PC running Excel, and since the data and correlation functions are clearly shown, the forecasting process is not a black box but rather the relationship between the demand forecast parameters and the forecast results can be easily understood.
Based on the above, demand forecasting training was conducted using Simple-E.

2.5.1 Creation and Organization of Training Materials

(1) Simple-E

Simple-E is an integrated simulation system that was developed from an econometric simulation tool. This tool supports the entire modeling process from data preparation to model building and simulation (prediction). Automation of estimation and prediction simulation through regression models provides seamless operation.
Simple-E was created as an add-in application for Microsoft Excel. It takes full advantage of the native Excel spreadsheet functions as well as the open interfaces with other Windows applications. At the same time, it integrates the processes of data inputs, modeling, testing, prediction, and simulations, with no new programming required. Moreover, the graphical and visible operations make Simple E easy to use and learn. Users can concentrate on the most demanding tasks of modeling and simulations with the advantages of full transparency and compatibility with other data and program interfaces within Windows
It integrates and controls Excel's function facility and offers various estimation options such as ordinary least squares (OLS), autoregressive, and nonlinear. A simultaneous equation is a set of simultaneous equations that includes a forward-looking model, with various forms of equations available, including regression models and definition equations. Each time series variable or its model is assigned to one row of the worksheet, and each period or each variable case is assigned to one column of the worksheet.
Simple-E consists of three sheets: 1. Data, 2. Model, and 3. Simulation. The three sheets are interlinked and essential for model building. Model building involves three processes from data input to simulation: 1) Model checking, 2) Model solving, and 3) Simulation (Simulation). The figure below shows the basic concept, and the relationship between each process and the three sheets. The user must enter data on the "1. Data" sheet and model specifications on the "2. Model" sheet. After data input and model specification, Simple-E checks the model and processes the simulation.

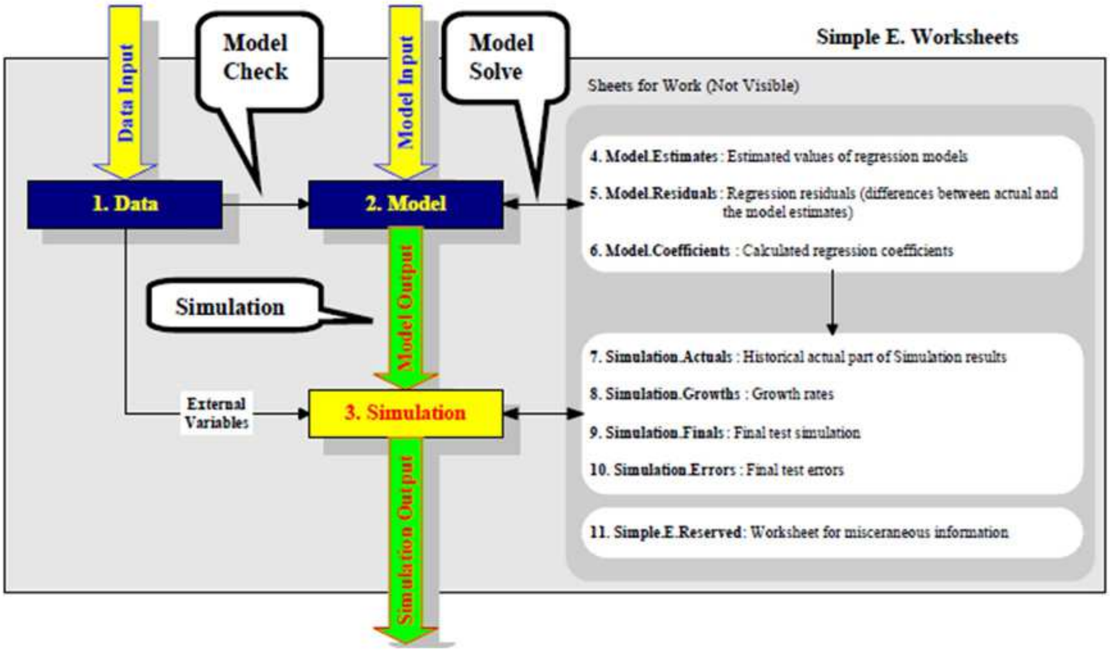


Fig. 2-9 Simple-E: Basic Concept and Process Flow Chart

(2) Creation of Materials, Data Collection and Organization

This training includes theoretical learning about model building and aims to enable training participants to actually build models. For this reason, we used official Cambodian government statistics for the macroeconomy (Asian Development Bank database) and statistics for the electricity sector published by EDC and EAC in creating training materials. However, the following issues exist in regards to material creation and data collection.

- While maintenance of statistical data for Cambodia is advancing, some of the data necessary for demand models is missing. For example, the EAC collects relevant data about electricity prices and number of customers but it is not organized chronologically.
- The lack of department-specific data does not allow for a deeper analysis of electricity demand by sector.
- Lack of advancement in the management of statistical data for the provinces (each state) makes it difficult to analyze electricity demand by region.

Since the above constraints cannot be resolved in the short term, electricity demand model building for this project was conducted from a macro perspective. The models built during the training include a scalable mechanism as a platform for future demand model building. This is expected to improve the accuracy of model predictions as the maintenance of statistical data in Cambodia progresses.

2.5.2 Training and Trainer Development

(1) Training Contents

Training for the development of trainers includes computer-based practical training, and technology transfer of methods for building electricity demand models through practical application and training. Specifically, the three themes of macroeconomic models, electricity demand prediction models, and province electricity demand models, which are organically linked to each other, were practically studied using Excel spreadsheets (Simple-E add-in). Using a macroeconomic model, students learned the theories of the most important aspects of econometrics, such as regression analysis, a method to formulate the relationship between energy (electricity) and economic activities, and also practiced formulating the relationship between the economy and electricity supply/demand using neighboring countries as examples.

The creation of materials for the trainer development training mainly focused on the basic theories of model building, software operation, and electricity demand model building. To achieve these objectives, we used actual statistical data from Cambodia with a training flow allowing all participants to experience the entire process of completing the model on their own computers while providing them with explanations of each step of the model building process from start to finish. Specific details and materials are as follows.

- Information about the structure of the Simple-E software (Refer to Attachment 8-1)
- Basics of energy demand models (Refer to Attachment 8-2)
- Operation of Simple-E software (Refer to Attachment 8-3)
- Electricity demand model building (Refer to Attachment 8-4)

As mentioned above, the training program was designed to enable participants to build their own electricity demand models with PCs using actual data from their own countries, and to learn while checking the results of their own work. The final model building results will remain on each participant's computer as an electronic file (Excel table format), which can be reused in the future by updating, modifying, or expanding the model according to the needs of their own work.

(2) Training Schedule for Trainer Development

The training was conducted for six days from Dec. 20, 2021 (Mon.) to Jan. 5, 2022 (Wed.), according to the schedule shown in the table below.

Table 2-3 Trainer Development Training Schedule

Session	Date	Training Contents
1	Dec. 20, 2021 (Mon.)	Structure of Simple-E software (Attachment 8-1)
2	Dec. 22, 2021 (Wed.)	Operation of Simple-E software (Attachment 8-3)
3	Dec. 23, 2021 (Thurs.)	Basics of Energy Demand Models (Attachment 8-2)
4	Dec. 24, 2021 (Fri.)	Basics of Energy Demand Models (Attachment 8-2)
5	Dec. 29, 2021 (Wed.)	Electricity Demand Model Building (Attachment 8-4)
6	January 5, 2022 (Wed.)	Electricity Demand Model Building (Attachment 8-4)

(3) Training Participants

All C/Ps (19 in total) participated in the WG3 trainer development training. Three of the participants became trainers.

(4) Remarks

This was the first time that training on electricity demand model building was conducted in the form of a web conference. The greatest benefit of web conferencing is the time savings. Instructors (lecturers) and participants do not have to physically travel, significantly reducing the time spent on travel. As the web conferencing format has just been recently adopted, there are many areas that need improvement, such as communication speed and unfamiliarity with the operations, but all of these problems can be overcome.

2.5.3 Training Conducted by Trainers and Follow-Up

(1) Contents of Training by Trainers

The goal of training by trainers is to disseminate the analytical tools and methods for electricity demand forecasting to the staff of the related institutions (MME, EAC, and EDC) in Cambodia in the future, led mainly by the three trainer participants. This training helped C/Ps to sustainably deploy analytical tools and other technologies related to electricity demand forecasting within their organizations. Since it was difficult to have four trainers create explanatory materials in the short time frame of the project, it was decided to conduct secondary education this time using the lecture materials used in the trainer development training. Specific details of the training of each trainer are as follows.

Session 1
Training focused on explaining the installation of the Simple-E software analytical tool.

Session 2
The instructor focused on Simple-E operations. Specifically, the trainees worked on practice problems using on their own computers in a practical manner. This training focused on learning basic statistical testing methods and key points, as well as methods and operations such as regression analysis and simulation analysis using the Simple-E tool.

Session 3
This session focused on how to build an electricity demand model. Specifically, the structure of the electricity demand model was explained, and electricity demand and macroeconomic trends were formulated as functional equations to perform regression analysis.

Session 4
Session 4 used an electricity demand model to forecast demand based on a simulation analysis. The lecture covered the applications of the model as well as electricity demand forecasting.

(2) Schedule of Training Conducted by Trainers

Four trainers and six trainees participated in this training. The training was conducted over two days from March 21 (Mon.), 2022 to March 22 (Tue.), 2022. The training schedule is shown in the table below.

Table 2-4 Schedule of Training Conducted by Trainers

Date	Session	Training Contents
March 21, 2022 (Mon.)	1	Introduction of Simple-E software (Attachment 8-3)
	2	Operation of Simple-E software (Attachment 8-2, Attachment 8-3)
March 22, 2022 (Tue.)	3	Basics of Electricity Demand Models (Attachment 8-4)
	4	Applications of Electricity Demand Models (Attachment 8-1, Attachment 8-5)

Session 1

Session 2

Session 3

Session 4

Fig. 2-10 Training Conducted by Trainers

(3) Issues

This training by trainers was conducted for the first time for C/Ps. The following specific issues were observed from this experience.

- Since most of the members are new to the field, they do not have sufficient experience, and trainers differ greatly in the skills they possess for building electricity demand models.
- There was not enough time for training participants to perform actual operations using their computers. For this reason, participants were exposed to the concepts of demand forecasting models, but not to the actual operations of electricity demand models.
- Demand forecasting requires not only knowledge of the energy sector, but also basic foundations in statistics and economics. The basics of these two areas were only lightly touched upon in this training and need to be addressed in the future.

(4) Remarks

The training conducted by trainers functioned well as the first secondary education program. The support has changed from the conventional method in which only the personnel providing assistance themselves created electricity demand forecasts to a method in which the C/Ps are assisted so that they can analyze and forecast electricity demand on their own. This type of support is expected to be more sustainable in terms of know-how and technology transfer for electricity demand forecasting. Conversely, the lack of practical experience of the trainers is a real problem, so continued support is needed even after the completion of this project.

2.5.4 Implementation of Demand Forecasting On-the-Job Training

(1) On-the-Job Training Contents

The goal of the on-the-job training ("OJT" hereinafter) was to assist C/Ps in building actual electricity demand models. It is expected that the OJT will help the C/Ps to establish electricity demand model

technology by using Simple-E and increase their own confidence in such operations. In addition, the training focused on the application of the models studied and constructed during the trainer development training as a platform to be updated, modified, and expanded while also explaining the problems and characteristics faced when actually constructing the model, and presenting methods for dealing with such problems.
The training materials focused on the applications of model analysis and to emphasize the important points when actually forecasting electricity demand. Specifically, the following four points are summarized in the material.

- Model Structure and Methodology (Refer to Attachment 8-6)
- Electricity Demand Analysis (Refer to Attachment 8-7)
- Model Evaluation (Refer to Attachment 8-8)
- Forecasting (Refer to Attachment 8-8)

(2) OJT Training Schedule

Due to scheduling constraints for participants, the OJT training was conducted on Feb. 16, 2022 (Wed.) and Feb. 28, 2022 (Mon.). The same content was repeated on Feb. 18 (Fri.) for the two trainers who were unable to attend on February 16 (Wed.).

Table 2-5 OJT Training Schedule

Session	Date	Training Contents
1	Feb. 16, 2022 (Wed.)	Model Structure and Methodology (Attachment 8-6)
2	Feb. 18, 2022 (Fri.)	Model Structure and Methodology (Repeat) (Attachment 8-6)
3	Feb. 28, 2022 (Mon.)	Electricity Demand Analysis, Model Evaluation and Forecasting (Attachment 8-7, Attachment 8-8)

(3) Training Participants

All C/Ps (19 total) participated in the OJT training of WG3. Four of the trainers were required to participate in the web conference in real time.

(4) Issues

Although the issues that are common with trainer development training are not restated here, the following issues were identified in regards to the portion of OJT training.

- Many of the participants were busy with their own tasks and it was difficult to coordinate time for the training, resulting in it being conducted over three days (one of which was repeated with the same contents).
- We planned to perform actual electricity demand forecasting with the participants using their latest data, and participants were requested in advance to update their data, but they did not provide the latest data, so the exercise was performed using the database from 2000 to 2018 that we had collected.
- New data (variables) need to be collected for future modification and expansion of electricity demand models. It has been recommended that the statistical database necessary for electricity demand forecasting be systematically constructed. Database development and management is essential to improve the performance of econometric analysis. Data collection is a process of evaluating, organizing, describing, and calculating the numerical values that have been gathered. This process requires the reading-in of a large amount of information

(5) Remarks

We built an electricity demand model from zero based on Cambodian statistical data for the training participants, and worked with them until the final demand forecast results were obtained and finalized. We believe that it is necessary to create a mechanism for continuous follow-up with training participants and support them until the related analytical methods are firmly established. Actual energy demand model analysis is more complex and requires more extensive knowledge. The analytical methods and model structures used in this training were developed for developing countries with underdeveloped statistical data. We hope that this training will lead to the introduction of energy demand models so that they can serve as a reference indicator for policy making.

2.6 WG4 Financial/Tariff Analysis

From the results of interviews with MME personnel, we know that they tend to refer to and follow precedents due to insufficient financial and tariff analysis capabilities, such that they cannot accurately determine the appropriateness of the details of a Power Purchase Agreement ("PPA" hereinafter) proposed by an IPP. For example, factors such as "location," "technical content," and "cost structure" differ for each power plant, as these are nearly never the same, making it quite difficult to evaluate the differences with a power plant that has been appropriately evaluated even if referring to precedents.
It is impossible to negotiate PPAs with IPPs in a favorable manner without financial and tariff analysis. For this reason, training was conducted to improve the financial and tariff analysis capabilities.

2.6.1 Creation and Organization of Training Materials

The training materials were created so that even trainees who have never seen a feasibility study proposal ("FS Proposal" hereinafter) before will be able to understand an overview of the commercial details of a FS Proposal. Specifically, topics such as profitability, income, tariff structure, and finance (corporate and project finances) were incorporated into the training materials. Additionally, the main items generally stipulated in the PPA as prerequisites for the revenue and tariff structure were also incorporated in the explanatory materials because the determination of whether the tariff level is appropriate depends on the risk profile of each project, and it is assumed that the IPPs in Cambodia will submit feasibility study proposals based on the PPA at this point.
To create such materials, we have introduced the viewpoints of lenders in order for the participants to understand the perspective from which IPPs and related entities intend to conduct a feasibility study as their viewpoints on the investment criteria (hurdle rate) and the position of MME are close to those of lenders who expect stable continuation of the project. Furthermore, concepts related to the perspective of financial analysis such as analysis of profitability, productivity, safety, and growth using financial statements and other statistical indicators were also incorporated into the training materials.

2.6.2 Training and Trainer Development

Since it was not possible to visit Cambodia due to the impact of the COVID-19 pandemic, training via web conferencing (Zoom) was conducted once or twice a week from the end of Dec. 2021 to Jan. 2022, for a total of five sessions.
Even though the training was conducted remotely, we received proactive questions about the specific hurdle rate levels (figures) that private companies take into consideration, the ratios that they deem as concerning for financial soundness, and the levels in cases of Japanese companies. For questions received during the class, followups were provided by explaining additional materials in the project after the questions were received.

2.6.3 Training Conducted by Trainers and Follow-Up

In order to assess the level of understanding of the training contents among the prospective trainers and their abilities as trainers, three prospective trainers conducted training sessions for young staff members as follows.

Table 2-6 Schedule of Training Conducted by Trainers

Session	Date
1	March 24, 2022 (Thurs.)*
2	March 24, 2022 (Thurs.)*
3	March 29, 2022 (Tue.)

*March 24 was divided into AM and PM sessions.

Session 1

Session 2

Session 3

Fig. 2-11 Training Conducted Trainers

Although there was some need for the C/Ps acting as trainers to check terms such as "off taker" and "escrow," during the training, they were able to train the participants on points that the C/Ps themselves had learned in the previous training. The trainers were eager to deepen their understanding of project finance, BOT, and related topics through discussions with younger personnel who participated in the training and other personnel. We requested the trainers to submit any new questions that came up during the training, but no additional questions have been raised since then.

2.6.4 Remarks

At the beginning of training, C/Ps were not familiar with some aspects of financial and tariff analysis, but through active questioning, they were able to learn the basics of various indicators and the concept of analytical methods. However, although C/Ps understood the basic ideas and concepts through this training, there were some questions about objective and easily understandable criteria, such as what values and conditions should be considered "good" or "bad" for practical implementation. It would be beneficial to survey and analyze specific values and conditions based on the current economic situation and business practices in Cambodia, and share them as a guideline for judgment criteria.

2.7 Other

2.7.1 Trainer Certification

The six participants who completed the entire curriculum were awarded certificates as trainers signed by the Chief Representative of JICA Cambodia Office.

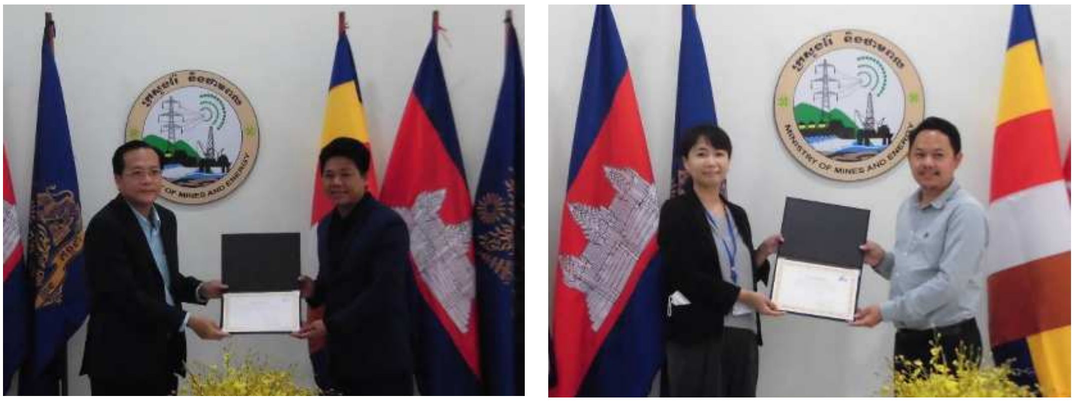


Fig. 2-12Certification Ceremony

Fig. 2-13 Certificate

2.7.2 Equipment Procurement

Initially, 10 licenses of the demand forecasting software Simple-E were to be procured, but due to the increase in the number of C/Ps, the number was changed to 15 licenses and they were purchased accordingly. The JICA Power Economics and Planning Adviser (right) presented the equipment handover to MME H.E. Heng Kunleang, Director-General (left) on Feb. 2, 2022.

Fig. 2-14 Handover

2.7.3 Publicity

a) FACEBOOK (First Round)

An announcement was made on the Facebook page of the JICA Cambodia Office regarding the start of the project on Jan. 18, 2022.

9:22

データモード　無料でアクセス

← JICA Cambodia Office - JICA...

JICA Cambodia Office - JICA カンボジア事務所
16時間前

[វគ្គបណ្តុះបណ្តាលកសាងសមត្ថភាពលើការវាយតម្លៃគម្រោងអ្នកផលិតថាមពលអគ្គិសនីឯករាជ្យ/ Training on Capacity Building for Independent Power Producers (IPP) Project Evaluation]

គម្រោងផលិតថាមពលអគ្គិសនីជាច្រើននៅប្រទេសកម្ពុជាពឹងផ្អែកទៅលើ អ្នកផលិតថាមពលអគ្គិសនីឯករាជ្យ (IPP)។ ដើម្បីធានាថាសំណើរគម្រោងរបស់អ្នកផលិតថាមពលអគ្គិសនីឯករាជ្យមានភាពត្រឹមត្រូវ ហើយរោងចក្រអគ្គិសនីផ្សេងៗត្រូវបានដាក់ឲ្យដំណើរការបានតាមផែនការនោះ ក្រសួងក៏ដូចជាស្ថាប័នពាក់ព័ន្ធផ្សេងៗ ចាំបាច់ត្រូវធ្វើការវាយតម្លៃគម្រោង IPP ទាំងនោះឲ្យបានត្រឹមត្រូវផងដែរ។ ដូចនេះ ចៃកាបានចាប់ផ្តើមគម្រោងបណ្តុះបណ្តាលមួយ ដែលមានគោលបំណងចូលរួមចំណែកលើកកម្ពស់ស្ថេរភាពនៃការផ្គត់ផ្គង់ថាមពលនៅកម្ពុជា តាមរយៈការធ្វើឲ្យប្រសើរឡើងនៃសមត្ថភាពវាយតម្លៃគម្រោង IPP របស់មន្ត្រីនៅក្រសួងរ៉ែ និងថាមពល និងស្ថាប័នពាក់ព័ន្ធនានាដែលចូលរួមក្នុងការវាយតម្លៃគម្រោង។ វគ្គបណ្តុះបណ្តាលត្រូវបានធ្វើឡើងដោយផ្តោតសំខាន់ទៅលើផ្នែកបច្ចេកទេសនៃរោងចក្រផលិតអគ្គិសនី ការព្យាករណ៍តម្រូវការថាមពលអគ្គិសនី ព្រមទាំងការវិភាគលើតម្លៃ និងហិរញ្ញវត្ថុ។ ការបណ្តុះបណ្តាលនេះបានចាប់ផ្តើមឡើងនៅថ្ងៃទី ២០ ខែធ្នូ ឆ្នាំ២០២១ តាមរយៈវីដេអូពីចម្ងាយ ដោយមានសិក្ខាកាមប្រមាណជា ២០នាក់ចូលរួម។ នៅក្នុងពេលបណ្តុះបណ្តាល ពួកគេបានលើកជាសំណួរ និងរួមគ្នាពិភាក្សាដោះស្រាយបញ្ហា និងភាពស្រពិចស្រពិលផ្សេងៗ។ នេះសបញ្ជាក់ពីការប្តេជ្ញាចិត្តខ្ពស់ក្នុងការអភិវឌ្ឍសមត្ថភាពរបស់ពួកគេតាមរយៈគម្រោងនេះ។

ក្រៅពីការផ្តល់នូវវគ្គបណ្តុះបណ្តាលនេះ ចៃកាក៏បានចូលរួមសហការយ៉ាងសកម្មជាមួយរាជរដ្ឋាភិបាលកម្ពុជាក្នុងវិស័យថាមពល ដើម្បីឲ្យវិស័យនេះមានការអភិវឌ្ឍជាលំដាប់។ គម្រោងចៃកាដែលកំពុងអនុវត្តសព្វថ្ងៃមានដូចជា គម្រោងពង្រីកប្រព័ន្ធបញ្ជូន និងចែកចាយអគ្គិសនីនៅទីក្រុងភ្នំពេញ ជំហ៊ានទី១ និងទី២ (កម្ចីហិរញ្ញប្បទានសហប្រតិបត្តិការអភិវឌ្ឍផ្លូវការ) កិច្ចសហប្រតិបត្តិការបច្ចេកទេសលើគម្រោងកែលម្អការគ្រប់គ្រង និងប្រតិបត្តិការបណ្តាញថាមពលអគ្គិសនី ព្រមទាំងមានការបញ្ជូនទីប្រឹក្សាផ្នែកផែនការ និងសេដ្ឋកិច្ចថាមពល (អ្នកជំនាញការចៃកា) ទៅកាន់ក្រសួងរ៉ែ និងថាមពលផងដែរ។

Most of the power generation projects in Cambodia rely on independent power producers (IPP). In order to ensure appropriateness of proposals by IPP and to develop and operate power plants as planned, ministries and/or governmental agencies need to conduct appropriate evaluation of IPP projects.
Therefore, JICA launched a training project in Cambodian power sector, which aims to contribute to the stable power supply by improving the IPP evaluation capacity of the Ministry of Mines and Energy and other organizations involved in the evaluation of IPP project. In this project, the training will be conducted on technical aspects of power plants, electricity demand forecast, and tariff and financial analysis. The training started on December 20, 2021 via WEB conference and about 20 people participated. The participants showed a positive attitude toward the training by asking questions and resolving doubts through discussions whenever necessary. It reflects their willingness to improve their capability through this training project.

Besides this training project, JICA has also been cooperating with the Royal Government of Cambodia in continuously developing Cambodia's energy sector through various projects in ODA Loan and Technical Cooperation schemes. The on-going projects include the Phnom Penh Transmission Line and Distribution System Expansion Project Phase 1 and 2 (ODA Loan), the Technical Cooperation Project for Enhancement of Operation and Management of Cambodian Transmission System, as well as dispatching the Power Economic and Planning Adviser (JICA Expert) to the Ministry of Mines and Energy.

Credited: Mr. Kurisu Yosuke (Training Support of IPP Training) & Industrial Development Section, JICA Cambodia Office.

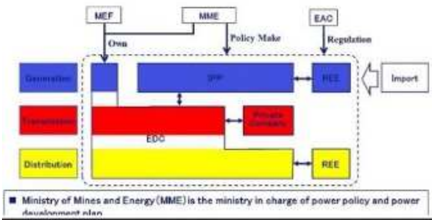


Fig. 2-15 Facebook (First Round Post)

b) FACEBOOK (Second Round)

An article was posted on the Facebook page of the JICA Cambodia Office about the development of trainers being conducted under this project on April 12, 2022.


JICA Cambodia Office - JICA カンボジア事務所
4月12日 10:44

Training on Capacity Building for Independent Power Producers (IPP) Project Evaluation]

Most of the power generation projects in Cambodia rely on Independent Power Producers (IPP). In order to ensure appropriateness of proposals by IPP and to develop and operate power plants as planned, ministries and/or governmental agencies need to conduct appropriate evaluation of IPP projects. Therefore, back in December 2021, JICA launched a training project, which aims to contribute to the stable power supply by improving the IPP evaluation capacity of the Ministry of Mines and Energy and other organizations involved in the evaluation of IPP projects.

The trainees whose capacities have been developed through this project are also expected to become trainers in the future. In March this year, the trainees provided training to young staff members on the contents such as electricity demand forecast and electricity tariff structure, which they learned through this project. This training was a good opportunity for them to reconfirm what they had learned by teaching themselves and to be aware of their roles as trainers.

Besides this training project, JICA has also been cooperating with the Royal Government of Cambodia in continuously developing Cambodia's energy sector through various projects in ODA Loan and Technical Cooperation schemes. The on-going projects include the Phnom Penh Transmission Line and Distribution System Expansion Project Phase 1 and 2 (ODA Loan), Technical Cooperation Project for Enhancement of Operation and Management of Cambodian Transmission System, as well as dispatching the Power Economic and Planning Adviser (JICA Expert) to the Ministry of Mines and Energy.

Credited: Mr. Kurisu Yosuke (Training Support of IPP Training) & Industrial Development Section, JICA Cambodia Office.

Fig. 2-16 FACEBOOK（Second Round Post）

Chapter 3 Innovative Methods, Lessons Learned, and Future Issues in Project Implementation and Operation (Task Implementation Methods, Management Systems, etc.)

3.1 Information Sharing and Remote Training

(Innovative Methods)

As mentioned in 2.3.3, the sharing of training materials and other information with all the C/Ps in this project was a challenge because there is little awareness in Cambodia of the need to share training materials and other information. In addition, it was necessary to devise new training methods because the Cambodian side requested that all C/Ps be able to participate in all training sessions, and the COVID-19 pandemic prevented us from traveling to the site for a long period of time.

The training materials were shared via Google Drive. This allows each C/P to refer to the training materials and download them to his/her PC at any time. Zoom, a web conferencing tool, was used to conduct the training. Zoom can record web conferences. The recorded data was uploaded to YouTube and set up so that anyone with the URL could view it. This was done to ensure that those who were unable to attend on the day of the training could still receive the same training at a later date, while additional questions could be asked through a post-training questionnaire using Google Form.

The links to these training materials, recorded data and questionnaires were provided to the C/Ps before and after the training, and the information of these URLs was compiled into a document that was also shared with the C/Ps. Training materials were shared prior to the training so that C/Ps could evaluation the content in advance.

The use of YouTube to provide training for all participants was indispensable for the project to proceed, as it was very difficult to coordinate the schedules of all the 19 counterparts, and it was also useful for the C/Ps to be able to watch the training repeatedly and reflect on the content.

(Lessons Learned)

Although there are major web conferencing tools other than Zoom including Teams and Meets, but the C/P side must be able to support them. In this project, when we tried to hold the training by using Teams due to the circumstances, some C/Ps were unable to attend and the date had to be changed. A common understanding of the web conferencing tools to be used should be established at the outset when conducting tasks remotely.

(Future Issues)

- Consideration should be given to the length of training time due to the fatigue caused by looking at computer screens during remote training, by limiting the time to about two to three hours per session.
- On-site training often makes it possible to provide direct instruction to participants, follow-up on individual differences in level, or in some cases, follow-up between trainees discussing among themselves in their own language, but these are difficult to do remotely.
- It is difficult to manage participants' attendance and to ascertain the participants' willingness to study.
- There may be a time lag in screens shared with participants depending on communication conditions.

Although we are aware of these issues throughout this project, we believe they will improve in the future with the improvement of the communication environment, and the development of VR technology and web conferencing tools.

3.2 Selection of C/Ps

(Lessons Learned)

Although the MME, EAC, and EDC, all of which play a central role in the IPP evaluation process, were expected to be named as C/Ps, the EDC expressed difficulty in being named as a C/P. We tried to coordinate by having the consultant send a letter and similar actions, but we could not get the EDC to join the project as a C/P. The EDC needed a letter from the MME but the MME did not provide a letter to the EDC, creating a rift that was not closed before the end of the project, which was very disappointing. Since the EDC and EAC were expected to participate in addition to the MME, which had submitted the request at the project formation stage, we felt that it will be necessary to provide information to the EDC and EAC at an early stage in the future.

(Innovative Methods)

As the EDC gave us permission to provide training materials to EDC personnel, we shared the above-indicated materials via Google Drive.

Chapter 4 Future Activities

After the completion of this project, it is recommended to implement the followings.

4.1 Regular Training by Certified Trainers

After implementing technical transfer in this project, it is necessary to utilize its capabilities in actual IPP examinations. However, since the IPP evaluation will be carried out only after receiving an application from the IPPs, the evaluation is not always near future. Therefore, in order to maintain the results of this project, it is recommended that the trainers certified by this project conduct regular training. In addition, the understanding will be further deepened by visiting neighboring countries with members centered on trainers and conducting third-country training on IPP evaluation. Therefore, it is also useful for JICA individual experts dispatched to MME to support this.

4.2 Review of Examination Manual

Regarding the evaluation manual created in this project, Director General Heng Kunleang said, "the materials will be reviewed by the Cambodian side in the future to make them better." Therefore, it is recommended to review the evaluation manual for each IPP evaluation. In the process of reviewing, if there are any new technical shortages in Cambodia, revision work should be carried out with the budget of JICA individual experts dispatched to MME, or follow-up project of this project should be carried out. If so, the review will be done at an appropriate time without any postponement due to the lack of budget of MME. In addition, in this project, training on "gas-fired power", "solar power", "hydropower", and "power system" was conducted, but since wind power IPP is not planned for the time being, wind power training was not conducted. In this way, it will be necessary in the future to prepare evaluation manuals for fields that have not been implemented now.

Chapter 5 Attachments

Attachment 1: Task Flowchart
Attachment 2: Expert Dispatch Results (Personnel Plan)
Attachment 3: Kick-Off Meeting Materials
Attachment 4: Materials for Kick-Off Meeting with C/Ps

[WG1] Evaluation System
Attachment 5: Evaluation Manual (Checklist)
Attachment 6: Recommendations

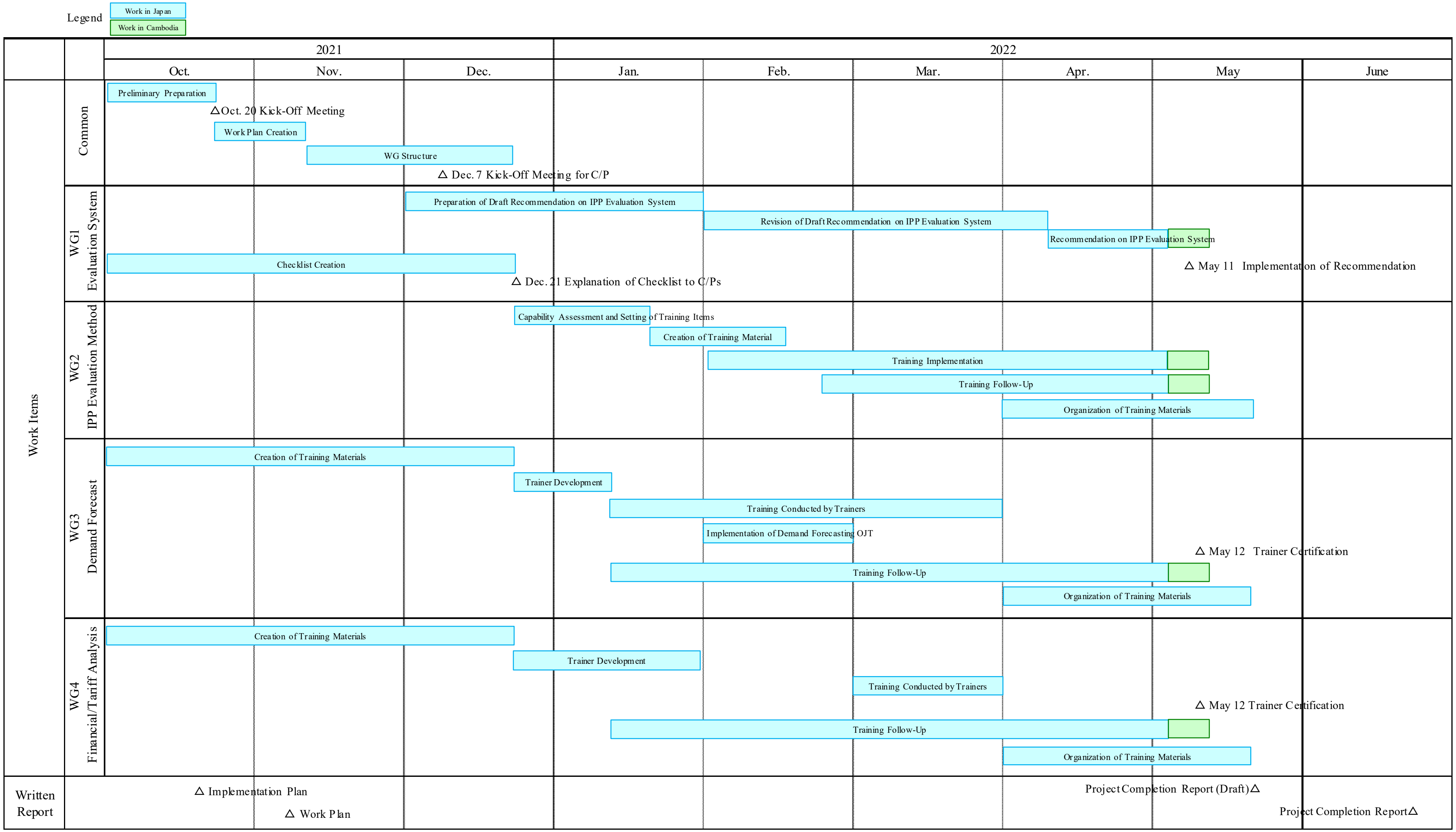
[WG2] Power Generation Planning
Attachment 7-1: LNG-fired Power Plant Training Text 1
Attachment 7-2: LNG-fired Power Plant Training Text 2
Attachment 7-3: LNG-fired Power Plant Training Text 3
Attachment 7-4: Hydro Power Plant Training Text 1
Attachment 7-5: Hydro Power Plant Training Text 2
Attachment 7-6: Hydro Power Plant Training Text 3
Attachment 7-7: Hydro Power Plant Training Text 4
Attachment 7-8: Hydro Power Plant Training Text 5
Attachment 7-9: Solar Power Plant Training Text 1
Attachment 7-10: System Interconnection Training Text 1
Attachment 7-11: Reference of Hydro Power Plant Training
Attachment 7-12: Reference of Solar Power Plant Training

[WG3] Demand Forecasting
Attachment 8-1: Demand Forecasting Training Text 1
Attachment 8-2: Demand Forecasting Training Text 2
Attachment 8-3: Demand Forecasting Training Text 3
Attachment 8-4: Demand Forecasting Training Text 4
Attachment 8-5: Demand Forecasting Training Text 5
Attachment 8-6: Demand Forecasting OJT Text 1
Attachment 8-7: Demand Forecasting OJT Text 2
Attachment 8-8: Demand Forecasting OJT Text 3
Attachment 8-9: Demand Forecasting Manual

[WG4] Financial/Tariff Analysis
Attachment 9-1: Financial/Tariff Analysis Training Text 1
Attachment 9-2: Financial/Tariff Analysis Training Text 2
Attachment 9-3: Financial/Tariff Analysis Training Text 3
Attachment 9-4: Financial/Tariff Analysis Training Text 4
Attachment 9-5: Financial/Tariff Analysis Training Text 5
Attachment 9-6: Supplementary Material of Financial/Tariff Analysis

Attachments

Attachment 1: Task Flowchart



Attachment 2: Expert Dispatch Results (Personnel Plan)

Personnel Plan

	Tasks Responsible	Name	Company	Rating	2021			2022						Person･Month Total	
					10	11	12	1	2	3	4	5	6	Cambodia	Japan
Work in Cambodia	Project Manager Power Generation Planning	HIROSE Masakazu	The Chugoku Electric Power Co., Inc.	2								(0.20)		0.20	
	Demand Forecast	Chew Chong Siang	The Chugoku Electric Power Co., Inc. (Corroborated by Asiam Research Institute)	3										0.00	
	Financial Analysis	FUJIWARA Takeshi	The Chugoku Electric Power Co., Inc.	3										0.00	
	Tariff Analysis	KENGI Shigeru	The Chugoku Electric Power Co., Inc.	3										0.00	
	Power System	NAKANISHI Koichi	The Chugoku Electric Power Co., Inc.	3										0.00	
	Training Assistance	KURISU Yosuke	The Chugoku Electric Power Co., Inc.	5								(0.20)		0.20	
					Subtotal of Work in Cambodia									0.40	
Work in Japan	Project Manager Power Generation Planning	HIROSE Masakazu	The Chugoku Electric Power Co., Inc.	2											3.54
	Demand Forecast	Chew Chong Siang	The Chugoku Electric Power Co., Inc. (Corroborated by Asiam Research Institute)	3											3.38
	Financial Analysis	FUJIWARA Takeshi	The Chugoku Electric Power Co., Inc.	3											1.76
	Tariff Analysis	KENGI Shigeru	The Chugoku Electric Power Co., Inc.	3											1.36
	Power System	NAKANISHI Koichi	The Chugoku Electric Power Co., Inc.	3											0.70
	Training Assistance	KURISU Yosuke	The Chugoku Electric Power Co., Inc.	5											1.99
					Subtotal of Work in Japan										12.73
		Submission of Reports				Implementation Plan Work Plan			Project Completion Report (Draft)		Project Completion Report				
					Total									13.13	

Legend: Work in Cambodia; Work in Japan

Training for Capacity Building on IPP Project Evaluation

Kick-off Meeting

October 20th, 2021

The Chugoku Electric Power Co., Inc.

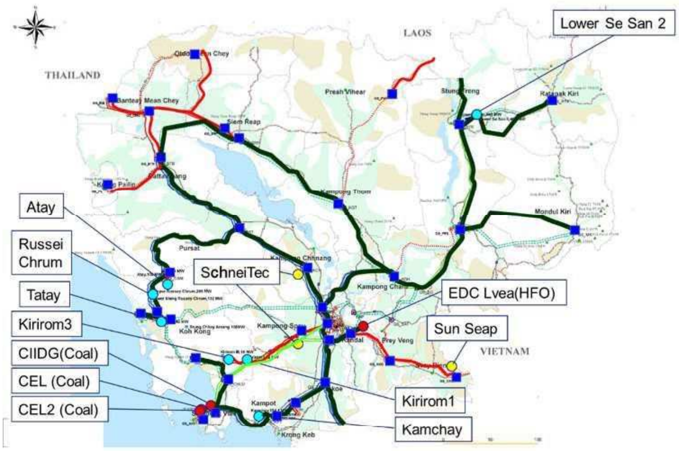
1. JICA Team

Position	Name	Company	Picture
Project Manager / Generation Planning	Mr. HIROSE Masakazu	Chugoku EPCO	
Demand Forecast	Dr. CHEW Chong Siang	Asiam Research Institute	
Financial & Tariff Analysis	Mr. FUJIWARA Takeshi	Chugoku EPCO	
	Mr. KENGI Shigeru	Chugoku EPCO	
Training Support	Mr. KURISU Yosuke	Chugoku EPCO	

2. Background & Purpose of the Project

- ■Electricity consumption has grown rapidly in order to support Cambodia’s development.
- ■For reliable power development, it is necessary to improve IPP project evaluation skill for managing generation development.

Power System (10 years ago)



Power System (Present)

Energia

3. Outline of the Project

■The Project will be conducted by Four Working Groups (WGs)

Recommendation

WG1: Evaluation System

- Making checklist of IPP evaluation.
- Clarification of demarcation and necessary abilities for IPP evaluation. (Recommendation)

Training

WG2: IPP Project Evaluation Methodology

- Counter Part (C/P) Training.

WG3: Demand Forecast

- Training of trainers.
- Training by trainers.
- On the Job Training (OJT).

WG4: Financial & Tariff Analysis

- Training of trainers.
- Training by trainers.

Energia

3. Outline of the Project

- ■Project Term: From October 2021 to April 2022.
- ■Training will be conducted from Japan. Training in Cambodia depends on COVID-19 situation.

	Oct	Nov	Dec	Jan	Feb	Mar
WG1: Evaluation System	Making check list	Draft recommendation		Finalization of recommendation		
WG2: IPP Project Evaluation Methodology		C/P training				
WG3: Demand Forecast	Training of trainers		Training by trainers		OJT	
WG4: Financial & Tariff Analysis	Training of trainers			Training by trainers		

4. (WG1) Evaluation System

- ■Making checklist for IPP project evaluation to ensure the quality of evaluation.
- ■Discussion in order to improve IPP project evaluation system will be conducted.
- ■JICA team will make proposals and/or recommendations.

Present Situation	Basic Policy
- A committee is organized each time IPP project evaluation is conducted. - The division of roles is decided according to the abilities of the organized committee members, and the roles of each organization are not stated clearly.	- Clarify the division of roles of each organization in the evaluation system, the knowledge that each organization should possess, and the human resources that should be trained. - Make a checklist for IPP evaluation to ensure the quality of evaluation, and training based on the checklist.

4. (WG1) Evaluation System

Purpose	- Clarification of demarcation & necessary abilities for IPP project evaluation.
Output	- Check list for IPP project evaluation - Recommendations about IPP project evaluation
Activity	- Making check list - Discussion

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Data collection	■						
1-2. Making check list (Japanese Side)	■						
2-1. Making draft recommendation		■					
2-2. Discussion about draft recommendation			■				
3-1. Revision of draft recommendation				■	■		
3-2. Finalization of recommendation					■	■	

5. (WG2) IPP Project Evaluation Methodology

- **Training about IPP project evaluation methodology will be conducted, especially methodology of Feasibility Study about Gas fired, hydro, solar power plant.**
- **Training focuses on what Cambodia power sector does not know.**

1. Submission of official letter for Pre-FS
2. Issue Letter of Permission (LOP) to give permission to implement Pre-FS
3. Implementation of Pre-FS
4. Approval of Pre-FS Report
5. Signing of MOU
6. Implementation of FS
7. Approval of FS Report
8. MME reports FS to the Cabinet of Prime Minister (=Council of Ministers)
9. Selection of Concessionaire
10. Contract of PPA, Submission of LA (Lease Agreement) and/or IA (Implementation Agreement)
11. Deliberation of National Assembly and Senate
12. Sign of PPA, LA and IA

IPP project procedure

5. (WG2) IPP Project Evaluation Methodology

Purpose	- Improvement of IPP project evaluation knowledge except Demand Forecast and Financial & Tariff Analysis
Output	- Training materials
Activity	- Training for WG2

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Discussion to grasp the ability of C/P							
1-2. Making training materials (Japanese Side)							
1-3. C/P training							

6. (WG3) Demand Forecast

- **Trainers will be developed. (Training of trainers)**
- **After that, training by trainers will be conducted.**
- **Finally, actual demand forecast as OJT by using Simple-E will be conducted.**

1. Demand forecast method (analysis flow, energy balance table, predictive model, data collection and analysis method etc)
2. Demand forecast accuracy verification method (GDP correlation, sensitivity analysis, predicted value / actual value / similar country comparison, etc.)
3. Sectoral analysis method (industry / consumer, energy conservation effect, etc.)
4. Demand forecast examples among ASEAN countries
5. How to use Simple-E

Training Contents (Tentative)

1. Data collection
2. Update / correction of forecast model
3. Implementation and verification of demand forecast

OJT Contents (Tentative)

6. (WG3) Demand Forecast

Purpose	- MME becomes to be able to conduct Demand Forecast
Output	- Training materials
Activity	- Training of trainers - Training by trainers - On the Job training (Actual Demand Forecast)

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)							
1-2. Training of trainers							
2-1. C/P conducts training for young engineers (Training by trainers)							
3-1. On the Job Training							
3-2. Certify as trainer						▲	

7. (WG4) Financial & Tariff Analysis

■**Trainers will be developed. (Training of trainers)**
■**After that, training by trainers will be conducted.**

1. Estimated project cost
    a. Profit and Loss Index (type of profit and loss index, discounted cash flow (DCF), internal rate of return (IRR), Hurdle rate)
    b. Financial system (type of finance, points of confirmation about corporate finance and project finance, loan scheme, etc.)

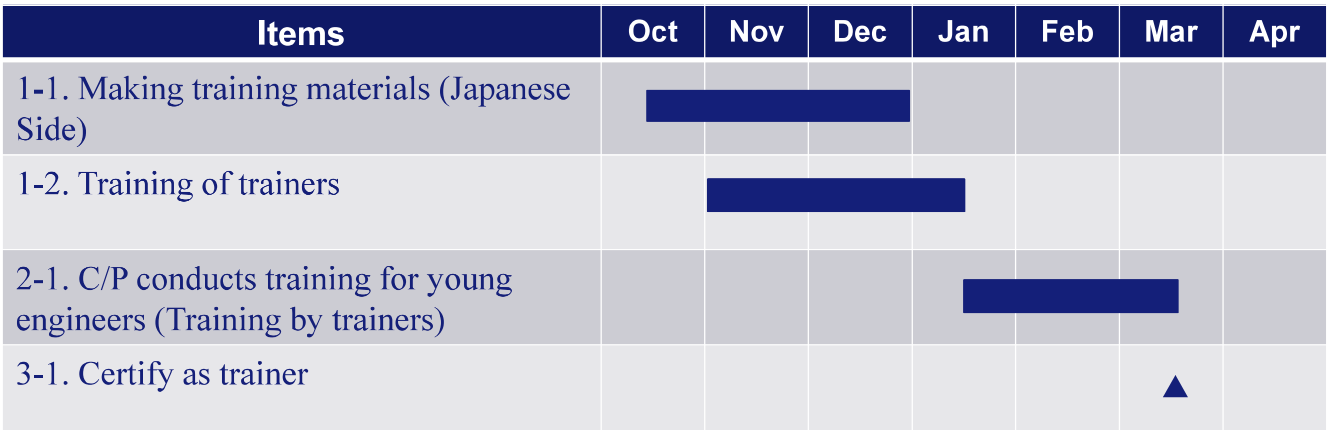
2. Electricity tariff structure
    a. Overview of Power Purchase Agreement (PPA)
        - Risk sharing (Power plant construction and operation, force majeure, change in law, Termination)
        - Payment condition (Local currency and dollar denominated, convertible policy)
    b. Tariff structure (capacity payment, energy payment etc.)

3. Others
    a. Investment structure etc.

Training Contents (Tentative)

7. (WG4) Financial & Tariff Analysis

Purpose	- Improvement of Financial & Tariff Analysis Skill
Output	- Training materials
Activity	- Training of trainers - Training by trainers



8. Request

■Please decide person in charge, counter part and contact person for each WG.

■Consideration of gender balance is necessary. In other words, it is encouraged for female engineers to join WG.

WG	Cambodian Side	Japanese Side
WG1: Evaluation System	Please decide below for each WG - Person in charge - Counter Part - Contact Person	Mr. HIROSE Masakazu
WG2: IPP Project Evaluation Methodology		Mr. KURISU Yosuke
WG3: Demand Forecast		Dr. CHEW Chong Siang
WG4: Financial & Tariff Analysis		Mr. FUJIWARA Takeshi Mr. KENGI Shigeru

Training for Capacity Building on IPP Project Evaluation

Kick-off Meeting for Counter Part (C/P)

December 16, 2021

The Chugoku Electric Power Co., Inc.

Energia

1. Background & Purpose of the Project

- Electricity consumption has grown rapidly in order to support Cambodia's development.
- For reliable power development, it is necessary to improve IPP project evaluation skill for managing generation development.

Power System (10 years ago)

Power System (Present)

2. JICA Team

Position	Name / E-mail	Company	Picture
Project Manager / Generation Planning	Mr. HIROSE Masakazu	Chugoku EPCO	
Demand Forecast	Dr. CHEW Chong Siang	Asiam Research Institute	
Financial & Tariff Analysis	Mr. FUJIWARA Takeshi	Chugoku EPCO	
	Mr. KENGI Shigeru	Chugoku EPCO	
Training Support	Mr. KURISU Yosuke	Chugoku EPCO	

3. Counter Part List (MME)

Name	Position	E-mail
Not disclosed due to personal information	Deputy Director, Energy Development	Not disclosed due to personal information
	Deputy Director, Energy Development	
	Deputy Director, Energy Development	
	Chief of Energy Statistics, Energy Development	
	Chief of Investment Procedure, Energy Development	
	Deputy Chief, Energy Development	
	Energy Development	
	Deputy Director, Thermal and Combustion Energy	
	Deputy Chief, Thermal and Combustion Energy	
	Chief, Hydroelectricity	
	Officer, Hydroelectricity	
	Deputy Chief, Technique and Energy Business Policy	
	Deputy Chief, Technique and Energy Business Policy	
	Deputy Chief, Renewable and Other Energy	
	Deputy Chief, Renewable and Other Energy	

3. Counter Part List (EAC)

Name	Position	E-mail
Not disclosed due to personal information	Chief of Monitoring and Data Collection Section of Generation Office, EAC	Not disclosed due to personal information
	Chief of Regulation and License Section of Transmission and Sub-Transmission Office, EAC	
	Chief Transmission and Sub-Transmission Office, EAC	
	Chief of Policy and Generation License Section of Generation Office	

4. WG List

Please choose "Thermal", "Hydro", "Solar", "Demand Forecast", "Financial & Tariff"

Name	WG1	WG2	WG3	WG4	Related Work
Not disclosed due to personal information	○	○	◎	○	
	○	○	○	○	
	○	○	○	○	
	○	○	◎	○	
	○	○	◎	○	
	○	○	○	○	
	○	○	○	◎	
	○	○	○	◎	Thermal
	○	○	○	○	Thermal
	○	○	○	○	Hydro
	○	○	○	○	Hydro
	○	○	○	◎	
	○	○	○	○	
	○	○	○	○	Solar
	○	○	○	○	Solar
	○	○	○	○	
	○	○	○	○	
	○	○	◎	○	
	○	○	○	◎	

◎: Person who will to be a trainer needs to conduct training for young engineer.

5. Outline of the Project

■The Project will be conducted by Four Working Groups (WGs)

Recommendation

WG1: Evaluation System
- Making checklist of IPP evaluation.
- Clarification of demarcation and necessary abilities for IPP evaluation. (Recommendation)

Training

WG2: IPP Project Evaluation Methodology
- Counter Part (C/P) Training.

WG3: Demand Forecast
- Training of trainers.
- Training by trainers.
- On the Job Training (OJT).

WG4: Financial & Tariff Analysis
- Training of trainers.
- Training by trainers.

5. Outline of the Project (WG2)

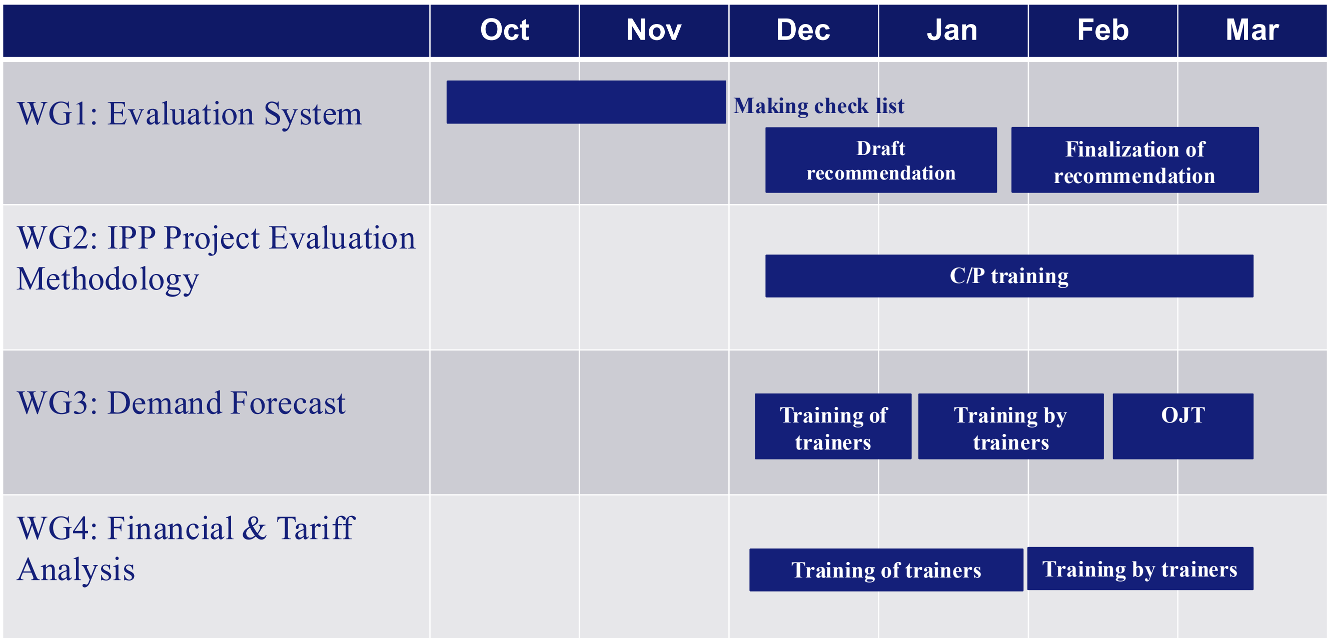
■WG2 is comprehensive technical training for Feasibility Study.
■We will select and concentrate contents about training.

	Contents
1	Overview
2	Power System Study
3	Fuel Supply and Transportation
4	Conditions of Plant Site
5	Project Proposal
6	Transmission Line
7	Environmental and Social Impact Analysis
8	Comprehensive Utilization
9	Labour Safety
10	Occupational Health
11	Resource Utilization
12	Energy Saving
13	Manpower Allocation
14	Required Conditions for Construction and Progress Schedule & Construction Period
15	Risk Analysis
16	Conclusions and Suggestions
17	Main Technical Indexes
18	Investment Estimation & Economic Evaluation

Example of FS Contents

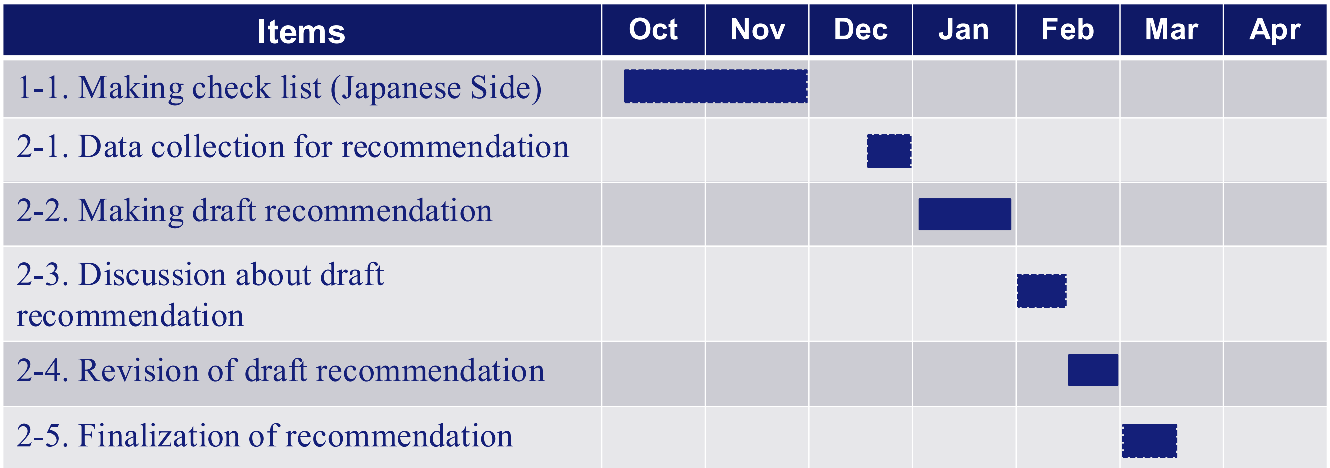
5. Outline of the Project (Schedule)

■Project Term: From October 2021 to April 2022.
■Training will be conducted using Zoom. Training in Cambodia depends on COVID-19 situation.



6. (WG1) Evaluation System

Purpose	- Clarification of demarcation & necessary abilities for IPP project evaluation.
Output	- Check list for IPP project evaluation - Recommendations about IPP project evaluation
Activity	- Making check list - Discussion



7. (WG2) IPP Project Evaluation Methodology

Purpose	- Improvement of IPP project evaluation knowledge except Demand Forecast and Financial & Tariff Analysis
Output	- Training materials
Activity	- Training for WG2

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Discussion to select training contents							
1-2. Making training materials (Japanese Side)							
1-3. C/P training							

8. (WG3) Demand Forecast

Purpose	- MME becomes to be able to conduct Demand Forecast
Output	- Training materials
Activity	- Training of trainers - Training by trainers - On the Job training (Actual Demand Forecast)

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)							
1-2. Training of trainers							
2-1. C/P conducts training for young engineers (Training by trainers)							
3-1. On the Job Training							
3-2. Certify as trainer						▲	

Energia

9. (WG4) Financial & Tariff Analysis

Purpose	- Improvement of Financial & Tariff Analysis Skill
Output	- Training materials
Activity	- Training of trainers - Training by trainers

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)	■	■	■				
1-2. Training of trainers			■	■			
2-1. C/P conducts training for young engineers (Training by trainers)				■	■	■	
3-1. Certify as trainer						▲	

10. Information Sharing

■Documents are shared by Google Drive.
■Training will be shared by You Tube.

✓**All documents (training schedule, material, link for You Tube etc.) are shared by Google Drive. The link for Google Drive will be shared by Mr. Watakabe, JICA expert for MME, and/or his project staff, Ms. Sovannavy Kheng.**

✓**All trainings will be conducted and recorded by Zoom, and updated to You Tube. Therefore, C/Ps who could not attend the training can study to see You Tube.**

Reference

(WG1) Evaluation System

- ■Making checklist for IPP project evaluation to ensure the quality of evaluation.
- ■Discussion in order to improve IPP project evaluation system will be conducted.
- ■JICA team will make proposals and/or recommendations.

Present Situation	Basic Policy
- A committee is organized each time IPP project evaluation is conducted. - The division of roles is decided according to the abilities of the organized committee members, and the roles of each organization are not stated clearly.	- Clarify the division of roles of each organization in the evaluation system, the knowledge that each organization should possess, and the human resources that should be trained. - Make a checklist for IPP evaluation to ensure the quality of evaluation, and training based on the checklist.

(WG2) IPP Project Evaluation Methodology

- Training about IPP project evaluation methodology will be conducted, especially methodology of Feasibility Study about Gas fired, hydro, solar power plant.
- Training focuses on what Cambodia power sector does not know.

1. Submission of official letter for Pre-FS
2. Issue Letter of Permission (LOP) to give permission to implement Pre-FS
3. Implementation of Pre-FS
4. Approval of Pre-FS Report
5. Signing of MOU
6. Implementation of FS
7. Approval of FS Report
8. MME reports FS to the Cabinet of Prime Minister (=Council of Ministers)
9. Selection of Concessionaire
10. Contract of PPA, Submission of LA (Lease Agreement) and/or IA (Implementation Agreement)
11. Deliberation of National Assembly and Senate
12. Sign of PPA, LA and IA

IPP project procedure

(WG3) Demand Forecast

- Trainers will be developed. (Training of trainers)
- After that, training by trainers will be conducted.
- Finally, actual demand forecast as OJT by using Simple-E will be conducted.

1. Demand forecast method (analysis flow, energy balance table, predictive model, data collection and analysis method etc)
2. Demand forecast accuracy verification method (GDP correlation, sensitivity analysis, predicted value / actual value / similar country comparison, etc.)
3. Sectoral analysis method (industry / consumer, energy conservation effect, etc.)
4. Demand forecast examples among ASEAN countries
5. How to use Simple-E

Training Contents (Tentative)

1. Data collection
2. Update / correction of forecast model
3. Implementation and verification of demand forecast

OJT Contents (Tentative)

(WG4) Financial & Tariff Analysis

■Trainers will be developed. (Training of trainers)
■After that, training by trainers will be conducted.

1. Estimated project cost
    a. Profit and Loss Index (type of profit and loss index, discounted cash flow (DCF), internal rate of return (IRR), Hurdle rate)
    b. Financial system (type of finance, points of confirmation about corporate finance and project finance, loan scheme, etc.)

2. Electricity tariff structure
    a. Overview of Power Purchase Agreement (PPA)
        - Risk sharing (Power plant construction and operation, force majeure, change in law, Termination)
        - Payment condition (Local currency and dollar denominated, convertible policy)
    b. Tariff structure (capacity payment, energy payment etc.)

3. Others
    a. Investment structure etc.

Training Contents (Tentative)

IPP_Feasibility Study Check List(Common)

Evaluation item	Specific elements	Department in charge of evaluation: MME	Department in charge of evaluation: EAC	Pass	Fail
Purpose of FS Check List	**This list is a compilation of items that should be checked in order to review Feasibility studies fairly and appropriately. Please check each evaluation item with points of interest.**				
1. Power System					
1.1 Situation of Power System	The conditions of power flow study should be the largest power flow time such as daytime peak, lighting peak, and other possible conditions after the planned year of interconnection.	Energy Development			
1.2 Necessity of Power Plant based on power development master plan	Confirm generator type, capacity, commercial operation date.	Energy Development			
1.3 Connection to Power System					
1.3.1 Specification	・System Frequency shall be nominally 50 Hz. System Voltage at the Connection Point will normally remain within the operating range. Operation range: 230kV:207kV～245kV, 115kV:103.5kV～123kV, 22kV:19.8kV～24kV ・Generating Units must be capable of supplying rated Active Power output at any point between the limits 0.85 power factor lagging and 0.95 power factor leading. ・Generating Units shall be capable of continuous operation in the frequency range of 47.5 to 52 Hz and shall be capable of operation for a period of 20 seconds in the frequency range of 47 to 47.5 Hz. ・Generating Units shall be capable of operation at all times under the control of a governor control system or frequency control device. ・The higher voltage windings of the Generating Unit transformer connecting a Generating Unit to the CTS at voltages of 115 kV and above shall be star connected with the star point earthed. ・Main transformer and shunt reactor shall be equipped with devices to automatically shutdown when over current or internal fault occurs. ・Power capacitor shall be equipped with devices to automatically shutdown when over current or over voltage or internal fault occurs. ・On medium-voltage lines, an over current circuit breaker shall be installed at the outgoing point and on the primary side of a transformer. A ground fault breaker that breaks circuit automatically when an earth fault happens in the lines shall be installed at an outgoing point. Surge arresters shall be installed at the places of lines such as a)A lead-out of overhead line, and b)The connecting point of overhead medium-voltage lines with a main transformer. ・Maximum time for fault clearance by primary protection shall be as follows: 230kV 100ms, 115kV 140ms. ・230 kV lines shall have following protective devices : Primary Protection - Current differential protection relay in conjunction with optical fiber communication from the transmission line. Back up Protection - Three or more zone distance protection with phase fault and earth fault measuring elements and with permissive inter trip for accelerating tripping at remote end in case of zone-2 fault. Reclosing provision shall be high speed first shot for single phase and three phase re-closing and further delayed multiple shot three phase re-closing. ・115 kV lines shall have following protective devices : Three or more zone static distance protection with permissive inter-trip for accelerating tripping at remote end in case of a zone-2 fault shall be provided as primary protection. The backup protection will be directional three poles over current and earth fault protection. ・22 kV lines shall have following protective devices : a minimum of over-current and earth fault protection at connection point. For parallel feeders or ring feeders, directional time lag over-current and earth fault relays. For Other feeers, non-directional time lag over-current and earth fault relay with suitable settings to obtain discrimination between adjacent relay stations. For long feeders, the relay with a high set instantaneous element.	Energy Development			
1.3.2 Impact on Power system	・For the power flow calculation results, the power flow of each transmission and distribution line shall not exceed the capacity of the line. ・Generating Unit shall be equiped a continuously-acting fast-response automatic excitation control system. The control system shall be included power system stabilizing equipment if required by the NTL. Generating Units shall be capable of contributing to frequency and voltage control by modulation of Active Power and Reactive Power supplied to the CTS. ・On-load tap changing facilities shall be equiped by Generating Unit transformer for dispatch of Reactive Power. The Reactive Power output at the Generating Unit terminals under steady state conditions and at rated Active Power should be fully available within the range ±5% of nominal grid system voltage at the Connection Point. ・The maximum total levels of harmonic voltage distortion and the total demand distortion of the current on CTS at a Connection Point shall be under the amounts specified in GridCode 3.3.1 c. ・The results of transient stability studies, voltage stabilities studies and steady state oscillatory stability studies shall be stable. ・Generating units shall be capable of curtailing output to balance supply and demand. (For solar power plants and wind power plants, If needed, in Japan)	Energy Development			
1.3.3 Countermeasures for accidents	The short circuit current level at a point on the CTS calculated by short circuit studies shall be below the levels stated below: 40 kA on the 230kV system, 31.5 kA on the 115kV system, 12.5 kA on the 22kV system.	Energy Development			
1.3.4 Control and communication requirements	The power plant shall be provided necessary communication equipment to monitor the operating status and to transmit commands.	Energy Development			
2. Transmission Line					
2.1 Transmission line	・Interconnection point shall be the bus line of a switchyard, substation or power plant or, If it is lower cost, existing transmission line . ・In the case of underground transmission lines, there shall be a reason(e.g. No land for a steel tower exists in the city) for using underground lines. The transmission line shall avoid areas with legal restrictions. ・Conformity with technical standards.(e.g. SREPTS Article 31, 40) ・In the case of a single line, generation curtailment during transmission line maintenance work shall be taken into account. ・In the case of crossing large rivers, railroads, existing power lines, etc., the method of crossing shall be considered. ・Transmission line capacity shall be greater than power plant generation capacity. The type of wire shall be inexpensive, taking into account construction and O&M costs, transmission losses, and service life.	Energy Development			
3. License & Permission					
3.1 Land acquisition	Land must be available (owned or leased) or expected to be available by the start of construction. The duration of the power generation project does not exceed the duration of land use. The use of the land for the power generation project is not restricted.	Energy Development			
3.2 Construction permission and power generation lic	Confirm power generation license and construction permit.	Energy Development	Regulation and License		
4. Legal Requirements					
4.1 Related laws and regulations	e.g. Energy Saving, Regulation of vibration and noise at site boundaries and around equipment, etc. Conform to Cambodian laws and regulations	Energy Development			
4.2 Environmental preservation	e.g. Discharge of Pollutants, Environmental Protection, Soil and Water Conservation, etc. Conform to Cambodian laws and regulations	Energy Development			
4.3 Social and Environmental Impact Assessment	Residents, rare animals, remains, etc. at the installation site Conform to Cambodian laws and regulations	Energy Development			
4.4 Health and safety	Occupational health, Labour safety Conform to Cambodian laws and regulations	Energy Development			
5. Power Off-Take					
5.1 Power Off-Take of the project	Confirm that the off-take assumptions are reasonable (e.g. Off-take period and the amount of power generation, etc.)	Energy Development			
5.2 Power Evacuation Options in case of trouble	During construction : Confirm who is supposed to bear the responsibility of compensation for loss in the event of construction delays and whether the patry in charge (i.e. EPC contractor and Sponsor company) that will bear the responsibility is sufficiently creditworthy. During operation : Make sure that who and how responsibility will be taken in the event of equipment failure and/or underperformance is well organized.	Energy Development			
5.3 Project development schedule and plan	Confirm that the construction schedule is reasonable, that the EPC contractor has extensive construction experience, that it is financially sound, that sufficient contingency is included in the project cost, and that the technology is proven.	Energy Development			
6. Financial analysis					
6.1 Financing cost	Confirm that financial terms and conditions commonly assumed in the similar projects (e.g. interest rate, loan amount and term) are included in the financial model.	Energy Development	Policy and Generation License		
6.2 Financial analysis	Confirm that the plan is based on reasonable assumptions primarily in the following aspects and that the business is stable and sustainable.				
6.2.1 Capital expenditures (CAPEX)	Make sure that the appropriate CAPEX amount is assumed and included in the financial model.	Energy Development	Policy and Generation License		
6.2.2 Operation and maintenance expenditures (O	Make sure that the appropriate O&M costs are assumed and included in the financial model.	Energy Development	Policy and Generation License		
6.2.3 Tariff	Make sure that proper electricity tariff, based on an appropriate profitability, is assumed and included in the financial model.	Energy Development	Policy and Generation License		
7. Risk Analysis					
7.1 Completion risk	The construction cost shall include contingency for possible risks, and the EPC contractor must have a proven track record.	Energy Development			
7.2 Operational and Management risk	The sponsor shall be able to support the operation, or plan to have an operator with a proven track record. The sponsor shall have a plan to anticipate possible risks that may occur during the operation and take countermeasures against them.	Energy Development			
7.3 Financial risk	The finance provider should be creditworthy. The cash flow model shall be able to sustain repayment against possible accidents, exchange rate fluctuations, etc.	Energy Development			

IPP_Feasibility Study Check List(LNG Thermal)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Fuel Supply					
1.1 Fuel Source	To enable stable supply, check the financial status and fuel supply experience of the fuel supplier. To make sure that the fuel supply contract period matches the IPP project period.	Thermal & Combustion Energy			
1.2 LNG Quality	Confirm Gas calorific value, Gas property, Environmental impact component (nitrogen, sulfur, etc.) Confirm the fuel is suitable for the GT specifications. Confirm the consistency between the amount of exhaust gas components and local environmental regulations	Thermal & Combustion Energy			
1.3 Fuel Handling Facility	-				
1.3.1 Transport Distance	Calculate the LNG consumption at the power plant and confirm that the required amount can be procured by LNG carriers considering the distance to power station, the number and the capacity of carriers	Thermal & Combustion Energy			
1.3.2 Unloading Place and LNG Jetty of Power Plant	Confirm feasibility of pier docking of LNG carriers considering vessel size, water depth of jetty.	Thermal & Combustion Energy			
2.Power Plant Site					
2.1 Conditions of Plant Site	-				
2.1.1 Location	Confirm the distance to transmission lines, the rivers as water source, access roads, obstacles such as unexploded ordnance	Thermal & Combustion Energy			
2.1.2 Natural Conditions of Site	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
2.2 Traffic	Confirm availability of air transportation method, sea transportation method, land transportation method, maximum transportable amount.	Thermal & Combustion Energy			
2.3 Engineering Geology	-				
2.3.1 Earthquake	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
2.3.2 Topography		Thermal & Combustion Energy			
2.3.3 Geotechnical Foundation Distribution Features		Thermal & Combustion Energy			
2.3.4 Natural phenomenon		Thermal & Combustion Energy			
3.Proposal of Project	-				
3.1 Overall Planning of Whole Plant	Confirm appropriateness of equipment layout				
3.1.1 Water Source for Power Plant and Cooling Mode	Confirm feasibility of construction for water intake facilities in the case of sea water cooling, temperature difference between intake water and discharged water	Thermal & Combustion Energy			
3.1.2 Plant Access Road	Confirm that access roads around the project site are designed to allow heavy duty trucks to pass (e.g. load capacity, road width and etc.). If necessary, Confirm that additional expenses for improvement and/or expansion of access roads put on a budget	Thermal & Combustion Energy			
3.1.3 Construction Area	Confirm area of storage for construction material is enough	Thermal & Combustion Energy			
3.1.4 Living Area	Confirm accommodation for personnel for both construction and O&M	Thermal & Combustion Energy			
3.1.5 Work area for periodic inspection	Confirm working area and accessibility for equipment are enough when periodic inspection	Thermal & Combustion Energy			
3.1.6 Crane for periodic inspection	Confirm the crane for periodic inspection to be installed	Thermal & Combustion Energy			
3.1.7 Mobile crane approach route (for inspection of each equipment)	Confirm the mobile crane access route for work	Thermal & Combustion Energy			
3.1.8 Flood Protection	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
3.1.9 Planning of Transportation and Roads	Confirm stable procurement and supply method of fuel, chemicals, consumables, etc.	Thermal & Combustion Energy			
3.1.10 Civil Engineering Structure	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
3.2 Capacity of Unit	Confirm consistency between power development plan, PPA and plant net output capacity.				
3.2.1 estimated performance curve	Confirm consistency between power development plan, PPA and plant net output capacity taking performance degradation into account.	Thermal & Combustion Energy			
3.2.2 Power generation range	Confirm capability of Minimum Load and Rated Load.	Thermal & Combustion Energy			
3.2.3 Load demand response	Confirm capability of Dispatch ramp rate and Reactive Power Capability.	Thermal & Combustion Energy			
3.2.4 Unsteady operation	Confirm capability such as House Load Operation, Runback and Gas turbine independent operation when steam turbine is unavailable.	Thermal & Combustion Energy			
3.2.5 Auxiliary power ratio	Confirm rationality of auxiliary power consumption rate	Thermal & Combustion Energy			
3.2.6 Electric power supply plan	Confirm consistency with PPA on e.g. Period of power plant operation, availability factor and capacity factor.	Thermal & Combustion Energy			
3.3 Main Technical Specification of BTG	Confirm manufacturer delivery record, competency, consistency with unit capacity				
3.3.1 Selective catalytic reduction(SCR) system, Flue gas desulphurisation(FGD) system, CO oxidation system	Confirm capability of such treatment facilities is capable of treating exhaust gas as to comply such regulation and fuel property	Thermal & Combustion Energy			
3.3.2 Emergency generator	Confirm capacity of emergency generator to operate the plant in case of black out	Thermal & Combustion Energy			
3.3.3 Start-up Bioler	Capacity to provide enough amount of steam required for start-up.	Thermal & Combustion Energy			
3.3.4 Heat recovery steam generator(HRSG),Material design of heat exchanger tube	Confirm heat resistance and corrosion resistance against sulfidation of heat exchanger panel materials, and countermeasures against flow-accelerated corrosion	Thermal & Combustion Energy			
3.3.5 Main Steam, Reheat Steam and Turbine Bypass System	Confirm capacity of turbine bypass valve to enable CTG to continue operation in case of STG trip if independent operation of CTG is required	Thermal & Combustion Energy			
3.3.6 Feed Water System	Confirm feedwater chemical control is accomplished through packaged chemical injection units	Thermal & Combustion Energy			
3.3.7 Extraction Steam System	To confirm Extraction Steam System is incorporated as to make efficiency high if it is thermal power station.	Thermal & Combustion Energy			
3.3.8 Condensed Water System	Confirm consistency with unit capacity	Thermal & Combustion Energy			
3.3.9 Heater Draining System	To confirm Extraction Steam System is incorporated as to make efficiency high if it is thermal power station.	Thermal & Combustion Energy			
3.3.10 Vacuum-pumping System for Steam Condenser	Confirm redundancy of vacuum pump and Capacity of vacuum pump to hold condenser vacuum	Thermal & Combustion Energy			
3.3.11 Circulating Water System	Confirm redundancy of pump and consistency with unit capacity	Thermal & Combustion Energy			
3.3.12 Closed Circulating Cooling Water System	Confirm redundancy of pump and consistency with unit capacity	Thermal & Combustion Energy			
3.3.13 Auxiliary Steam System	Confirm Capacity to provide enough amount of steam required for start-up.	Thermal & Combustion Energy			
3.3.14 Main Electrical Wiring	Confirm wiring within desks and panels shall be supported on trays and shall be segregated according to voltage level	Thermal & Combustion Energy			
3.3.15 Power System	PSS(Power System Stabilizer) is generally required by Grid System Operator/PPA. Confirm consistency of them.	Thermal & Combustion Energy			
3.3.16 Auxiliary Power Ratio	Confirm rationality of auxiliary power consumption rate.	Thermal & Combustion Energy			
3.4 LNG handling facility	-				
3.4.1 LNG unloading system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability Confirm the LNG carrier and the loading arm match. Confirm that the specifications are compatible with the emergency shutdown system.	Thermal & Combustion Energy			
3.4.2 LNG storage system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability Confirm the heat insulation and capacity to resist pressure of the tank. Confirm the fire extinguishing system in case of fire. Make sure it complies with your country's regulations.	Thermal & Combustion Energy			
3.4.3 LNG vaporization system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability Make sure that the seawater temperature is taken into consideration as it affect efficiency of vaporization system.	Thermal & Combustion Energy			
3.4.4 Boil off gas system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy Confirm that its capacity is enough considering the amount of gas generated much at the receiving of LNG.	Thermal & Combustion Energy			
3.4.5 LNG tank capacity (fuel)	Consistency with unit capacity Check the capacity of the LNG tank is sufficient for stable operation, taking LNG receiving plan into consideration .	Thermal & Combustion Energy			
3.4.6 LAG tank capacity (ammonia for SCR system)	Confirm spill prevention measures from ammonia tank (e.g. installation of ammonia detector, double-walled tank) Consistency between consumption and capacity of ammonia tank	Thermal & Combustion Energy			
3.4.7 Preparation for handling of light LNG	Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure of LNG, density detection system. Confirm the pump is compatible with light LNG and the capacity to feed the required amount.	Thermal & Combustion Energy			

Evaluation item	Specific elements	MME	EAC	Pass	Fail
3.5 Balance of Plant	–				
3.5.1 Water Source and Water Quality	Confirm accessibility to water source, quality and amount comply with requirement of unit	Thermal & Combustion Energy			
3.5.2 Boiler Make-up Water Treatment System	Confirm if water quality comply with requirement of unit	Thermal & Combustion Energy			
3.5.3 Chemical Dosing System	Confirm chemical dosing system enable water purity to pass the requirement of HRSG and ST	Thermal & Combustion Energy			
3.5.4 On-Line Water and Steam Sampling and Analysis System	Confirm monitoring item covers required water quality	Thermal & Combustion Energy			
3.5.5 Circulating Cooling Water Treatment System	Confirm if water quality comply with requirement of unit	Thermal & Combustion Energy			
3.5.6 Central Industrial Waste Water Treatment	Confirm waste water treated comply regulation in your country	Thermal & Combustion Energy			
3.5.7 Oil Treatment System	Confirm waste water treated comply regulation in your country	Thermal & Combustion Energy			
3.6 On-site monitoring system	–				
3.6.1 Continuous Emission Monitoring System	Confirm CEMS monitor flue gas as per regulation in your country	Thermal & Combustion Energy			
3.6.2 Closed Circuit Television System	Confirm covered area is enough in terms of security	Thermal & Combustion Energy			
3.6.3 Fire Alarm System	Confirm covered area is enough in terms of security	Thermal & Combustion Energy			
3.6.4 Entrance Guard System and Patrolling System	Check conformity with regulation in your country	Thermal & Combustion Energy			
3.7 Safety measures	–				
3.7.1 Fire protection plan, quantitative risk assessment for LNG	Confirm the measures to be taken in the event of a fire or gas leak. Confirm it comply with regulation in your country	Thermal & Combustion Energy			
3.7.2 Countermeasures for handling light LNG	Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure and density detection system	Thermal & Combustion Energy			
3.7.3 Firefighting facilities	Confirm the fire fighting system comply with regulation in your country	Thermal & Combustion Energy			
4.Labour Safety	Confirm contractor comply with regulation in terms of safety	Thermal & Combustion Energy			

IPP_Feasibility Study Check List(Hydro)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Survey Plan for Hydroelectric Power Plant					
1.1 Selection of the Type	・ N/A	Hydroelectricity			
1.2 Location Survey	・ N/A	Hydroelectricity			
1.3 Traffic	・ A survey of the general transportation conditions (transportation method, transportation routes and transportation capacity) in the vicinity of the construction area and a survey of the power supply for the construction (capacity of existing transmission lines) shall have been conducted. ・ Existing transportation facilities/method shall be checked, and expansion plan of existing transportation facilities or new construction of transportation facilities shall be considered if necessary.	Hydroelectricity			
1.4 Topographic, Geological Survey					
1.4.1 Topographic Survey	・ In addition to the main civil engineering structures such as dams, waterways, power plants, etc., and reservoir areas, a topographic map should be prepared with a certain amount of leeway to cover construction roads, material extraction sites, and sites for temporary facilities. ・ A cross-sectional survey of the river at the point of the outlet should be conducted and a discharge rating curve (H-Q curve) should be prepared.	Hydroelectricity			
1.4.2 Geological Survey	(Common) ・ Appropriate geological investigations, permeability tests, and strength tests shall be conducted for the ground at the proposed location and around the reservoir, depending on the size of the dam and reservoir capacity. ・ The possibility of landslides around the reservoir must be considered. In particular, narrow ridges and potential landslide areas should be investigated in detail. ・ No geological serious problems that may affect the feasibility of the project should be identified. ・ In the case of collecting aggregate for concrete or filling materials for fill dams, the distribution of materials in the area where the materials are to be collected, the amount of material that can be collected, and the physical and mechanical properties of the collected materials should be investigated. (For Concrete dam) ・ The required performance of the foundation of the concrete dam shall be determined by in-situ testing.	Hydroelectricity			
1.4.3 Earthquake	・ Seismic studies have been conducted and the seismic loads assumed at the proposed site have been appropriately set.	Hydroelectricity			
1.5 Hydrology Survey	(For the study of power generation plans) ・ Accuracy and duration of river flow data, which will serve as the basis for the study of the power generation plan, shall be sufficient. If sufficient flow data is not available, the river flow shall be calculated by an appropriate method. ・ The flow data used in the power generation planning shall be daily flow data in the study a run-of-river type, and monthly flow data in the study of a reservoir type. ・ In the case of a reservoir type, studies and analyses related to evaporation shall have been conducted. (For the study of the design flood) ・ Design flood shall be established in a manner appropriate to the size of the dam or reservoir. ・ Design flood are appropriately set based on adequate and appropriate hydro-meteorological investigations and analyses. (For the study of sediment volume) ・ Analysis of sediment volume has been conducted, and the estimated sediment volume and its impact on power generation has been properly calculated and evaluated.	Hydroelectricity			
1.6 Enegy Generation Calculation					
1.6.1 Energy Generation of Run-of-river type	・ The calculation method of maximum output and electric energy shall be appropriate.	Hydroelectricity			
1.6.2 Energy Generation of Reservoir type	・ The calculation method of maximum output and electric energy shall be appropriate. ・ In the case of a reservoir type, the reservoir operation (rule curve) shall be efficient, taking into account the changes in flow during the wet and dry seasons. ・ The power generation operation must meet the power demand of the grid.	Hydroelectricity			
2.Basic Design of Each Structures					
2.1 Intake facilities					
2.1.1 Weir/D	(Common) ・ Necessary freeboard (margin height) shall be secured according to the type of dam, presence or absence of flood discharge facilities, and wave height in the reservoir. ・ The reservoir should not adversely affect the surrounding ground. ・ There is no risk of flooding of houses, etc. in the upstream area due to the rise in water level caused by the construction of the dam and sand deposition. If there is a risk of flooding, appropriate measures shall be taken. ・ The dam water level (such as N.H.W.L., F.W.L., and L.W.L.) and the height of the non-overflow portion of the dam body shall be set appropriately. ・ The anticipated loads (including earthquake inertia forces) to be considered in the design of the dam shall be appropriately calculated. ・ The dam foundation shall have the necessary shear strength and shall not cause significant settlement, cracking, slip failure, erosion, etc. ・ Appropriate measures (grouting, drainage systems, etc.) shall be implemented in the dam foundation to prevent increased uplift pressure and significant leakage and seepage failures. ・ The reservoir does not cause harmful leaks or landslides that could damage settled are, farms, roads, etc. Water leakage prevention and/or landslide prevention measures shall be taken as necessary. ・ The reservoir is not expected to cause deterioration of water quality in or downstream of the reservoir, such as cold water and turbid water problems. If deterioration of water quality in or downstream of the reservoir is expected, appropriate measures such as removal and purification of pollutants around the reservoir and/or mitigation measure must be planned in accordance with the EIA report. ・ When installing a facility that discharges the amount of water necessary for water utilization or environmental preservation into a reduced water flow area, the facility must be capable of discharging the necessary amount of water and must be stable against vibration during partial discharge. (For concrete gravity dam) ・ The structural stability of the concrete gravity dam shall be ensured. ・ The dam and its foundation (including the dam foundation rock and the contact surface between the dam and the bedrock) must be watertight and strong enough to support the anticipated loads. (For fill dam) ・ The main body of the fill dam shall be designed to be safe against failure due to slips and seepage. ・ The fill material (impervious material, semi-permeable material, permeable material) shall have the specified mechanical properties. ・ The dam foundation (including the dam foundation bedrock and the contact surface between the dam body and the bedrock) must have the specified performance and be safe against failure caused by sliding, slipping, or seepage flow. ・ The technical requirements applicable to each dam type (uniform type, zoned type, and surface impervious type) must be satisfied.	Hydroelectricity			
2.1.2 Discharge equipment	(Common) ・ Flood discharges facilities capable of safely and reliably discharging design flood and lower flows shall be installed. ・ The flood discharge does not affect the stability of the dam. ・ The discharge water from the dam must be adequately reduced so that it does not adversely affect the dam itself or the downstream areas. ・ Appropriate measures are taken to ensure that water is discharged as necessary for water use and conservation of the river environment in the downstream areas of the dam or water intake. ・ Discharge facilities for water utilization, flood control, and water management must be constructed so that they will not be rendered unusable by sedimentation or other causes. (For fill dam) ・ The dam body must not be planned to have a flood discharge or a channel that would cause cracks in the interior of the dam. ・ No spillway is planned to be installed in the dam body.	Hydroelectricity			
2.1.3 Intake	・ The Intake shall be safe against collapse of the surrounding mountain slope, soil and rocks. ・ The channel must be able to properly take water from rivers, reservoir, regulating reservoir. ・ The structure and location shall be such that sediment, debris, dust, etc. cannot flow in. ・ The structure must be safe against anticipated loads. ・ Sluice gates or watertight panels are to be installed to allow for inspection and repair of the waterway. ・ If the water intake is connected to a pressure conduit, conduit, or hydraulic steel pipe, it must be located and structured to prevent air from entering the waterway, and must be capable of taking water at any water level within the range of the water depth to be used.	Hydroelectricity			
2.1.4 Settling basin	・ The structure shall be capable of settling suspended sand that may cause damage to downstream channels and turbines, and shall allow for easy flow of settled and deposited sediment. ・ The structure must be safe against collapse of surrounding mountain slope, soil and rocks. ・ Stable against anticipated loads.	Hydroelectricity			

Evaluation item	Specific elements	MME	EAC	Pass	Fail
2.2 Headrace facilities					
2.2.1 Headrace (water way)	(Common) ・ The waterway shall not be damaged by flooding or landslides. ・ Construction of the waterway shall not cause leakage, landslides, or other adverse effects. In the event of water leakage from within the channel, it must not affect the surrounding ground or structures. ・ Necessary countermeasures shall be taken when passing through areas with weak geological conditions. ・ The waterway shall be safe against anticipated loads. ・ In case of possible settlement of the surrounding area (due to water leakage from the channel), lining or other measures shall be provided. ・ The channel must be able to safely and reliably control the designed flow rate and be stable against expected hydraulic phenomena. ・ Sediment deposited in the channel shall not cause damage to downstream channels or turbines. (For open channel) ・ There should be no danger of landslides near the waterway route. (For culvert channel) ・ The structure must be safe against external pressure (groundwater pressure, earth pressure, grouting pressure, etc.). (For pressure type (conduit type)) ・ The structure shall be safe against external pressure (ground pressure, earth pressure, grouting pressure, etc.) and internal pressure (hydrostatic pressure, water hammer pressure, surging pressure, etc.). ・ The headrace shall be installed below the hydraulic gradient line of the lowest water level in the intake system and the surge tank.	Hydroelectricity			
2.2.2 Head tank/Surge tank	(Common) ・ Be safe for the anticipated loads. (For head tank) ・ The capacity must be sufficient to prevent air from entering the hydraulic iron pipe during normal operation and load surges. ・ It must have a spillway that can safely discharge the maximum amount of water used in the event of a full load shutdown. However, this does not apply if the facilities are capable of safely discharging water by a method other than a spillway. ・ The water level rise at the time of overflow from the head tank must not adversely affect the upstream channel/culvert. ・ The discharge of excess water shall not adversely affect the surrounding facilities or rivers. ・ It must be designed to prevent dust and floating sand from flowing into the penstock, and must be capable of easily discharging accumulated sand. ・ It must have the necessary surface area to mitigate the effects of water surface fluctuations and wave action during normal operation. (For surge tank) ・ The structure shall be such that water level fluctuations in the surge tank do not increase and equilibrium is achieved in a short period of time (damping condition). ・ The water level in the surge tank (up-surge) shall not overflow at the time of full load shutdown. However, this does not apply if facilities are installed to safely divert surplus water (full-load shutdown condition). ・ The water level in the surge tank (down-surge) shall not fall below the top of the waterway and hydraulic iron pipe during a half-load surge (half-load surge condition).	Hydroelectricity			
2.2.3 Head tank Spillway	・ It shall be stable under the anticipated loads. ・ The structure shall be designed to prevent slides and to prevent water tightness. ・ An energy dissipater shall be installed at the end of the channel to ensure safe discharge of water. ・ When excess water is discharged directly into a river, the structure must prevent excessive scouring of the river bed. ・ In the case of a pipeline, ventilation holes shall be installed at bends.	Hydroelectricity			
2.2.4 Penstock	(Common) ・ The penstock shall be safe under the anticipated loads for each type of penstocks (exposed type, bedrock embedded type, and soil embedded types). The thickness of the penstock shall be set in consideration of the required load. ・ The top of the penstock shall be set lower than the hydraulic gradient line when the water level in the head tank or surge tank is at its lowest. ・ The penstock must be safe and stable against vibration, buckling, and corrosion. ・ The hydraulic pipes must not cause serious leakage. (For exposed type) ・ The route shall be planned to be unaffected by natural disasters such as landslides. ・ In the case of an exposed pipe, anchor blocks and concrete saddles shall be installed to support the penstock. Anchor blocks and concrete saddles shall be stable under the anticipated loads. ・ Concrete saddles shall be able to move smoothly according to the expansion and contraction of the water hydraulic pipe. (For embedded type) ・ It shall be planned on a route with sufficient soil cover and good geological quality.	Hydroelectricity			
2.3 Powerhouse					
2.3.1 Types of Powerhouse	・ N/A	Hydroelectricity			
2.3.2 Location of Powerhouse	・ No damage from flooding or landslides.	Hydroelectricity			
2.3.3 Design of Powerhouse	・ The power plant building shall be stable against expected loads. ・ Structures around the turbine shall be stable against vibration. ・ Space for overhaul and repair of water turbines, generators, etc. shall be provided in the powerhouse.	Hydroelectricity			
2.4 Tailrace	・ Layout and structure shall be such that it will not be damaged by river water or drifted riverbed. ・ Be safe under the anticipated loads. ・ Leakage from tailrace shall not affect the surrounding ground and structures. ・ If collapse of tailrace occur, it will not have a significant adverse effect on the downstream area. ・ If settlement of the surrounding area (due to leakage from tailrace) is anticipated, lining or other measures shall be provided.	Hydroelectricity			
3.Basic design of hydroelectric equipments					
3.1 Water turbine-related facilities					
3.1.1 Design of water turbine	・The items necessary for water turbine design shall be selected. ・The materials such as river flow conditions shall be calcurated appropriately. ・The number and type of turbines shall be selected according to the efective head and the amount of water used. ・The turbine output shall be calculated in consideration of the turbine efficiency. ・The optimum water turbine suction height shall be set.	Hydroelectricity			
3.1.2 Selection of inlet valve	・The inlet valve shall be selected according to the capacity of the power plant. ・An inlet valve or other device shall be installed to shut off incoming water.	Hydroelectricity			
3.1.3 Design of appurtenant equipment	・The appurtenant equipment shall be designed in consideration of the size and operation of the power plant.	Hydroelectricity			
3.2 Generator-related facilities					
3.2.1 Design of generator	・The type of generator and installation method shall be selected according to the scale of the power plant. ・The generator output, rated power factor, and generator capacity shall be appropriate. ・The generator voltage shall be selected to match the generator capacity.	Hydroelectricity			
3.2.2 Design of exciter	・The exciter shall be selected according to the power plant operation method and generator capacity. ・The exciter shall equip necessary functions.	Hydroelectricity			
3.3 Main circuit-related facilities					
3.3.1 Main circuit connection system	・The main circuit configuration and power plant layout shall be according to the importance of the power plant.	Hydroelectricity			
3.3.2 Composition of electric equipments	・The capacity of the transformer shall be consistent with the rated capacity of the generator. ・Does the house transformer capacity match the capacity of the power consumption in the power plant. ・An appropriate circuit breaker shall be selected. ・Water turbines, generators and other protective devices shall be properly selected.	Hydroelectricity			
3.3.3 operation・control・protective device	・The operation control method shall be selected according to the type of the power plant.	Hydroelectricity			
3.3.4 DC power supply system	・The capacity of the DC power supply system required for control shall be available.	Hydroelectricity			
3.4 Other equipments					
3.4.1 Design of crane	・The rated load, lifting height, and movable range of the crane shall be appropriate.	Hydroelectricity			
3.4.2 Design of ground wire	・The design value of grounding resistance shall be less than or equal to the target value.	Hydroelectricity			
3.4.3 Design of emergency power supply system	・An emergency power generation facility with an installed capacity according to the operation shall be installed.	Hydroelectricity			

IPP_Feasibility Study Check List (PV)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1. Site Assessment					
1.1 Site Location	The site location is appropriate for PV installation? (Compared to the case of flat and plane land, it is necessary to consider the influence when it is on slope in the mountains, or sea breeze close to the sea, etc.)	Renewable & Other Energy			
1.2 Site Boundary	Are not there any private houses and/or factories around the site location? (It should be avoid the influence of shade from the building. Also, if it is close to a residential area, it is necessary to check whether there is a complaint due to the reflection of the panel. And if it is close to the factory, it is necessary to check whether the contaminated dusts comes in.)	Renewable & Other Energy			
1.3 Site Connectivity	Is easy road access to the site location? (It is necessary to confirm the access conditions to carry in and out of sand soil to the site, and such as transportation of equipment under the construction, also operation and maintenance is ease or not.)	Renewable & Other Energy			
1.4 Geography	Is the ground condition suitable for PV installation? (Because the basic design changes depending on whether the ground condition is hard or soft, it is necessary to check the ground conditions before construction.)	Renewable & Other Energy			
1.5 Natural disaster risks					
1.5.1 Seismic	Is a low probability of an earthquake? (It is necessary to confirm whether the risk of equipment damage due to the occurrence of an earthquake in the area is evaluated as based on the data of the Cambodia Meteorological Agency and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
1.5.2 Flood hazard	Is a low probability of flood disasters and landslides such as in the mountains? (It is necessary to confirm whether the risk of equipment damage due to heavy rain disasters or landslides in the area is evaluated as based on Cambodia Meteorological Agency data and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
1.5.3 Cyclone	Is a low probability that the cyclone will adverse affect the equipment? (It is necessary to confirm whether the risk of equipment damage due to cyclone storms, etc. in the area is evaluated as based on Cambodia Meteorological Agency data and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
1.5.4 Lightning	Is low probability that the equipment will be affected by a lightning strike? (It is necessary to confirm whether the risk of equipment damage due to lightning strikes in the area is evaluated as based on Cambodia Meteorological Agency data and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
2. PV System					
2.1 Facility Structure	Is the equipment design appropriate such as single diagram? (It is necessary to confirm that the single diagram, device configuration, and various device specifications are properly designed or not.)	Renewable & Other Energy			
2.2 Foundation	Is the foundation design appropriate depending on the ground conditions? (It is necessary to confirm whether the foundation is properly designed according to the ground conditions, and how the ground soil improvement if necessary.)	Renewable & Other Energy			
2.3 Frame structure	Is the mount frame design appropriate depending on the weather conditions? (It is necessary to confirm that the mount frame is properly designed, such as the panel will not fly away when a cyclone storm coming.)	Renewable & Other Energy			
2.4 Solar PV module	Is appropriate the module manufacturer that has much delivered record in other projects, and appropriate the proposed equipment performance and warranty period? (It is necessary to confirm whether the module manufacturer has a lot of experience, and whether the proposed equipment performance and warranty period are appropriate or not.)	Renewable & Other Energy			
2.5 PCS	Is appropriate PCS manufacturer that has much delivered record in other projects, and the proposed device performance? (It is necessary to confirm whether the module manufacturer has a lot of experience, and whether the proposed equipment performance is appropriate or not.)	Renewable & Other Energy			
2.6 Tilt angle optimisation	Is appropriate panel angle depending on the illuminance conditions? (It is necessary to confirm whether an panel angle is appropriate according to the illuminance conditions or not.)	Renewable & Other Energy			
2.7 DC / AC ratio for optimal plant configuration	If it is PV panel overloaded, the whole design is appropriate? (It is necessary to confirm whether the proposed overload design is appropriate or not.)	Renewable & Other Energy			
2.8 DC Cabling	Are appropriate cable laying design for each string to the CB hub and PCS specification? (It is necessary to confirm whether the cable laying design from the PV panel to each CB and PCS are appropriate or not.)	Renewable & Other Energy			
2.9 AC Cabling, Voltage transformer ,Grid interconnection	Are appropriate design for the AC equipment, transformer, and circuit breaker? (It is necessary to confirm whether AC equipment, transformer, and circuit breaker design are appropriate or not.)	Renewable & Other Energy			
2.10 Facility protection device	Are appropriate design and specifications for the protective system in the event of a ground fault, short circuit, or lightning strike? (It is necessary to confirm whether protection system is appropriate or not, when ground faults, short circuits, lightning surges during lightning strikes, etc. are occurred.)	Renewable & Other Energy			
2.11 Monitoring and Control Equipment	Are appropriate design for the specifications of remote monitoring / control system such as SCADA? (It is necessary to confirm whether the remote monitoring / control device design is appropriate or not.)	Renewable & Other Energy			
2.12 Boundary wall and fencing	Are appropriate desigin for the equipment boundaries? (It is necessary to confirm whether the design has been made and proposed to prevent electric shock due to the invasion of humans and/or animals, and also equipment damage, etc.)	Renewable & Other Energy			
2.13 O&M	Are appropriate design for the operation and maintenance plan such as checking the power generation, PV panels and mounts, peripheral facility, and weed treatment? (It is necessary to confirm whether the operation / maintenance plan is appropriate or not.)	Renewable & Other Energy			
3. Energy Assessment					
3.1 Evaluation of site	Are appropriate illuminance conditions at the PV installation site? (It is necessary to confirm whether the appropriate illuminance conditions and whether it is not shaded by trees or building.)	Renewable & Other Energy			
3.2 Calculation of solar PV system energy yield	Is appropriate power generation forecast according to the equipment conditions such as illuminance conditions and panel / PCS performance? (It is necessary to confirm whether the appropriate power generation in consideration of illuminance conditions, and including panel / PCS degradation, transmission / transformation loss, etc.)	Renewable & Other Energy			
3.3 Evaluation of results of Curtailment	Is appropriate power output evaluation according to the energy demand, capacity of the transmission, power tidal current, etc.? (If curtailment occurs, it is necessary to confirm whether the power output evaluation is appropriate or not.)	Renewable & Other Energy			

Training for Capacity Building on IPP Project Evaluation

(WG1)

May, 2022

The Chugoku Electric Power Co., Inc.

Current Situation

- **Cambodia power sector has conducted IPP evaluations so far, and has a certain amount of experience and knowledge.**
- **However, there are some issues in ensuring the quality of evaluations and human resource development.**

Experience	・More than ten IPP evaluation experiences in hydro, coal and solar power plants.
Evaluation system & method	・Pre-FS and FS work flows are Page 8. ・Although there are a wide variety of IPP evaluation items, there is no manual for ensuring quality. ・The evaluation is conducted by consultation by the evaluation committee selected each time.
Human Resource Development	・ IPP evaluations are conducted once or twice a year. Therefore, only OJT is not enough to develop human resources about young engineers. ・ Materials related to past IPP projects and past training are not shared. It is difficult for Cambodia power sector to spread the technology to young engineers.

Basic Policy

Evaluation system / Evaluation method

Measures to carry out the evaluation efficiently and systematically will be recommended.

Basic Policy

- **Utilization of IPP evaluation checklist made by WG2**
- **Sharing of technical materials with anyone**

Human Resource Development

Measures to develop human resources involved in evaluation work will be recommended.

Basic Policy

- **Understanding each person's ability**
- **Implementation of continuous education by trainers**

Recommendation

In the current situation where the IPP evaluation committee members appointed by individual names, not as organization carry out IPP evaluations through discussions, it is expected that the evaluation quality will vary depending on the abilities of the appointed members. In order to keep the evaluation quality constant and to take responsibility for the evaluation, we propose the following recommendations so that the evaluation can be made into routine work and can be carried out efficiently and systematically.

(1) In order to keep the evaluation quality constant and ensure the fairness of the evaluation, a checklist for the IPP evaluation will be created and the evaluation items will be clarified. This checklist will be reviewed regularly by MME.

(2) In order to make the organization responsible for the evaluation, determine the responsible organization and/or department for each item in the checklist.

(3) Each organization and/or department will continue to develop human resources such as in-house training for checklist, and strive to improve the evaluation quality. For example, it is recommended to grasp the abilities of each staff member every year and conduct training based on the results of this grasp. It is expected that the training will be conducted mainly by the C/P of this project.

(4) Since the technical materials related to the training created in this project are stored so that anyone in MME and EAC can refer to them, we recommend to continue to share information.

Energia

WG2: IPP Project Evaluation Methodology
-Thermal power plant-
1st Class : :Basics of Gas Turbine Combined Cycle

The Chugoku Electric Power Co., Inc.

中国電力株式会社
THE CHUGOKU ELECTRIC POWER CO.,INC

Contents

Contents

1.1 Fuel Property of LNG

	Coal 	LNG 
Transport	- Marine transport (conveyer, coal unloader etc.)	- Marine transport (LNG carrier) (pipe, pump etc.)
Storage	- Coal yard - Silo	- LNG storage tank
Environmental effect	- NOx, SOx, Coal Ash - High CO_2 Emissions	- NOx - Low CO_2 Emissions
Others	- Low calorific value - Cheaper than LNG	- High calorific value - More expensive than Coal

1.1 Fuel Property of LNG

-162 ˚C liquid

LNG is a liquid obtained by cooling natural gas to -162 ˚C and is colorless and transparent.

1/600 volume of gas

The volume in the liquid state is 1/600 of that in the gas state.

(Liquefied for mass transportation and storage)

Clean energy

LNG is clean energy when compared to other fossil fuels.

The amount of CO_2 generated is small, and SOx and soot are not generated.

High calorific value

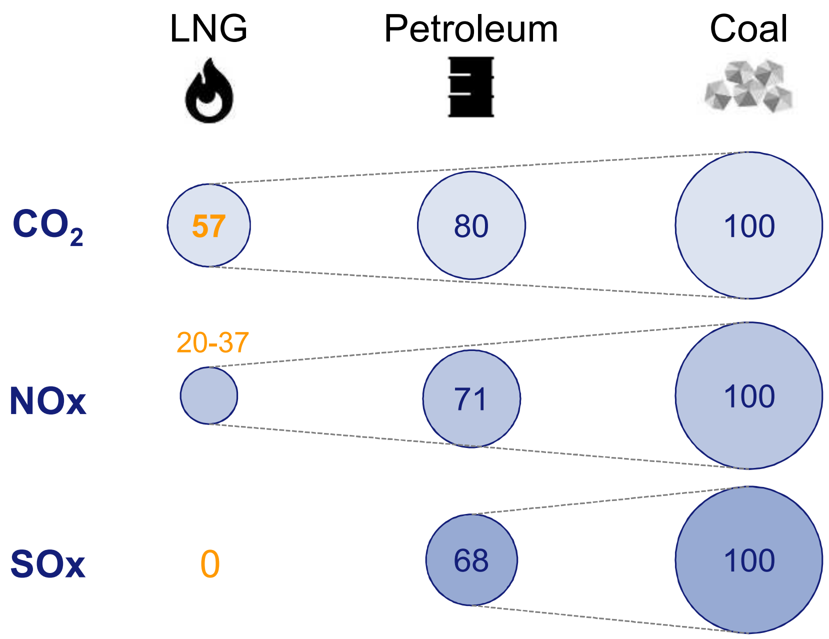
LNG has a high calorific value per unit weight.

Calorific value by fuel

LNG	LPG	Coal	Crude oil
13,068 kcal/kg	11,963 kcal/kg	6,231 kcal/kg	9,139 kcal/L

1.1 Fuel Property of LNG

Comparison of exhaust gas

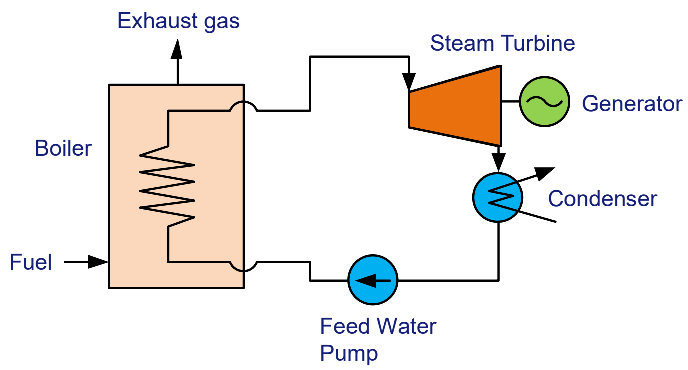


- LNG produces a small amount of carbon dioxide, which is one of the greenhouse gases.
- The amount of NOx generated, which is a cause of air pollution, is also small.
- Sulfur is removed during liquefaction, so SOx is not generated.

Data source "Osaka Gas Renewal Report 2017"
https://www.osakagas.co.jp/company/ir/library/ar/pdf/2017/67-68.pdf

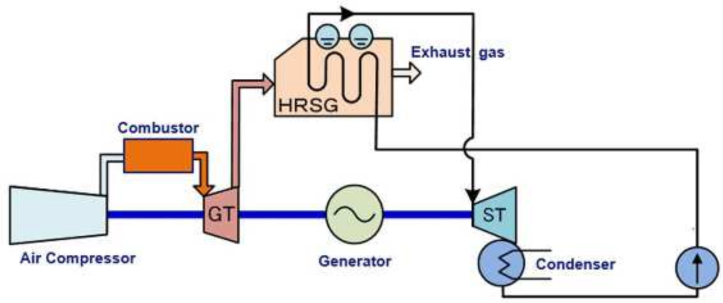
Difference between “Conventional” and “Combined cycle” power generation

Conventional

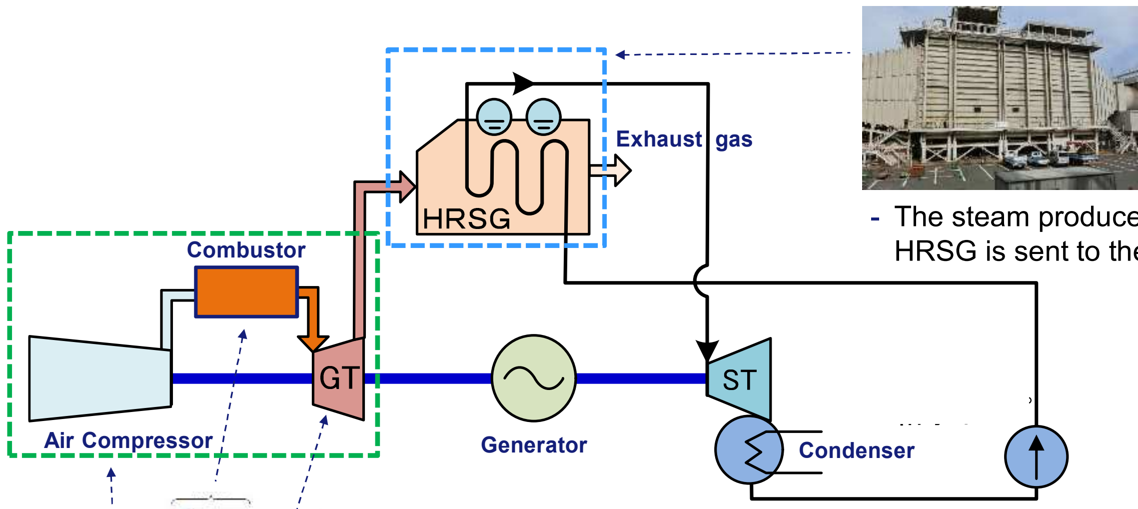


GTCC

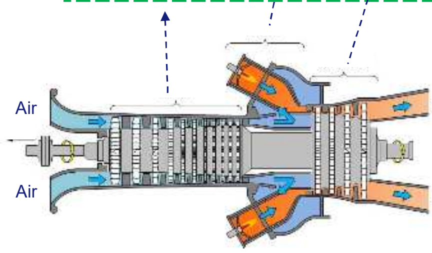
HRSG : Heat Recovery Steam Generator



- Generating by a gas turbine using combustion gas.
- Steam is generated by HRSG using the exhaust gas of Gas Turbine, and this steam is used to turn the steam turbine to generate electricity.



- The steam produced by the HRSG is sent to the turbine.

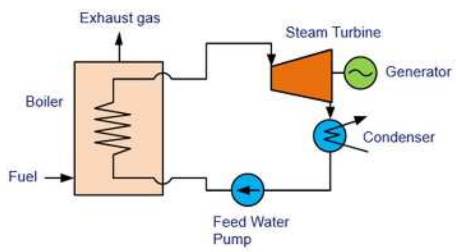


- Air is compressed by air compressor, mixed with fuel and burned.
- The combustion gas expands in the gas turbine and rotates the gas turbine rotor.

1.2 Power generation system

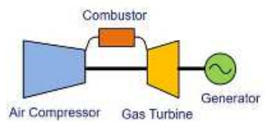
Thermal efficiency

Conventional



45%

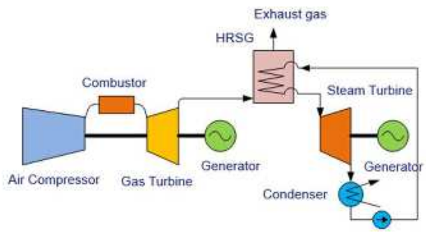
Gas turbine



40%

- With the single gas turbine operation, the exhaust loss is large and the efficiency is about 40%.

GTCC



60%

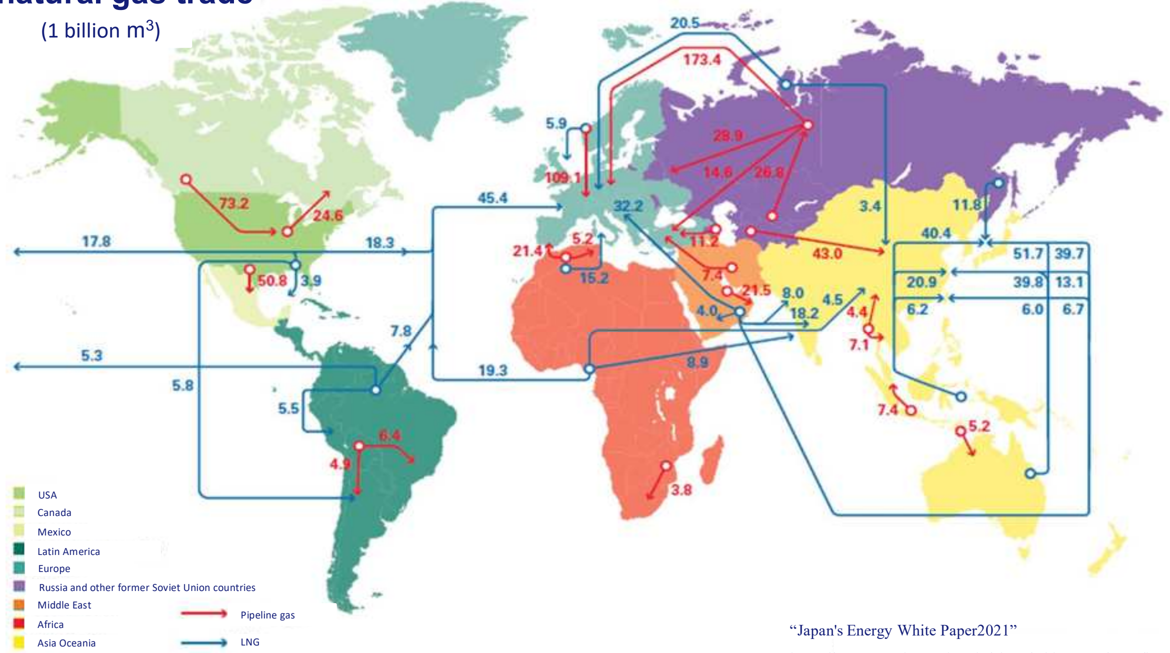
- High efficiency is achieved by recovering the energy of the exhaust gas with a steam turbine.

Contents

2. Fuel supply and Operation plan

World natural gas trade

(1 billion m^3)

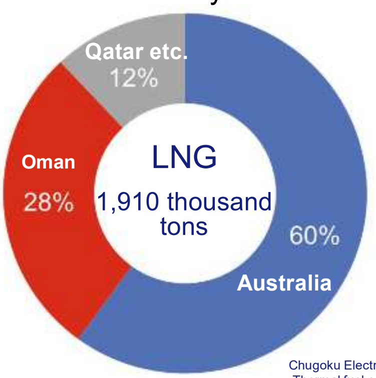


“Japan's Energy White Paper2021”
https://www.enecho.meti.go.jp/about/whitepaper/2021/html/2-2-2.html

2. Fuel supply and Operation plan

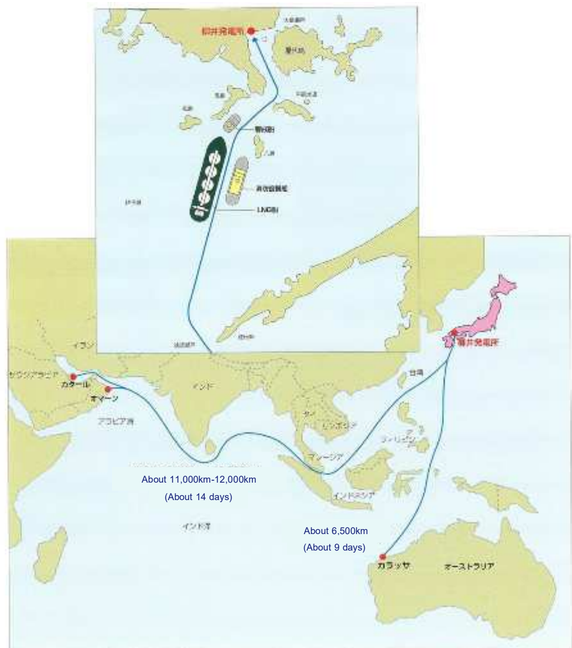
LNG import of “Chugoku Electric Power”

- We procure LNG mainly from Australia, the Middle East and other countries under long-term contracts.
- We procure additional LNG as required, and are working to expand the variety of country for LNG procurement in order to ensure stable procurement and economic efficiency in the future.



Chugoku Electric Power Co., Inc.
Thermal fuel consumption 2018

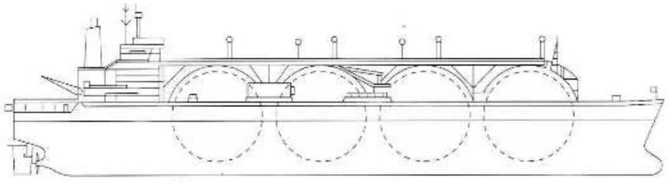
LNG import route



LNG carrier

Australia

One way 6,500km（9days）



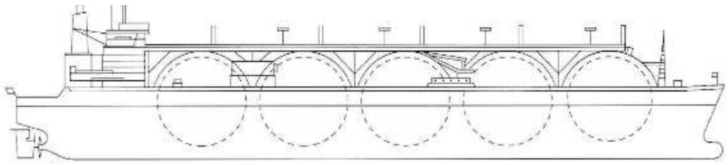
Capacity: 125,000m³

Length: about 272m

Width: about 47m

Qatar

One way 12,000km（14days）



Capacity: 135,000m³

Length: about 298m

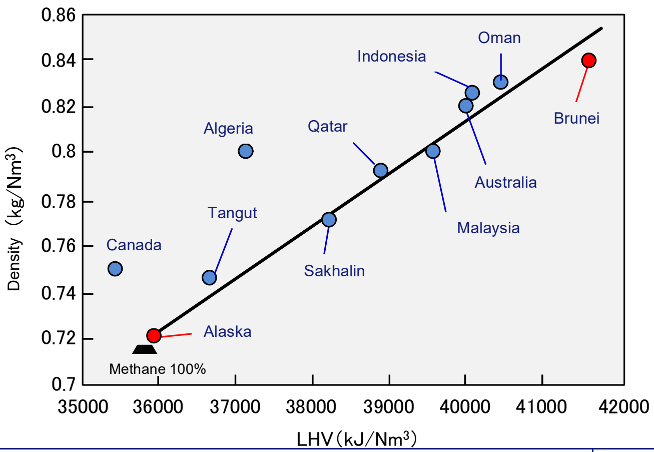
Width: about 46m

LNG property

- Natural gas is mainly composed of methane (CH_4), and its proportion varies depending on where the natural gas is produced.
- Since the calorific value differs depending on the component ratio, it affects the combustion of the gas turbine. Manufacturers set the range of calorific value that can be burned by the combustor.

Composition of natural gas (Example) (volume %)

	Methane	Ethane	Propane	Butane	Nitrogen
Alaska	99.8	0.1	-	-	0.1
Sakhalin	92.8	3.9	1.7	0.8	-
Brunei	88.8	5.6	3.7	1.8	0.1
Indonesia	87.7	6.9	3.1	1.8	0.4
Qatar	89.9	6.6	2.3	0.4	0.2
Australia	87.5	8.3	3.3	0.4	0.1
Malaysia	91.6	4.1	2.7	1.4	0.1
Canada	91.9	2.0	0.9	0.3	4.9
Abu Dhabi	75.1	23.1	1.7	0.1	-
Algeria	83.7	6.8	2.1	0.8	5.8



2. Fuel supply and Operation plan

■ Yanai Power Plant (LNG)

Approval Output: 1,539MW

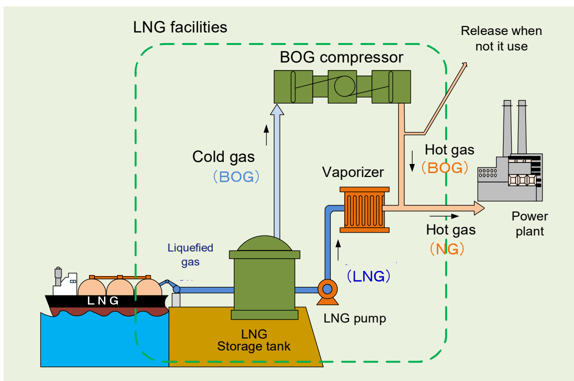
- Unit 1 Series 139MW×6 units
- Unit 2 Series 198MW×4 units

Site area (The area of green space)		About 500,000㎡ (About 120,000㎡ 24%)
Annual results		
Main fuel		LNG
LNG receiving amount		1,514,000 t
Number of LNG carriers / year		25 ships
(Tank lorry)	shipment	64,000 t
(Pipe line)	shipment	170,000 t

2. Fuel supply and Operation plan

LNG facilities

- In Japan, many gas turbine power plants import LNG from overseas.
- LNG is a liquid and has characteristics such as ultra-low temperature. Therefore, gas turbine power plants are equipped with LNG receiving facilities that are different from coal-fired power plants.



➢ **Confirmation**

Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability.

LNG unloading facility

- LNG carriers are so large that there is a jetty where large LNG carrier can arrive.
- The LNG carrier is connected by a large loading arm and from which LNG is received on the land side.

➢ Confirmation

- Confirm the LNG carrier and the loading arm match.
- Confirm that the specifications are compatible with the emergency shutdown system.

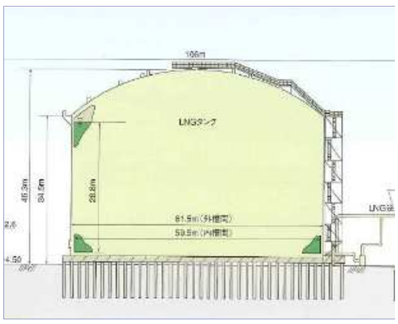
2. Fuel supply and Operation plan

LNG storage tank

- Since liquefied natural gas is extremely cold, the tank has a double wall (double shell), and the part in contact with the liquid is made of a material that can withstand low temperatures. Steel plates and concrete for heat insulation are used on the outside.

➢ Confirmation

- Check the capacity of the LNG tank is sufficient for stable operation, taking LNG receiving plan into consideration.



(Yanai Power Plant)
Six LNG tanks, each capacity is 80,000kl.

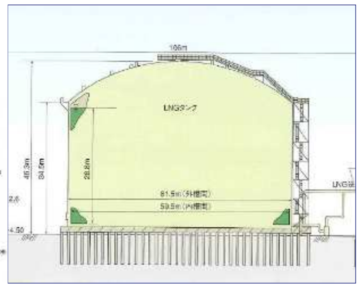
2. Fuel supply and Operation plan

LNG storage tank

✓ **Example of LNG tank operation**

In consideration of risks such as ship delays, secure the minimum amount of fuel required for operation.

- As a risk of delay of LNG carriers due to bad weather, etc., secure average daily consumption x 3 days.
- As a risk of delay in ship allocation from the time of planning, secure average daily consumption x 2 days.

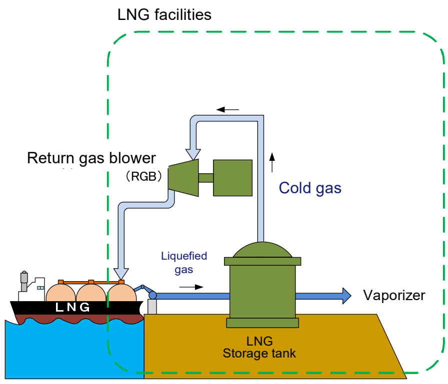


(Yanai Power Plant)
Six LNG tanks, each capacity is 80,000kl.

2. Fuel supply and Operation plan

Return gas blower

- When receiving LNG from an LNG transport ship, the pressure in the transport ship tank drops, so the BOG (Boil Off Gas) generated in the storage tank is returned to the LNG transport ship and the pressure in the transport ship tank is adjusted.
- The facility that returns this BOG to the transport ship is the Return Gas Blower (RGB).

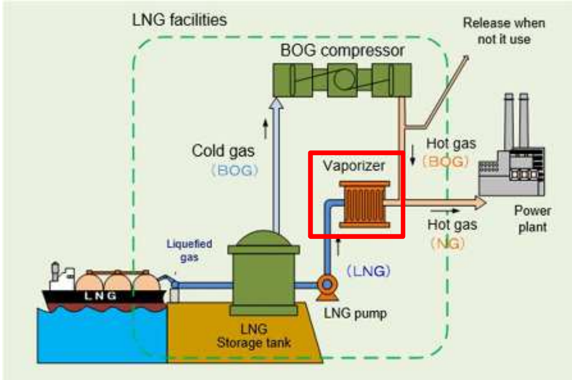


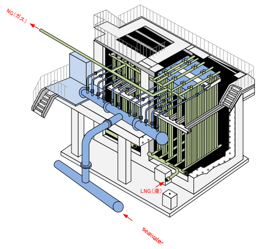
Vaporizer

- The vaporizer commonly used is an open rack vaporizer (ORV).
- LNG passes through a heat transfer tube, and the outer surface of the heat transfer tube is heated with seawater.
- The heated gas is called hot gas and is sent to the gas turbine as fuel for power generation.

➢ **Confirmation**

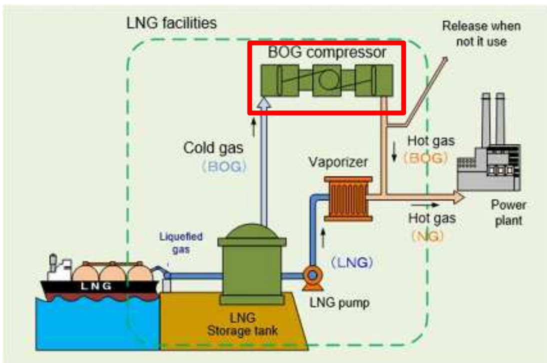
- Confirm the seawater temperature is taken into consideration as it affect efficiency of vaporization system.





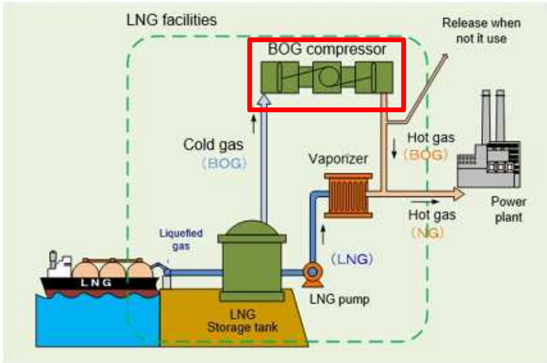
BOG(Boil Off Gas) compressor

- A part of LNG is naturally vaporized and gasified during the receiving or storage. This gas is called BOG (BOG: Boil Off Gas).
- The component of the BOG is methane(CH_4). This is because methane has the lowest boiling point and is vaporized first.
- BOG stays in the upper part of the LNG storage tank and raises the tank internal pressure, so it is necessary to extract the BOG. BOG generated inside the tank has a low temperature (about -160 to -140 ˚C) and is called cold gas. BOG is boosted by a BOG compressor and then mixed with hot gas (NG) and supplied to the gas turbine.



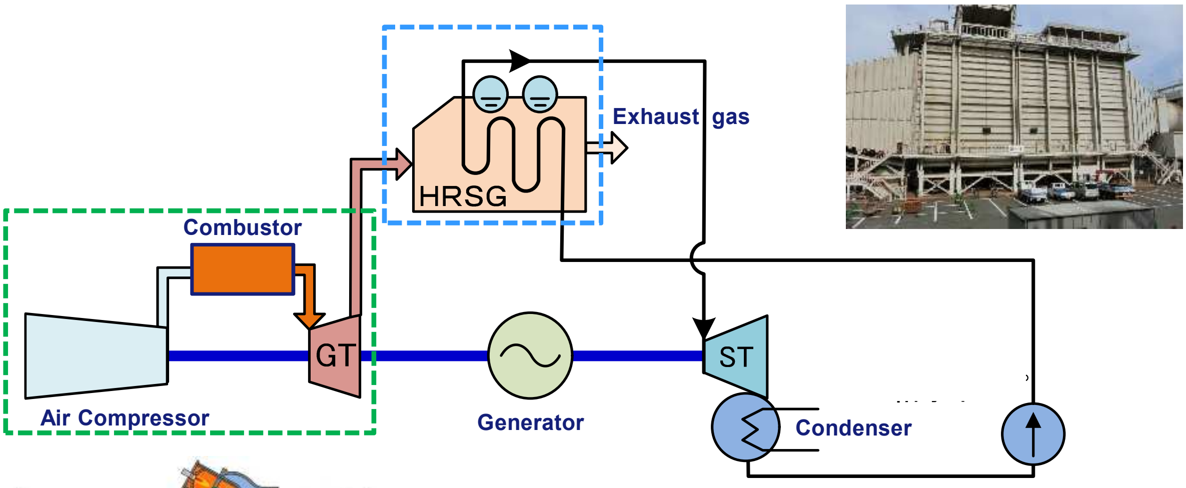
BOG(Boil Off Gas) compressor

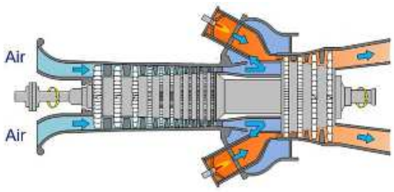
- In particular, during LNG is received, BOG is often generated from the tank. Ultra-low temperature gas (BOG) is generated 3 to 4 times as much as in normal times.
- When BOG is generated, the tank internal pressure rises, so the BOG is extracted by the BOG compressor and the tank internal pressure is automatically adjusted.
- For effective utilization of BOG, compressed natural gas is utilized as fuel at the gas turbine.



Contents

3. Comparison of alternatives for power generation type and specifications





3. Comparison of alternatives for power generation type and specifications

Features of Gas Turbine Combined Cycle

High efficiency

- Since the steam turbine recovers the waste heat of the gas turbine to generate electricity, it has high thermal efficiency.
- The latest GTCC is more than 60% efficient.

Short startup time

- At a coal-fired power plant, it takes several hours to generate steam, but at a GTCC power plant, the startup time is fast and it can be started in about 40 to 80 minutes(Hot starting).

High load change rate

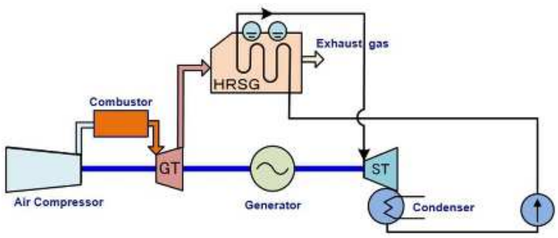
- The load change rate is higher than that of coal-fired power.

Effect of atmospheric temperature

- The maximum output is affected by the outside air temperature. If the outside temperature is high, the maximum output may drop and it may not be possible to generate electricity up to the rated output.

Small impact of inspection

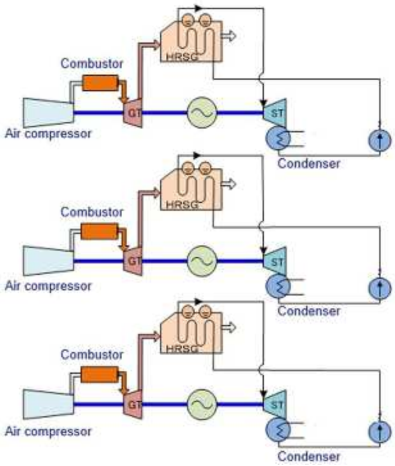
- By installing multiple combined units, it is possible to reduce the amount of reduction in plant load during periodic inspections and accidents.



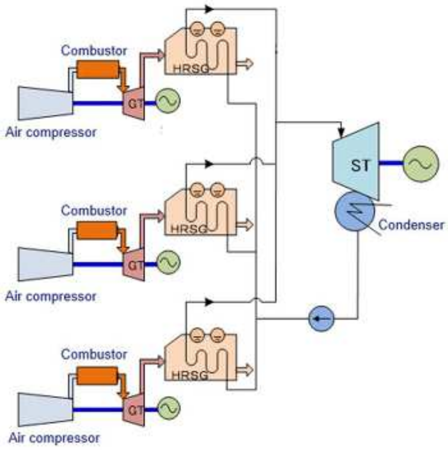
There are two types of equipment combinations:

- "Single-shaft type" in which one steam turbine and one gas turbine are directly connected to the same shaft,
- "Multiple-shaft type" in which a plurality of gas turbines are combined for one steam turbine.

Single-shaft type

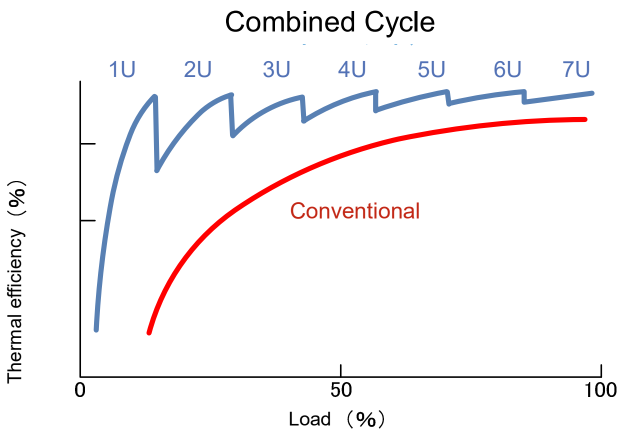


Multiple-shaft type



Combination of multiple units

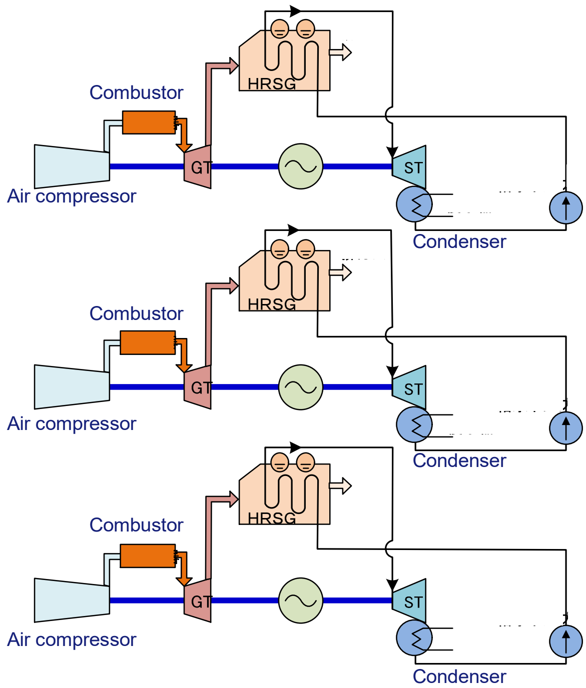
- In typical combined cycle, several medium or small capacity units are installed and the total capacity is configured as a large-capacity.
- This is because the thermal efficiency of the gas turbine at the partial load is very low compared to the thermal efficiency at the rated load.



➢ High efficiency is achieved in a wide output range by increasing or decreasing the output according to the number of operating units.

Single-shaft type

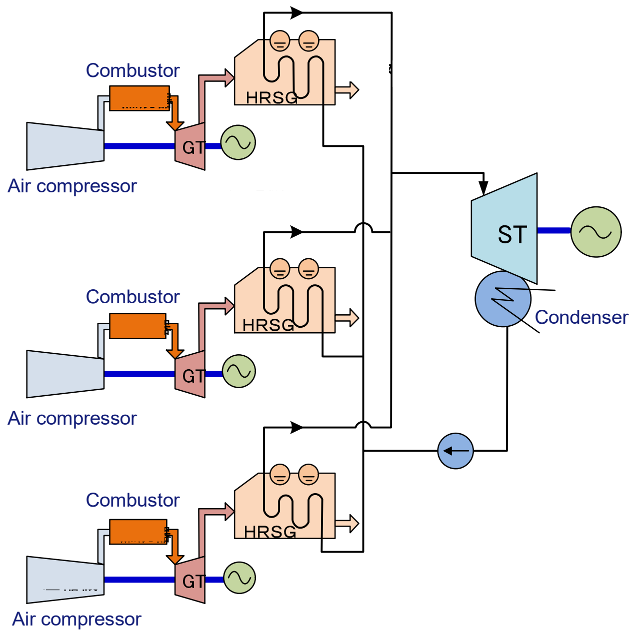
- Small capacity steam turbine
- Less efficiency reduction at partial load
- Start up in a short time
- Short outage period during periodic inspection



3. Comparison of alternatives for power generation type and specifications

Multiple-shaft type

- Large capacity steam turbine
- High thermal efficiency at rated load. (For base load)
- Long power generation outage period (during periodic inspection)



Contents

4. Construction plan

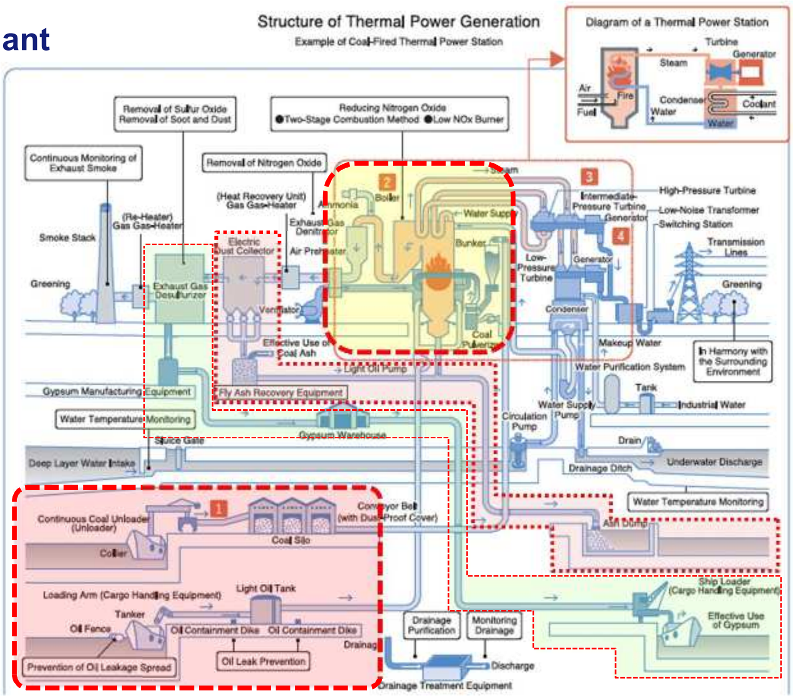
Difference from conventional power plant

- LNG receiving facilities



- Gas turbine and HRSG


- Exhaust Gas Desulfurizer
  - Desulfurizer is not installed because LNG does not contain sulfur
- Electric Dust Collector
  - Electric Dust Collector is not installed because no soot is generated.



"COMPANY PROFILE 2021-2022" https://www.energia.co.jp/e/corp/pr/pamph.html

Difference from conventional power plant

	Coal fired	GTCC
Turbine	✓ Steam turbine	✓ Gas turbine , Steam turbine
Boiler	✓ Boiler	✓ HRSG
Storage	✓ Coal yard / Silo coal receiving facilities	✓ LNG tank LNG receiving facilities
Denitrification equipment	✓	✓
Desulfurization equipment	✓	-
Electric dust collector	✓	-

"COMPANY PROFILE 2021-2022" https://www.energia.co.jp/e/corp/pr/pamph.html

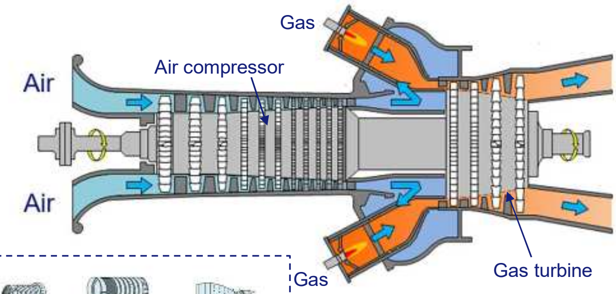
Contents

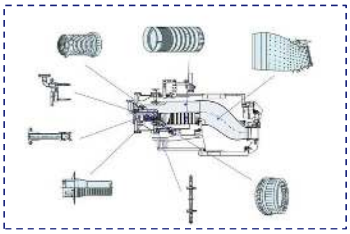
Hot parts

- The parts of gas turbine heated by high temperature combustion gas are called Hot Parts.
- Since it is used under high temperature condition, it is especially necessary to do appropriate periodical inspection and maintenance.

1-stage blade

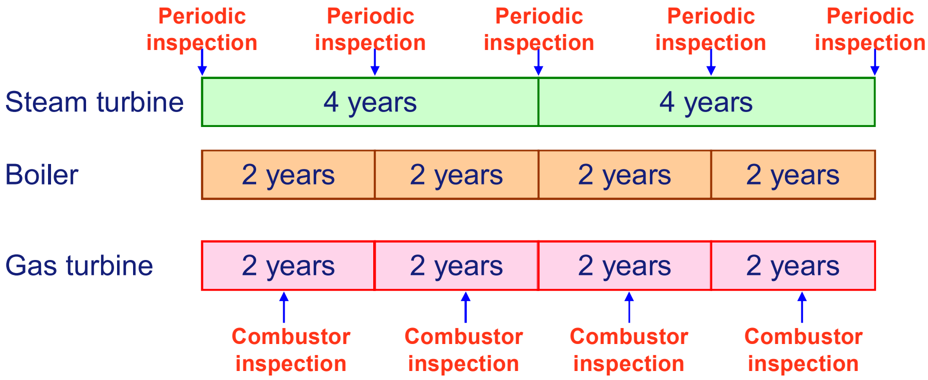
1-stage nozzle





Inspection cycle

- In Japan, steam turbines need to be inspected every four years, and boilers need to be inspected every two years in line with Japanese regulation. On the other hand, periodical inspection for gas turbines for power station is not obligation according to Japanese regulation, but it is inspected every two years in several power station for stable operation. In addition, the combustors are inspected every year.
- This is because the materials of gas turbines and combustors operating in high temperature environments cannot withstand use for more than a year or two.

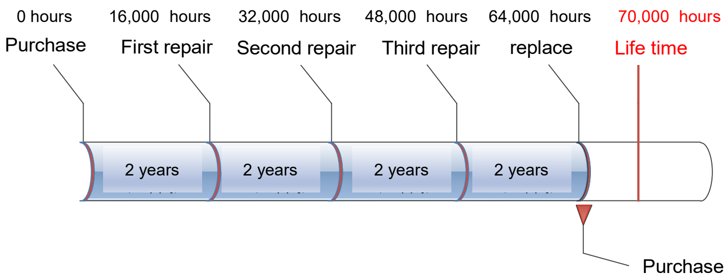


5. O&M plan

Hot parts life cycle example

Gas turbine nozzle

Lifetime: 70,000 hours



- Repair standards and replacement standards are set by the manufacturer.
- Maintenance plan is made considering not only manufacturer's standard but also actual condition.

➢ LTSA (Long Term Service Agreement)

Recently, LTSA are also available.
Manufacturer is responsible for repairing or replacing hot parts over a long period.

5. O&M plan

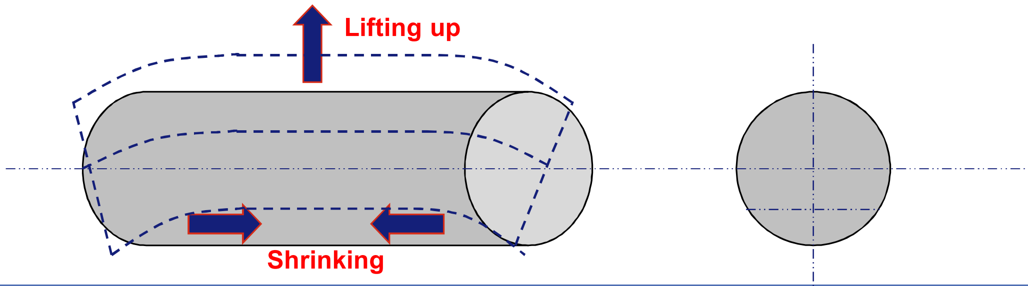
Point to be noted when receiving LNG

- It is necessary to cool-down when you receive LNG as its temperature is quite low.
- Cool-down is conducted by pouring LNG gradually.
- If you pour LNG rapidly, LNG evaporate suddenly inside piping and damage piping.

Receiving pipe for LNG

Bowing phenomenon

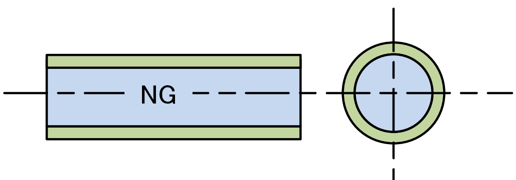
- The Bowing phenomenon means that the pipe warps like a bow due to the temperature difference between the upper part and the lower part of the pipe.
- As a result, the piping is damaged or leakage from the flange occurs.



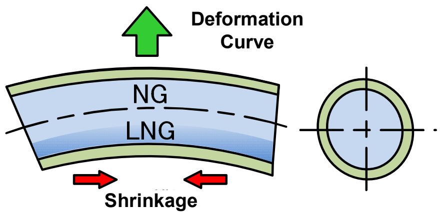
- **Occurs when piping is rapidly cooled from ordinary temperature with LNG.**
  It is necessary to cool-down gradually.
- **Occurs when the LNG piping is left with a low liquid level.**
  It is necessary to purge LNG not to leave it inside piping.

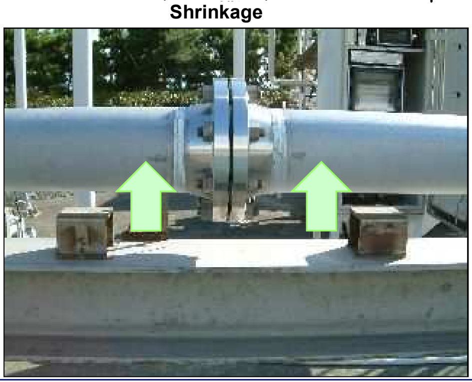
Bowing phenomenon

Before



After

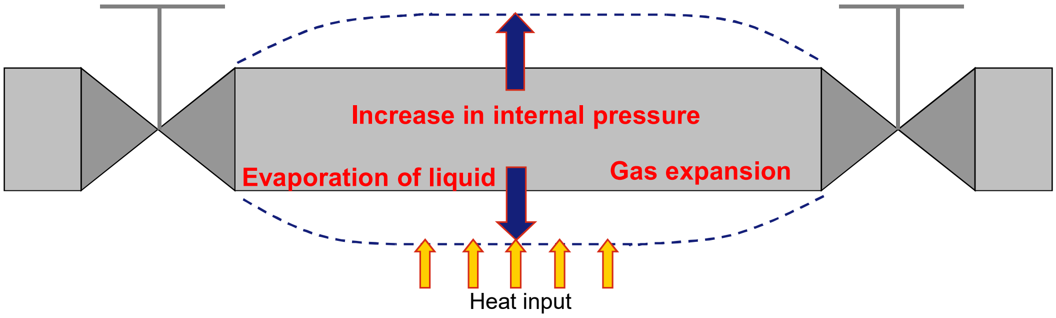




5. O&M plan

Liquid seal

- In case LNG is confined in the pipe by isolation, the internal liquid can be gasified (about 600 times the volume) due to heat input from the outside, and the internal pressure rises. As a result, leakage from the flange of the valve seat and deformation or breakage of the piping occur.



Cause of liquid seal

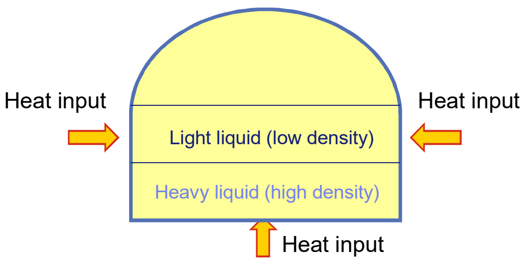
- **When the liquid is not drained at the time of isolation.**
  It is necessary to purge with N2 completely.
- **When the valve is accidentally closed. Operator needs to take care it.**

5. O&M plan

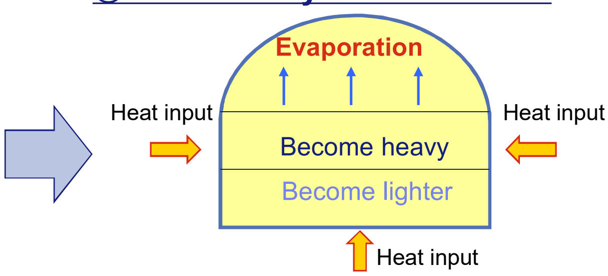
Rollover phenomenon

- Since LNG is composed of multi-component hydrocarbons, when LNG with different components is stored in the same storage tank, it can be layered if the mixture is insufficient.
- If it is stored for a long time as it is with layered condition, it will be mixed suddenly due to the composition change by evaporation caused by heat input from outside, and BOG will be generated abnormally.

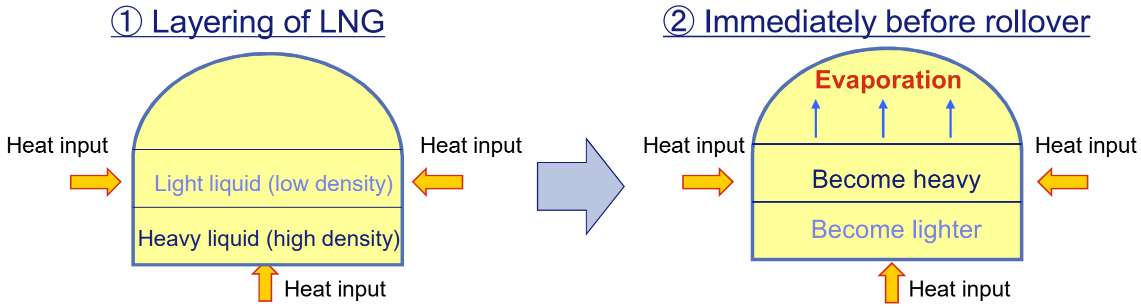
① Layering of LNG



② Immediately before rollover



Rollover phenomenon

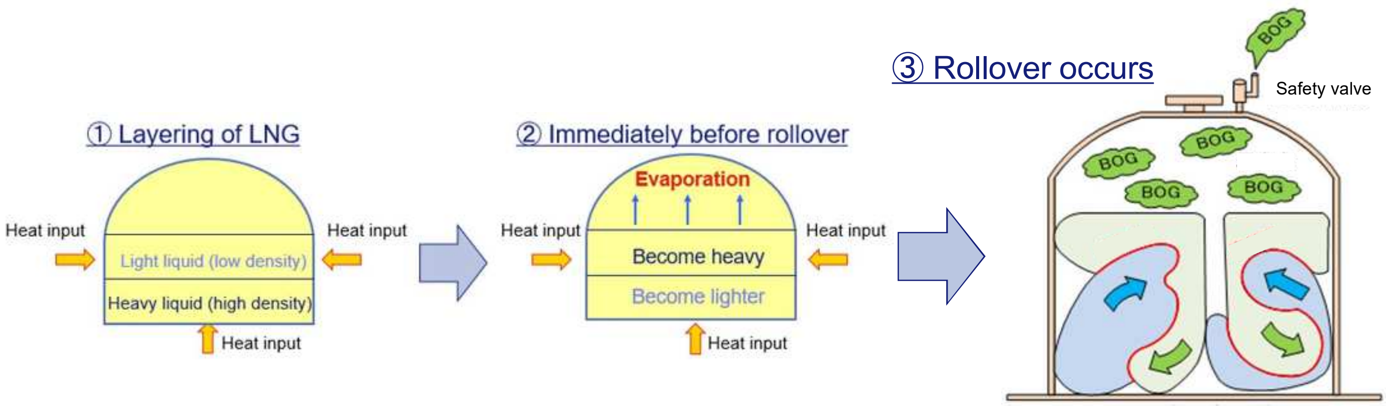


① LNG with different compositions / densities form two layers
- Upper layer : Light LNG (low density)
- Lower layer : Heavy LNG (high density)

② Density difference between LNG layers is reduced
- Upper layer : BOG generation is promoted by heat input, and it becomes heavier and denser.
- Lower layer : Liquid temperature rises and density decreases due to heat input

Rollover phenomenon

③ Rollover occurs
The difference in density between LNG layers becomes the same, and the two layers are mixed within a short time. At this time, the heat energy stored in the lower layer is rapidly released as BOG.



Countermeasures for rollover

- ✓ **Analysis of LNG to be mixed**

  Confirmation of composition, temperature, and liquid density of the liquid to be mixed

- ✓ **Operational measures**

  Installation of receiving nozzles from the top and bottom
  Tank selection at the time of LNG receiving

- ✓ **Detection of rollover**

  Monitoring Temperature difference and density difference in the height direction in the tank

- ✓ **Countermeasure to prevent Two-layer separation**

  Transfer to another tank and mixing with other tank liquids
  Liquid circulation in own tank

WG2: IPP Project Evaluation Methodology
-Thermal power plant-
2nd Class : Supplemental Explanation on Check list

The Chugoku Electric Power Co., Inc.

Contents

1. Fuel Supply
2. Power Plant Site
3. Proposal of Project
4. Labor Safety

Contents

1. Fuel Supply

1.1 Fuel Source

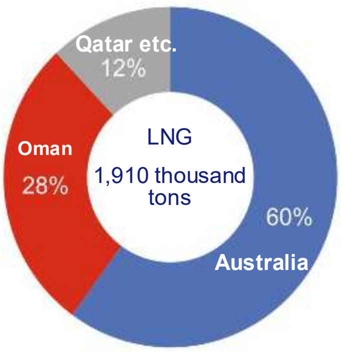
✓ **Check Point**

To enable stable procurement, check the financial status and fuel supply experience of the fuel supplier.

To make sure that the fuel supply contract period matches the IPP project period.

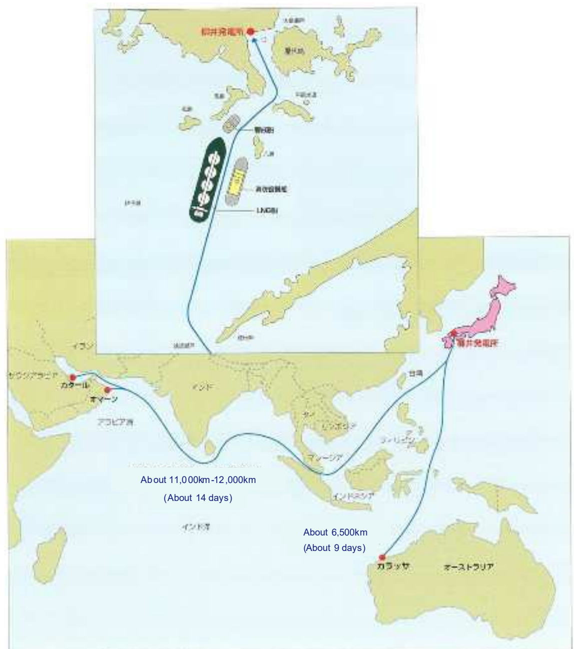
✓ **Reference**

Chugoku procures LNG mainly from Australia, the Middle East and other countries under long-term contracts



Chugoku Electric Power Co., Inc.
Thermal fuel consumption 2018

LNG import route (CEPCO)



1. Fuel Supply

1.2 LNG Quality

✓ Description

- Natural gas is mainly composed of methane (CH4), and its proportion varies depending on country of origin
- Since the calorific value differs depending on the component ratio, it affects the combustion of the gas turbine.

✓ Check Points

- Gas calorific value, Gas property, Environmental impact property such as nitrogen and sulfur
- The consistency between the concentration of exhaust gas and local environmental regulations
- The fuel is suitable for the Gas Turbine specifications.

Composition of natural gas (Example) (volume %)

	Methane	Ethane	Propane	Butane	Nitrogen
Alaska	99.8	0.1	-	-	0.1
Sakhalin	92.8	3.9	1.7	0.8	-
Brunei	88.8	5.6	3.7	1.8	0.1
Indonesia	87.7	6.9	3.1	1.8	0.4
Qatar	89.9	6.6	2.3	0.4	0.2
Australia	87.5	8.3	3.3	0.4	0.1
Malaysia	91.6	4.1	2.7	1.4	0.1
Canada	91.9	2.0	0.9	0.3	4.9
Abu Dhabi	75.1	23.1	1.7	0.1	-
Algeria	83.7	6.8	2.1	0.8	5.8

1. Fuel Supply

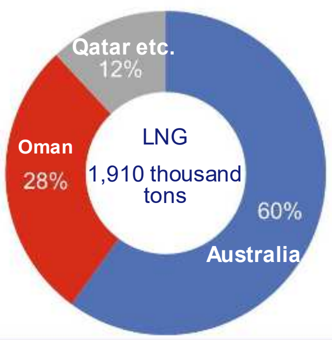
1.3 Fuel Handling Facility

1.3.1 Transport Distance

✓ Check Point

Confirm if the required amount can be procured by LNG carriers considering:

- LNG consumption at the power plant
- The distance to power station
- The number and the capacity of LNG carriers.



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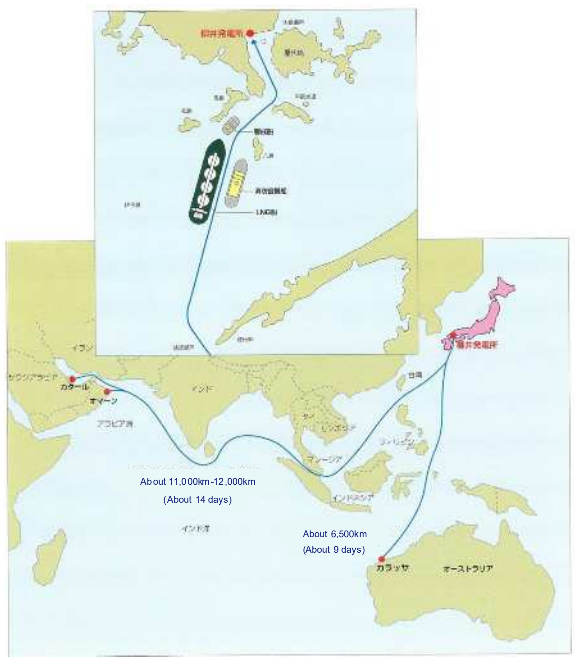


1. Fuel Supply

1.3.2 Unloading Place and LNG Jetty of Power Plant

✓ Check Points

Confirm feasibility of pier docking of LNG carriers considering vessel size, water depth of jetty.

Contents

2.1.1 Location

✓ **Check Points**

To confirm following points:

- Feasibility of pier docking of LNG carriers
- The distance to transmission lines
- The distance to rivers as water source
- Access roads
- Recirculation of thermal discharge
- Securing fresh water
- Obstacles such as unexploded ordnance and mines

2.2 Traffic

✓ **Check Points**

To confirm following points:

- Air transportation method
- Sea transportation method
- Land transportation method
- Maximum transportable amount

Contents

3. Proposal of Project

3.1.1 Water Source for Power Plant and Cooling Mode

✓ **Check Points**

To confirm feasibility of water intake work, effect of thermal discharge

IPP needs to procure cooling-water to cool-down equipment for operation from sea/river. It is necessary to confirm if power plant can access such water source. The temperature of cooling water after heat exchange rise and return back to sea/river. You need to confirm if thermal impact is acceptable environmentally.

3.1.3 Construction Area

✓ **Check Points**

To confirm area of storage for construction material is enough

Contractor uses a lot of equipment/parts during construction. So storage space for such material is necessary.

3.1.4 Living Area

✓ **Check Points**

To confirm if accommodation for personnel for both construction and Operation & Maintenance is considered

3.1.5 Work area for periodic inspection

✓ **Check Point**

To confirm working area and accessibility for equipment are enough when periodic inspection

3.1.6 Crane for periodic inspection

✓ **Check Point**

To confirm the crane for periodic inspection to be installed

3.1.7 Mobile crane approach route for inspection of each equipment

✓ **Check Points**

Confirm the mobile crane access route for work

3.1.9 Planning of Transportation and Roads

✓ **Check points**

To confirm stable procurement and supply method of fuel, chemicals, consumables.

Contents

■3.2.1 estimated performance curve

✓ **Description**

It is known that plant efficiency shall drop gradually due to performance degradation. As a result of the degradation, IPP might not generate rated output in the future.

IPP should take such degradation into account so that IPP can generate rated output to satisfy requirement of PPA even in a few decades.

✓ **Check Point**

Confirm consistency between PPA and plant net output capacity taking performance degradation into account.

3.2.2 Power generation range
3.2.3 Load demand response
3.2.4 Unsteady operation

IPP shall comply with requirements by Grid System Operator and Power Purchase Agreement (“PPA”). You need to confirm if proposal comply with them.

✓ **3.2.2 Power generation range**

✓ **Check Point**

You need to confirm if following item of proposal comply with PPA.

✓**Minimum Load**

Minimum Load is the lowest possible output (MW) for stable and continuous operation under fully automatic control. IPP shall be capable of being dispatched at the Minimum Load whenever required by the Grid System Operator. Minimum Load of GTCC is basically around 15%.

✓**Rated Load**

IPP might not generate rated load due to aging performance degradation in a few decades. It is necessary to confirm performance degradation assumption.

✓ **3.2.3 Load demand response**

✓ **Check Point**

You need to confirm if IPP has capability on following items as per PPA/requirement by Grid

✓ **Dispatch Ramp Rate**

IPP shall be capable of meeting dispatch ramp rate requirements. Dispatch ramp rate for GTCC is basically around 10%/min

✓ **Reactive Power Capability**

e.g. IPP shall be capable of supplying full load at any point between 0.85 power factor lagging and 0.95 power factor leading at the generator terminals.

3.2.4 Unsteady operation

✓ **Check items**

Even in case of trouble, IPP have to continue stable operation as much as possible. Grid System Operator/PPA requires IPP to keep stable operation even in the event of trouble. You need to confirm if IPP has following capability as per PPA/requirement by Grid. e.g.:

✓ **House Load Operation**

The occurrence of certain faults or disturbance incidents in the grid system leading to tripping of the associated high-voltage circuit breaker (HVCB) may result in the disconnection of generating units from the grid system. In the event of such disconnection, IPP have to keep operation supplying the house load without trip.

✓ **Runback**

IPP shall keep steady operation even in case one of the duty running machines trip. When duty running machine trip, output decrease rapidly and automatically to continue operation.

✓ **Gas turbine independent operation when steam turbine operation is unavailable**

Capability to continue operation with only gas turbine when steam turbine get unavailable

3.2.5 Auxiliary power ratio

✓To confirm rationality of auxiliary power consumption rate. Generally, it is around 2.3%.

$$\text{Auxiliary power consumption rate} = \frac{\text{Auxiliary Power consumption(MW)}}{\text{Gross output(MW)}}$$

3.2.6 Electric power supply plan

✓To confirm if following item fits with PPA

- Period of power plant operation : e.g. 25 years
- Availability Factor: e.g. 85%

$$\text{Availability} = \frac{\text{Available Hour (hr)}}{\text{Period Hour (hr)}}$$

- Capacity Factor : e.g. 80%

$$\text{Capacity factor} = \frac{\text{Actual Generration (MWh)}}{\text{Maximum Generation(MWh)}}$$

Reference: IEEE Std 762™-2006

✓ **Common Check Points**

- To make sure competency of manufacturer by checking delivery record and past trouble record

3.3 Main Technical Specification of BTG

3.3.1 Selective catalytic reduction(SCR) system, Flue gas desulphurization (FGD) system

✓ **System Description**
- SCR is the equipment that removes NOx from the flue gas
- FGD is the equipment that removes SOx from the flue gas

SCR

✓ **IPP shall comply with environmental regulation such as;**
- NOx
- SOx
- CO

✓ **Check Points**
- Such treatment facility is capable of treating flue gas to comply such regulation
- Environmental regulation in your country
- Fuel property

  As LNG is almost SOx-free fuel, FGD is basically not necessary. However, you need to confirm property of fuel just in case.

3.3 Main Technical Specification of BTG

3.3.2 Emergency generator

✓ **System Description**

In case of black out of power station, the emergency diesel generator supply power to operate the plant.

✓ **Check Points**
- Capacity of emergency generator

  The emergency diesel generator should be capable of operating the plant for safety shutdown including essential load requirements in blackout condition. The emergency diesel generator set is basically composed of 2 sets of generators as redundancy and have some capacity margins to the total load requirements.

Emergency generator

3.3.3 Start-up Boiler (Auxiliary Boiler)

✓**System Description**

Start-up boiler is required for following purpose during start-up of the power station:

- To supply gland steam at steam turbine when start-up of power station to build up the vacuum in the condenser
- For warming-up and deaeration of feedwater at feedwater tank

✓ **Check Points**

capacity to provide enough amount of steam required for start-up.

3.3.4 Heat recovery steam generator(HRSG), Material design of heat exchanger tube

✓**System Description**

The heat recovery steam generator (HRSG) is the equipment that utilize exhaust gas from a combustion turbine and produces steam rotating steam turbine. A heat recovery steam generator is used in a combined-cycle power station.

✓ **Check Points**

To confirm heat resistance and corrosion resistance against sulfidation of heat exchanger panel materials, and countermeasures against flow-accelerated corrosion

HRSG

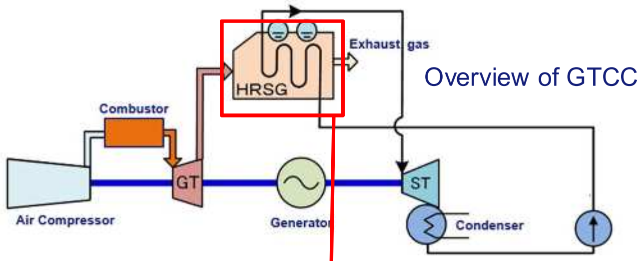
Tubes inside HRSG

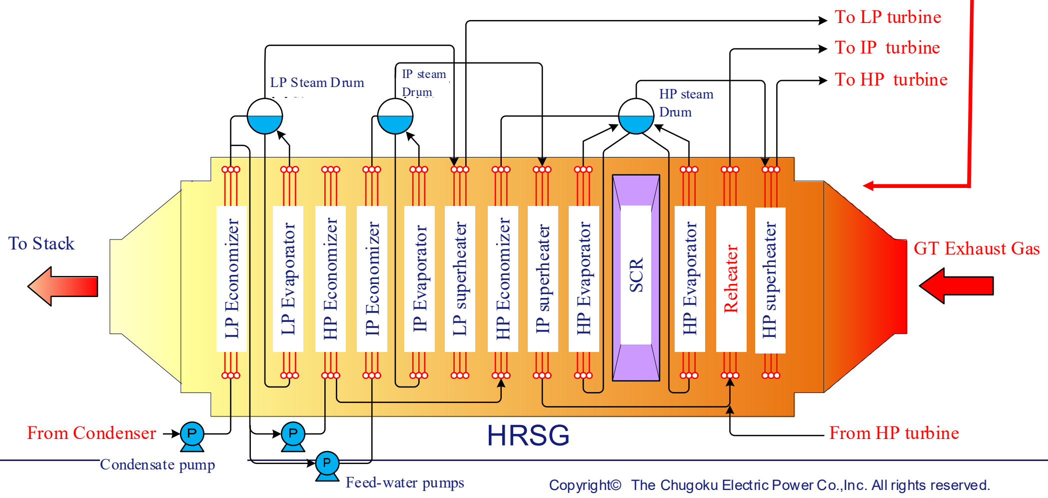
3.3.5 Main Steam, Reheat Steam and Turbine Bypass System

✓ **System Description**

• **Main steam/Reheat steam**

The main steam system transports steam from HRSG to ST. Exhaust steam from the HP turbine (cold reheat) come back to HRSG and go through the reheater. Steam from the reheater is conveyed to the IP turbine. The steam for LP turbine come from the LP superheaters.





3.3.5 Main Steam, Reheat Steam and Turbine Bypass System

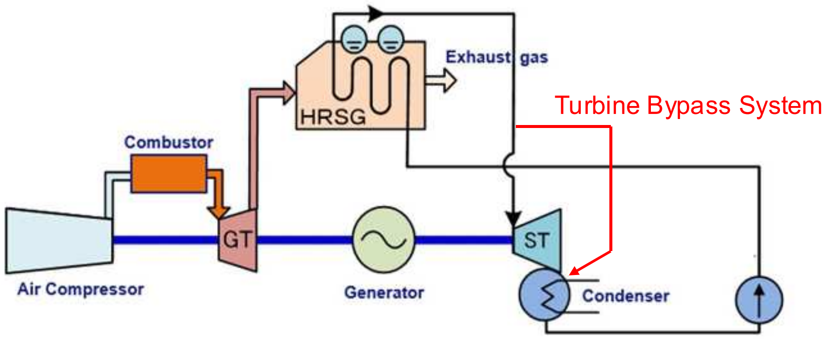
✓ **System Description**

• **Turbine Bypass system**

The turbine bypass system accommodates the steam generated in the HRSG during CTG startup before STG admission, to ensure that steam temperature matches the STG metal temperatures during any type of startup event. In addition to that, turbine bypass system enables the CTG to continue operation at full load even in the case of STG trip. The system will divert 100 percent of the HP, re-heater steam and LP steam flow at rated pressure to the condenser.

✓ **Check points**

Capacity of turbine bypass system to enable CTG to continue operation in case of STG trip if independent operation of CTG is required



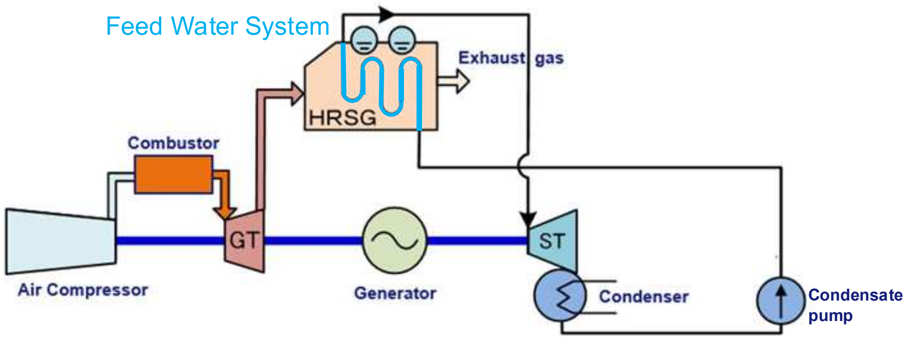
3.3.6 Feed Water System

✓ **System Description**

Feedwater system supply heated, deaerated feedwater to the HP and IP economizer in the HRSG.

✓ **Check Points**

- Consistency with capacity
- Feedwater chemical control is accomplished through packaged chemical injection units



3.3.7 Extraction Steam System
3.3.9 Heater Draining System

System for Thermal Power Station

✓ **System Description**

Steam is extracted from the steam turbine at various stages and used to heat the condensate and feedwater through various heaters. This results in higher cycle efficiency, as the temperature of condensate and feedwater is increased, also, reducing the amount of energy loss by turbine exhaust steam in the Condenser. Steam utilized at heater become drain and go to condenser.

✓ **Check Points**

To confirm Extraction Steam System is incorporated as to make efficiency high if it is thermal power station.

3.3.8 Condensed Water System

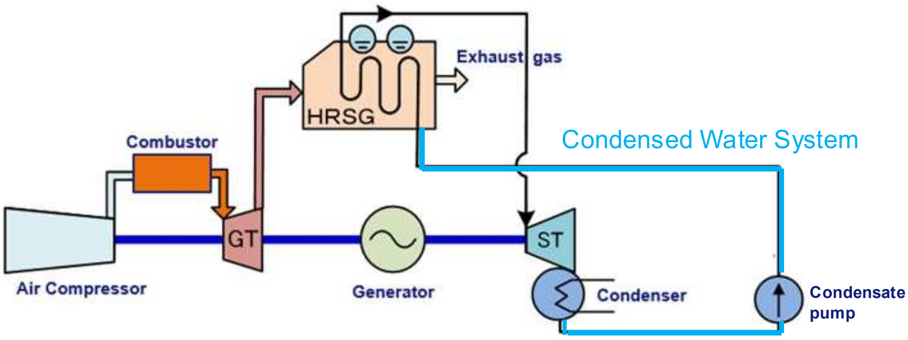
✓ **System Description**

Condensate system removes condensed LP turbine exhaust steam and other process drains from the condenser and pump the condensate water to the LP economizer section of the HRSG.

The condensate system includes the condenser, condensate pumps, gland steam condenser, valves and controls necessary for system operation and protection.

✓ **Check Point**

- Consistency with capacity



3.3 Main Technical Specification of BTG

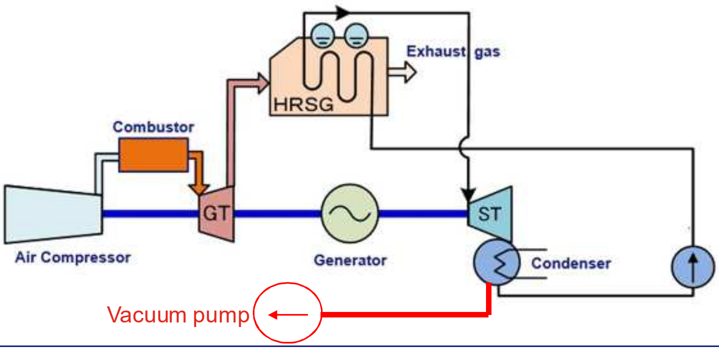
3.3.10 Vacuum-pumping System for Steam Condenser

✓**System Description**

The condenser includes an air removal system consisting of two vacuum pumps to hold condenser vacuum. Each pump capable of holding condenser vacuum during operation.

✓**Check Points**

- Redundancy of vacuum pump
- Capacity of vacuum pump to hold condenser vacuum



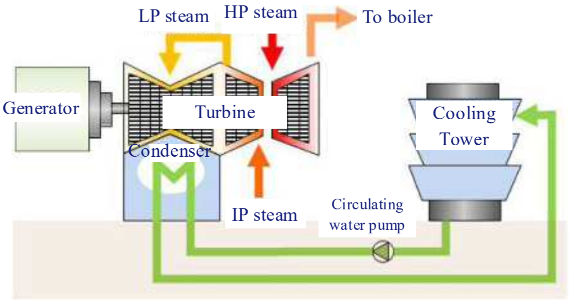
3.3.11 Circulating Water System

✓ **System Description**

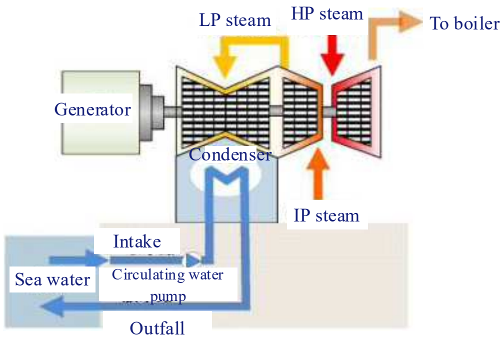
Circulating water system provide a continuous supply of circulating water to the facility.
Recirculating type of system use a cooling tower as the heat sink. Components of the heat sink system includes the cooling tower, circulating water pumps, surface condenser, and closed cooling water heat exchangers. For 1,000MW class power station, Seawater cooling is preferable because heat efficiency is better than cooling tower.

✓ **Check Point**

- Redundancy of pump
- Consistency with capacity



Power plant at inland
Cooling tower cooling



Power plant along the coast
Seawater cooling

3.3.12 Closed Circulating Cooling Water(CCCW) System

✓ **System Description**

The CCCW system provide closed cooling water to water-cooled components. The CCCW system uses plate and frame heat exchangers as the heatsink. Equipment requiring water cooling includes:

- STGs/CTGs
  - Lubricating oil coolers
  - Hydraulic coolers
  - Generator hydrogen coolers

✓ **Check points**

- Redundancy of CCW pumps
- Consistency with capacity

3.3.13 Auxiliary Steam System

✓ **System Description**

The Purpose of Auxiliary Steam System is to provide auxiliary steam to various equipment, from Auxiliary Steam Header. It shall be used to provide dry superheated steam to the following consumers:

- Pre-warming of main Steam Turbine before start up.
- Turbine gland steam seal during start-up till the turbine self-sealing system is in operation.
- Deaerator & Feedwater Tank initial heating.

✓ **Check Points**

Capacity to provide enough amount of steam required for start-up.

3.3 Main Technical Specification of BTG

3.3.14 Main Electrical Wiring

✓ **System Description**

Electricity is supplied with each equipment thorough electrical wiring. Its thickness differ subject to voltage.

✓ **Check Points**

- Wiring within desks and panels shall be supported on trays and shall be segregated according to voltage level.
- Wiring carrying AC and D.C. voltage shall also be segregated.
- All desks, panels, cubicles and racks shall be factory-wired with regard to the internal connections.

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3.3 Main Technical Specification of BTG

3.3.15 Power System

✓ **System Description**

The Excitation control system with Power System Stabilizer (PSS) is required for constant terminal voltage control of the Unit in responding to deviations in interconnection voltage, without instability over the entire operating range of the Unit.

✓ **Check Point**

If PSS is required by Grid System Operator/PPA. Confirm consistency of them.

3.3 Main Technical Specification of BTG

3.3.16 Auxiliary Power Ratio

Same as 3.2.5

✓**Check Point**

To confirm rationality of auxiliary power consumption rate. Generally, it is around 2.3% for 1,000MW power class unit.

$$\text{Auxiliary power consumption rate} = \frac{\text{Auxiliary Power consumption(MW)}}{\text{Gross output(MW)}}$$

Contents

3.4 LNG handling facility

3.4.1 LNG unloading system

✓ **System Description**

Operator receive LNG with loading arm from LNG carrier.

✓ **Check Points**

- Confirm the LNG carrier and the loading arm match.
- Confirm the emergency shutdown system is equipped.

  Emergency shutdown system enable separate between LNG carrier and loading arm immediately in case of emergency trouble such as fire.

3.4 LNG handling facility

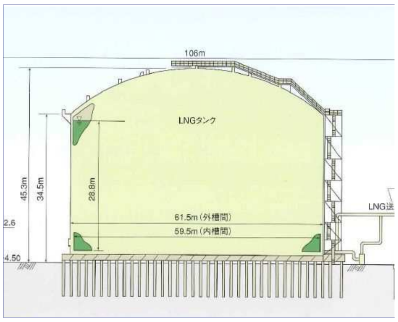
3.4.2 LNG storage system
3.4.5 LNG tank capacity (fuel)

✓ System Description

Since liquefied natural gas is extremely cold, the tank has a double wall (double shell), and the parts in contact with the liquid is made of a material that can withstand low temperatures. Steel plates and concrete are used on the outside.

✓ Check Points

- Check the capacity of the LNG tank is sufficient for stable operation, taking LNG receiving plan into consideration. You need to consider the risk of delay of receiving LNG due to bad weather and delay in ship allocation from the time of planning.
- Confirm the heat insulation and capacity to resist pressure of the tank, and the fire extinguishing system in case of fire.
- Make sure it complies with your country's regulations.

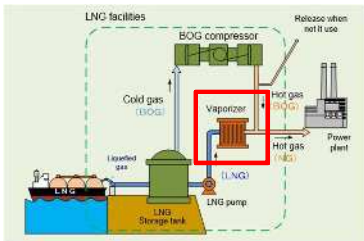


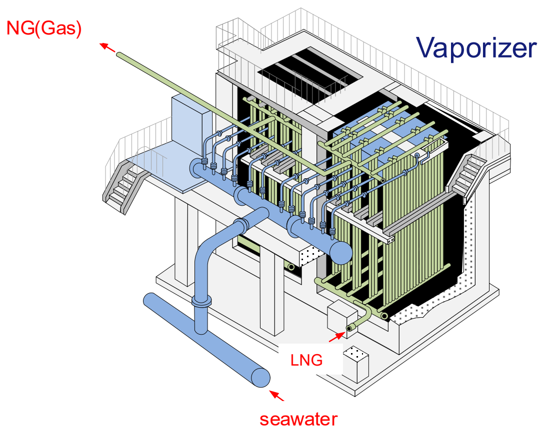
(Yanai Power Plant)
Six LNG tanks, each capacity is 80,000kl.

3.4 LNG handling facility

3.4.3 LNG vaporization system

- LNG passes through a heat transfer tube, and the outer surface of the heat transfer tube is heated with seawater.
- The heated gas is called hot gas and is sent to the gas turbine as fuel for power generation.





✓ Check Point

- Confirm the seawater temperature is taken into consideration as it affect efficiency of vaporization system.

3.4 LNG handling facility

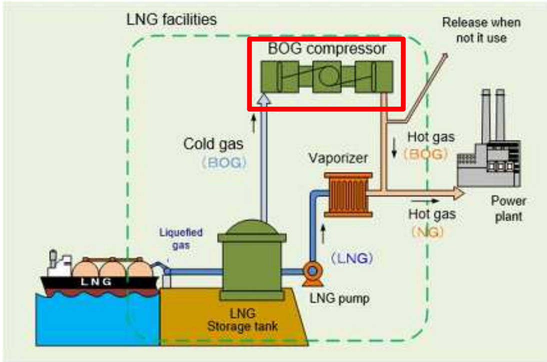
3.4.4 Boil off gas system

✓ **System Description**

- A part of LNG is naturally vaporized and gasified during the receiving or storage. This gas is called BOG (BOG: Boil Off Gas).
- The component of the BOG is methane(CH_4). This is because methane has the lowest boiling point and is vaporized first.
- BOG stays in the upper part of the LNG storage tank and raises the tank internal pressure, so it is necessary to extract the BOG. BOG generated inside the tank has a low temperature (about -160 to -140 ˚C) and is called cold gas. BOG is boosted by a BOG compressor and then mixed with hot gas (NG) and supplied to the gas turbine.

✓ **Check Point**

- Confirm that its capacity is enough considering the amount of gas generated much at the receiving of LNG.



3.4 LNG handling facility

3.4.6 LAG tank capacity（ammonia for SCR system）

✓ **System Description of Ammonia Storage**

An ammonia storage and delivery system is provided to store and deliver aqueous ammonia to the HRSG SCR for NOx reduction. Trucks deliver aqueous ammonia solution to the site. Aqueous ammonia is stored in storage tanks, and is pumped from the tanks by pumps to the HRSG.

✓ **System Description of SCR**

An SCR system is incorporated into the HRSGs for NOx control. Aqueous ammonia is vaporized using CTG exhaust gas as a heat source. The ammonia and CTG exhaust gas mixture is introduced to the flue gas. The ammonia and NOx pass through the catalyst, which converts the NOx to N2 and H2O vapor.

✓ **Check Point**

- To confirm spill prevention measures from ammonia tank (e.g. installation of ammonia detector, double-walled tank)
- Consistency between consumption and capacity of ammonia tank

Ammonia tank

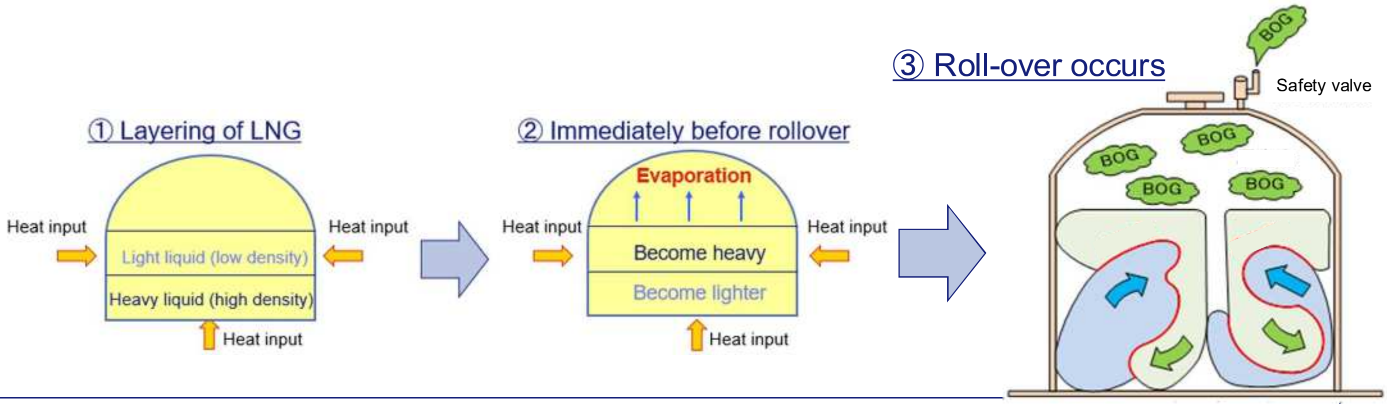
3.4.7 Preparation for handling of light LNG

✓ **General Description**

When operator store light and heavy LNG in one tank, operator need to handle carefully. If different type of LNG mixed in the tank, a lot of BOG (Boil off Gas) generate due to friction heat, which is called Rollover.

✓ **Check Point**

Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure and density detection system



Contents

3.5.1 Water Source and Water Quality

✓ **System Description on Raw Water System**

Raw water is injected with sodium hypochlorite and treated in a pre-filter. The pre-filter act as a roughing filter to reduce the total suspended solids (TSS) concentration.

✓ **Check Points**

- Accessibility to water source such as availability of water pipeline
- To confirm if water quality and amount satisfy requirement of unit

3.5 Balance of Plant

3.5.2 Boiler Make-up Water Treatment System

✓ **System Description**

The water treatment system is generally the equipment that removes minerals and other impurities in the water, which is used in the condensate/feedwater system and the condenser and cooling water system.

✓ **Check Points**

To confirm if water quality comply with requirement of unit

3.5.3 Chemical Dosing System

✓ **System Description**

The function of the HRSG feedwater chemical injection system is to control steam cycle chemistry to minimize corrosion. For example, amine feed pumps inject ammonium hydroxide for pH control into the condensate pump discharge.

✓ **Check Point**

To confirm chemical dosing system enable water purity to satisfy the requirement of HRSG and ST

3.5.4 On-Line Water and Steam Sampling and Analysis System

✓ **System Description**

Water treatment system has appropriate instruments for continuous analysis of water quality. Water quality input from these analyzers is sent to the DCS (Distributed Control System) for trending and report development so that operator can monitor the status at all times.

Example of analyzed items are following:

- Conductivity
- pH
- Dissolved oxygen

✓ **Check point**

To confirm monitoring item covers required water quality

3.5.5 Circulating Cooling Water Treatment System

✓ **System Description**

The function of the cooling tower chemical injection system is to inject chemical solutions into the cooling tower circulating water for chemistry control. The system include:

- Cooling tower pH control system
- Cooling tower chlorination system

✓ **Check Points**

To confirm if water quality satisfy requirement of unit

3.5.6 Central Industrial Waste Water Treatment
3.5.7 Oil Treatment System

✓ **System Description**

Plant wastewater is discharged to sea or river after treatment. It is monitored for compliance with effluent limitations before discharging. For example, IPP have to comply following parameters:

- PH
- Temperature
- Oil and grease
- Phosphorus

✓**Check Point**

To confirm waste water treated comply regulation in your country

Contents

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3.6 On-site monitoring system

■ 3.6.1 Continuous Emission Monitoring System (CEMS)

✓ **System Description**

The continuous emissions monitoring system is the equipment that monitors emissions. For example, CEMS monitors following concentration in flue gas:

- NOx
- SOx
- CO

✓ **Check point**

To confirm if CEMS cover all item required to monitor as per regulation in your country

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3.6 On-site monitoring system

3.6.2 Closed Circuit Television System
3.6.4 Entrance Guard System and Patrolling System

✓ **System Description**
The Closed Circuit Television System(CCTV) system is for the process supervision for plant operation and the intrusion supervision.

✓ **Check Point**
To confirm covered area is enough in terms of security

CCTV

3.6 On-site monitoring system

3.6.3 Fire Alarm System

✓ **System Description**
The fire protection system is the equipment that detects, suppresses and extinguishes fires.

✓ **Check Point**
To check conformity with regulation in your country

Contents

3.7 Safety measures

3.7.1 Fire protection plan, quantitative risk assessment for LNG

✓ **General Description**

IPP shall submit the fire protection plan/strategy, which includes:

- Fire fighting system
- Detection system (Smoke detection, heat detection, gas detection, LNG spill detection)
- Fire scenario (affecting zone in case of leakage of LNG from tank)

✓ **Check Point**

To confirm it comply with regulation in your country

3.7.2 Countermeasures for handling light LNG

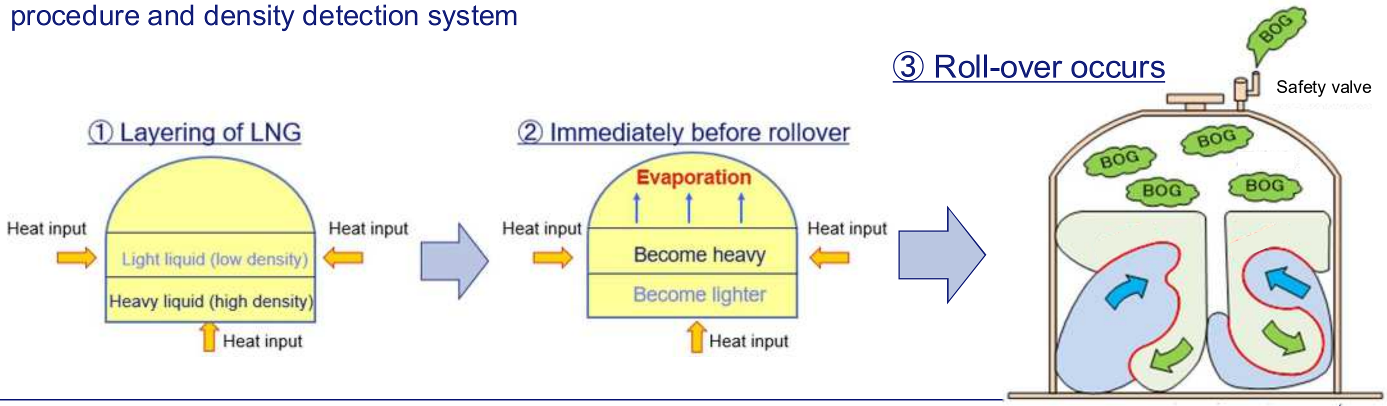
Same as 3.4.3

✓ **General Description**

When operator store 2 kind of LNG, light and heavy LNG in one tank, operator need to handle carefully. If different type of LNG form layer and mixed suddenly in the tank, a lot of BOG (Boil off Gas) generate due to friction heat, which is called Rollover.

✓ **Check Point**

Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure and density detection system



3.7.3 Firefighting facilities

✓ **System Description**

Purpose of firefighting system is to protect the life safety and property from the hazards created by fire in this plant. For example, firefighting facility is consist of following facilities:

- Fire Water Storage Tank
- Fire Water Pump
- External Hydrant System
- Automatic Water Spray System
- Automatic Sprinkler System
- Fixed CO2 Fire Extinguishing System
- Portable Fire Extinguishers
- Fire Detection and Alarm System
- Smoke Exhaust System
- Anti-static

✓ **Check Point**

To check if the fire fighting system comply with regulation in your country

4. Labor Safety

✓ **Safety Personnel**

Contractor shall assign a full-time Project Site safety officer who shall be responsible for introducing, administering, and monitoring procedures to promote safe working conditions on the Project Site and compliance with Applicable Law.

Contractor shall furnish adequate numbers of trained, qualified, and experienced personnel and appropriate safety and other equipment in good condition, suitable for performance of the Work.

✓ **Check Point**

To confirm contractor comply with regulation in terms of safety