Case Study of Energy Audits (2)

Examined EE&C Technologies

Examined technologies	Examination / Evaluation	Financial Analysis
Efficient motors	Proposed	• Investment cost • Cash-flow • Pay back period • IRR • NPV
PV system	Proposed	
PV system with financial incentives	Proposed	
Inverter to motors	Already included	-
Improvement of power factor of receiving ends	Analyzed high enough	-
Inverter to compressors	Recommended	-
Efficient transformers	Recommended	-
Efficient lighting	Recommended	-
Electrically-driven dump trucks for a mine	Recommended	-
Trolley dump trucks for a mine	Recommended	-

Case Study of Energy Audits (2)

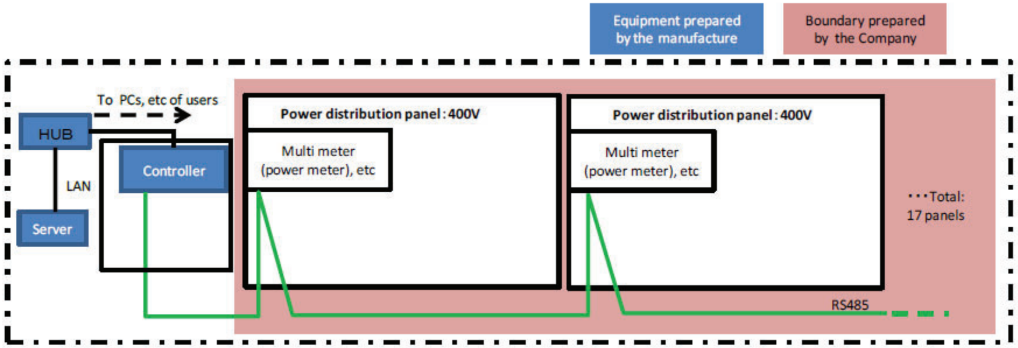
Source Energy Conservation Centre of Japan

Electrically-driven dump trucks for a mine

Source Energy Conservation Centre of Japan

Electrically-driven dump trucks for a mine

Case Study of Energy Audits (2)



Structure of EMS for 17 Power Distribution Panels

Estimates for the introduction of EMS

Item	Cost (USD)
The cost of the hardware and software	XXXXX
The cost of design, installation and construction	XXXXX
The total cost of introduction of EMS	XXXXX

Case Study of Energy Audits (2)

Representative Monitoring Items and Functions with the EMS

Monitoring items and functions	Comments
Peak demand of electric power	Alarm function included. (in case of exceeding threshold value)
Demand history of electric power	Displaying the power demand history.
Power consumption history by the distribution panel	Displaying the power demand history by the equipment groups.
Analysis by the output level (e.g. in manufacturing) and energy management (targets/actual results)	Analysis by the output level and equipment groups. The following targets and actual results to be displayed in the tables and the graphs on monthly basis. a. Electric power consumption b. Primary energy consumption c. CO_2 emissions d. Costs
Creation of the reports	Creation of the reports on daily, monthly and yearly basis regarding energy consumption.
Creation of the reports required by the government	Creation of the reports to be submitted to the government.

4. Energy Audit Best Practice at Aquarium & Amusement Park in Japan

Outline of the Aquarium & Amusement Park

- ✓ The company was Established in 1990.
- ✓ The amusement park was opened in 1993.
- ✓ Annual number of visitors; 4 to 5 million (Top 5 in Japan).
- ✓ The park is type-1 designated energy management factory under "the law concerning the Rational Use of Energy".

◆ Three-story aquarium with thousands of fish which is one of the largest in Japan.
⇒ A lot of cold energy & heat (chilled & hot water) are necessary to maintain water temperature in water tanks constant all year around as well as space heating & cooling for visitors.

◆ Other attractions

- ➢ Vertical fall amusement (BLUE FALL) with 107 meters high.
- ➢ Japan's first roller coaster that swings out over the ocean.
- ➢ World famous Merry-Go-Round with thousands of lights glittering.

Outline of the Aquarium & Amusement Park



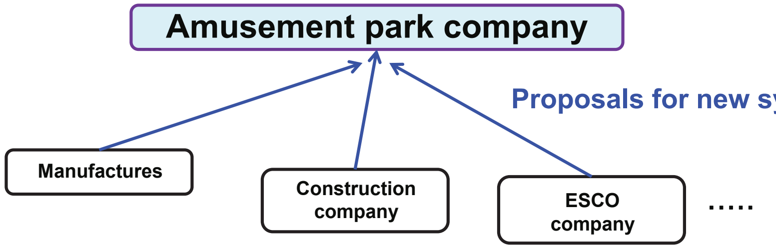

4 WANTS in the Company

1. Cut energy cost
2. Improve the efficiency of maintenance and operation of facilities
3. Promote further energy savings and environmental measures
4. Asset-light business operation by reducing investments

Two major backgrounds in Japan

- ✓ Increasing interests in energy savings by the law concerning the Rational Use of Energy.
- ✓ Increasing interests in CO_2 emissions reduction.

Toward the Realization of 4 WANTS



- Several companies proposed new system.
- Amusement park company itself analyzed and examined each proposal for more than a year.
- In the process of examination, the responsible person was appointed by the company played an important role on;
  - Providing suggestion to management from technical angle.
  - Verification of various figures indicated in proposals such as consumption of electric power, city gas, water.

Key Point 1 for Realization of 4 WANTS

1. Reduction of maintenance fee for co-generation
2. High efficiency system which contributes to energy savings and CO_2 reductions
3. Simple system toward the realization of efficient operation

Stop operation of co-gen (2 units) and introduction of high efficiency air-source heat pumps instead.

- In case of air-source HPs, cooling water necessary in the existing system will not become necessary by air-source HPs.

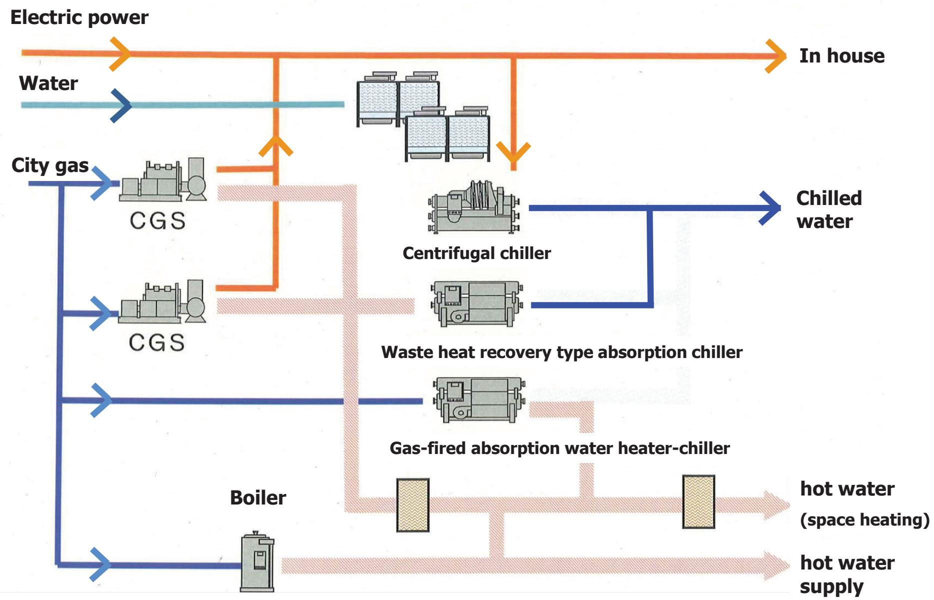
Key Point 2 for Realization of 4 WANTS

Adoption of high efficiency heat pumps

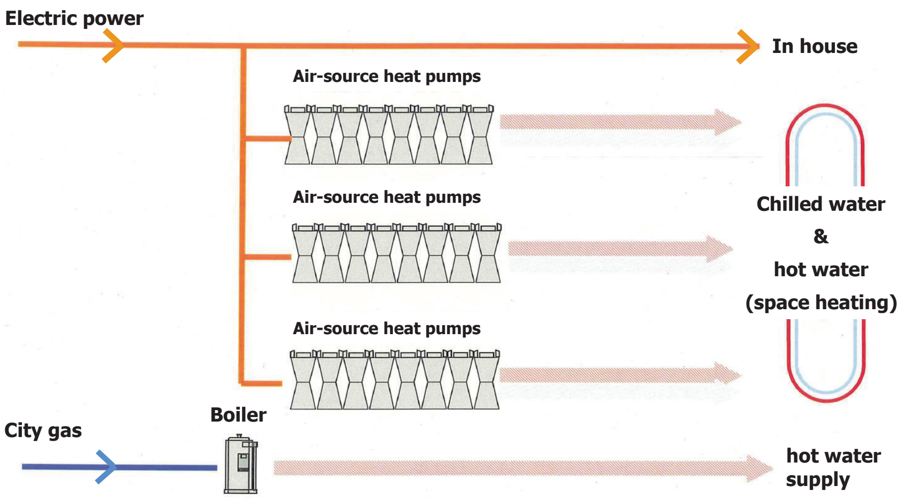
- The industry's first large-scale heat pumps with high efficiency.
- This heat pump won the Minister of Economy, Trade and Industry Prize at the Energy Conservation Awards.

Picture of high efficiency heat pumps

System Comparison – existing system -

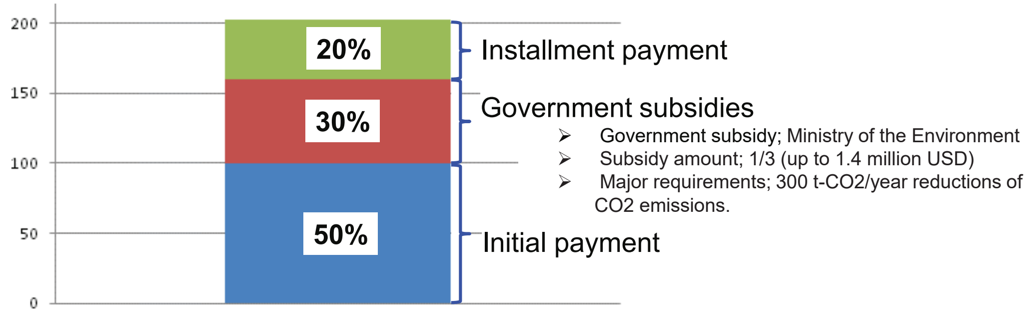


System Comparison – renewed system -



New system is more simple.
⇒ Needs no water and less space.

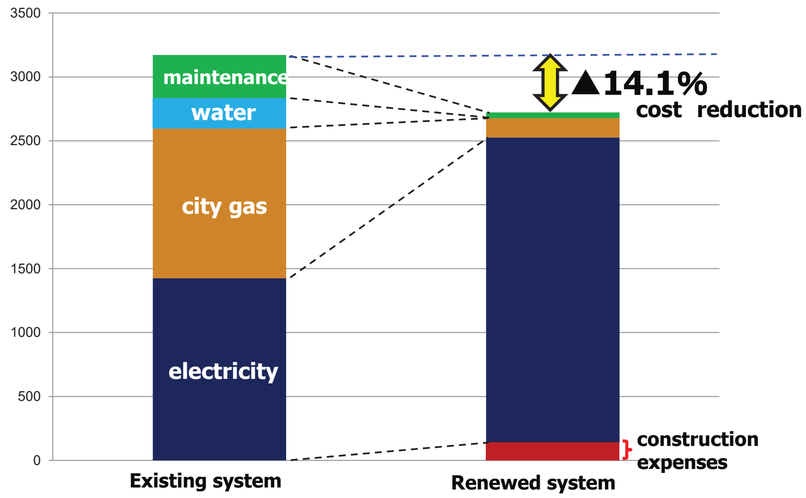
Construction Cost



Composition on payment for construction cost

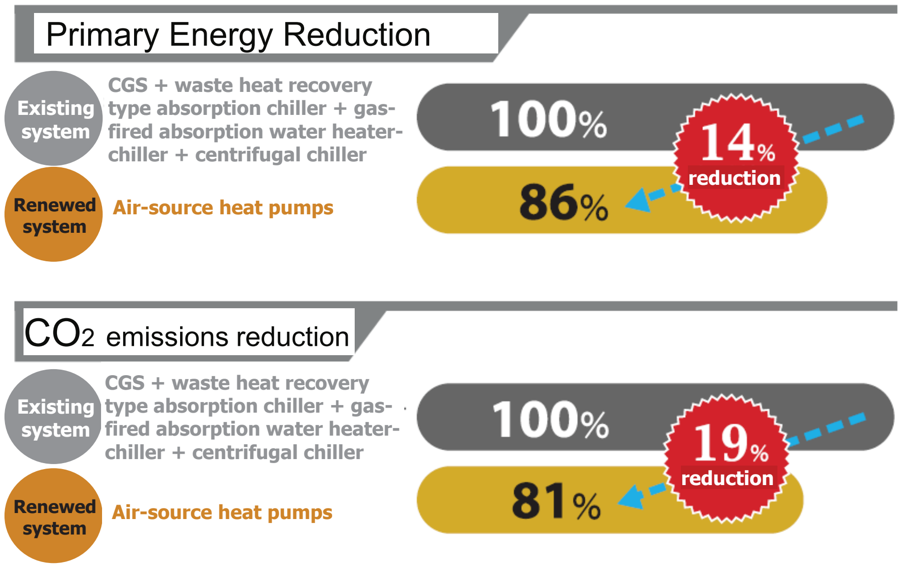
- ➢ 10% out of total cost are interests.
- ➢ Term of installment payment is 15 yrs.

Comparison of Life Cycle Cost



Comparison of LCC (15yrs)

Primary Energy & CO_2 Emissions Reduction



Through 2 Years Operation

■ Operational cost reduction

➡ Approx. 70 million JPY (0.5 million USD) was reduced annually.

⬇

Construction cost was already recovered within 2 years.

■ CO_2 emissions reductions

➢ Obligated amounts of reductions by MOE = Approx. 600 t-CO_2/year

➡ Approx. 1,800 t-CO_2 was reduced within 2 years.

⬇

CO_2 emissions clears the designated level by MOE.

Thank you very much for your kind attention !

The Technical Cooperation Project to Promote Energy Efficiency in Caribbean Countries

Market Study of EV

November 2022

Nippon Koei Co., Ltd.
PADECO Co., Ltd.

Today's Agenda

- ✓ Market analysis of EVs
- ✓ Market analysis of storage batteries
- ✓ Introduction of new technologies

1. Different Types of EVs

Different Types of EVs

■ Different types of EVs

	Automobile
With battery for drive	**BEV: Battery-powered vehicle** PHEV: Plug-in hybrid vehicle
No battery for drive	FCV: Fuel-cell vehicle (hydrogen vehicle) Solar car Trolley bus

Ref. UZABASE

ICV: Internal Combustion Engine Vehicle

Different Types of EVs

■ Pros & Cons of EVs

ICV: Internal Combustion Engine Vehicle
BEV: Battery-powered vehicle
PHEV: Plug-in hybrid vehicle
FCV: Fuel-cell vehicle (hydrogen vehicle)

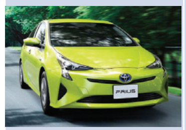
	Pros	Cons
ICV 	• Cheaper to buy • Longer driving range • Wider cabin space • Good infrastructure (many gas stations) • Short refueling time	• Higher CO2 emission • Higher running cost
BEV 	• No CO2 emission • Cheap running cost • Can be charged at home	• More expensive than ICV • Shorter driving range • Limited cabin space • Limited number of charging stations • Longer charging time (rapid charge takes 30 mins)

Ref. UZABASE

Different Types of EVs

■ Pros & Cons of EV

ICV: Internal Combustion Engine Vehicle
BEV: Battery-powered vehicle
PHEV: Plug-in hybrid vehicle
FCV: Fuel-cell vehicle (hydrogen vehicle)

	Pros	Cons
PHEV 	• Longer driving range • Lower CO2 emission • Cheaper running cost than ICV • Good infrastructure (many gas stations) • Short refueling time • Can be recharged at home	• More expensive to buy (because there are 2 driving systems of ICV and BEV) • Limited cabin space
FCV 	• Longer driving range • No CO2 emission • Wider cabin space • Short filling time (takes 5 mins)	• Limited number of hydrogen filling stations • Limited car models

Ref. UZABASE, ENEOS

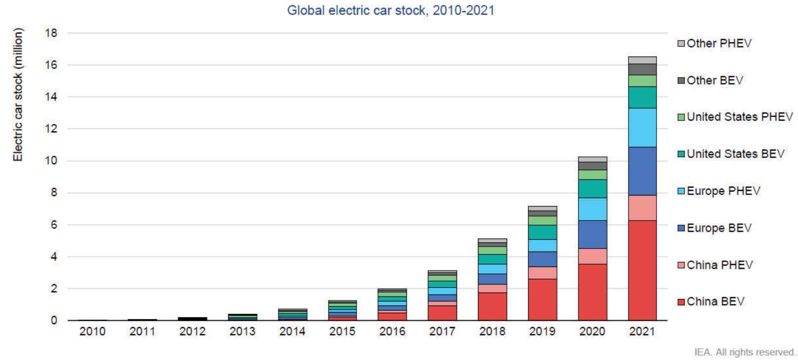
2. Market Analysis of EVs & Storage Batteries

Market Analysis of EVs

■ Market size of EVs

The EV market is rapidly growing, and sales of EVs were 6.6 million units in the world in 2021. There were over 16.5 million EVs on the road. EVs are 10% of all vehicles.

Global electric car stock, 2010-2021



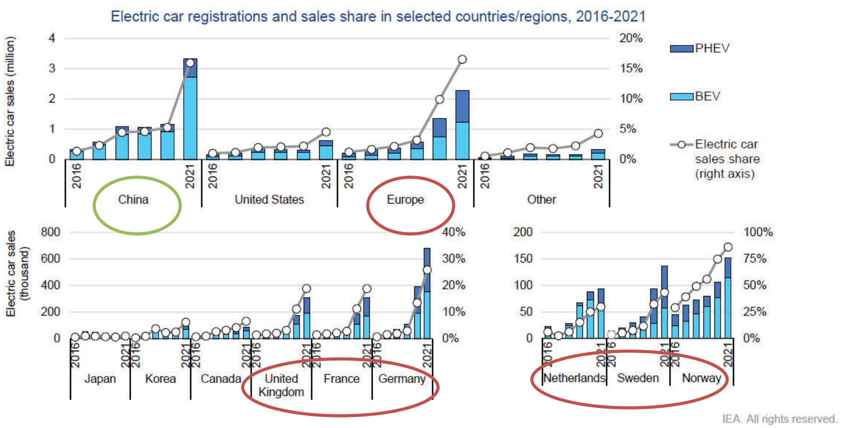
Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle. Electric car stock in this figure refers to passenger light-duty vehicles. "Other" includes Australia, Brazil, Canada, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand. Europe in this figure includes the EU27, Norway, Iceland, Switzerland and United Kingdom.
Sources: IEA analysis based on country submissions, complemented by ACEA; CAAM; EAFO; EV Volumes; Marklines.

Ref. Global EV Outlook 2022, IEA

Market Analysis of EVs

■ Market size by countries/regions
China and Europe are the top 2 growing markets of EV sales.

Electric car registrations and sales share in selected countries/regions, 2016-2021



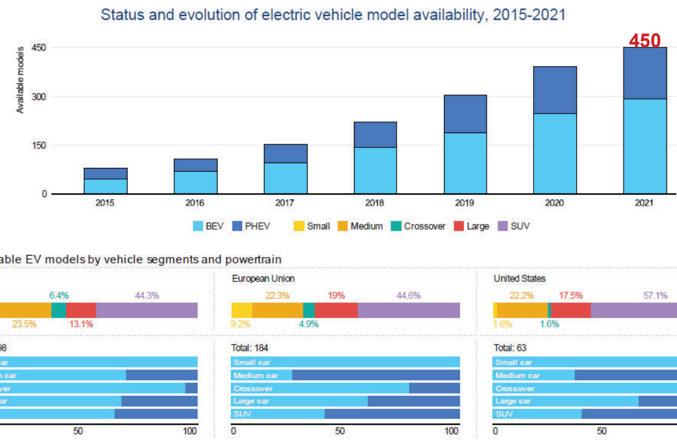
Notes: The countries/regions shown are the world's largest EV markets and are ordered by size of the total car market (i.e. all powertrains) in the upper half of the figure and by sales share of electric cars in the lower charts. Acronyms and geographic groupings are defined in the Notes of the previous figure. Regional EV registration data can be interactively explored via the Global EV Data Explorer.
Sources: IEA analysis based on country submissions, complemented by ACEA; CAAM; EAFO; EV Volumes; Marklines.

Ref. Global EV Outlook 2022, IEA

Market Analysis of EVs

■ Increase of EV models

Status and evolution of electric vehicle model availability, 2015-2021



70% was BEV, 30% was PHEV in the road in 2021

SUVs were the most popular

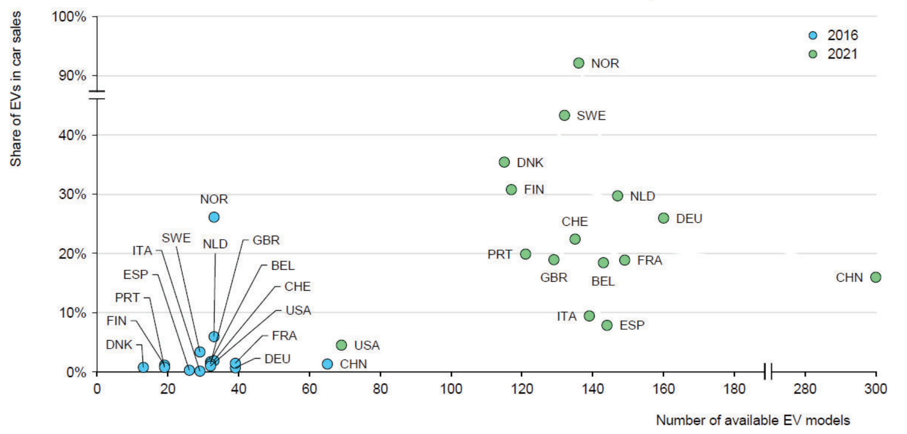
Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid vehicle. Small cars include A and B segments. Medium cars include C and D segments. Crossovers are a type of sports utility vehicle (SUV) built on a passenger car platform. Large cars include E and F segments and multi-purpose vehicles. Vehicle models do not include the various trim levels.
Sources: IEA analysis based on EV Volumes and Marklines.

Ref. Global EV Outlook 2022, IEA

Market Analysis of EVs

■ Increase of EV models and sales

Number of available EV models relative to EV sales share in selected countries, 2016 and 2021



Notes: EVs = BEVs and PHEVs. Vehicle models do not include the various trim levels.
Sources: IEA analysis based on EV Volumes.

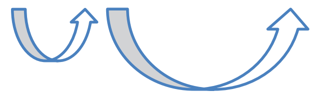
Ref. Global EV Outlook 2022, IEA

Market Analysis of EVs

■ Future EV market size

- The total sales of EVs is expected to be 18 million units in 2025 and over 30 millions in 2030.
- ICV will be 13% of new car sales in 2025, and over 20% in 2030. EV will be the main passenger car in the world.

	2021	2025	2035
EV	16.5 mil units	18 mil units	30 mil units



Ref. Global EV Outlook 2022, IEA

Market Analysis of EVs

■ Policy and Regulation

Automobile regulation of each country, subsidy and policy for EVs

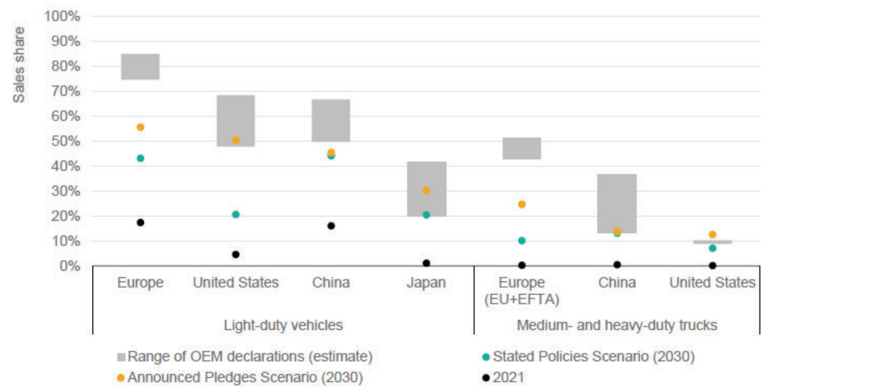
Country	Regulation	EV Subsidy & Policy
China	Introduce NEV regulation to produce and import 10% of NEV (EV, PHEV, FCV) out of 30,000 units of yearly production and import vehicle.	Subsidy for BEV, PHEV No tax for purchasing BEV, PHEV Mitigation measure of issuing number plate of BEV Increase number of NEV sales to 20% by 2025.
EU	The "Green Deal Policy" launched by the European Union in 2019 aims to reduce carbon emissions by at least 50% by 2030 and achieve carbon neutrality targets by 2050. ● Germany Stop selling ICV (Internal Combustion Engine Vehicle) by 2030. ● France Stop selling ICV (Internal Combustion Engine Vehicle) by 2040.	● Germany Subsidy for BEV, PHEV 10yrs preferential treatment of car tax (5yrs no tax and 5yrs 50% tax reduction) ● France Subsidy for BEV, PHEV Penalty in case CO2 emission is over 120g/km
US	Introduced ZEV regulation to promote sales of new generation vehicle to reduce CO2 emission	Subsidy for BEV, PHEV
Japan	Reach 30% of EV sales by 2030 Set goal of fuel consumption of new car to 25.4km/l by 2030 (19.2km/l in 2016).	Subsidy for BEV, PHEV No tax for purchasing BEV Preferential treatment of car tax by regional government

Market Analysis of EVs

■ Policy and Regulation

Zero emissions vehicle announcements by automakers are more ambitious than policy targets

OEM targets and registrations in the Stated Policies and Announced Pledges scenarios, 2030

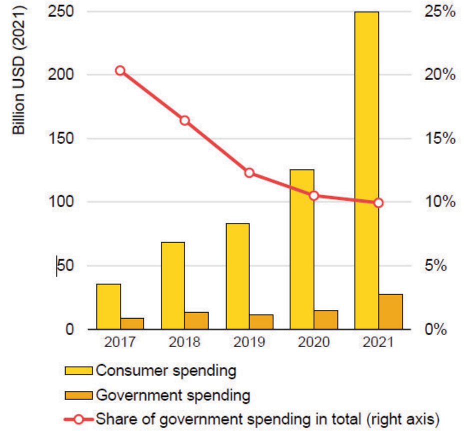


Ref. Global EV Outlook 2022, IEA

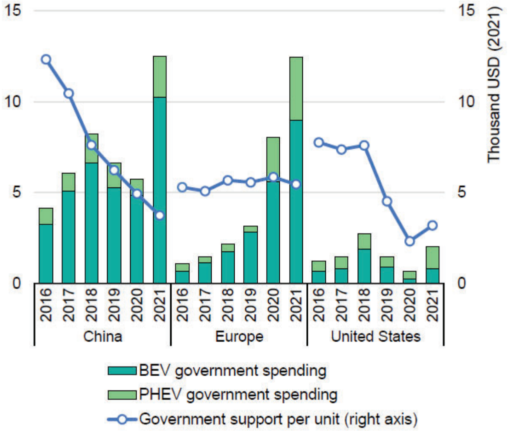
Market Analysis of EVs

- Subsidies
Chinese and European governments spent more money on EVs.
Sales price of EVs remain cheaper in China.

Consumer and government spending on electric cars, 2016-2021



Government spending on electric cars by region, 2016-2021

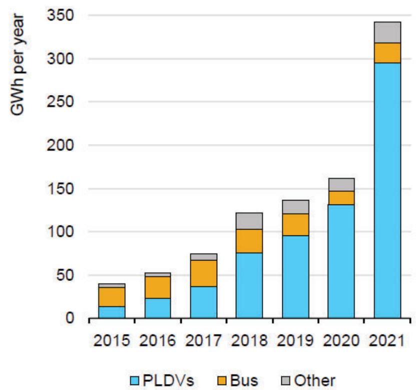


Ref. Global EV Outlook 2022, IEA

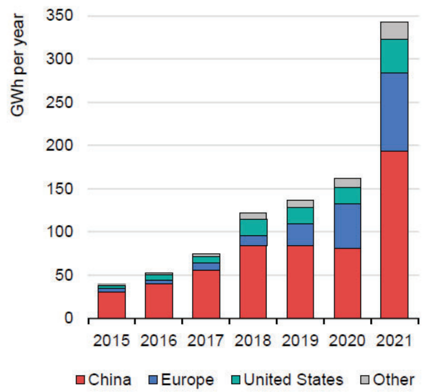
Market Analysis of EV Batteries

- Increase market demand of EV batteries

Battery demand by mode, 2015-2021



Battery demand by region, 2015-2021



Notes: GWh = gigawatt-hours; PLDVs = passenger light-duty vehicles; other includes medium- and heavy-duty trucks and two/three-wheelers. This analysis does not include conventional hybrid vehicles.
Sources: IEA analysis based on EV Volumes.

Market Analysis of EV Batteries

- Market size of EV batteries

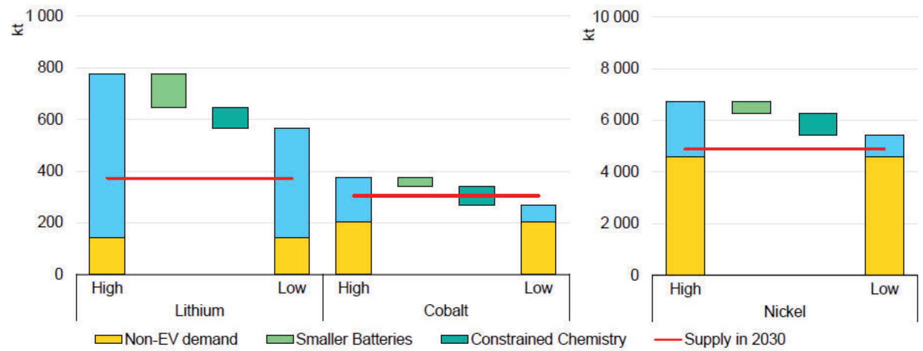
- The EV battery market is expected to be worth 218.47 billion USD by 2027, from 34.08 billion USD in 2020 (CAGR of 31.56%).
- The lithium-ion battery segment is expected to dominate the market.
- There are technological advancements of the lithium-ion battery market and reduced the overall cost of lithium-ion battery production.
- Asia Pacific is expected significant growth in the EV battery market due to increasing demand from China, India, Japan, and other countries.
- The increasing share of EVs and rising sales volumes are also driving demand for lithium-ion battery in the U.S. and Europe("Green Deal Policy").

Market Analysis of EV Batteries

- Increase market demand of EV batteries

Demand side measures such as limiting the growth of battery size can help bridge the gap

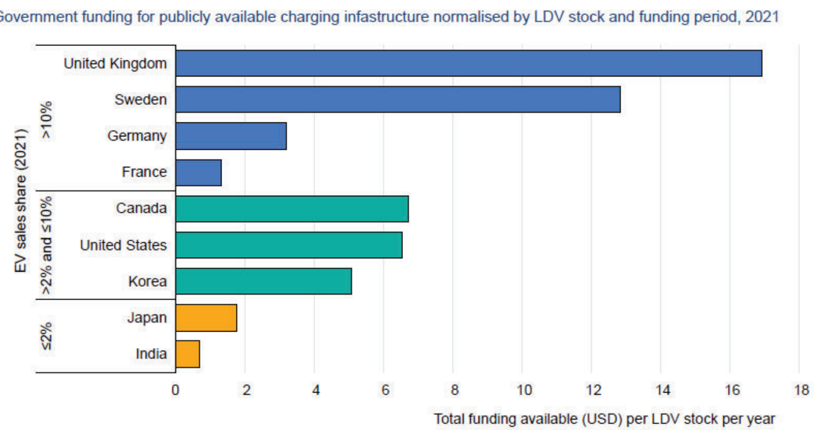
Measures to lower metal demand in 2030 in the Net Zero Scenario



Notes: NZE = Net Zero Emissions by 2050 Scenario; STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.
Sources: IEA analysis based on Benchmark Mineral Intelligence for supply capacity.

Charging Infrastructure

■ Increase number of EV charging stations
China and Europe boast the largest EV charging networks in the world. Governments provide subsidies for installation of charging stations.



Ref. Global EV Outlook 2022, IEA

3. Analysis of EV Markers

Analysis of EV Markers

■ EV auto makers

Ref) UZABASE

Analysis of EV Markers

■ EV auto makers

Companies included in the EV, battery and top-ten automaker indices

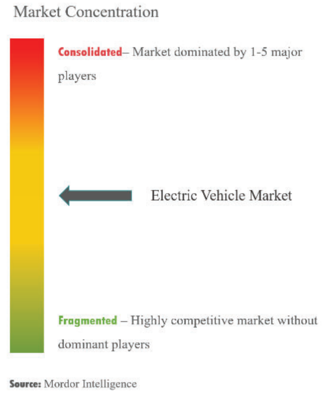
EV index	Battery index	Top-ten automaker index
• Tesla • Lucid Group • Rivian Automotive • NIO • Li Auto • XPeng • Fisker • Nikola • Arrival • Proterra • Lion Electric • Hyzon Motors • Canoo • Hyliion Holdings Corp	• LG Energy Solution • BYD • Contemporary Amperex Technology Ltd • Samsung SDI • Gotion High-Tech • Eve Energy Co • Farasis Energy Gan Zhou	• Toyota Motor • Volkswagen • Kia • General Motors • Ford Motor • Nissan Motor • Stellantis • Renault • Hyundai Motor • Mercedes-Benz Group

Analysis of EV Markers

■ Main players of EV makers

Main players

1. Tesla
2. BYD Company Ltd
3. Mercedes-Benz Group
4. Volkswagen
5. Toyota

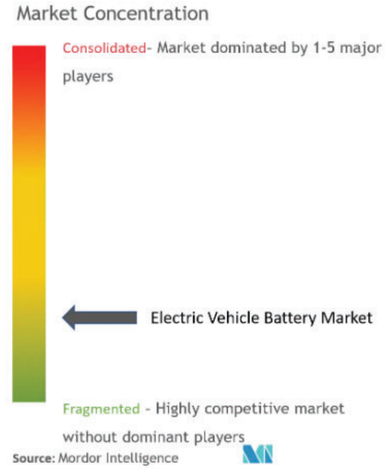


Analysis of EV Maker

■ EV storage battery makers

Main players

1. Panasonic Corporation
2. Contemporary Amperex Technology Co Ltd
3. Samsung SDI Co. Ltd.
4. BYD Company Limited
5. LG Energy Solution Ltd



4. Case Study

Case Study (Japan)

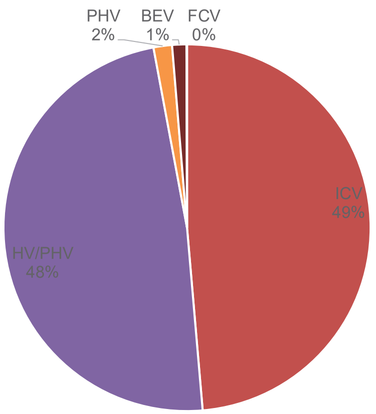
■ Cost analysis of each vehicles in Japan
BEV is the lowest cost, but shorter driving range and longer charging time are challenges.

	Car Type	Sales Price	Pay on a spot	Driving range	Distance that can be traveled for 1,000 yen
BEV	Tesla Model S 	12,000,000 yen	600 yen	650 km	923km
PHEV	Toyota SIENTA (PHEV) 	2,910,000 yen	6,720 yen	1,142 km	169 km
ICV	Toyota SIENTA (ICV)	2,560,000 yen	6,560 yen	850 km	129 km
FCV	Toyota MIRAI 	7,100,000 yen	6,720 yen	850 km	126 km

Ref. Tesla Japan, Toyota,
https://car.rakuten.co.jp/magazine/articles/2022/carlife05/

Case Study (Japan)

■ Car Sales by Fuel Type in Japan (January to October 2022)



ICV	HV/PHV	PHV	BEV	FCV	Others	Total
887315	883432	29738	22861	810	68	1824224
48.64%	48.43%	1.63%	1.25%	0.04%	0.00%	100.00%

Ref: Japan Automobile Dealer Association

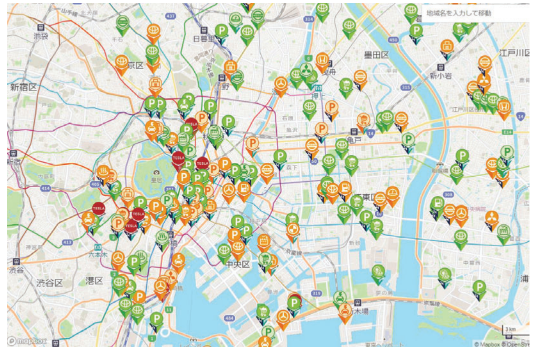
Case Study (Japan)

■ Comparison of infrastructure in Japan

Fuel stations: 28,500
EV charging stations: 21,000
FCV hydrogen filling stations: 161
(as of Nov. 2022)

ICV: Internal Combustion Engine Vehicle
BEV: Battery-powered vehicle
FCV: Fuel-cell vehicle (hydrogen vehicle)

■ Increase no. of EV charging stations



Location of EV charging stations in central Tokyo

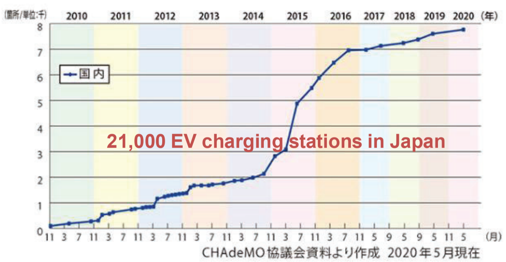
■ Limited no. of hydrogen filling stations

Location of FCV hydrogen stations in central Tokyo (5 stations only)

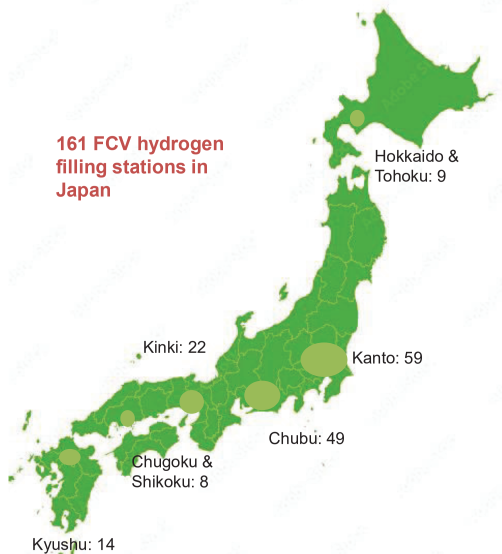
Ref. GoGoEV, NeV, ENEOS, Toyota Mirai

Case Study (Japan)

■ Increase no. of EV charging stations in Japan



■ Limited no. of hydrogen filling stations in Japan



Ref. GoGoEV, NeV, ENEOS, Toyota Mirai

Case Study (Japan)

■ Different types of EV stations

■ Cost of installation of charging station in Japan

Rapid charging station: 21,500-36,000USD
Normal charging station: 1,500 -2,900USD

■ Plan of EV stations for general customers in Japan

Plan to use EV charging station	Rapid charge plan	Normal Charge plan	Combine plan
Charging machine	Rapid charger	Normal charger	Both
Monthly plan	28.5 USD/mo	10 USD/mo	31.5 USD/mo
Pay on a spot	0.1 USD/min	0.02 USD/min	0.1 USD/min 0.02 USD/min
Registration charge	10 USD		

Ref. Guliver, GoGoEV, NeV, ENEOS

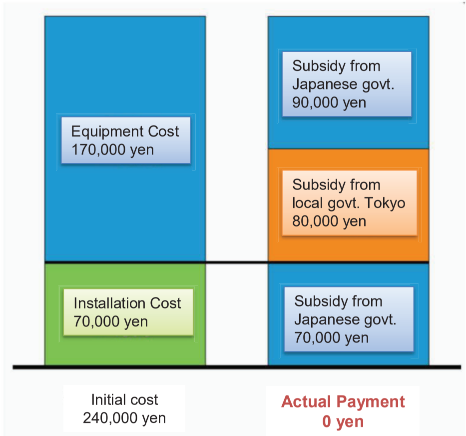
Case Study (Japan)

- Household EV charger

◆ Installation of household charging plugs:
JPY 40,000-120,000 (USD 270-820)

◆ Running cost: EV < ICV
When you drive 10,000km with EV (Nissan Leaf) and ICV (Toyota Prius), running cost of Nissan Leaf is JPY 30,000 (USD 200) cheaper than Toyota Prius.

- Subsidy in Japan
Details can be access from
http://www.cev-pc.or.jp/english/cev-subsidy.html



Example of subsidies for household EV charger

Ref. ENECHANGE

Case Study (Japan)

- Different types of FCV hydrogen filling stations

Consumer price: 8-8.7 USD/Litter

@Hydrogen filling station

@ Convenience store

@ Gas station

@ Compressed Natural gas station

@ Liquefied petroleum gas station

@ Airport

- Cost of installation of hydrogen filling station in Japan

Installation :	500 million yen (3.6 million USD)
Subsidy of govt :	350 million yen (2.5 million USD)
Initial cost:	150 million yen (1.1 million USD)

Ref.
https://www.jhym.co.jp/station/
https://www.etic.co.jp/feature/hydrogen-station1118//

Case Study (Japan)

- Japanese EV makers analysis

Name	Area	Analysis
Toyota	Automobile	• Focused on PHEV, FCV & BEV. By 2025, Toyota will introduce EV (PHEV, BEV, FCV) in all models. • BEV for personal mobility (car for 1-2 passenger use), connected EV & MaaS (Mobility as a Service). • Creating EV platform called 'e-TNGA' with Subaru for efficiency of EV development.
Nissan	Automobile	• Nissan set goal of EV & e-POWER sales ratio as 30% by 2022. • Nissan developed a simple Hybrid system called 'e-POWER', which uses engine only for power creation. E-POWER can realize shorter charging time and cheap selling price. • Nissan also develops small EVs.
Panasonic	Electronics	• Operating EV battery factory 'GIGA factory' with Tesla. • In April 2022, Panasonic established 'Prime Planet Energy & Solutions' with Toyota to produce EV battery. • Panasonic launched EV with self-driving system called Spacy.
Prime Earth EV energy	Battery	• Toyota and Panasonic established together in 1996 to produce EV battery. • Increasing production capacity based on Toyota's plan. • A factory for HEV battery (nickel metal hydride battery) was established in 2021.

Case Study (Japan)

- Each Japanese makers analysis

Name	Area	Analysis
Prime Planet Energy & Solutions	Battery	• EV battery maker for Lithium-ion battery funded by Toyota (51%) and Panasonic (49%). • Developed EV battery for all-solid battery and started operation in April 2020. • Provide batteries not only for Toyota but also for other makers.
Denso	Electronic parts for automobile	• Toyota was agreed to business transfer and Denso of main electronic parts business (such as inverter, motor, semiconductor) to increase competitive advantage. • To develop auto driving car, Denso strength cooperation with Toyota.
Aishin Seiki	Powertrain	• For development of auto driving car, management integration with subsidiary named Aishin AW in April 2021, and changed company name to Aishin. Mass production of EV motor parts started in 2020 and supply the parts to Toyota EV production in China.
Hitachi Automotive Systems	Electronic parts for automobile	• Provide EV motor to GM (General Motors), Inverter to GM, Ford Motors, Mercedes, BMW etc. • In October 2019, management integration with Honda suppliers (Kehin, Nisshin Kogyo, and Showa) in purpose to become a maga player in the field of auto powertrain, chassis, self-drive, and ADAS (Advanced driver-assistance systems).

Case Study (Japan)

■ Each Japanese makers analysis

Name	Area	Analysis
Meidensha	Heavy power (Power equipment)	• Provide EV motor and inverter to Mitsubishi auto factory. • Invested 7 billion yen to equipment facility at 3 factories in 2018. • Invested to subsidiary Meidensha for EV production in China in 2019. • Established new factory development for motor and invertor with investment of 5 billion yen in Feb 2020.
NiDec	Motor	• Produce EV motor, and parts of together with motor and inverter. • Order of EV motor was rapidly increased by 2023, decided to expand production lines in Poland and Mexico in addition to a current factory in China.
Mitsubishi Electric	Electronics	• Provide inverter to Honda, Suzuki and Daimler. • Develop V2H (Vehicle to Home) system, that utilize EV battery for household power supply.
TDK Automotive Technologies	Inverter	• EV inverter maker funded by TDK (75%) and Toshiba (25%). • Provide inverter to Volkswagen and Ford Motors etc.

Ref. SPEEDA

Case Study (Barbados)

■ EV Dealers in Barbados

• Megapower Barbados
https://www.megapower365.com/

■ Private vehicles
MG
NISSAN
JAGUAR

■ Commercial vehicles
BYD (bus, van, trucks etc.)

• Courtesy Garage Barbados
https://www.courtesygarage.com/showroom/

■ Private vehicles
Hyundai (EV and HV)

NISSAN ARIYA (BEV)
@Megapower
150,000 BBD

NISSAN X-TRAIL (ICV)
@COURTESY
117,995 BBD

NISSAN JUKE 2015 (ICV)
@qv motors
55,900 BBD

Case Study (Barbados)

■ Cost of charging station

- 0.15 kWh/km to 0.2 kWh/km
- About 2,200 to 2,900 kWh of electricity per year
- About $1,300 to $1,700 per year in electricity based on our residential tariff

- Megapower rate

Top-up charger (Garo)	$1.5/kWh
Medium & fast chargers (DBT)	$1.75/kWh
All you can charge	$600/month
All you can charge (non-megapower Evs)	$1,000/month

- Charging speed
Ultra charger 100kW: 30-45 mins
Rapid charger 25kW: 2-3 hours
Fast charger 7.2kW 10-16 hours

■ Map of EV Charging Station

Ref) The Barbados Light & Power Company Limited, Megapower

Case Study (Barbados)

■ New Incentives of the Barbados Government

- Government workers who can borrow up to $100,000 interest-free for purchase an electric or hybrid vehicle (it was $50 000 for vehicle purchase)
- Tax and VAT holiday on electric vehicles for 24 from April 1, 2022. Also, 10% import duty for the next two years on the purchase of electric vehicles".

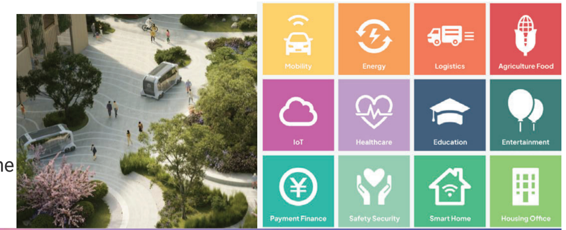
Ref) Electric cars tax breaks, but new alternate levy
https://barbadostoday.bb/2022/03/15/electric-cars-tax-breaks-but-new-alternate-levy/

5. Introduction of New Technology

Introduction of New Technology

■Toyota's Woven City: a Prototype City of the Future

YouTube Video:
https://www.youtube.com/watch?v=ng3X39lenvg



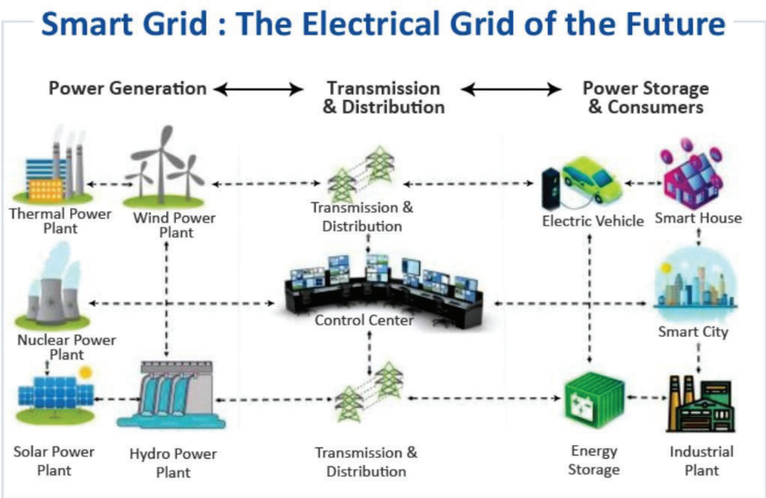
Toyota has revealed plans to build a prototype "city" of the future on a 175-acre site at the base of Mt. Fuji in Japan.

Called the Woven City, it will be a full connected ecosystem powered by hydrogen fuel cells. Envisioned as a "living laboratory," the Woven City will serve as a home to full-time residents and researchers who will be able to test and develop technologies such as autonomy, robotics, personal mobility, smart homes and artificial intelligence in a real-world environment.

Read more about Toyota's Woven C
https://blog.toyota.co.uk/toyota-wove...

Introduction of New Technology

Smart Grid is the integration of our existing Electrical Grid with **2-way communication** and **digital sensing technology** in order to enhance the capabilities of the current grid and make it more secure, reliable, efficient, and self-sufficient.



Introduction of New Technology

■Wireless Transmission

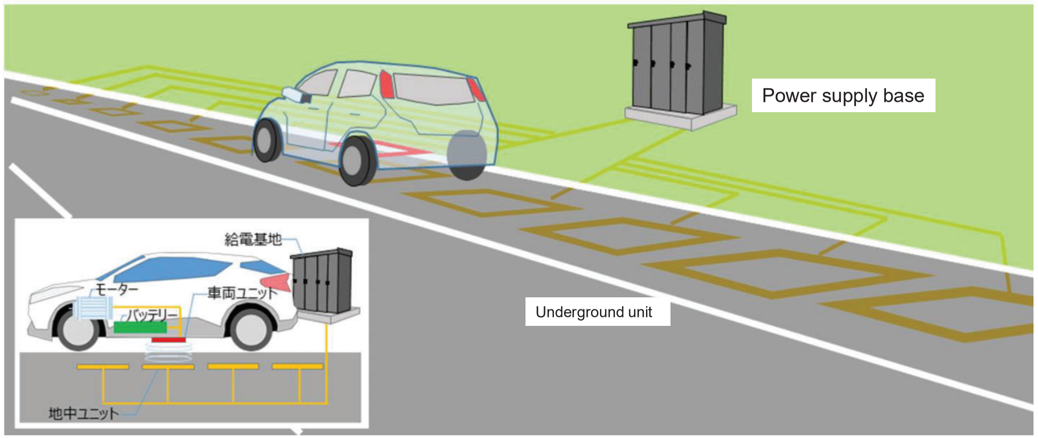


Image of wireless charging of EV

Ref) https://www.toyota.co.jp/jpn/tech/partner_robot/news/202112_01.html

Introduction of New Technology

Experiment of PV and wireless charging system

https://media.dglab.com/2022/05/02-dwpt-01/

Introduction of New Technology

■Wireless Transmission

Image of wireless transmission to a large flying object for use in a communication network

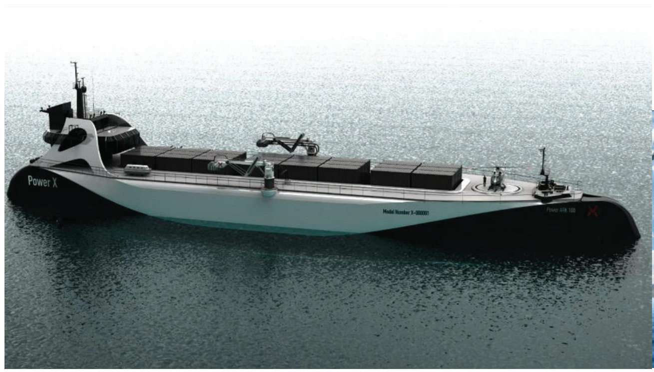
Image of wireless transmission to remote islands
*There is a plan to build a PV generation facility in space for wireless transmission.

Ref. https://www.ieice.org/~cs-edit/magazine/ieice/spsec/Bplus57_sp.pdf

Introduction of New Technology

■ Electric carrier ship

Power X is an electric carrier ship that stores electricity generated from the ocean in batteries and transports it. Power X Inc. manufactures and operates large storage batteries and deliver clean power generated by offshore wind power stations to around the world.
Conventional power transmission systems using submarine cables are problematic in terms of installation costs (e.g., drilling of the seabed) and environmental impact, but Power X does not require large-scale construction work and has minimal environmental impact.



Ref. Power X, PowerX, Inc. (power-x.jp)

Thank you!

Anna Miyaura (Ms.)
JICA Expert of Human Resources Development/Monitoring
Project Consultant @PADECO
amiyaura@padeco.co.jp

Appendix 4-1-2 Attendant list of the 1st Energy Efficiency Workshop (Barbados)

Attendant List

Project: Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

Meeting Title:
Energy Efficiency Workshop for Barbados

Venue: Dover Beach Hotel, Bridge town Date: 11/23/2022 Time: 10AM - 3PM

No	Name	Organization	Title	E-mail	Signature
1	FABIAN SCOTT	BNSI	Mr	[redacted]	
2	DAMIEN PRESCOD	BNSI	Metrologist	[redacted]	
3	CHARMAINE GILLEANS	BLPC	Engineer	[redacted]	
4	ALEX HAREWOOD	JET	Technical Asst.	[redacted]	
5	Natasha Corbin	UWI	Project Officer	[redacted]	
6	Danielle Evanson	UWI	Researcher	[redacted]	
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20					

Energy Efficiency & Conservation (EEC) Materiel Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

- Energy Consumption Analysis & EEC Roadmap -

Barbados, January 2023

Nippon Koei Co., Ltd.
PADECO Co., Ltd.

Contents

1. Energy Consumption Analysis from Energy Balance Table

Energy Consumption Analysis from Energy Balance Table

- **Current situation :Energy consumption outlook by sector and energy source**
  - **Transportation is the largest energy consuming sector (33%) followed by Commercial & public service sector (28%) and residential sector (19%).**
  - **Electricity is the largest energy source (52%)** followed by oil (43%).

Energy consumption by sector and energy source on primary energy basis (2019, ktoe)

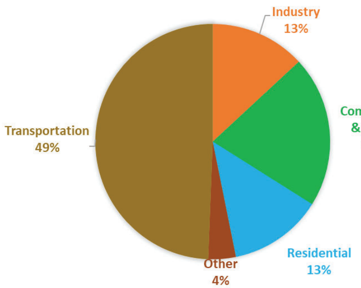
	Industry	Commercial & public	Residential	Other	Transportation	Total	
Oil	20	15	8	1	141	185	43%
Natural gas	1	10	2	0	0	12	3%
Bio/waste	7	0	0	1	0	8	2%
Charcoal	0.0	0.0	0.2	0.0	0.0	0.2	0%
Electricity (Primary energy basis)	28	97	72	26	0	223	52%
Total	55	122	83	27	141	428	100%
	13%	28%	19%	6%	33%	100%	

Note 1: Primary energy conversion factor of electricity is utilized to evaluate the effect of energy saving by reduction of 1kWh of electricity consumption at demand side.
Note 2: To calculate primary energy consumption of electricity, energy efficiency at end use (36.3%) was used based on the material by Government of Barbados.
Source: JET with reference to energy balances (2019) by United Nations Statistics Division for overall energy balance and the material above mentioned (Note 2) for primary energy conversion factor calculation of electricity.
https://unstats.un.org/unsd/energystats/dataPortal/

Energy Consumption Analysis from Energy Balance Table

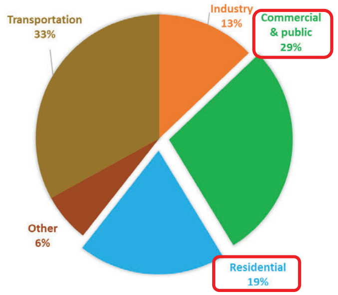
- Energy consumption should be evaluated on primary energy basis.
- Commercial & residential sectors share about half of the primary energy consumption.

Energy consumption by sector on final consumption basis (2019)



1 kWh consumption corresponds to 2.75 kWh as primary energy supply.
• 1 kWh / 0.363 =2.75 kWh

Energy consumption by sector on primary energy basis (2019)

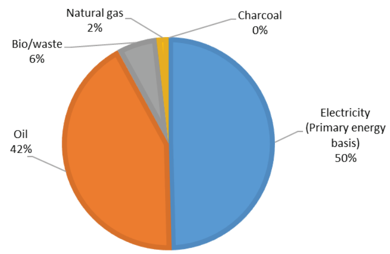


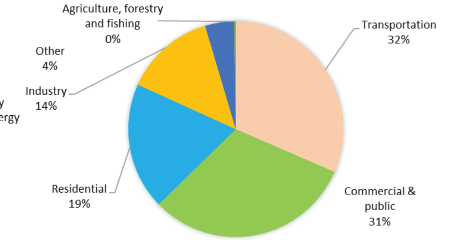
Source: JET with reference to energy balances (2019) by United Nations Statistics Division for overall energy balance.

Energy Consumption Analysis from Energy Balance Table

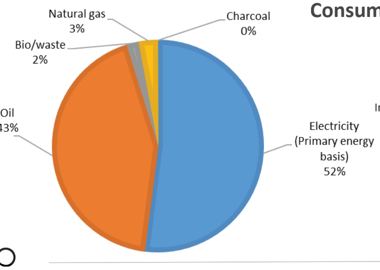
- No particular change has been observed in energy consumption by fuel nor by sector between 2010 and 2019 on primary basis.

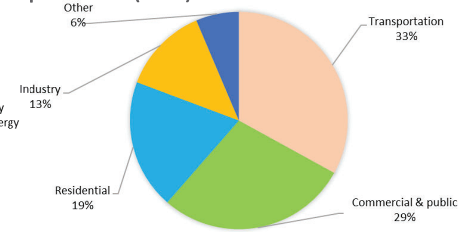
Energy Consumption by Fuel (left) and by Sector (right) on Primary Energy Consumption Basis (2010)





Energy Consumption by Fuel (left) and by Sector (right) on Primary Energy Consumption Basis (2019)





Energy Consumption Analysis from Energy Balance Table

Energy Consumption by Fuel and by Sector on Primary Energy Consumption Basis (2010)

	Industry	Commercial & public	Residential	Other	Transportation	Agriculture, forestry and fishing	Total	
Oil	820	723	487	25	6,045	47	8,147	42%
Natural gas	25	240	80	0	0	0	345	2%
Bio/waste	1,146	0	11	29	0	0	1,186	6%
Charcoal	0	0	0	0	0	0	0	0%
Electricity (Primary energy basis)	623	5,036	3,077	785	0	0	9,521	50%
Total	2,614	5,999	3,655	839	6,045	47	19,199	100%
	14%	31%	19%	4%	31%	0%	100%	

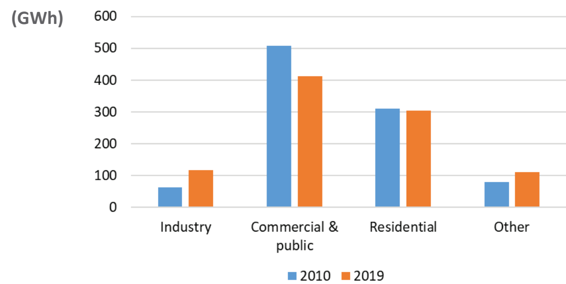
Energy Consumption by Fuel and by Sector on Primary Energy Consumption Basis (2019)

	Industry	Commercial & public	Residential	Other	Transportation	Total	
Oil	821	616	351	36	5,937	7,761	43%
Natural gas	22	402	94	0	0	518	3%
Bio/waste	312	0	0	27	0	339	2%
Charcoal	0	0	9	0	0	9	0%
Electricity (Primary energy basis)	1,163	4,091	3,019	1,085	0	9,358	52%
Total	2,318	5,109	3,473	1,148	5,937	17,985	100%
	13%	28%	19%	6%	33%	100%	

Energy Consumption Analysis from Energy Balance Table

- Electric power consumption was reduced by 2% between 2010 and 2019, some changes have been observed by sector:
  - Industry: Increased by 87%
  - Commercial: Decreased by 19%
  - Residential: Decreased by 2%

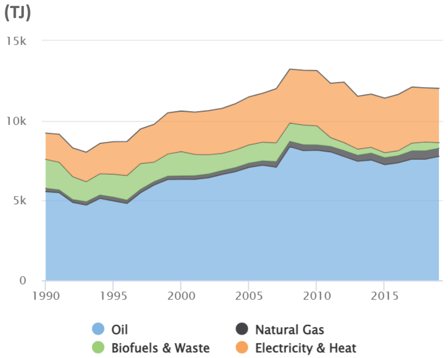
Changes in Electric Power Consumption by Sector from 2010 to 2019



Energy Consumption Analysis from Energy Balance Table

- **Electricity and oil consumption have decreased slightly while natural gas consumption have been increasing during 2010 – 2019.**
- **Biofuel & waste consumption has decreased significantly.**
- **As total, final consumption was reduced by 1.0 % during 2010 – 2019.**

Final Consumption by Fuel



Trend of Final Consumption by Fuel (2010 – 2019)

(TJ)

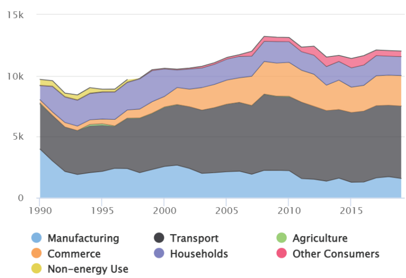
	2010	Share	2019	Share	AAGR
Electricity	3456	26%	3398	28%	-0.2%
Biofuels & Waste	1186	9%	348	3%	-12.7%
Natural Gas	346	3%	518	4%	4.6%
Oil	8148	62%	7761	65%	-0.5%
Total	13136	100%	12025	100%	-1.0%

Note: AAGR = Annual Average Growth Rate

Energy Consumption Analysis from Energy Balance Table

- **Most of major sectors reduced final energy consumption and the industry sector is the largest among all (AAGR = -3.9%) during 2010 – 2019.**

Final Consumption by Sector

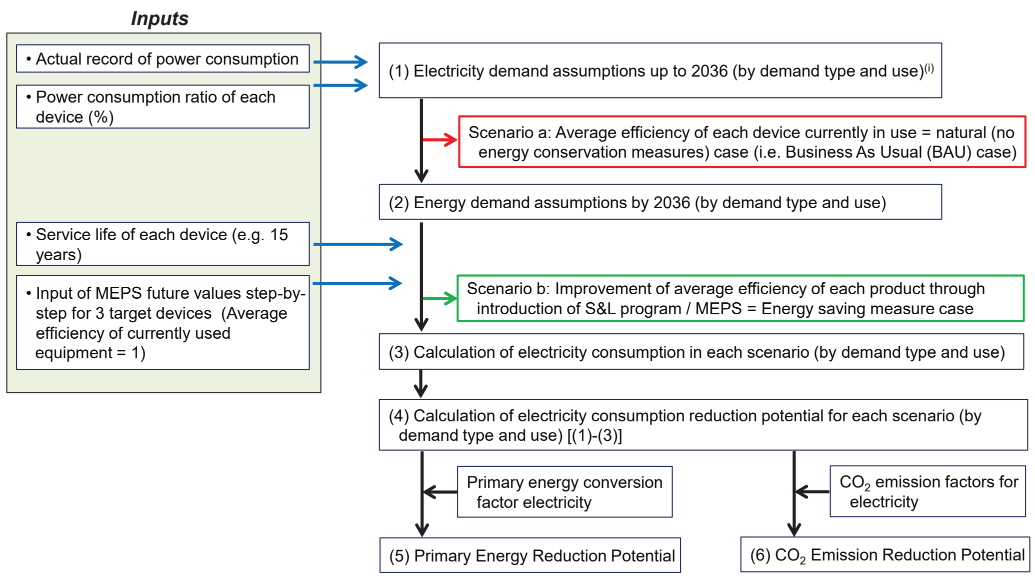


Trend of Final Consumption by Sector (2010 – 2019)

	2010	Share	2019	Share	AAGR
Transport	6045	46%	5937	49%	-0.2%
Commerce	2791	21%	2503	21%	-1.2%
Households	1695	13%	1550	13%	-1.0%
Industry	2217	17%	1557	13%	-3.9%
Agriculture	47	0%	0	0%	-100.0%
Other consumers	340	3%	457	4%	3.3%
Total	13135	100%	12004	100%	-1.0%

2. Energy Efficiency & Conservation Roadmap -Residential Sector-

Energy Efficiency & Conservation (EEC) Roadmap

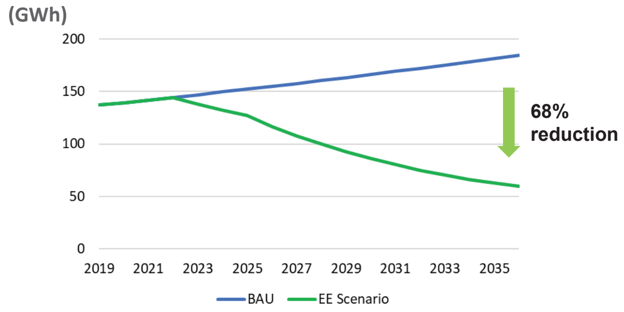


(i) Source:1 Barbados Country Energy Balance Table (UN),
Source 2: Long-Term Peak Power Outlook: Report submitted to Prime Minister's Office, Government of Barbados (Mar 2017),
Note: the report does not present EEC measure scenarios.

Energy Efficiency & Conservation (EEC) Roadmap

- Electric power consumption of refrigerator has been estimated to be **reduced by 68%** with EE Scenario compared with BAU Scenario.
- Energy efficiency of refrigerator in use at households will be **3.1 times more efficient** compared with that of currently used in 2036 in EE Scenario with Introduction of MEPS.

Electric Power Consumption by Refrigerator up to 2036 (BAU and EE Scenario)



Assumed MEPS (EE Index) introduction for refrigerator in EE Scenario

EE index	
Present	1
2023	2
2026	3
2029	3.5
2032	4

Average EE index currently used at all households (Present)

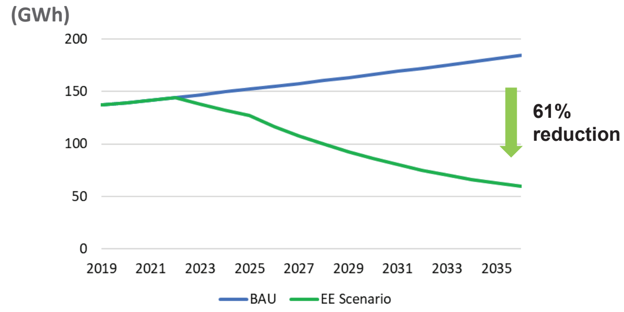
Assumed stepwise introduction of MEPS (2023–2032)

Average EE index will be 3.1 in 2036 used at all households

Energy Efficiency & Conservation (EEC) Roadmap

- Electric power consumption of air conditioner has been estimated to be **reduced by 61%** with EE Scenario compared with BAU Scenario.
- Energy efficiency of air conditioner in use at households will be **2.6 times more efficient** compared with that of currently used in 2036 in EE Scenario with Introduction of MEPS.

Electric Power Consumption by Air Conditioner up to 2036 (BAU and EE Scenario)



Assumed MEPS (EE Index) introduction for air conditioner in EE Scenario

EE index	
Present	1
2023	2
2026	2.5
2029	3

Average EE index currently used at all households (Present)

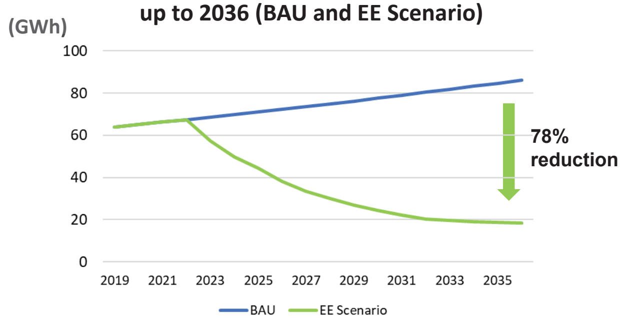
Assumed stepwise introduction of MEPS (2023–2029)

Average EE index will be 2.6 in 2036 used at all households

Energy Efficiency & Conservation (EEC) Roadmap

- Electric power consumption of lighting equipment has been estimated to be **reduced by 78%** with EE Scenario compared with BAU Scenario.
- Energy efficiency of lighting equipment in use at households will be **4.7 times more efficient** compared with that of currently used in 2036 in EE Scenario with Introduction of MEPS.

Electric Power Consumption by Lighting Equipment up to 2036 (BAU and EE Scenario)



Assumed MEPS (EE Index) introduction for lighting equipment in EE Scenario

EE index	
Present	1
2023	3
2026	4
2029	4.5
2032	5

Average EE index currently used at all households (Present)

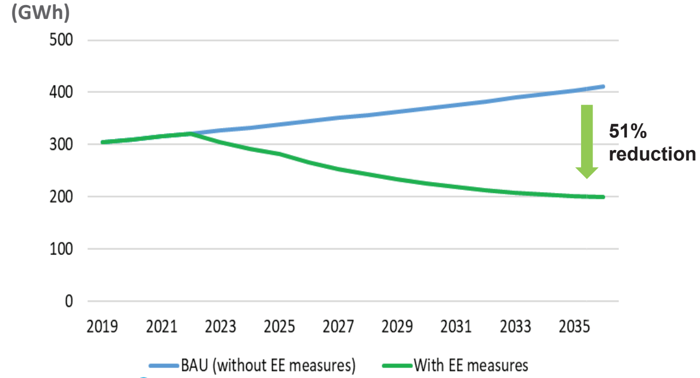
Assumed stepwise introduction of MEPS (2023–2032)

Average EE index will be 4.65 in 2036 used at all households

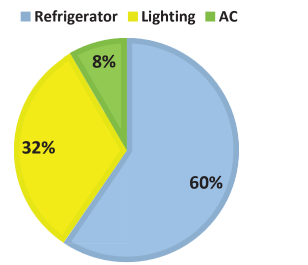
Energy Efficiency & Conservation(EEC) Roadmap

- With MEPS introduction targeting refrigerator, lighting equipment and air conditioner, it has been estimated power consumption will be **reduced by 51% in 2036.**

Energy Saving Potential in Residential Sector up to 2036 (BAU and EE Scenario)



Energy Saving Ratio by Appliance in 2036 (EE Scenario)

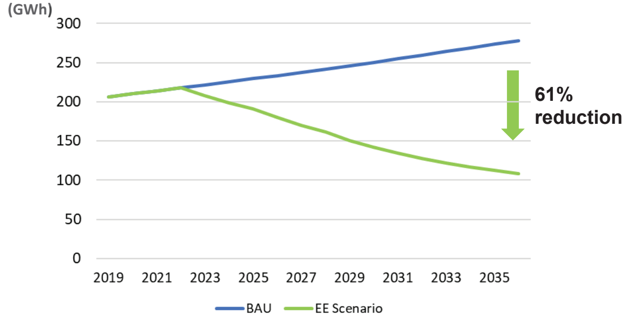


3. Energy Efficiency & Conservation Roadmap -Commercial Sector-

Energy Efficiency & Conservation Roadmap -Commercial-

- Electric power consumption of air conditioner has been estimated to be **reduced by 61%** with EE Scenario compared with BAU Scenario.
- Energy efficiency of air conditioner in use at households will be **2.6 times more efficient** compared with that of currently used in 2036 in EE Scenario with Introduction of MEPS.

Electric Power Consumption by Air Conditioner up to 2036 (BAU and EE Scenario)



Assumed MEPS (EE Index) introduction for air conditioner in EE Scenario

	EE index
Present	1
2023	2
2026	2.5
2029	3

Present: Average EE index currently used in commercial field

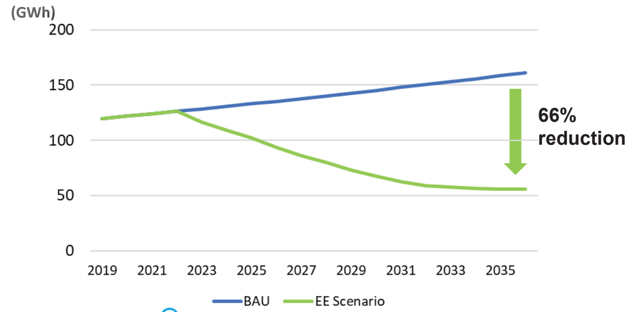
2023–2029: Assumed stepwise introduction of MEPS

Average EE index will be 2.6 in 2036 used in commercial field

Energy Efficiency & Conservation Roadmap -Commercial-

- Electric power consumption of lighting equipment has been estimated to be **reduced by 66%** with EE Scenario compared with BAU Scenario.
- Energy efficiency of lighting equipment in use at households will be **2.9 times more efficient** compared with that of currently used in 2036 in EE Scenario with Introduction of MEPS.

Electric Power Consumption by Lighting Equipment up to 2036 (BAU and EE Scenario)



Assumed MEPS (EE Index) introduction for lighting equipment in EE Scenario

	EE index
Present	1
2023	2
2026	2.5
2029	3

Present: Average EE index currently used in commercial field

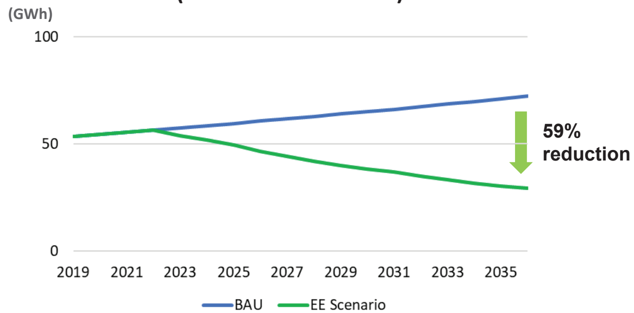
2023–2029: Assumed stepwise introduction of MEPS

Average EE index will be 2.9 in 2036 used in commercial field

Energy Efficiency & Conservation Roadmap -Commercial-

- Electric power consumption of refrigerator has been estimated to be **reduced by 59%** with EE Scenario compared with BAU Scenario.
- Energy efficiency of refrigerator in use at commercial field will be **2.5 times more efficient** compared with that of currently used in 2036 in EE Scenario with Introduction of MEPS.

Electric Power Consumption by Refrigerator up to 2036 (BAU and EE Scenario)



Assumed MEPS (EE Index) introduction for refrigerator in EE Scenario

	EE index
Present	1
2023	2
2026	2.5
2032	3

Present: Average EE index currently used in commercial field

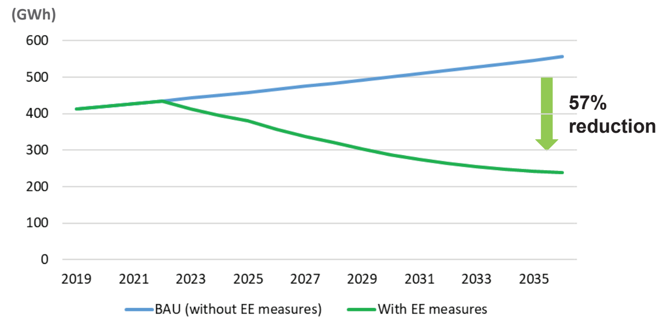
2023–2032: Assumed stepwise introduction of MEPS

Average EE index will be 2.5 in 2036 used in commercial field

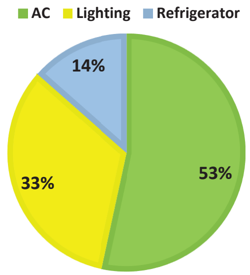
Energy Efficiency & Conservation Roadmap -Commercial-

- With MEPS introduction targeting refrigerator, lighting equipment and air conditioner, it has been estimated power consumption will be reduced by 57% in 2036.

Energy Saving Potential in Commercial Sector up to 2036 (BAU and EE Scenario)



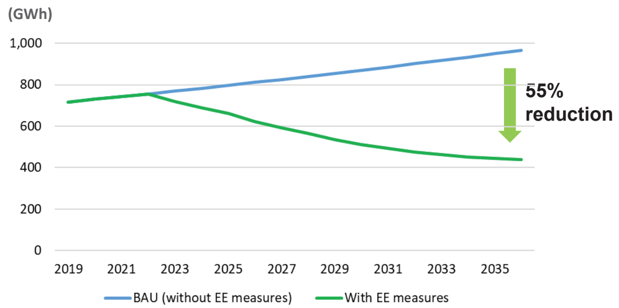
Energy Saving Share by Equipment in 2036 (EE Scenario)



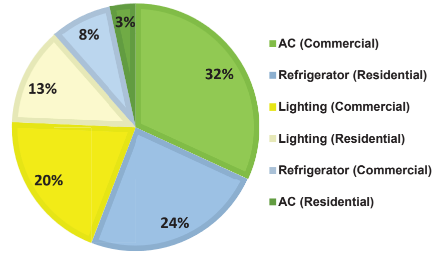
EE&C Roadmap -Residential + Commercial Sectors-

- With MEPS introduction targeting refrigerator, lighting equipment and air conditioner, it has been estimated power consumption will be reduced by 55% in residential and commercial sectors in 2036.

Energy Saving Potential in Residential + Commercial Sector up to 2036 (BAU and EE Scenario)



Energy Saving Share by Equipment and Sector in 2036 (EE Scenario)

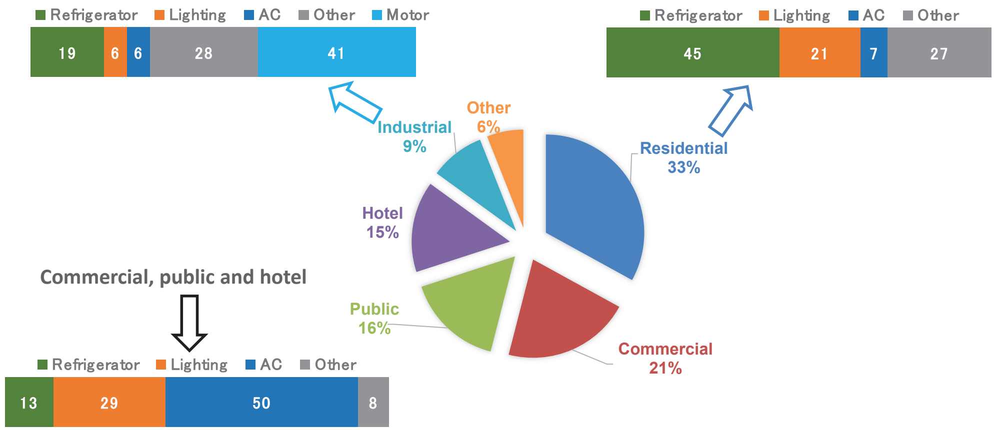


AC (R+C)	35%
Lighting (R+C)	33%
Refrigerator (R+C)	32%

Energy Efficiency & Conservation(EEC) Roadmap

- Current situation: Electricity consumption by sector and end-use

Electricity sales by demand group (last 10 years) and end-use



Source: JET with reference to Barbados NATIONAL ENEGY POLICY (2019-2030) and material by the Government of Barbados

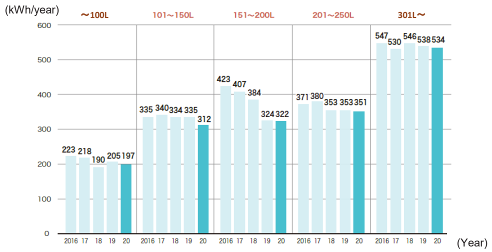
4. Promising Energy Efficient Technologies in non-industrial sectors

Trends of EE Improvement of Refrigerator (Res), Japan

Trends in Annual Energy Consumption of Refrigerator (401 –450ℓ, 2003 - 2013)

Source: Energy Saving Catalogue 2014 Summer (METI)

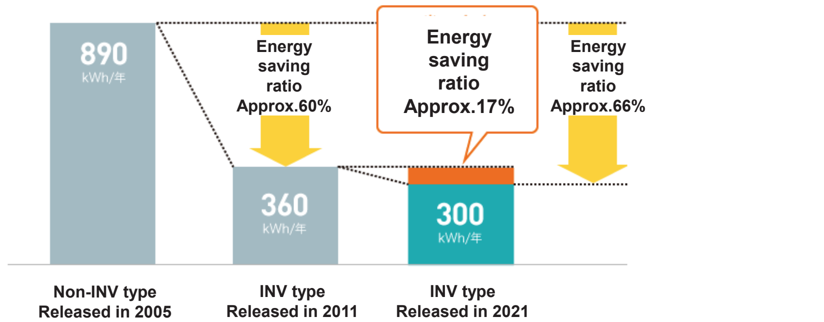
Trends in Annual Energy Consumption (2016 – 2020)



Source: Energy Saving Catalogue 2021 (METI)

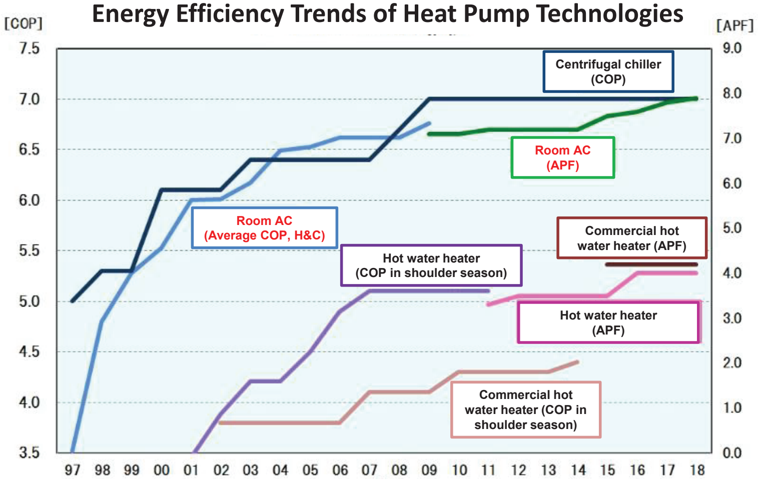
EE Improvement of Refrigerator (Commercial), Japan

Comparison of Annual Energy Consumption of Refrigerator (Commercial)



Source: HOSHIZAKI CORPORATION

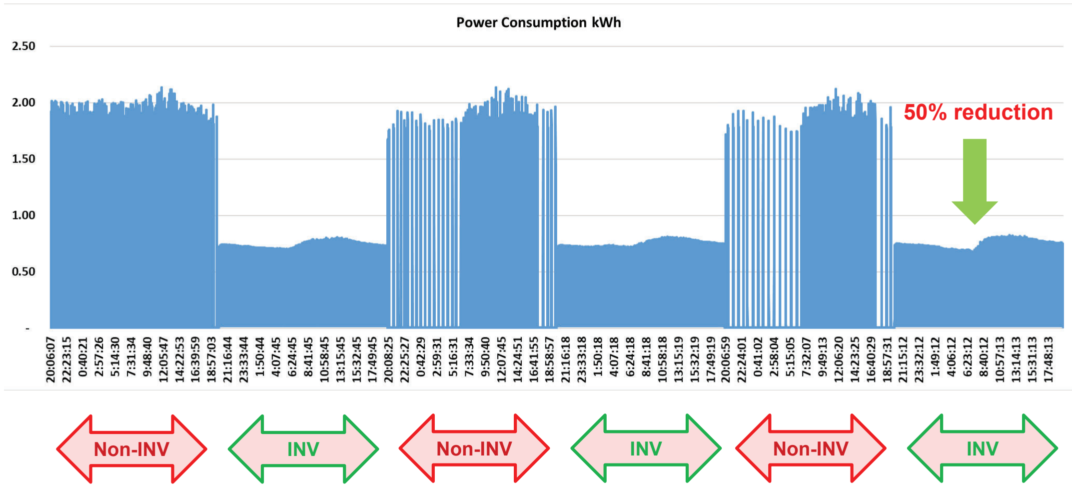
Trends of EE Improvement of various ACs, Japan



Source: Manufactures' Catalogue, Energy Saving Catalogue (METI)

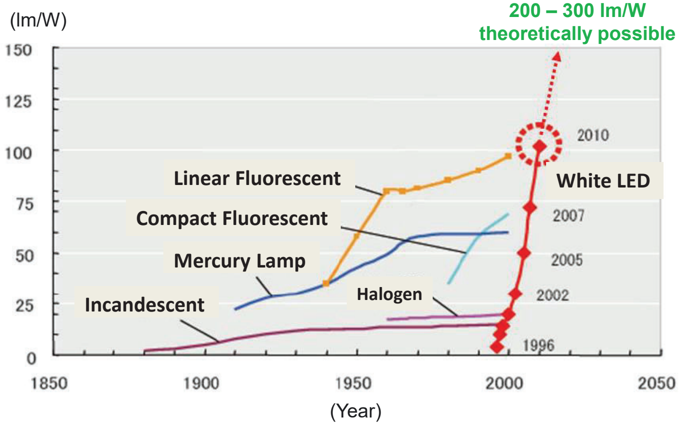
Note 1: COP stands for Coefficient of Performance, energy efficiency at rated operation (kWh/kWh)
Note 2: APF stands for Annual Performance Factor, energy efficiency throughout a year (kWh/kWh)

Results of Comparison Experiment, INV vs Non-INV AC



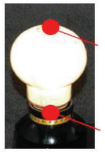
Trends of EE Improvement of Lighting Equipment, Japan

Trends of Luminous Efficiency



Source: Ministry of Economy and Trade and Industry, METI

Comparison of heat generation (Incandescent lamp vs LED lamp)

Incandescent Lamp (810 lm, 54W)	LED lamp (810 lm, 9W)
30 minutes after lighting	
 80 ℃ / 110 ℃	 26 ℃ / 55℃

Contributes less AC demand

Introduction Examples of LED streetlamps (1)

Daytime view

Road width	4.8 m
Installation interval	Approx. 35 m
Installation height	Approx. 4.5 m

Before refurbishment: Mercury lamp 80W

Horizontal plane (average)		2.75 Lux
Vertical plane (Min.)	Road center	0.41 Lux
	Both sides of the road	0.39 Lux

After refurbishment: LED 33W

Horizontal plane (average)		7.09 Lux
Vertical plane (Min.)	Road center	1.59 Lux
	Both sides of the road	1.49 Lux

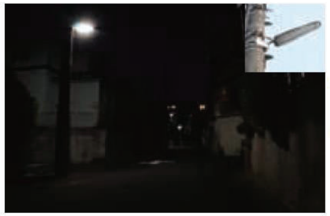
Source: Japan security systems association

Introduction Examples of LED streetlamps (2)

Daytime view

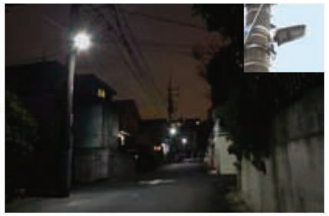
Road width	5.1 m
Installation interval	Approx. 30 m
Installation height	Approx. 5.0 m

Before refurbishment: CFL 20W



Horizontal plane (average)		1.76 Lux
Vertical plane (Min.)	Road center	0.17 Lux
	Both sides of the road	0.12 Lux

After refurbishment: LED 17W



Horizontal plane (average)		5.56 Lux
Vertical plane (Min.)	Road center	0.78 Lux
	Both sides of the road	0.64 Lux

Source: Japan security systems association

Introduction Examples of LED on Highways

Source: IWASAKI ELECTRIC CO., LTD.

5. References

EEC Implementation Best Practice - Commercial Sector -

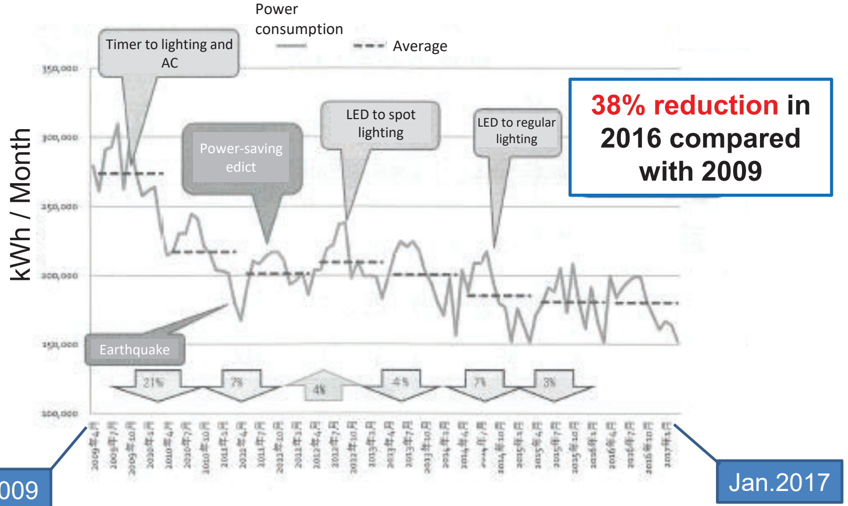
- **Outline of the building**
  - **Location: Tokyo**
  - **Floor area: 19,550m²**
  - **Building structure: RC (Basement 1F – 4 floors)**
  - **AC system: DHC (District Heating and Cooling) + AC units (partially)**
  - **Number of workers: Approx.200 persons**

- EEC approaches (STEP by STEP)
  - Introduction of auto timer to lighting and AC in 2009. (ON/OFF switch was operated manually in the past)
  - Introduction of LED to spot lighting equipment (approx. 1,000 units) in 2012
  - Introduction of LED to regular lighting equipment (approx. 2,000 units) in 2014

EEC Implementation Best Practice - Commercial Sector -

Trend of Power Consumption Reductions

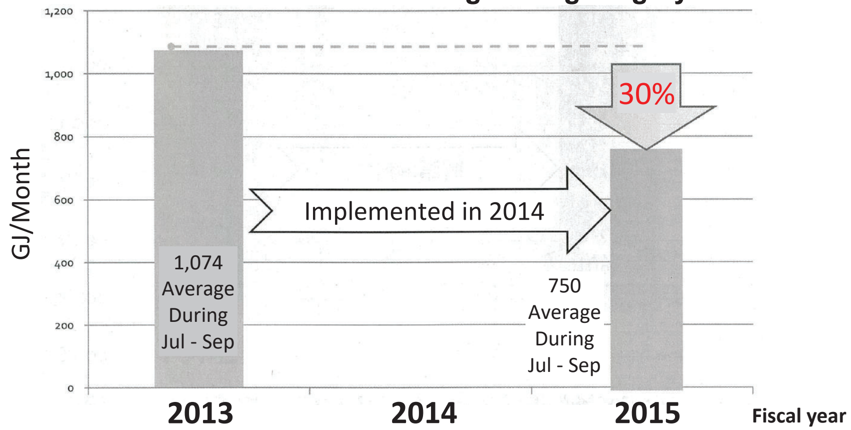
(approx.8years: Apr.2009-Jan.2017)



Source: The Consultant based on the material by the Tokyo metropolitan government (Jul.2017)

EEC Implementation Best Practice - Commercial Sector -

Effects on Cooling Demand Reductions with Introduction of LED to Regular Lighting System



Source: JET based on the material by the Tokyo Metropolitan government (Jul.2017)

Introduction of LED realized reductions of waste heat from lighting equipment and achieved cooling demand reductions (30%) in summer.

EEC Implementation Best Practice - Commercial Sector -

Evaluation of Energy Consumption Reductions on Primary Energy Basis

	Before		After		Primary energy consumption reductions
Energy	2009	2013	2015	2016	
Electric power consumption	275 MWh x 12 = 3,300 MWh/year			171 MWh x 12 = 2,052 MWh/year	
Primary energy consumption	3,300 x 9.97 = **32,901** GJ/year			2,052 x 9.97 = **20,458** GJ/year	32,901 – 20,458 = **12,443 GJ/year**
Cooling& heating demand		445 GJ x 12 = 5,340 GJ/year	325 GJ x 12 = 3,900 GJ/year		
Primary energy consumption		5,340 GJ x 1.36 =**7,262** GJ/year	3,900 GJ x 1.36 =**5,304** GJ/year		7,262 – 5,304 = **1,958 GJ/year**
Total	32,901 + 7,262 = 40,163 GJ/year		20,458 + 5,304 = 25,762 GJ/year		**14,401 GJ/year (36%)**

Note1: Calculation was made by JET
Note2: Conversion factors for electric power and DHC were based on the guide for completing periodical report regarding EE law . (METI, Aug.2017)
Note3: Changes of both heating and cooling demands by the introduction of LED are taken into account.
Source: JET based on the material by the Tokyo Metropolitan government (Jul.2017)

Thank you very much for your kind attention !

Energy Efficiency & Conservation (EEC) Materiel Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

- Energy Efficiency Building Code -

Barbados, January 2023

Nippon Koei Co., Ltd.
PADECO Co., Ltd.

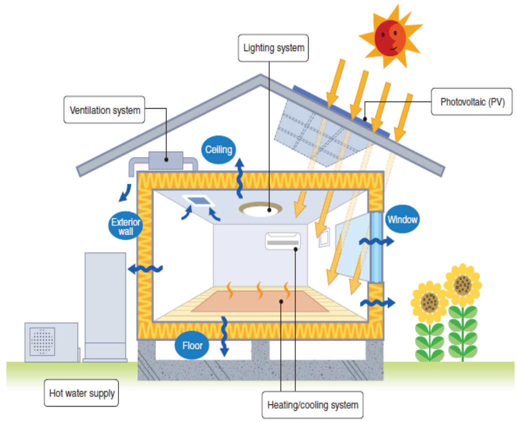
Contents

1. Outline of EE Regulations in Residential Building

- **Overview of the Energy Efficiency Standards for Residential Buildings**

The evaluation of energy efficiency (EE) performance for residential buildings uses the following two standards:

- Standards to evaluate **envelope performance** (e.g. windows, exterior walls of residential buildings
- Standards to evaluate the **primary energy consumption amount of equipment and appliances** etc.

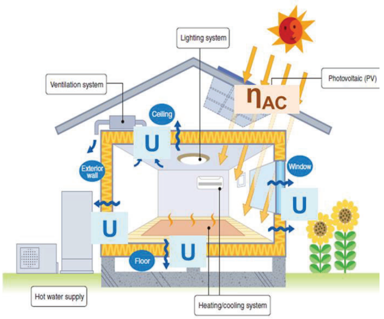


Envelope performance

- Average outer shell heat transmission coefficient (U_A)

$$U_A \; (W/m^2 \cdot K) = \frac{\text{Amount of total heat loss per unit of temperature difference}}{\text{Total surface area of exterior}}$$

- U_A
  - ✓ An indicator of the ease of heat transfer between indoor and outdoor air.
  - ✓ When the temperature difference between the inside and outside of the building is 1 °C, the amount of heat released per unit time from the inside of the building to the outside of building is divided by the total surface area of exterior.
  - ✓ **The smaller the value**, the more difficult it is for heat to enter and exit, and the **higher the insulation performance**.

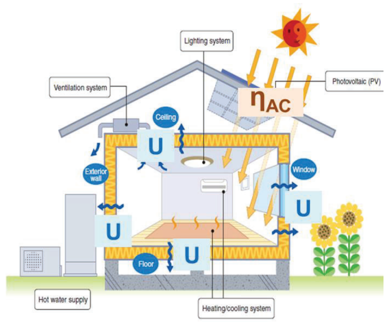


Envelope performance

- Average solar heat gain coefficient during cooling period (η_{AC})

$$\eta_{AC} \; (-) = \frac{\text{Amount of total solar heat gain per unit of solar radiation intensity}}{\text{Total surface area of exterior}} \times 100$$

- η_{AC}
  - ✓ An indicator of how easily solar radiation enters the room.
  - ✓ Amount of heat acquired inside the building from solar radiation per unit of solar radiation intensity averaged by the cooling season and divided by the total surface area of exterior.
  - ✓ **The smaller the value**, the less sunlight enters and the **higher the shielding performance**.

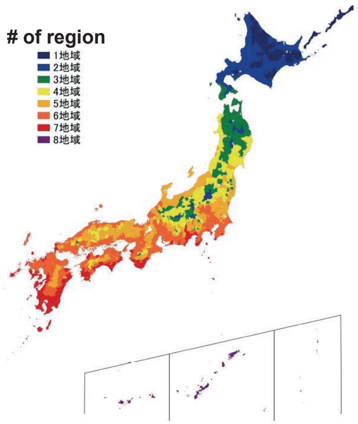


JICA

❑ **Envelope performance**

U_A	Design Value	≦	Standard Value
η_{AC}	Design Value	≦	Standard Value

✓ **Standard values of U_A and η_{AC} are defined by region by region. (regions are classified in 8 regions in Japan)**



Region	1&2	3	4	5	6	7	8
Standard Value of U_A	0.46	0.56	0.75	0.87	0.87	0.87	-
Standard Value of η_{AC}	-	-	-	3.0	2.8	2.7	6.7

Revised in Apr.2020 as previous value was too strict (3.2)

JICA

● **Primary energy consumption amount**

+ heating/cooling system primary energy consumption amount
+ ventilation system primary energy consumption amount
+ lighting system primary energy consumption amount
+ hot water supply primary energy consumption amount
+ other (household appliances) primary energy consumption amount
- reduction amount of primary energy consumption through PV, etc

= **primary energy consumption amount**

❑ **Evaluation of primary energy consumption amount**

$$\frac{\text{Design value (excludes home appliances etc.)}}{\text{Standard value (excludes home appliances etc.)}} \leqq 1.0$$

JICA

❑ **Promulgated on June 17, 2022 (Ministry of Land, Infrastructure, Transport and Tourism Housing Bureau**

➢ Mandate that **all new residential and nonresidential buildings** comply with EEC standards

➢ Conducted as part of the building permit process, integrated with the structural safety regulation conformity assessment.

➢ **Enforcement will be made by FY2025**, while ensuring a sufficient preparation period in consideration of small and medium-sized construction firms and the development of the screening system.

	current	
	Non-residential	Residential
large-scale 2,000m² or more	Compliance obligation	Notification obligation
mid-scale	Compliance obligation	Notification obligation
Less than 300m² small scale	Explanation obligation	Explanation obligation

➡

	revision	
	Non-residential	Residential
large-scale 2,000m² or more	Compliance obligation	Compliance obligation
mid-scale	Compliance obligation	Compliance obligation
Less than 300m² small scale	Compliance obligation	Compliance obligation

JICA

2. Examples of Simplified Calculation in Residential Building (6 Region)

Simplified Calculation

Envelope performance

Region	Legend of sheet number
6 Region	6 − 1 − 1 Category 1: Wooden 2: Reinforced Steel, Steel, etc. 1: Floor-insulated dwelling (Bathroom floor insulation) 2: Floor-insulated dwelling (Bathroom foundation insulation) 3: Floor-insulated dwelling (no bathroom floor in contact with outside air, etc.) 4: Foundation-insulated dwelling
wooden	

Average heat transmission coefficient U_A

Please fill in the values in the bold frame below.

In the case where a single part has several different specifications, the heat transfer coefficient shall be that of the specification with the largest heat transfer coefficient. If the area of a window is less than or equal to the total floor area of the unit dwelling multiplied by 0.02, the window specification concerned may be excluded.

				Heat transmission coefficient U		Result	
Roof or ceiling		0.194	×	0.258	=	0.051	(1)
Outer wall	general section	0.489	×	0.430	=	0.211	(2)
	Foundation wall (Entrance)	0.004	×	4.11	=	0.017	(3)
Floor	Bathroom	0.009	×	3.34	=	0.031	(4)
	Other Floors	0.121	×	0.492	=	0.060	(5)
Window		0.107	×	2.91	=	0.312	(6)
Door		0.014	×	3.49	=	0.049	(7)

↑ Rounded up to the fourth decimal place

				Linear thermal transmittance ψ		Result	
Periphery of dirt floor, etc.	Entrance etc.	0.021	×	0.99	=	0.021	(8)

↑Rounded up to the fourth decimal place

Average heat transmission coefficient of envelope: U_A [W/(m^2·K)] Sum of (1)-(8) = 0.76

*Rounded up to the third decimal place (Conforming if the standard value is 0.87 [W/(m^2·K)] or less)

Average solar heat gain during cooling season η_{AC}

Please fill in the values in the bold frame below.

If a site has several different specifications, the thermal transmittance of the specification with the largest thermal transmittance should be used.
If a window has several different specifications, the vertical solar heat gain shall be the vertical solar heat gain of the specification with the largest vertical solar heat gain. If the area of a window is less than or equal to the total floor area of the unit dwelling multiplied by 0.04, the window specification concerned may be excluded.

				Heat transmission coefficient U		Result	
Roof or ceiling		0.659	×	0.258	=	0.171	(9)
Outer wall	General section	0.762	×	0.430	=	0.328	(10)
	Foundation Wall (Entrance)	0.004	×	4.11	=	0.017	(11)
Door		0.020	×	3.49	=	0.070	(12)

↑Rounded up to the fourth decimal place

			Coefficient of Vertical Surface Solar Heat Gain Coefficient η_d		Results	
Window	4.356	×	0.32		1.394	(13)

↑Rounded up to the fourth decimal place

Average solar heat gain during cooling season η_{AC} [-] Sum of (9)-(13) = 2.0

*Rounds up to the second decimal place (Conforming if the standard value is 2.8 [-] or less)

Average solar heat gain during the heating season η_{AH}

Please enter the values in the bold boxes below.

If a site has several different specifications, the thermal transmittance of the specification with the largest thermal transmittance should be used.
If a window has several different specifications, the vertical surface solar heat gain shall be that of the specification with the lowest vertical surface solar heat gain. If the area of the window is less than or equal to the total floor area of the unit dwelling multiplied by 0.04, the window specification concerned may be excluded.

				Heat transmission coefficient U		Result	
Roof or ceiling		0.658	×	0.258	=	0.169	(14)
Outer wall	general section	0.882	×	0.430	=	0.379	(15)
	Foundation Wall (Entrance)	0.002	×	4.11	=	0.008	(16)
door (Western-style)		0.014	×	3.49	=	0.048	(17)

↑Rounded down to the fourth decimal place

			Coefficient of Vertical Surface Solar Heat Gain Coefficient η_d		Results	
window	4.786	×	0.32	=	1,531	(18)

↑Rounded down to the fourth decimal place

Average solar heat gain during the heating season η_{AH} [-] Sum of (14)-(18) = 2.1

*Rounded down to the second decimal place (Reference value: None)

Simplified Calculation
Primary energy consumption performance

6 Region

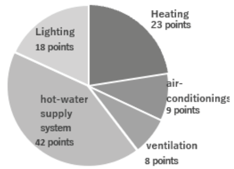
Sheet No.	Principal living space	Other living space
6-ENE-1	Not installed	
6-ENE-2	Room air conditioner	
6-ENE-3	Hot water floor heating (Oil latent heat recovery hot water heater)	Room air conditioner
6-EN-4	Hot water floor heating (Gas latent heat recovery hot water heater)	Room air conditioner

Please fill in the envelope performance.

Please fill in the figures in the bold frame below.

Average heat transmission coefficient U_A [W/(㎡・K)]	0.76
Average solar heat gain during cooling season η_{AC} [-]	2.0
Average solar heat gain during the heating season η_{AH} [-]	2.1

From the Point Listing page, post the points you selected in (1) through (5) in the bolded box below and calculate the total.



Reference] Approximate points for each facility (excluding other facilities)

Please fill in the points in the bold frame below.

heating facilities	Transcribe the numbers in (1)	=	29	(a)
air-conditioning facilities	Transcribe the numbers in (2)	=	10	(b)
ventilation equipment	Transcribe the numbers in (3)	=	8	(c)
hot-water supply system	Transcribe the numbers in (4)	=	36	(d)
Lighting equipment	Transcribe the numbers in (5)	=	10	(e)

Primary energy consumption performance points Total of (a)-(e) = 93

(Conforming If less than or equal to 100 points)

(1) Envelope performance and heating system

*Confirm the average heat transmission coefficient and the average solar heat gain during the heating season for the house in question, and check the points of the heating equipment with ☑ the relevant envelope performance value. (However, only if the average solar heat gain during the heating season is 1.8 or higher.

Average heat transmission coefficient U_A [W/(㎡・K)]	Average solar heat gain during the heating season η_{AH} [-]	point
✔ Greater than 0.69 0.78 or less	✔ 1.8 or higher Less than 2.3	29
	☐ 2.3 or higher Less than 2.8	28
	☐ 2.8 or higher Less than 3.3	26
	☐ 3.3 or higher Less than 3.8	25
	☐ 3.8 or higher Less than 4.3	24
	☐ 4.3 or higher	21

(2) Envelope performance and cooling system

*Confirm the average heat transfer coefficient of the external envelope of the house in question and the average solar heat gain during the cooling season, and check the points of the cooling system with ☑ the relevant external envelope performance value. (However, only if the average solar heat gain during the cooling season is 4.3 or less.

Average heat transmission coefficient U_A [W/(㎡・K)]	Average solar heat gain during the cooling season η_{AC} [-]	point
✔ 0.69 or more Less than 0.78	☐ 1.8 or less	9
	✔ 1.8 Larger 2.3 or less	10
	☐ 2.3 Larger 2.8 or less	11
	☐ 2.8 Larger 3.3 or less	13
	☐ 3.3 Larger 3.8 or less	14
	☐ 3.8 Larger 4.3 or less	16

(3) Ventilation equipment

*Please check the points by ticking the appropriate ones.

	type	point
☐	Ducted Type 1 Ventilation System	13
☐	Ducted Type 2 ventilation equipment or ducted Type 3 ventilation equipment	10
☐	Wall-mounted Type 1 ventilation equipment	10
✔	Wall-mounted Type 2 ventilation equipment or Wall-mounted Type 3 ventilation equipment	8

2. Examples of Simplified Calculation in Residential Building (6 Region)

(4) Hot-water supply system

*Please check the points by ticking the appropriate ones.

type	Hot water-saving faucet*.1	point
☐ Not installed	-	43
☐ Conventional gas water heater	☐ No	47
	☐ Yes	44
☐ Gas latent heat recovery water heater	☐ No	40
	☐ Yes	38
☐ Conventional oil water heaters	☐ No	42
	☐ Yes	39
☐ Oil latent heat recovery water heater	☐ No	40
	☐ Yes	38
☐ Electric heat pump water heater (CO_2 refrigerant)	☑ No	36
	☐ Yes	34

*1: "Yes" can be selected for hot water-saving faucets when faucets with the following functions are installed in all "kitchen", "bathroom shower", and "washbasin" areas.
Kitchen": water shut-off function or priority water dispensing function
Bathroom shower: Hand-held shut-off function or low-flow discharge function
Washbasin": Priority water dispensing function

2. Examples of Simplified Calculation in Residential Building (6 Region)

(5) Lighting equipment

*Check the points for all fixtures in the main living room and all other living rooms by ☑ in the appropriate combination. However, lighting fixtures in non-occupied rooms must be non-incandescent.

type		point
Lighting fixtures in principal living rooms*.2	Lighting fixtures in other living rooms *.2	
☐ Not installed	☐ Not installed	9
	☐ LED	9
	☐ Other than incandescent lamps	10
	☐ Incandescent lamp	13
☑ LED	☐ Not installed	9
	☐ LED	9
	☑ Other than Incandescent lamps	10
	☐ Incandescent lamp	13
☐ Other than incandescent lamps	☐ Not installed	11
	☐ LED	11
	☐ Other than incandescent lamps	11
	☐ Incandescent lamp	14
☐ Incandescent lamp	☐ Not installed	15
	☐ LED	15
	☐ Other than incandescent lamps	16
	☐ Incandescent lamp	18

2: "LED": LEDs are used in all devices.
"Non-incandescent": All equipment uses non-incandescent lamps.
"Incandescent": Incandescent lamps are used in any of the devices.

2. Examples of Simplified Calculation in Residential Building (6 Region)

Primary energy consumption calculation results (residential version)

1. Design primary energy consumption etc.

(1) Name of housing type	○○○○ residence (detached house)			
(2) Floor area.	Principal living space	Other living space	Non-living space	Total
	29.81 m2	51.34 m2	38.93 m2	120.08 m2
(3) Regional classification	6 Region		**********	
(4) Primary energy consumption (per dwelling)			Design primary [MJ].	Standard Primary [MJ].
	heating facilities		17236	15382
	air-conditioning facilities		5390	5611
	ventilation equipment		4583	4542
	hot-water supply system		20940	25091
	lighting equipment		5964	10763
	Other equipment.		21241	21241
	On-site consumption of electricity generated by power generation facilities *1		--	--
	Deductions related to the amount of electricity sold from cogeneration facilities *2		--	--
	total amount		75353	82629
(5) BEI	Primary energy consumption (excluding others) [GJ/(unit/year)].		54.2	61.4
	BEI		0.89	

*1: Power generation facilities include cogeneration facilities and photovoltaic facilities. *2: This is the amount of primary energy consumption required to generate the electricity sold by the cogeneration facility.

3. Examples of Simplified Calculation in Residential Building (8 Region)

Simplified Calculation

Envelope performance

Region	Legend of sheet number
8 Region	8 − 1 − 1
wooden	Category 1: Wooden 2: Reinforced Steel, Steel, etc. 1: Floor-insulated dwelling (Bathroom floor insulation) 2: Floor-insulated dwelling (Bathroom foundation insulation) 3: Floor-insulated dwelling (no bathroom floor in contact with outside air, etc.) 4: Foundation-insulated dwelling

Average heat transmission coefficient U_A Please fill in the values in the bold frame below.

In the case where a single part has several different specifications, the heat transfer coefficient shall be that of the specification with the largest heat transfer coefficient. If the area of a window is less than or equal to the total floor area of the unit dwelling multiplied by 0.02, the window specification concerned may be excluded.

				Heat transmission coefficient U		Result	
Roof or ceiling		0.194	×	0.99	=	0.192	(1)
Outer wall	general section	0.489	×	0.430	=	0.211	(2)
	Foundation wall (Entrance)	0.004	×	4.11	=	0.017	(3)
Floor	Bathroom	0.009	×	3.34	=	0.031	(4)
	Other Floors	0.121	×	0.492	=	0.060	(5)
Window		0.107	×	6.0	=	0.642	(6)
Door		0.014	×	3.49	=	0.049	(7)

↑ Rounded up to the fourth decimal place

				Linear thermal transmittance ψ		Result	
Periphery of dirt floor, etc.	Entrance etc.	0.021	×	0.99	=	0.021	(8)

↑Rounded up to the fourth decimal place

Average heat transmission coefficient of envelope: U_A [W/(m^2·K)] Sum of (1)-(8) = 1.22

Note 1: U_A of roof /ceiling was adopted the standard value in region 8 while other values are set at same value as region 6 (there is no standard values for them).
Note 2: For window, adopted coefficient of vertical surface solar heat gain of single-layer glass.

Average solar heat gain during cooling season η_{AC} Please fill in the values in the bold frame below.

If a site has several different specifications, the thermal transmittance of the specification with the largest thermal transmittance should be used.
If a window has several different specifications, the vertical solar heat gain shall be the vertical solar heat gain of the specification with the largest vertical solar heat gain. If the area of a window is less than or equal to the total floor area of the unit dwelling multiplied by 0.04, the window specification concerned may be excluded.

				Heat transmission coefficient U		Result	
Roof or ceiling		0.959	×	0.99	=	0.949	(9)
Outer wall	General section	0.762	×	0.430	=	0.330	(10)
	Foundation Wall (Entrance)	0.004	×	4.11	=	0.016	(11)
Door		0.019	×	3.49	=	0.066	(12)

↑Rounded up to the fourth decimal place

			Coefficient of Vertical Surface Solar Heat Gain Coefficient η_i		Results	
Window	4.55	×	0.63	=	2.867	(13)

↑Rounded up to the fourth decimal place

Average solar heat gain during cooling season η_{AC} [-] Sum of (9)-(13) = 4.2

*Rounds up to the second decimal place
(Conforming if the standard value is 6.7 [-] or less)

Note : For window, adopted coefficient of vertical surface solar heat gain of single-layer glass.

Simplified Calculation

Primary energy consumption performance

8 Region

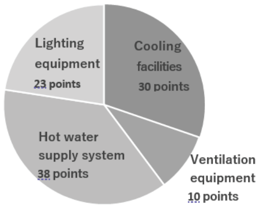
Sheet No.	Principal living space	Other living space
8-ENE-1	Not installed	
8-ENE-2	Room air conditioner	

Please fill in the envelope performance.

Please fill in the figures in the bold frame below.

Average heat transmission coefficient U_A [W/(m²・K)]	1.22
Average solar heat gain during cooling season η_{AC} [-]	4.2

From the Point Listing page, post the points you selected in (1) through (4) in the bolded box below and calculate the total.



Reference] Approximate points for each facility (excluding other facilities)

Please fill in the points in the bold frame below.

air-conditioning facilities	Transcribe the numbers in (1)	=	35	(a)
ventilation equipment	Transcribe the numbers in (2)	=	10	(b)
hot-water supply system	Transcribe the numbers in (3)	=	26	(c)
Lighting equipment	Transcribe the numbers in (4)	=	12	(d)

Primary energy consumption performance points Total of (a)-(d) = 83

(Conforming If less than or equal to 100 points)

(1) Envelope performance and cooling system

*Confirm the average heat transfer coefficient of the external envelope of the house in question and the average solar heat gain during the cooling season, and check the points of the cooling system with ☑ the relevant external envelope performance value. (However, only if the average solar heat gain during the cooling season is 8.7 or less.

Average heat transmission coefficient U_A [W/(m²・K)]	Average solar heat gain during the cooling season η_{AC} [-]	point
☑ 1.05 or more Less than 1.50	☐ 1.7 or less	19
	☐ 1.7 Larger 2.7 or less	25
	☐ 2.7 Larger 3.7 or less	30
	☑ 3.7 Larger 4.7 or less	35
	☐ 4.7 Larger 5.7 or less	40
	☐ 5.7 Larger 6.7 or less	45
	☐ 6.7 Larger 7.7 or less	50
	☐ 7.7 Larger 8.7 or less	55
☐ 1.50 or more Less than 1.95	☐ 1.7 or less	17
	☐ 1.7 Larger 2.7 or less	22
	☐ 2.7 Larger 3.7 or less	26
	☐ 3.7 Larger 4.7 or less	30
	☐ 4.7 Larger 5.7 or less	35
	☐ 5.7 Larger 6.7 or less	40
	☐ 6.7 Larger 7.7 or less	45
	☐ 7.7 Larger 8.7 or less	49

(2) Ventilation equipment

*Please check the points by ticking the appropriate ones.

type	point
☐ Ducted Type 1 Ventilation System	16
☐ Ducted Type 2 ventilation equipment or ducted Type 3 ventilation equipment	13
☐ Wall-mounted Type 1 ventilation equipment	13
☑ Wall-mounted Type 2 ventilation equipment or Wall-mounted Type 3 ventilation equipment	10

(3) Hot-water supply system

*Please check the points by ticking the appropriate ones.

type	Hot water-saving faucet*.[1]	point
☐ Not installed	-	38
☐ Conventional gas water heater	☐ No	42
	☐ Yes	39
☐ Gas latent heat recovery water heater	☐ No	36
	☐ Yes	33
☐ Conventional oil water heaters	☐ No	38
	☐ Yes	35
☐ Oil latent heat recovery water heater	☐ No	36
	☐ Yes	33
☐ Electric heat pump water heater (CO_2 refrigerant)	☑ No	26
	☐ Yes	25

(4) Lighting equipment

*Check the points for all fixtures in the main living room and all other living rooms by ☑ in the appropriate combination. However, lighting fixtures in non-occupied rooms must be non-incandescent.

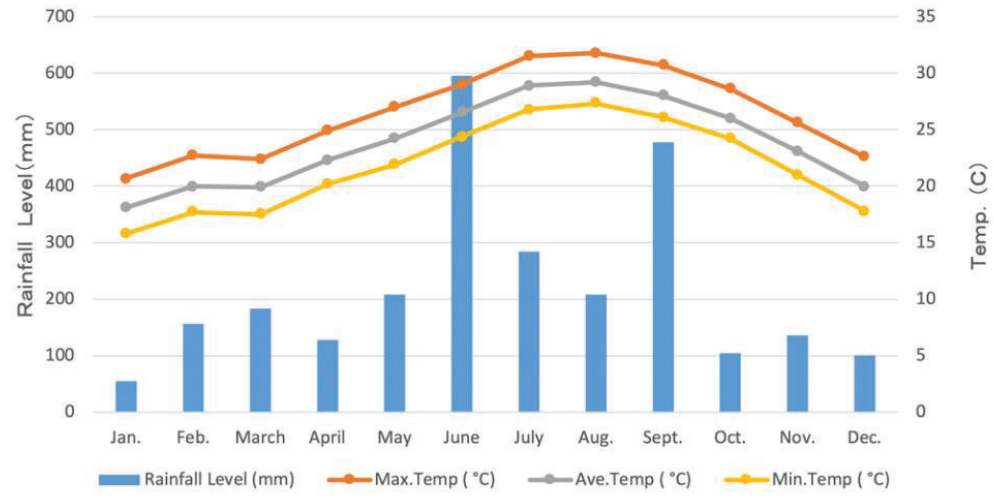
type		point
Lighting fixtures in principal living rooms*.[2]	Lighting fixtures in other living rooms *.[2]	
☐ Not installed	☐ Not installed	11
	☐ LED	11
	☐ Other than incandescent lamps	12
	☐ Incandescent lamp	16
☑ LED	☐ Not installed	11
	☐ LED	11
	☑ Other than Incandescent lamps	12
	☐ Incandescent lamp	16
☐ Other than incandescent lamps	☐ Not installed	13
	☐ LED	13
	☐ Other than incandescent lamps	14
	☐ Incandescent lamp	17
☐ Incandescent lamp	☐ Not installed	19
	☐ LED	19
	☐ Other than incandescent lamps	20
	☐ Incandescent lamp	23

2: "LED": LEDs are used in all devices.
"Non-incandescent": All equipment uses non-incandescent lamps.
"Incandescent": Incandescent lamps are used in any of the devices.

1. Design primary energy consumption etc.

(1) Name of housing type	○○○○ residence (detached house)			
(2) Floor area.	Principal living space	Other living space	Non-living space	Total
	29.81 m2	51.34 m2	38.93 m2	120.08 m2
(3) Regional classification	8 Region		**********	
(4) Primary energy consumption (per dwelling)			Design primary [MJ].	Standard Primary [MJ].
	heating facilities		0	0
	air-conditioning facilities		15483	21289
	ventilation equipment		4583	4542
	hot-water supply system		12338	17922
	lighting equipment		5964	10763
	Other equipment.		21241	21241
	total amount		59609	75756
(5) BEI	Primary energy consumption (excluding others) [GJ/(unit/year)].		38.4	54.6
	BEI		0.71	

*1: Power generation facilities include cogeneration facilities and photovoltaic facilities. *2: This is the amount of primary energy consumption required to generate the electricity sold by the cogeneration facility.



Data source: Japan Meteorological Agency

4. EEC Unique Approaches in Residential Building, Okinawa, Japan

Energy Reduction Effects by Applying Efficient Technologies in Okinawa

Use	Energy consumption standard value (GJ)	Efficient technology		Energy consumption rate (standard value is set at 1.0) more efficient → Level 1	Level 2	Level 3	Level 4
Cooling	10.3 (15%)	Use and control of natural wind		0.96	0.91	0.88	
		Solar radiation shielding method		0.9	0.8	0.75	0.7
		Cooling system plan (efficient AC, etc.)		0.9	0.8	0.75	0.65
Ventilation	3.1 (5%)	Ventilation equipment	ducted	0.7	0.5		
	2.8		wall-mounted	0.8			
Hot water supply	13.8 (21%)	Solar hot water supply		0.9	0.7	0.5	0.3
		Hot water supply system		0.9	0.8	-	0.6
Lighting	13.6 (20%)	Daylight use		0.97～0.98	0.95	0.9	
		Lighting Equipment planning		0.85	0.8	0.7	
Appliances	21.4 (32%)	Introduction of high-efficiency appliances		0.8	0.6		
Other (Cooking)	4.4 (7%)						
Total amount	66.6						
	66.3						

Source: Energy efficient house guidelines (Okinawa prefecture, 2015)

4. EEC Unique Approaches in Residential Building, Okinawa

Adopted EE Methods and Estimation of Energy Saving Effects - Example of the Model House - (1)

Use	Efficient technologies	Evaluation level	Energy consumption rate	Adopted EE methods
Cooling	Use of natural wind	3	0.88	• Openings on ventilation paths • Openings with consideration of the prevailing wind direction • Use of high windows
	Solar radiation shielding method	4	0.7	• Thermal barrier paint • Thermal barrier block
	Cooling system planning	3	0.75	• High-efficiency air conditioner (COP 4 or higher) + fan
Hot water supply	Hot water supply system planning	4	0.6	• CO2 heat pump water heater
Ventilation	Ventilation system planning	1	0.8	• Simplified ventilation system
Lighting	Daylight use	2	0.95	• LD and individual rooms
	Lighting Equipment Planning	3	0.7	• High efficiency, control, and design ingenuity
Appliances		2	0.6	• Efficient products + reduced standby power

4. EEC Unique Approaches in Residential Building, Okinawa

Adopted EE Methods and Estimation of Energy Saving Effects - Example of the Model House - (2)

Use	Standard value (GJ)	A	B	C	Design value (GJ)	Energy saving rate (%)	Note
Cooling	10.3	0.88	0.7	0.75	4.76	53.7	4.76 = 10.3 X 0.88 X 0.7 X 0.75
Hot water supply	13.8	0.6			8.28	40.0	8.28 = 13.8 X 0.6
Ventilation	3.1	0.8			2.48	20.0	2.48 = 3.1 x 0.8
Lighting	13.6	0.95	0.7		9.04	33.5	9.04 = 13.6 x 0.95 x 0.7
Appliances	21.4	0.6			12.84	40.0	12.84 = 21.4 x 0.6
Other	4.4				4.4	0	
Total	66.6				41.8	37.2	

Energy saving rate

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 1: Sunshine Shield

● Methods to shield sunshine

✓ It is basic to keep the building skeleton close to the ambient temperature, not to heat it.

✓ The strong sunshine of Okinawa should be blocked outside.

Sunshine Shield in Urban Area

Sunshine Shield in Suburban Area

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 1: Sunshine Shield

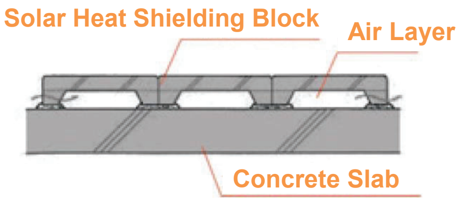
➢ Green roof

➢ Solar Heat Shielding Paint

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 1: Sunshine Shield

- **Solar Heat Shielding Block**



4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 1: Sunshine Shield

- **HANA Block**

4. EEC Unique Approaches in Residential Building, Okinawa

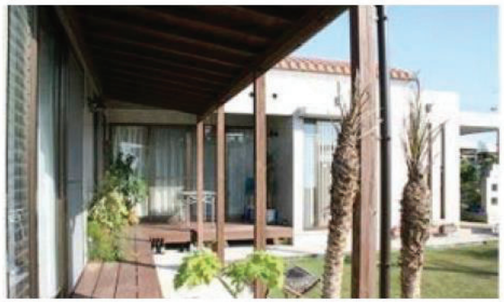
Key Points 1: Sunshine Shield

- **Wall-surface Greening**

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 1: Sunshine Shield

- **AMAHAJI**



AMAHAJI is Okinawa’s traditional eaves where customers are welcomed as there is not entrance in Okinawa’s unique houses.

Key Points 1: Sunshine Shield

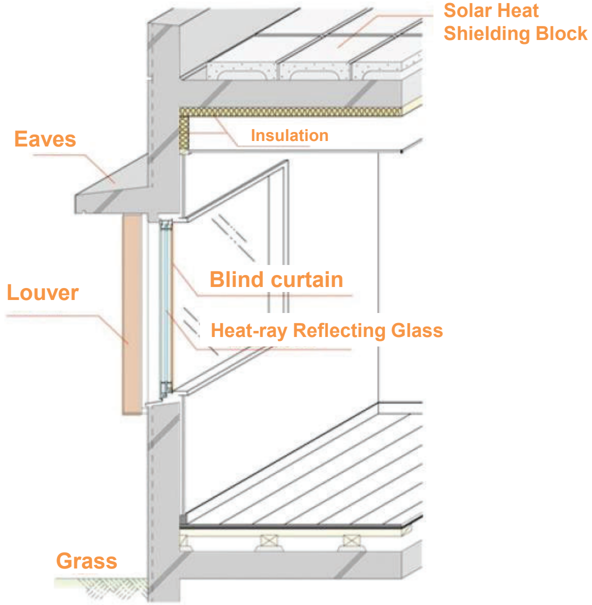
- Eaves

Key Points 1: Sunshine Shield

- Louver

Key Points 1: Sunshine Shield

Example of Solar Heat Shielding Measures for Opening and Roof ⇨



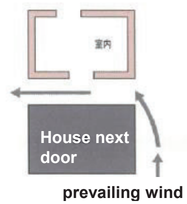
Key Points 2: Create Cool Breeze, Bring Cool Breeze

●Methods to Create Cool Breeze, Bring Cool Breeze

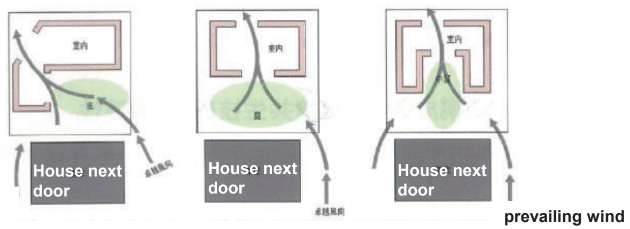
✓ It is basic to bring **cool breeze** in rooms

✓ Ingenuity in building layout and window positions

- In summer, cool breezes are drawn into the building from the south.
- In winter, the wind from the north should be blocked.



If the house is close to the house next door, the wind will blow parallel to the window. It will be difficult to have wind into the room.



Wind can be taken in effectively if a certain space (e.g. garden) is provided without being in close contact with the house next door.

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 2: Create Cool Breeze, Bring Cool Breeze

- ➢ **Windows at high position**

Windows at high position (from outside)

Windows at high position (from inside)

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 2: Create Cool Breeze, Bring Cool Breeze

- ➢ **Security-friendly small window**

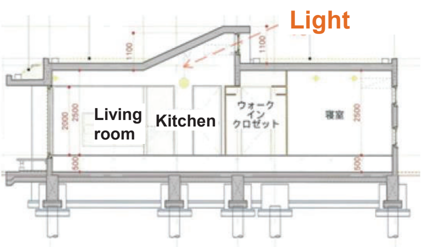
4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 3: Make good use of daylight

● **Methods to Make good use of daylight**

- ✓ It is basic to **allow light to enter a room while blocking direct sunshine.**
- ✓ Utilization of **inner court, high sidelight (windows on high position) and louver**, etc.

- ➢ **High Sidelight**



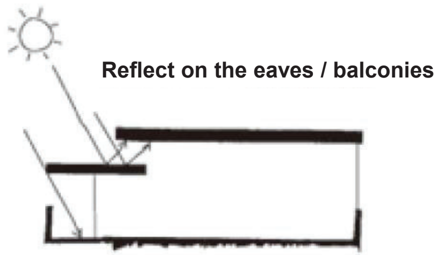
High Sidelight

High Sidelight (sunshine enters indirectly)

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 3: Make good use of daylight

- ➢ **Introduction of light shelf concept**



- If the eaves on the south side of the building are made two-tiered, the eaves blocks direct sunshine from entering the window.
- The light reflected on the upper part of the eaves is diffusely reflected on the ceiling of the room and light up the back of the room.

4. EEC Unique Approaches in Residential Building, Okinawa

Key Points 3: Make good use of daylight

- **HANA Block**

Lighting with utilization of HANA block

Thank you very much for your kind attention !

Energy Efficiency & Conservation (EEC) Materiel Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

- Energy Audit including Walk Through Survey -

Barbados, January 2023

Nippon Koei Co.
PADECO Co.

Contents

Overview of MEB (energy division) Building in Bridgetown, Barbados (entrance)

Basic Data of the Building

Item	Basic Data
Number of floors	2
Floor area	966 m2
Building use	Government
Annual power consumption	167,635 kWh
Annual power consumption per floor area	174 kWh/m2

Bird 'eye view of MEB (energy division) Building

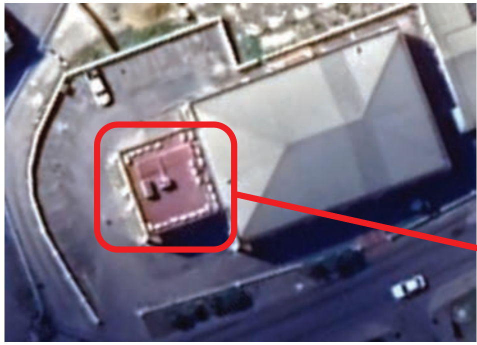
1. Overview of MEB Building (energy division) in Bridgetown, Barbados

Bird 'eye view of MEB (energy division) Building

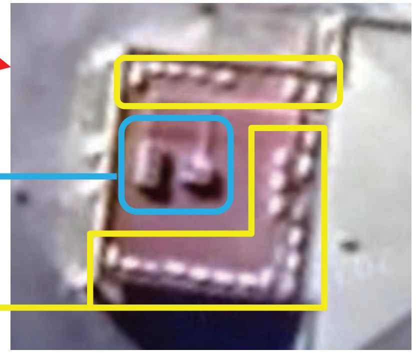
Parking lot

1. Overview of MEB Building (energy division) in Bridgetown, Barbados

Bird 'eye view of MEB (energy division) Building



More than 20 outdoor units of mini split air-conditioners and couple of outdoor units of central air-conditioners are observed.



Outdoor units of roof top air-conditioners

Outdoor units of mini split air-conditioners

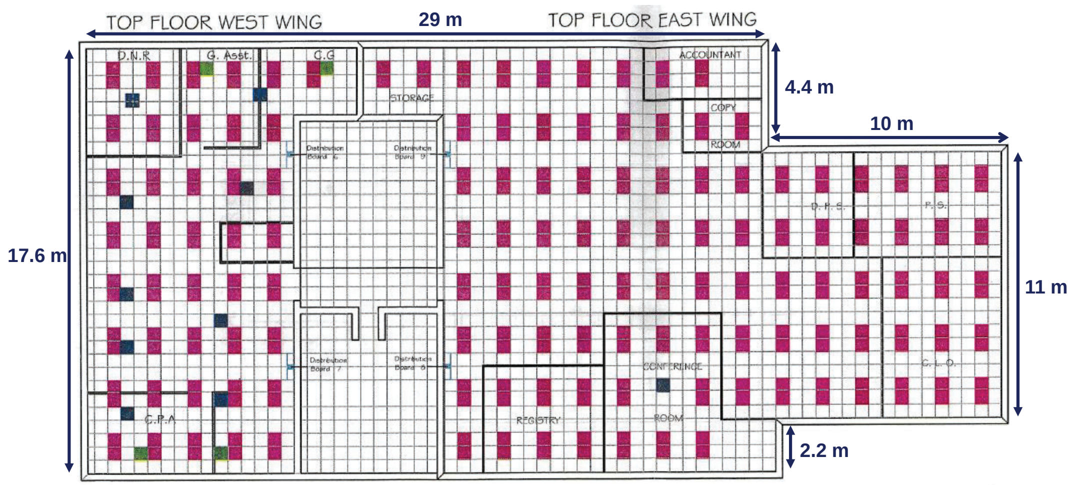
1. Overview of MEB Building (energy division) in Bridgetown, Barbados

- **Floor plan of the building (ground floor)**

Floor area of ground floor = 346 m2

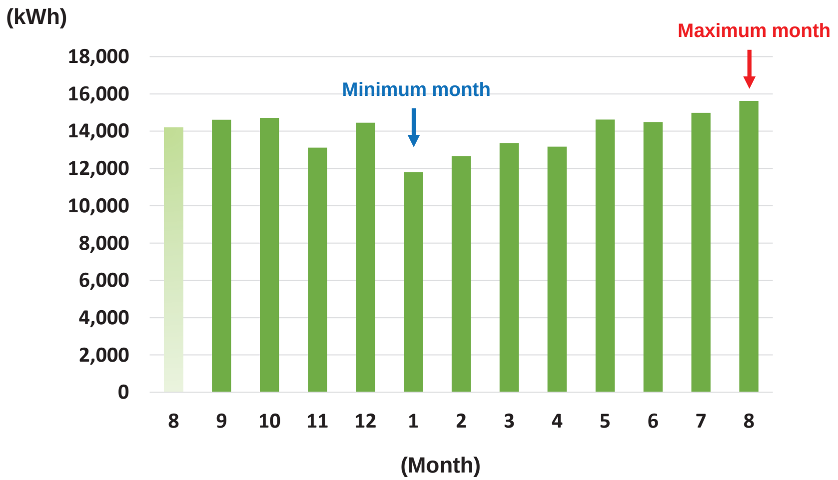
1. Overview of MEB Building (energy division) in Bridgetown, Barbados

- **Floor plan of the building (top floor)**

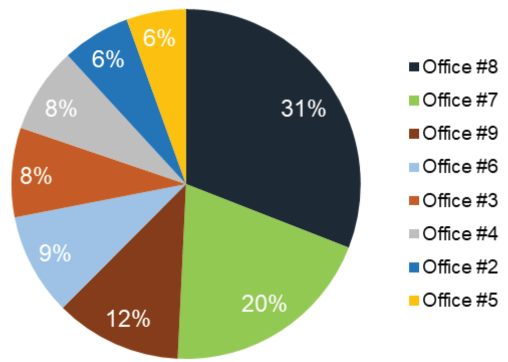


Floor area of top floor = 620 m2 ➡ Total floor area of the building = 966 m2

Monthly Power Consumption Trends at MEB Office Building (actual data, Aug.2021 - Aug.2022)

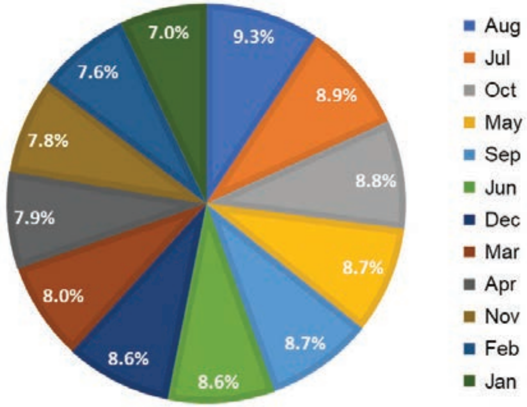


Annual Power Consumption Share by Each Office (actual data, Sep.2021 - Aug.2022)



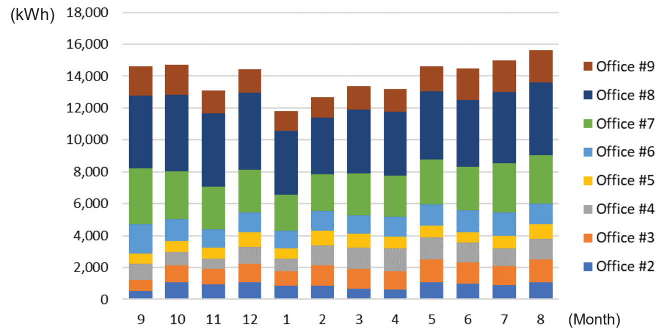
Office #8 is the largest power consumer and Office #8 and #7 share more than half of the total power consumption.

Annual Power Consumption Share by Month (actual data, Sep.2021 - Aug.2022)



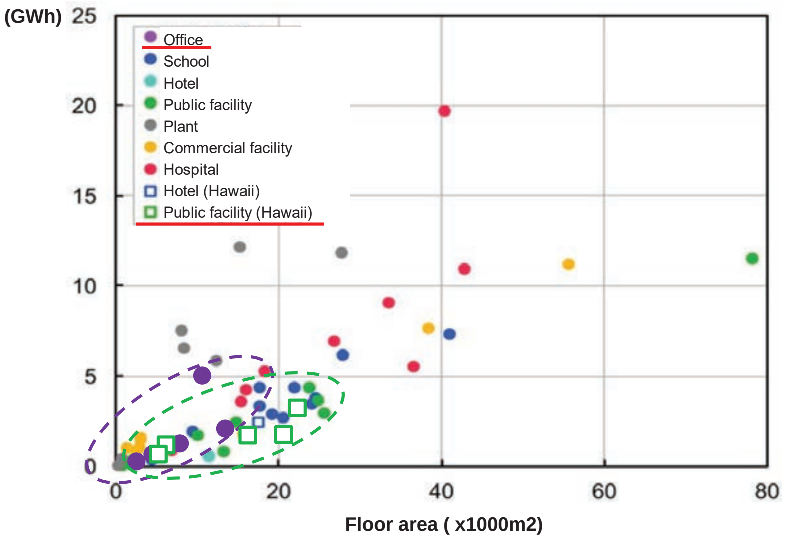
Power consumption in August is the largest month through a year. However, there is no significant difference by months.

Power Consumption Trends at the Building (actual data, Sep.2021 - Aug.2022)



	9	10	11	12	1	2	3	4	5	6	7	8	TOTAL	AVE	MAX	MIN
Office #2	540	1,070	943	1,082	846	840	680	596	1,055	977	911	1,068	10,608	884	1,082	540
Office #3	695	1,055	978	1,136	929	1,275	1,209	1,186	1,455	1,342	1,166	1,442	13,868	1,156	1,455	695
Office #4	987	839	620	1,060	756	1,243	1,355	1,409	1,383	1,239	1,135	1,277	13,303	1,109	1,409	620
Office #5	650	692	677	928	676	958	851	758	707	661	767	927	9,252	771	958	650
Office #6	1,854	1,402	1,186	1,233	1,091	1,236	1,169	1,215	1,335	1,384	1,453	1,310	15,868	1,322	1,854	1,091
Office #7	3,506	2,993	2,655	2,662	2,268	2,302	2,615	2,611	2,819	2,725	3,090	3,008	33,254	2,771	3,506	2,268
Office #8	4,562	4,760	4,600	4,862	3,986	3,523	4,026	3,984	4,311	4,188	4,468	4,575	51,845	4,320	4,862	3,523
Office #9	1,820	1,905	1,456	1,490	1,252	1,290	1,463	1,410	1,560	1,973	1,998	2,020	19,637	1,636	2,020	1,252
Total	14,614	14,716	13,115	14,453	11,804	12,667	13,368	13,169	14,625	14,489	14,988	15,627	167,635	13,970	15,627	11,804

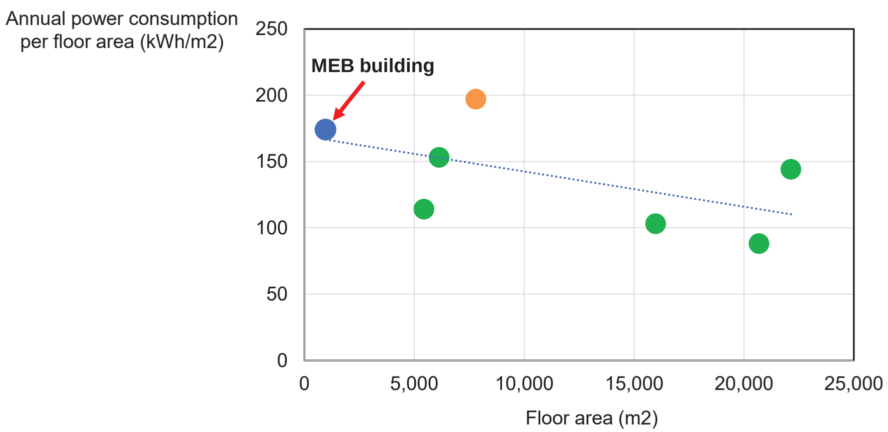
Annual Power Consumption Data (Okinawa & Hawaii)



Summary Table of Annual Power Consumption per Floor Area

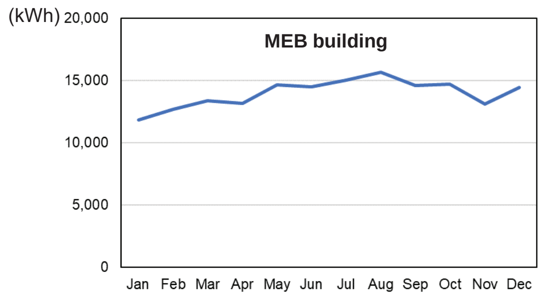
Location	Building use	Data number of buildings	Floor area (m2)	Annual power consumption (kWh)	Annual power consumption per floor area (kWh/m2)
Okinawa	Office	5	7,807 (average)	7,678,185	197
Hawaii	State gvrnt office 1	1	15,989	1,641,600	103
	State gvrnt office 2	1	5,442	618,920	114
	State gvrnt office 3	1	6,140	942,400	153
	State gvrnt office 4	1	22,146	3,184,800	144
	State gvrnt office 5	1	20,688	1,828,400	88
Barbados	MEB office	1	966	167,635	174

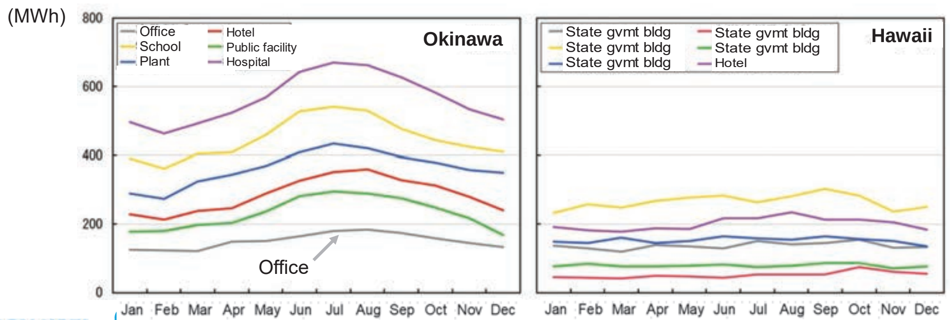
Graph of Annual Power Consumption per Floor Area



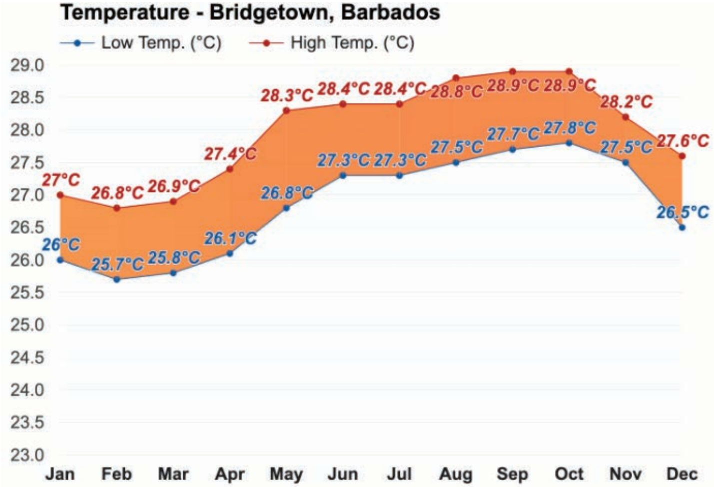
Monthly Power Consumption

- A bit larger difference has been observed in MEB building by season than those in Okinawa and Hawaii.



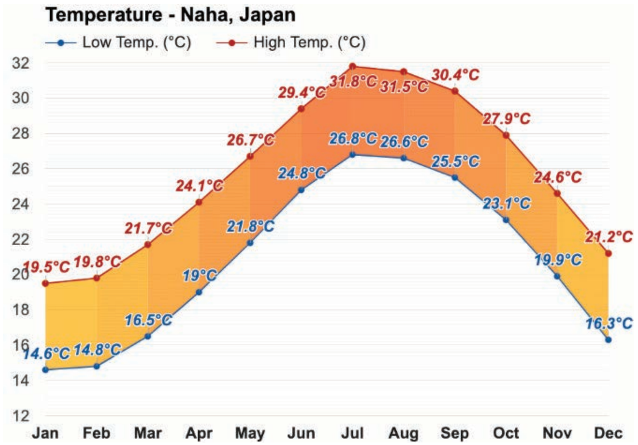


Average Temperature Bridgetown, Barbados



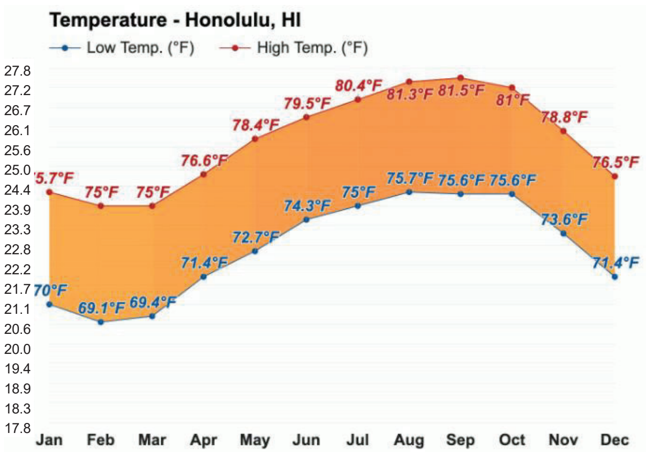
Source: Weather Atlas

Average Temperature Naha (Okinawa), Japan



Source: Weather Atlas

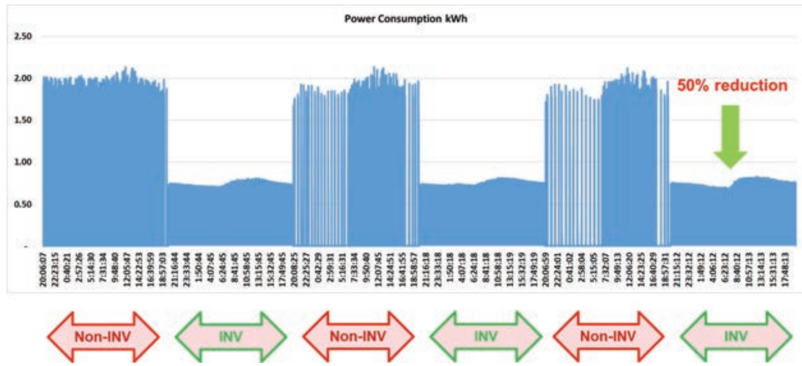
Average Temperature Honolulu (Hawaii), USA



Source: Weather Atlas

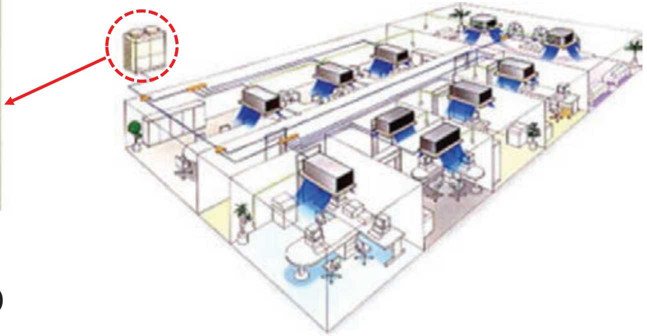
- **Examination of energy savings by adopting efficient air conditioning technologies and approaches**
  - **(i-a) Adoption of Inverter mini split air conditioners**
    - **Reduction of 50% power consumption**

Ref: Results of power consumption measurement of Inverter vs Non-Inverter AC



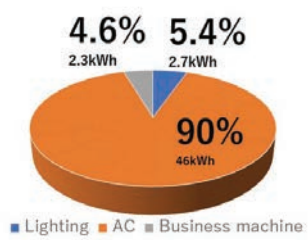
(i-b) Adoption of Variable Refrigerant Flow (VRF, Inverter always equipped) as an alternative of roof top air conditioners (Non-Inverter)

VRF (Inverter equipped) outdoor unit

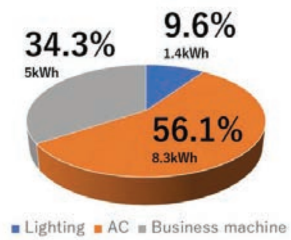


Ref: Measured power consumption data in 2 office rooms on Jun.12.2022 (24 hours, highest temp: 32.2 ºC, lowest temp: 26.1 ºC)

Measured Data of Electricity Consumption in Office 1



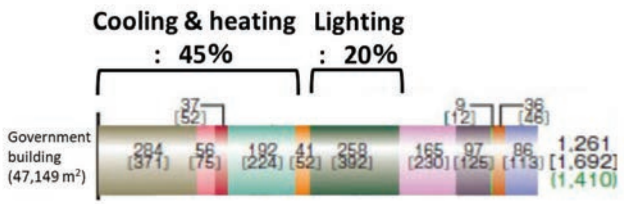
Measured Data of Electricity Consumption in Office 2



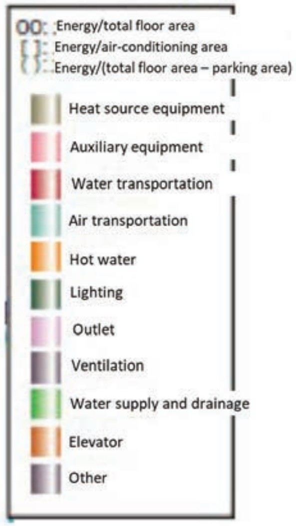
Note: All lighting equipment is LED.

Ref:

Energy Consumption Data in Office Building, Japan



Source: Energy Conservation Center, Japan

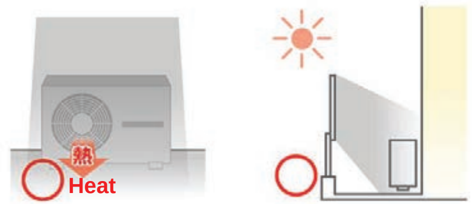


(ii) Heat shielding of outdoor units

➢ **10 % power reduction was observed by heat shielding**

← Construction of heat shielding

	Room A inv [kWh]	Room B inv [kWh]	Effect of EE&C [%]
Jan.14	150	164	-9%
Jan.16	207	202	3%
Jan.20	93	86	8%
Jan.22	115	84	27%
Jan.28	146	122	16%
Jan.30	129	116	10%
Feb.3	148	141	4%
Feb.5	119	107	10%
Feb.9	152	132	13%
Feb.11	129	100	22%
Feb.13	126	103	18%
Feb.17	108	108	1%
ave.	135	122	10%



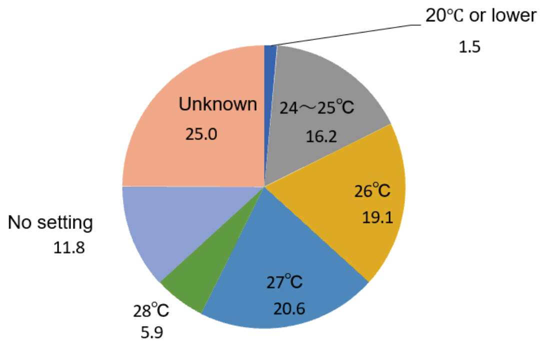
Source: "Data collection survey on energy efficiency in the D.R. final report" (Jan. 2016, JICA)

(iii) Lower temperature setting of air conditioner

➢ **10 % power reduction by setting 1 ºC higher temperature**

Note: 13 % of power reduction with setting 1 ºC higher temperature (by Ministry of Environment)

Ref: Setting temperature of air conditioner in Okinawa



❑ Results of Examination (1) : power & cost savings

		Present situation		
Annual power consumption for cooling	kWh	83,818		
Power consumption by INV AC	kWh	27,939		
Power consumption by Non-INV AC	kWh	55,879		
Cooling loads by INV AC	kWh	139,697		
Cooling loads by Non-INV AC	kWh	139,697		
Total cooling loads	kWh	279,393		
		EE measure (i)	EE measure (i)+(ii)	EE measure (i)+(ii)+(iii)
Power consumption after EE measures	kWh	55,879	50,291	45,262
Power savings per year	kWh	27,939	33,527	38,556
Power saving ratio	**%**	**33**	**40**	**46**
Cost savings per year	$	17,881	21,457	24,676
Annual power consumption per floor area	kWh/m2	145	139	134

Assumption:
- **50% of ACs are INVERTER at present**
- **Efficiency of INV AC = 5 in kW/kW**
- **Efficiency of Non-INV AC = 2.5 in kW/kW**

Note: Unit rate of power (customer charge + demand charge + energy charge + fuel charge) = $0.64/kWh

❑ Results of Examination (2) : Investment in INVERTER ACs

Estimation of cooling capacity of existing Non-INV ACs

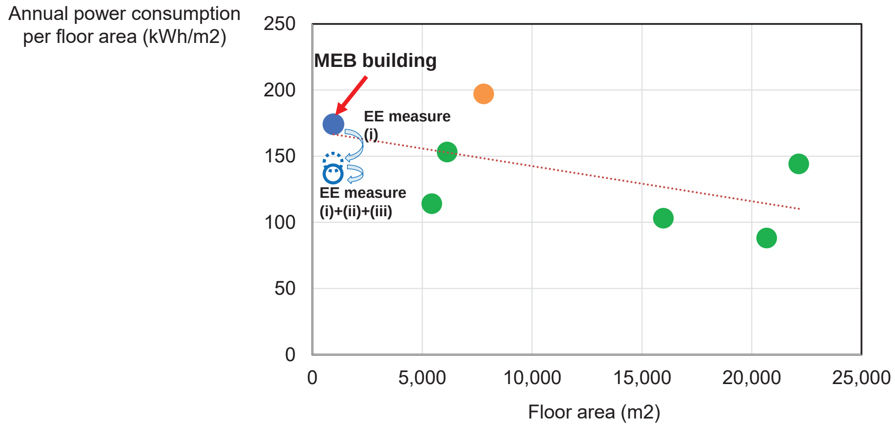
Item	Unit	Value
Total power capacity of building	kVA	85
Power factor	%	90
Total power demand of building	kW	76.5
Power demand of ACs	kW	38.3
Power demand of INV ACs	kW	12.8
Power demand of Non-INV ACs	kW	25.5
Cooling capacity of Non-INV ACs	**kW**	**63.8**

Item	Unit	Value
INV AC cost (5.27 kW in cooling capacity)	$	1,700
Necessary number of AC	Unit	13
Total investment cost of INV AC	**$**	**22,100**

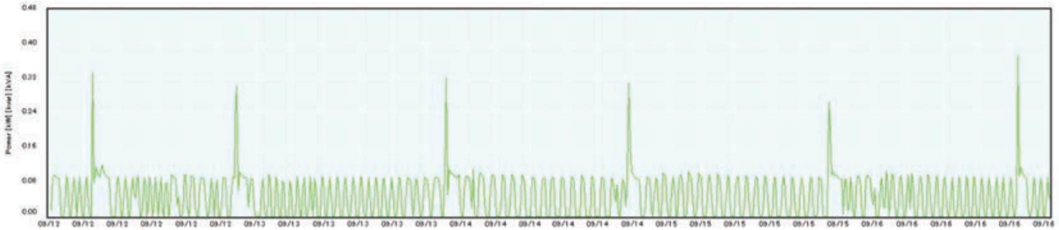
Note: AC market survey conducted in Barbados by JET in 2019

Simple payback year = 22,100 / 17,881 = 1.2 year

Graph of Annual Power Consumption per Floor Area with EE Measures



Ref: Measured Power Consumption Data of Refrigerator in MEB Office (Sep.12 – 16, 2022)



➡ **Existing refrigerator (Non-INVERTER) can be replaced with efficient one with INVERTER**

Illuminance standards for offices in Japan (JIS Z 9110)

Illuminance (lux)	Place	Work
2000		—
1500		● design ● drawing ● type ● calculation ● keypunch
1000	office (a)(*) , sales room, design room, entrance hall (daytime)(**)	
750		

(Note)
(*) In the event that the office is used for **detailed visual work** or where daylight makes the room feel dark inside and bright outside the window, (a) should be selected.
(**) In the entrance hall, the illuminance should be high because the interior of the hall appears dark when the eye is applying the tens of thousands of lux from outdoor natural light during the day. The entrance hall (nighttime) and (daytime) may be adjusted with staged flashing.

Illuminance (lux)	Place			Work
750	—	Office (b), boardroom, conference room, printing room, computer room, control room, clinic room • switchboards and instrument panels in electrical and machine rooms, etc. • reception (desk)		—
500				
300	reception room, waiting room, dining room, cooking room, recreation room, guard room, entrance hall (at night), elevator hall	warehouse, electrical room, auditorium, machine room, miscellaneous workroom, elevator	—	
200	—		washing area, hot water heating area, bathrooms, corridors, stairs, lavatories	
150	coffee room, rest room, lodging room, changing rooms, storage, entrance (porch)			
100			—	
75	indoor emergency staircase			
50				
30				

Source: JET based on EEC guidebook for building, 2022 (Energy Efficiency and Conservation Center of Japan)

EEC Promotion System

- ✓ Do you have a mechanism for continuous EEC (e.g. EEC committee, etc.)?
- ✓ Are PDCA cycles for EEC activities being implemented with management participation?
- ✓ Have you designated a person or leader responsible for promoting EEC?
- ✓ Have you set EEC targets?
- ✓ Are energy consumption statuses posted for employees to see?
- ✓ Have you established a policy and implementation plan for EEC measures?
- ✓ Do you conduct personnel training and EEC awareness activities?
- ✓ Do you have the time and budget for EEC efforts?

Source: JET based on EEC guidebook for building, 2022 (Energy Conservation Center of Japan)

Measurement, Recording and Maintenance

- ✓ Do you maintain equipment ledger, drawings and other documents?
- ✓ Have you identified equipment that should be intensively managed for EEC?
- ✓ Do you have operation records (daily, monthly, etc.) for major facilities?
- ✓ Have you set values to be managed and their ranges to check operating conditions?
- ✓ Do you perform daily inspection and maintenance of equipment?
- ✓ Are there management standards for major facilities (air conditioning, ventilation, lighting, production facilities, etc.)?
- ✓ Do you perform periodic calibration and inspection of measuring instruments?
- ✓ Are filters, strainers, etc. cleaned and replaced regularly?
- ✓ Do you conduct periodic repairs and leak inspections (water, steam, compressed air, etc.) of piping, etc.?

Energy Management

- ✓ Do you tabulate (graphs, etc.) and visualize energy consumption by month/year?
- ✓ Is energy consumption measured and recorded by type and use, and constantly monitored?
- ✓ Do you measure hourly power usage and manage peak power?
- ✓ Do you analyze energy consumption taking into account outside temperatures and other factors?

Management of Energy Intensity, etc.

- ✓ Have you calculated a common energy unit cost for the office (e.g. $/kWh, $/litre, $/m3)?
- ✓ Do you manage intensity ("energy use/floor area", "energy cost/floor area", etc.)?
- ✓ Do you manage energy intensity / expenses by each department?

Management Cycle -PDCA-

- ✓ Are you reviewing your EEC targets?
- ✓ Are you verifying the effectiveness of improvement measures implemented to date?
- ✓ Are you reviewing your plans for implementing future facility improvements and measures?

Source: JET based on EEC guidebook for building, 2022 (Energy Efficiency and Conservation Center of Japan)

Improvements of Air Conditioning Efficiency

- ✓ Are outdoor units shaded and watered during the summer months?
- ✓ Are window blinds utilized to reduce heat gain through windows?
- ✓ Are filters cleaned regularly?
- ✓ Are shading films attached to window glass, and has plantings near windows implemented?
- ✓ Is air introduced into the room at night when the outside temperature is cooler (**night purge**)?
- ✓ Can we reduce the size of the air-conditioned area (partitions, high ceiling linings, etc.)
- ✓ Are spot coolers used when the air-conditioned area is large and the number of people is small?
- ✓ Are air-conditioned areas blocking drafts?
- ✓ Are you updating to high-efficiency air conditioners?

Lighting Fixture Management and EEC

- ✓ Is the illuminance standard for each room determined and controlled?
- ✓ Are window lights turned off (using daylight)?
- ✓ Are lights turned off when not needed, such as in unoccupied rooms or during lunch breaks?
- ✓ Do you adjust the lighting hours and number of exterior lights according to the hours of daylight?
- ✓ Have you cleaned the lamps and replaced old lamps?
- ✓ Are motion sensors used in restrooms, warehouses, etc.?
- ✓ Is the installation position (height and placement) of the lighting fixture appropriate for the required brightness?
- ✓ Are lighting circuits subdivided so that lights can be turned off in unoccupied areas, etc.?
- ✓ Are lights dimmed or turned off by automatic control?
- ✓ Are you updating to LED lighting?
- ✓ Have you considered task ambient lighting (all room lighting => overall + hand lighting)?

Thank you very much for your kind attention !

Technical Cooperation to Promote
Energy Efficiency in Caribbean Countries

Information Sharing Material
- Energy Efficiency Policy in Japan -

Barbados, January 2023

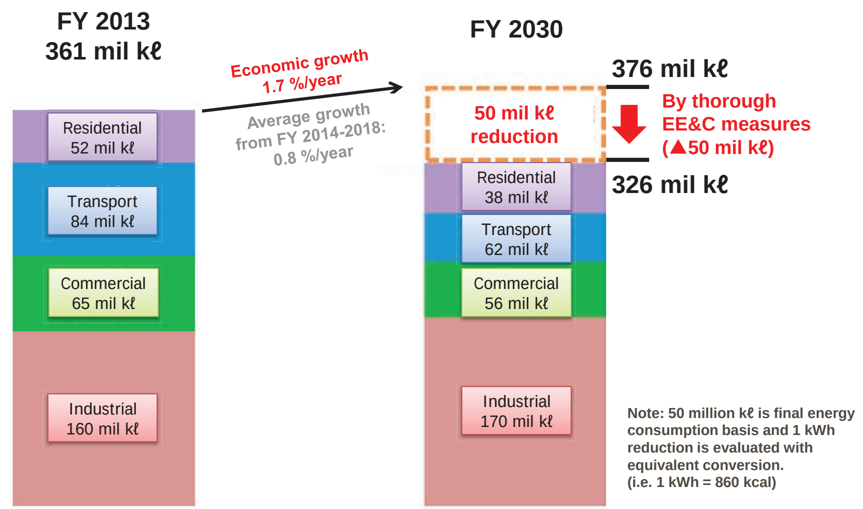
Nippon Koei Co., Ltd.
PADECO Co., Ltd.

Energy Efficiency - Energy Policy incl. EE&C in Japan -

Year	Policy
2002	**Basic Act on Energy Policy**
2003-2014	**Released Basic Energy Policies 4 times in 2003, 2007, 2010, 2014**
2015	**Long-term outlook for energy demand and supply** ● **Energy Mix** in 2030 (ratio of power sources): RE: 22-24%, Nuclear: 20-22%
2018	**5th Basic Energy Policy** ● 2030: To achieve Energy Mix surely ● 2050: Challenge to energy conversion and decarbonization
Oct.2020	**Prime Minister's speech** ● Greenhouse gas emissions to zero by 2050 ● Establishment of a stable energy supply by thorough EE as well as introducing RE to the maximum extent.

Energy Efficiency - EE&C Targets in Energy Mix -

EE&C Target for 2030 in Long-term Outlook for Energy Demand and Supply (energy mix)

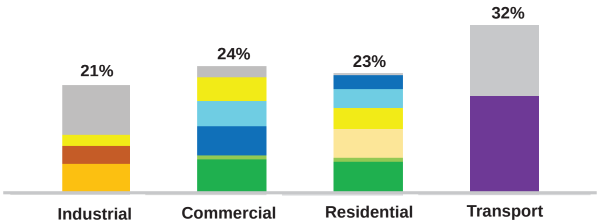


Note: 50 million kℓ is final energy consumption basis and 1 kWh reduction is evaluated with equivalent conversion. (i.e. 1 kWh = 860 kcal)

Source: JET based on the Ministry of Economy, Trade and Industry's (METI) material. Mar.2021

- **EE&C 2030 targets were developed sector by sector as well as technology by technology (bottom-up approach)**

EE&C 2030 Targets by Sector (in Energy Mix)

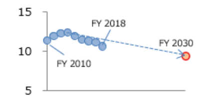
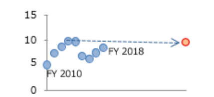
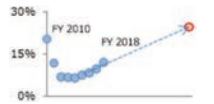
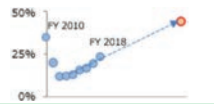
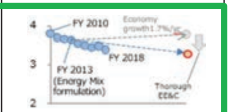


- **Various EE&C technologies / approaches could be applied across the sectors, and these exceeded 40% of the energy-saving target amount.**

Cross Sectorial EE&C Approaches (in Energy Mix targets)

(%)

	Industrial	Commercial	Residential	Total
Improvement of energy performance in new buildings/homes		6.6	6.2	12.8
High efficiency lighting	2.1	4.5	4	10.6
Energy management by utilizing BEMS / HEMS		4.7	3.5	8.2
Improvement of energy performance of specified equipment (Top runner program)		5.5	2.7	8.2
Energy saving (retrofit) of buildings/homes		0.8	0.8	1.6
Total	2.1	22.1	17.2	41.4

	FY 2018 results	Targets in FY 2030	Progress
1. Energy-originated CO_2 emissions (total GHG emissions)	1.06 billion Ton (GHG:1.24 billion Ton)	0.93 billion Ton (GHG:1.04 billion Ton)	
2. Electricity cost (fuel cost + FIT purchase cost)	8.5 Tera Yen • Fuel cost: 5.7 Tera Yen (Crude oil cost: 63$/bbl) • FIT cost: 2.8 Tera Yen	9.2~9.5 Tera Yen • Fuel cost: 5.3 Tera Yen (Crude oil cost: 128$/bbl) • FIT cost: 3.7~4.0 Tera Yen	
3. Energy self-sufficiency rate (whole primary energy)	12%	24%	
4. Zero emission power supply ratio	23% • RE: 17% • Nuclear: 6%	44% • RE: 22~24% • Nuclear: 22~20%	
5. EE&C (final energy consumption in crude oil equivalent)	339 mil kℓ • Commercial/industry: 210 • Residential: 50 • Transport: 80	326 mil kℓ • Commercial/industry: 230 • Residential: 40 • Transport: 60	

Source: JET based on METI's material. Jul.2020

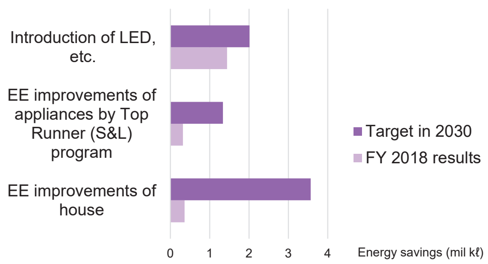
- **Energy savings achieved in FY 2018 = ▲13.4 mil kℓ**
  - **Progress rate = 26.6% # Average progress rate = 33.3% (2013-2030)**

Progress of Energy Savings by Sector

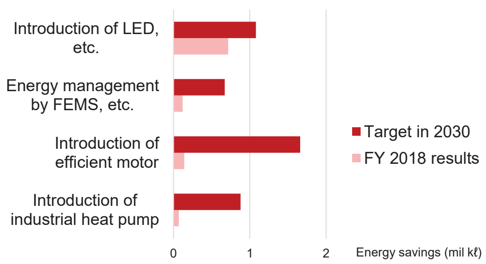
Sector	FY 2018 results			
	Energy savings	Progress rate	Progress rate by EE&C measure	
Residential	▲2.9 mil kℓ	24.9%	• Introduction of LED, etc. • EE improvements of appliances • EE improvements of house	72% 24% 10%
Commercial	▲3.3 mil kℓ	27.1%	• Introduction of LED, etc. • Energy management by BEMS, etc. • Introduction of efficient refrigerator -freezer and router / server, etc.	63% 25% 18%
Industrial	▲2.8 mil kℓ	26.3%	• Introduction of LED, etc. • Energy management by FEMS, etc. • Introduction of efficient motor • Introduction of industrial heat pump	66% 18% 9% 8%
Transport	▲4.4 mil kℓ	27.6%	• Other measures in transport sector • Diffusion of next generation vehicle	47% 14%

Source: JET based on METI's material, Mar.2021

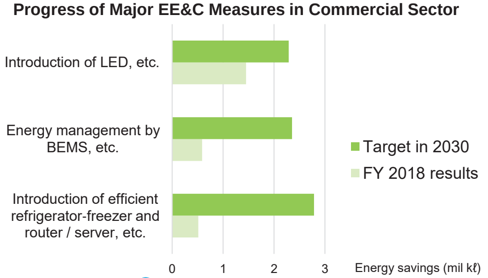
Progress of Major EE&C Measures in Residential Sector



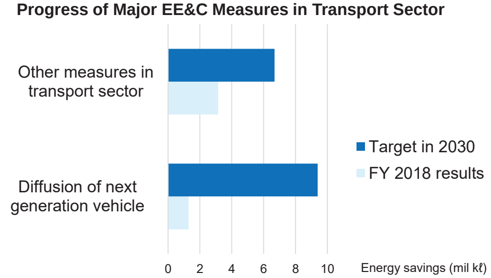
Progress of Major EE&C Measures in Industrial Sector



Progress of Major EE&C Measures in Commercial Sector



Progress of Major EE&C Measures in Transport Sector



Source: JET based on METI's material, Mar.2021

Major Issues and EE&C Regulations by Sector

	Industrial	Commercial	Residential	Transport: Passenger	Transport: Freight
Major issues	Improving EE remains at a standstill ⇒ Promotion of EE&C investment	Limitations of improving equipment efficiency ⇒ Utilization of IoT, AI, etc., EE&C promotion for houses and buildings		⇒ Full-scale spread of EV / PHV / FCV	More frequent and smaller ⇒ Promotion of cooperation between shipper and freight operator
Regulation	Top Runner Program (Energy saving standards for equipment, etc.) ⇒ Examination of appropriate system design, etc.				
	Regulation on factories, etc. ⇒ Strengthen execution, etc.	EE law of buildings ⇒ Take highly effective measures for each scale / use to ensure compliance with EE standards			Regulation of shipper Regulation on freight operator ⇒ Examination on EE&C efforts of supply chain, etc.

Source: JET based on METI's material, Mar.2021

- **Top runner program started in 1998 which was defined in EE law (establishment: 1979)**
  - **Standards for performance of appliances, etc. are set at the top runner performance in that year.**
  - **Other products (runner-up, etc.) are required to catch up and qualify the top runner level in designated duration.**

Current Target Products of Top Runner Program (32 products)

Passenger Vehicles	Video Tape Recorders	Vending Machines	Printers
Freight Vehicles	Electric Refrigerators	Transformers	Heat Pump Water Heaters
Air Conditioners	Electric Freezers	Electric Rice Cookers	AC Motors
TV Sets	Space Heaters (Gas/Oil)	Microwave Ovens	Bulbs
Copying Machines	Gas Cooking Appliances	DVD Recorders	Refrigerating Showcases
Computers	Gas Water Heater	Routers	Insulation Materials
Magnetic Disk Units	Oil Water Heaters	Switches	Sashs
Lighting equipment	Electric Toilet Seats	Multi-function Printers	Double Glazing

Source: JET based on METI's homepage

Thank you very much for your kind attention !

Energy Efficiency & Conservation (EEC) Materiel
Technical Cooperation to Promote
Energy Efficiency in Caribbean Countries

Information Sharing Material - Energy Audit Best Practice at Aquarium & Amusement Park in Japan -

Barbados, January 2023

Nippon Koei Co., Ltd.
PADECO Co., Ltd.

Outline of the Aquarium & Amusement Park

✓ The company was Established in 1990.
✓ The amusement park was opened in 1993.
✓ Annual number of visitors; 4 to 5 million (Top 5 in Japan).
✓ The park is type-1 designated energy management factory under "the law concerning the Rational Use of Energy".

◆ Three-story aquarium with thousands of fish which is one of the largest in Japan.
⇒ A lot of cold energy & heat (chilled & hot water) are necessary to maintain water temperature in water tanks constant all year around as well as space heating & cooling for visitors.

◆ Other attractions
- Vertical fall amusement (BLUE FALL) with 107 meters high.
- Japan's first roller coaster that swings out over the ocean.
- World famous Merry-Go-Round with thousands of lights glittering.

Outline of the Aquarium & Amusement Park

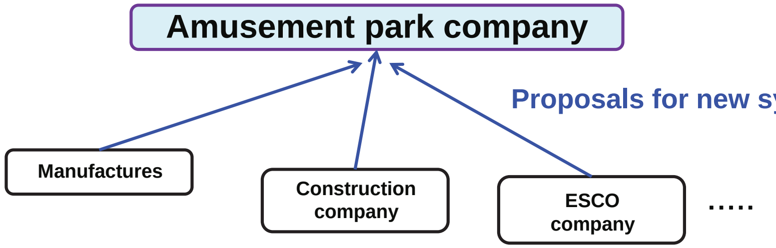
4 WANTS in the Company

1. Cut energy cost
2. Improve the efficiency of maintenance and operation of facilities
3. Promote further energy savings and environmental measures
4. Asset-light business operation by reducing investments

Two major backgrounds in Japan

✓ Increasing interests in energy savings by the law concerning the Rational Use of Energy.
✓ Increasing interests in CO_2 emissions reduction.

Toward the Realization of 4 WANTS



- Several companies proposed new system.
- Amusement park company itself analyzed and examined each proposal for more than a year.
- In the process of examination, the responsible person was appointed by the company played an important role on;
  - Providing suggestion to management from technical angle.
  - Verification of various figures indicated in proposals such as consumption of electric power, city gas, water.

Key Point 1 for Realization of 4 WANTS

1. Reduction of maintenance fee for co-generation
2. High efficiency system which contributes to energy savings and CO_2 reductions
3. Simple system toward the realization of efficient operation

Stop operation of co-gen (2 units) and introduction of high efficiency air-source heat pumps instead.

- In case of air-source HPs, cooling water necessary in the existing system will not become necessary by air-source HPs.

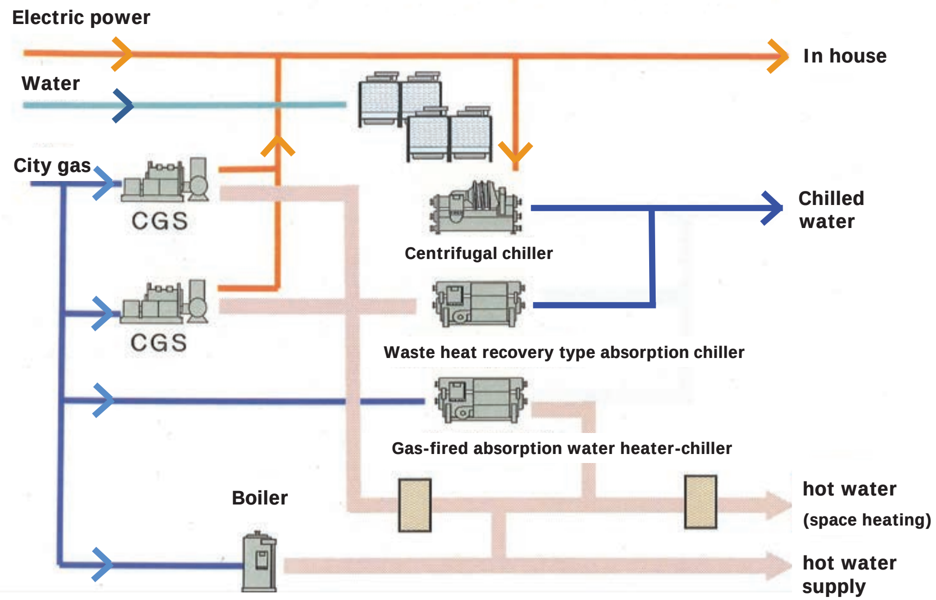
Key Point 2 for Realization of 4 WANTS

Adoption of high efficiency heat pumps

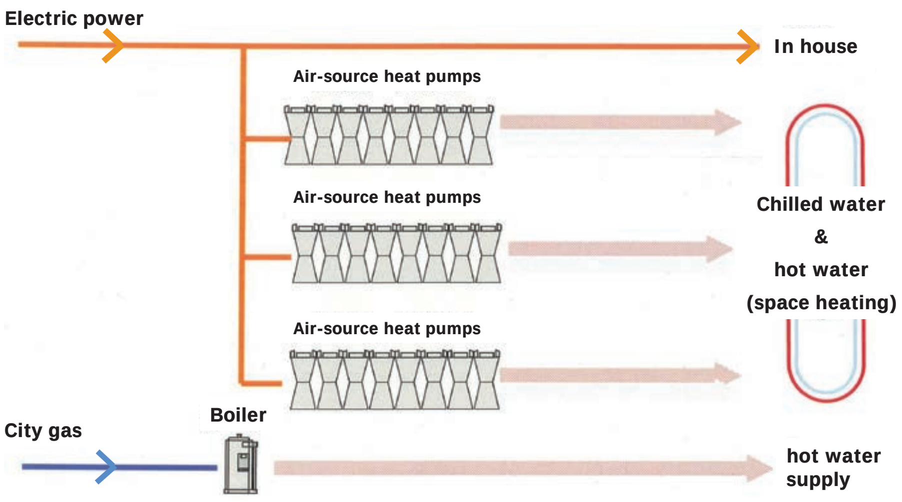
- The industry's first large-scale heat pumps with high efficiency.
- This heat pump won the Minister of Economy, Trade and Industry Prize at the Energy Conservation Awards.

Picture of high efficiency heat pumps

System Comparison – existing system -

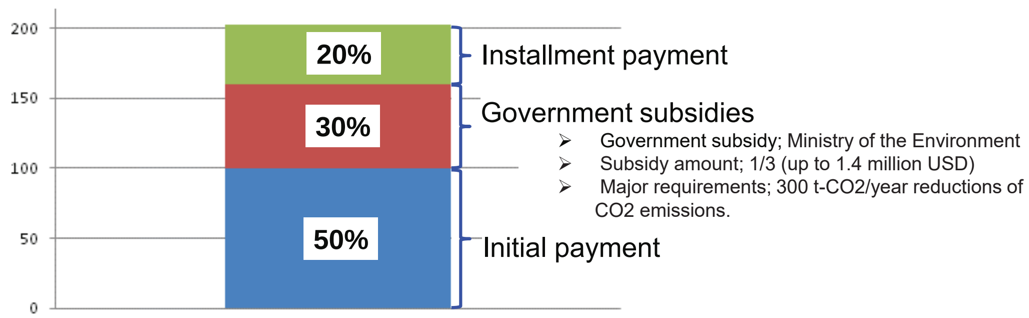


System Comparison – renewed system -



New system is more simple.
⇒ Needs no water and less space.

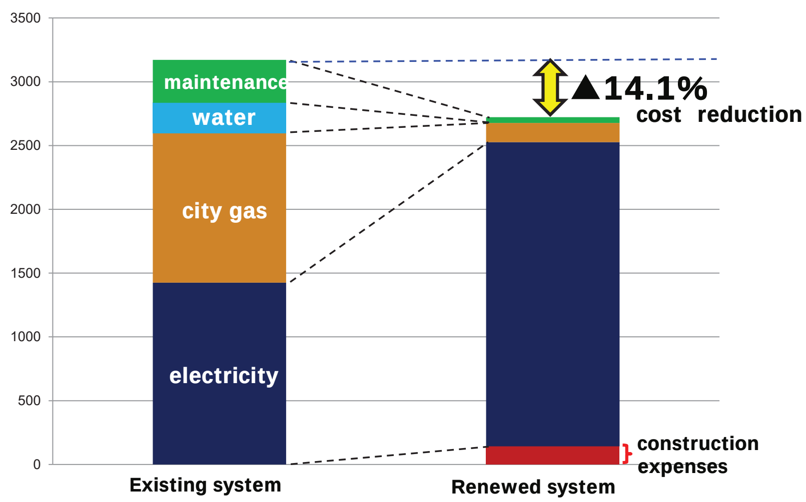
Construction Cost



Composition on payment for construction cost

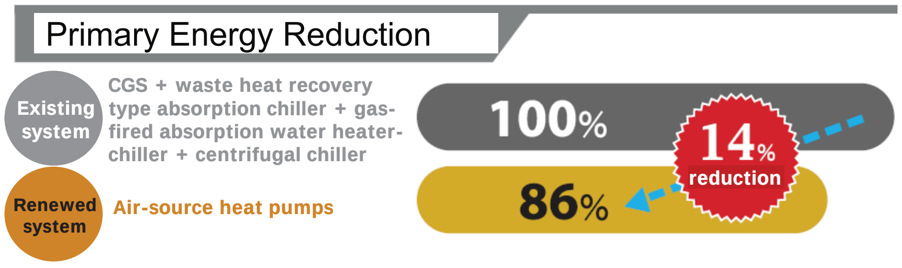
- 10% out of total cost are interests.
- Term of installment payment is 15 yrs.

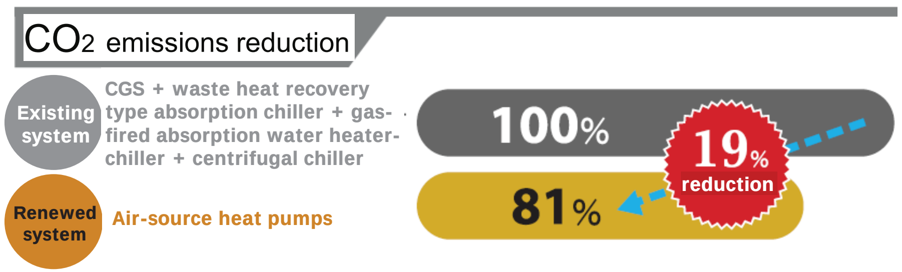
Comparison of Life Cycle Cost



Comparison of LCC (15yrs)

Primary Energy & CO_2 Emissions Reduction





Through 2 Years Operation

- **Operational cost reduction**

  ➡ **Approx. 70 million JPY (0.5 million USD) was reduced annually.**

  ⬇

  Construction cost was already recovered within 2 years.

- **CO_2 emissions reductions**

  ➢ **Obligated amounts of reductions by MOE = Approx. 600 t-CO_2/year**

  ➡ **Approx. 1,800 t-CO_2 was reduced within 2 years.**

  ⬇

  CO_2 emissions clears the designated level by MOE.

Thank you very much for your kind attention !

The Technical Cooperation Project to Promote Energy Efficiency in Caribbean Countries

Organizational Management

Energy Efficiency Workshop

January 2023

Nippon Koei Co., Ltd.
PADECO Co., Ltd.

Organizational Management

Essential functions of organization

By Chester I. Barnard

1. **Common purpose**
2. **Willingness to cooperate***Incentive and Persuasion
3. **Communication***to share common purpose/make organizational activities effective and efficient.

Review of JICA project & baseline survey

JICA project design & outputs

Overall Goals

Energy security is ensured through introduction of renewable energy (RE) and promotion of energy efficiency (EE)

Project Purpose

Human and institutional capacities are enhanced for the introduction of RE and promotion of EE

Output 1
The basic information is confirmed for the capacity building for the introduction of RE

Output 3
The human and institution capacity are enhanced for the mass introduction of RE

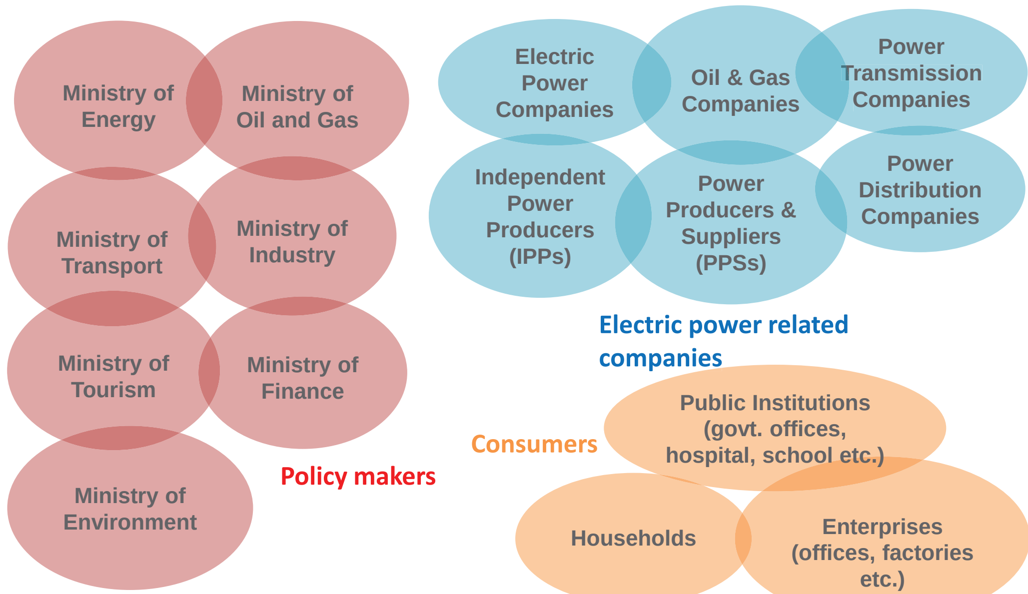
Output 5
The human and institution capacity are enhanced for the promotion of Power Network Resiliency

Output 2
The basic information is confirmed for the capacity building for the promotion of EE

Output 4
The human and institution capacity are enhanced for the promotion of EE

Organizational management is an important aspect to enhance human and institutional capacity

Various stakeholders in energy sector



Stakeholders of JICA project

Barbados: MEB, BNSI, BLPC, BREA, UWI
St. Kitts & Nevis: MPI, SKELEC, NIA, NEVLEC
Jamaica: MSET, JPS

Red: policy makers
Blue: electric power related companies
Black: non-governmental institutes

Barbados: Energy sector

Policy makers

Ministry of Energy and Business Development of Barbados (MEB)
Energy Division
- Policy, legislative and regulatory initiatives of energy sector
- Supervise Barbados energy sector

etc.

Fair Trading Commission (FTC)
- Sets electricity rates & standards for grid power

etc.

Barbados National Standards Institution (BNSI)
- standardization to meet international competitiveness of goods & services

etc.

Electric Power Related Companies

Barbados Light & Power Company (BLPC)
- generate electricity and deliver electricity
- invest in ways to make electricity generation cleaner and in getting that energy to market

Independent power producers (IPPs)

Consumers

Consumers
- Enterprises
- Households
- Public Institutions

...etc

Non-governmental Institutions

NGOs
Barbados Renewable Energy Association (BREA)
Help to create business environment & harmonious development of energy sector etc.

University
The university of the West Indies at Cave Hill, Barbados (UWI)
- Research of energy sector
- Provide necessary advices to stakeholder from the academic perspective

etc.

Source: JET
As of Jan 2023

St. Kitts & Nevis: Energy sector

Policy makers

Ministry of Public Infrastructure and Utilities, Transport, Information, Communication and Technology and Post (MPI)/ Energy Unit
- implementation and monitoring of government policies and regulations relating to electricity in order to deliver the best quality services to all customers

Nevis Island Administration (NIA)
- Energy policy making of Nevis
- Owner of NEVLEC and monitoring energy sector in Nevis

Electric Power Related Companies

St. Kitts Electricity Company Ltd. (SKELEC)
- a public utility that provides electric power generation, transmission and distribution services

Nevis Electricity Company Ltd (NEVLEC)
- the sole provider of electricity in Nevis and a fully owned subsidiary of NIA
- work as a power generator, transmitter and distributor, and electricity service provider in Nevis

Consumers

Consumers in St. Kitts
- Enterprises
- Households
- Public Institutions

... etc

Consumers in Nevis
- Enterprises
- Households
- Public Institutions

... etc

Source: JET
As of Jan 2023

Jamaica: Energy sector

Policy makers

Min. of Science, Energy &Technology (MSET) /Energy Division
- provide advice on policy, legislative and regulatory initiatives
- Supervise Jamaica energy sector
- Analysis of data to support the demand and supply on the oil market

Petroleum Corporation of Jamaica (PCJ) /IRP group
- Making roadmap - Integrated Resource Plan (IRP)
- Implement energy saving diagnosis
- Capacity building of ministry

National Energy Solution Limited (NESol) (state-owned)
- Implement Rural Electrification Programme (REP)
- Electrification of rural area
- Implement energy saving diagnosis for public facilities

Electric Power Related Companies

Jamaica Public Service Co., Ltd. (JPS)
- IPP (Independent Power Producer)
- Integrated electric utility company
- Sole distributor of electricity in Jamaica.

power purchase agreement (PPA)

Wigton Windfarm Ltd. (WWF)
- New IPP
- Facilitate and promote the use of wind and other alternative forms of energy

WRB Energy & Content Solar Ltd.
- New IPP
- Solar PV energy production, , and integrated utility operations

Jamaica Energy Partners (JEP).
- IPP
- Heavy fuel oil and diesel power production and Solar PV energy production

Consumers

Consumers
- Enterprises
- Households
- Public Institutions

... etc

Source: JET
As of July 2019

Note: Organizational restructuring was planned in MSET and need information update

Findings from baseline survey

Common challenges from the perspective of organizational analysis

- Limited human resources & qualified staffs (1 staff covered wide area)
- Limited human resource development plan and training opportunities
- Communication gaps between organizations (including data & information sharing)

Organizational management can improve these challenges

Organizational structure

-How to improve organization-

Different types of organizational structure

✓ To destroy tangible and intangible organizational barriers
✓ To collect and share information
✓ To realize speedy / right decision making

- Committee organization
- Matrix organization
- Project organization
- Network organization
  - internal network - IT, different hierarchy
  - external network
- Flat organization
- Small organization

Strengthen horizontal networking (Committee, Matrix, Project organization)

Optimization and diversification of information route (Network organization)

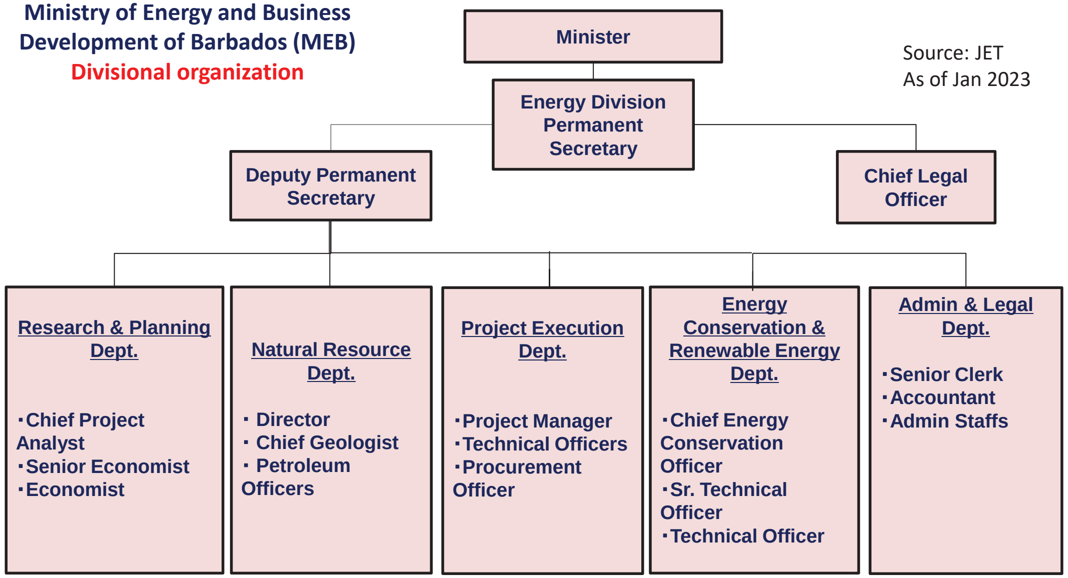
Communication of hierarchical relationship (Flat organization, Small organization)

Source: Masatake Ushiro (2002)

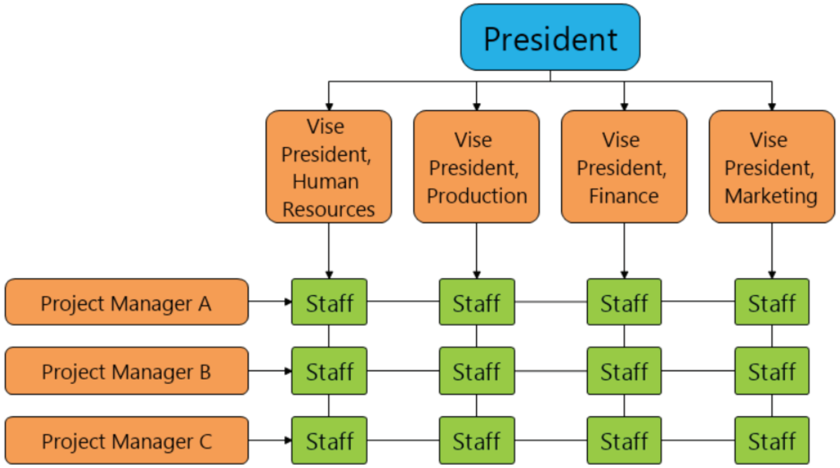
Barbados: MEB organizational chart

Ministry of Energy and Business Development of Barbados (MEB)
Divisional organization

Source: JET
As of Jan 2023



Matrix organization - Strengthen horizontal networking

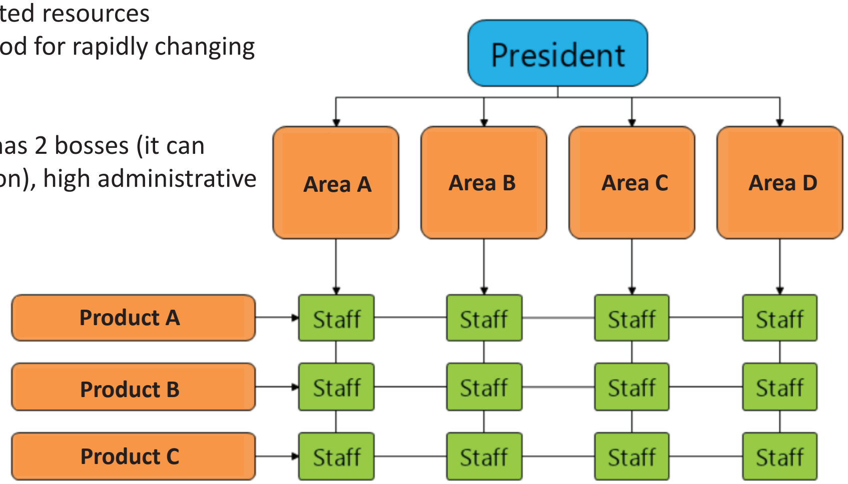


Source: Masatake Ushiro (2002)

Matrix organization - Strengthen horizontal networking

Pros: Use limited resources effectively, good for rapidly changing environment

Cons: 1 staff has 2 bosses (it can make confusion), high administrative cost



Source: Masatake Ushiro (2002)

Project organization - Strengthen horizontal networking

Project based organization

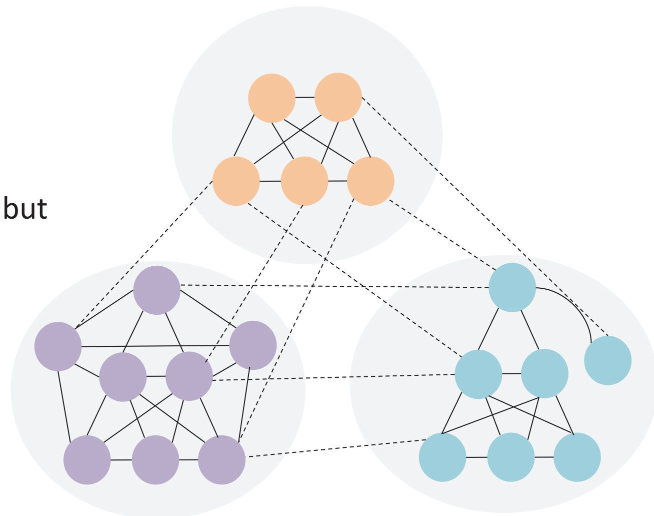
- **Short time/small people**
- **Gathering expert** of each division (better to recruit those who are interested in the project)
- **Clear purpose/direct linkage with top management**
- **Top priority**
- **Close communication** within members
- **Visualization of result/feedback**

Source: Masatake Ushiro (2002)

Network organization

- Optimization and diversification of information route

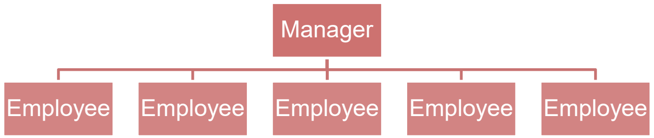
- Between members / departments / organizations
- **Functional relationship**, but no hierarchy
- **Independence**
- **Variety of information networks**
- **Variety of learning opportunities**



Source: Masatake Ushiro (2002)

Flat organization

- Communication of hierarchical relationship



- **Quick decision making**
  - ✓ simplification of information route and decision-making process
- **Reduce administrative cost**

Source: Masatake Ushiro (2002)

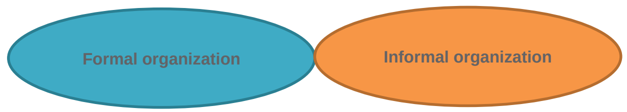
Point of excellent company

Excellent company

Informal organizations are developed, and their activities **support formal organization** to achieve common purpose

Non-excellent company: Informal organizations work against common purpose

Source: Masatake Ushiro (2002)



Organizational communication

-How to keep good relationship/improve relationship-

Dealing with cultural differences

1. Ignore differences
- be physically or mentally isolated/separated
- deny

2. Recognise differences but Evaluate them Negatively
- denigrate others
- feel superior
- place others on a pedestal

3. Recognise differences but Minimise their Importance
- trivialize
- fail to notice uniqueness « We are all the same »

Source: Philippe Rosinski (2022)
Bennett: « Towards Ethnorelativism: A Developmental Model of Intercultural Sensitivity. » 1993
Rosinski: « Beyond Intercultural Sensitivity: Leveraging Cultural Differences . » 1999

Dealing with cultural differences

4. Recognise and Accept differences
- acknowledge, appreciate, understand
- acceptance agreement, surrender
- acceptance needs to be instinctual and emotional as much as intellectual

5. Adapt to differences
- move outside one's comfort zone
- empathy (temporary shift in perspective)
- adaptation adoption, assimilation

6. Integrate differences
- hold different frames of reference in mind
- analyse and evaluate situations from various cultural perspectives
- remain grounded in reality essential to avoid becoming dazzled by too many possibilities

7. Leverage differences
- make the most of differences, strive for synergy
- proactively look for gems in different cultures
- achieve unity through diversity

Effective communication

Intercultural communication **–** Being able to rely on various forms of communication: explicit and implicit, direct and indirect, affective and neutral, formal and informal

Source: Philippe Rosinski (2022)

Mindset for differences

Differences in response due to high homogeneity and high heterogeneity

	high homogeneity		high heterogeneity
communication	Responsibility of listeners	⟺	Responsibility of speakers
relationship	Staging vertical relationships	⟺	Staging horizontal relationships
thinking	Seeking for a right answer	⟺	Seeking for optimized answer

It is important to develop positive mindset for differences.

Source: Shinji Kawakami (2017)

Effective negotiation

Distributive negotiation

- Only one party "wins"
- Focus on outcomes; not the relationship
- Outcomes seen as fixed
- Goals mutually exclusive
- Emphasize differences
- Emphasize positions
- Short-term perspective
- Key: preparation & tactics
- Guarded communication
- Distrust

Integrative negotiation

- Both parties "win"
- Concerned with mutual outcomes and relationship
- Outcomes can be maximized
- Goals not mutually exclusive
- Emphasize similarities & differences
- Emphasize interests
- Long-term perspective
- Key: cooperation & creativity
- Open communication
- Trust

How to keep good relationship?

Source: Dr. Ahmad Siddiquei (2022)

Communication tools

✓ Information sharing

report, presentation, chat, interview
mailing list, message board, SNS, group chat
newsletters, operational manuals, circulation of documents
cloud storage (share file/folder)…

✓ Meeting

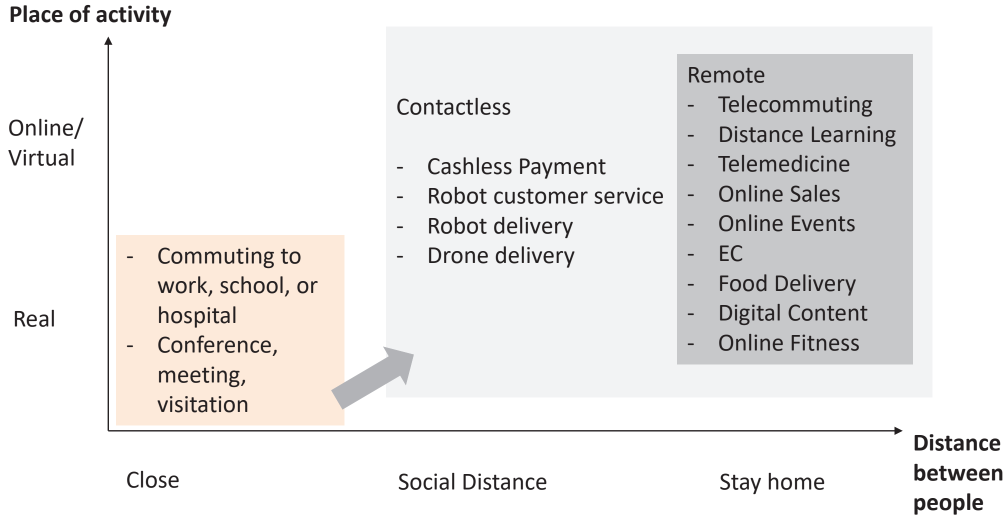
frequency of meeting - monthly, weekly, daily… regular or irregular
face to face, online…

✓ Training

Internal- OJT, OFF-JT, mentor, workshop, group work…
External- trainings for civil servant, college courses, seminars, online trainings…

Information technology & DX

Shift from real to online with information technology and digital transformation (DX)



Ref) Kenichi Ohmae (2021)

Discussion

How can you improve organizational communication in your work?

Summary

Various stakeholders and common challenges

- There are policy makers, electric power related companies and consumers in energy sector.
- Result of baseline survey shows limited resources, budget & time to enhance human and institutional capacity…

Optimize organizational structure & communication

- There are different types of organizational structure
- Good use of informal organization helps formal organization to achieve a goal

Importance of organizational communication

- Accept, adapt, integrate and leverage difference and develop positive mindset for difference
- There are different negotiation styles and what do you select?
- There are many communication tools. How do you maximize use of information technology and DX?

Thank you!

Anna Miyaura (Ms.)
JICA Expert of Human Resources Development/Monitoring
Project Consultant @PADECO
[redacted]

Appendix 4-2-2 Attendant list, and Q&A, of the 2nd Energy Efficiency Workshop (Barbados)

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

2nd EE Workshop: Attendant Day-1 (23 Jan 2023) **Total** **9**

No.	Name	Position	Org.	How to participate	Count
1	Horace Archer	Senior Technical Officer	MEB	Physical	OK
2	Frank Branch	Technical Officer	MEB	Physical	OK
3	Fabian Scott	Chief Technical Officer	BNSI	Physical	OK
4	Renate Lynn Sealy	Technical Officer	BNSI	Physical	OK
5	Jonathan Platt	Technical Officer	BNSI	Physical	OK
6	Damien Prescott	Technical Officer	BNSI	Physical	OK
7	Robert Goodridge	President	BREA	Physical	OK
8	Felicia Whyte	Project Development Officer	CCREEE	Physical	OK
9	Ayanna Evelyn	Knowledge Management Associate	CCREEE	Physical	OK
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

2nd EE Workshop: Attendant Day-2 (24 Jan 2023) **Total** **8**

No.	Name	Position	Org.	How to participate	Count
1	Horace Archer	Senior Technical Officer	MEB	Physical	OK
2	Frank Branch	Technical Officer	MEB	Physical	OK
3	Fabian Scott	Chief Technical Officer	BNSI	Physical	OK
4	Jonathan Platt	Technical Officer	BNSI	Physical	OK
5	Damien Prescott	Technical Officer	BNSI	Physical	OK
6	Robert Goodridge	President	BREA	Online	OK
7	Felicia Whyte	Project Development Officer	CCREEE	Physical	OK
8	Ayanna Evelyn	Knowledge Management Associate	CCREEE	Physical	OK
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

EE Workshop on 23 Jan: Q&A

No	Item	Content	Name	Answer
1	Question	Why is there an increase in the industry sector?	R. Goodridge	The increase is related to more companies working or factory working hours
2	Comment	The industry increase when compared to the overall energy use is quite small. The commercial decrease can be attributed to decrease in economic activity in that sector.	H. Archer	We agree.
3	Comment	It takes about 3 joules of fossil fuel produces only 1 joule of electricity.	W. Hinds	Thank you for this comment.
4	Question	In terms of industry, are standard a/c units still being made as inverter technology is more efficient? Is it being phased out?	H. Archer	Small scale, inverter tech is popular in mini splits. But VRF, and large chillers have no MEPS. These medium and large scale chillers are used in 10,000-30,000 m^2 buildings and have water piping. They intake fresh air and expel heated air from building via an air handler. VRF and mini-split a/c just control temperature of the room.
5	Comment	There are examples of inefficient LED installations in Barbados that needs to suit the Street lighting application.	W. Hinds	The correct reflective materials are needed as LED shine at 120 degrees where conventional mercury/CFL bulbs are 360 degrees.
6	Question	What are the costs for adding in the LED lighting initiatives for commercial industry? So a proper Cost Benefit Analysis can be conducted.	R. Goodridge	The details are not available, but the reduction of the energy use correlated to the amount of chilled water the case study was billed each month. LED payback periods are usually 2-3 years.
7	Comment	In 2009, India's Govt started something similar for lighting, where they dimmable lighting on streets and highways and it saved them money. Something like this can be done in commercial spaces.	F.Hinds	This happens in commercial buildings since the 1990's where timing and proximity sensors were used to decrease energy demand and control lighting. Now with the advent of LED lighting, the energy savings can be enhanced significantly. The LED lighting we have installed have the capacity to be dimmable, but those modules wasn't installed.
8	Question	The total value for the box and the windows are added for our building requirement calculations?	W. Hinds	Yes we add them in the calculations.
9	Question	Would we have similar values for our windows to calculate our heat gain?	W. Hinds	These values were given by the Japanese Gov't, but some of the values are provided from the window manufacturers catalogue.
10	Question	Can a Household Energy Efficiency calculation sheet be developed for Barbados? And can the solar water heater be added to our special revision?	W. Hinds	Yes it can be developed, and the solar water heating is the most efficient method- for heating in this region.
11	Question	Have you discovered the law is now accelerating EE measures, i.e. an increase of EE installations in Japan?	F.Hinds	EE measures an installations have increased due to the tightening EE laws in Japan as most regulations are mandatory.
12	Comment	The CREEBEC is quite similar to this simplified calculation method.	J.Platt	Yes we have this standard in our possession and we reviewed it.
13	Comment	The CREEBEC is very complex and this approach is simple and easy to use	J.Platt	Thank you for this comment.

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

EE Workshop on 23 Jan: Q&A

No	Item	Content	Name	Answer
14	Comment	Passive Cooling is something we as Barbadians should look into, primarily insulation of roofs	W. Hinds	This is something we can see as very beneficial to Barbadian homes, especially in decreasing the cooling requirement.
15	Comment	Large eaves can't work in Barbados as we are in the Hurricane Belt, so we can use paints etc.	J.Platt	Thank you for this comment.
16	Comment	Need to introduce an Energy Efficiency Standard for houses in Barbados. Might have to be like European Standards and not like the Japanese approach that does a calculation.	W. Hinds	The simplified version can work for Barbados.
17	Comment	There is still a need to ensure the EE measures are done correctly in Barbados, despite the lack of resources.	J.Platt	Agreed, even in Japan planning for verification is still ongoing and checking will start in 2025.
18	Question	What energy reduction can we see in the residential and commercial sector?	W. Hinds	Half of the demand for a/c, refrigerator and lighting will be achieved by 2050

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

EE Workshop on 24 Jan: Q&A

No	Item	Content	Name	Answer
1	Question	Shading of the a/c units are beneficial, but what can we do to minimize the impact of salt mist in the air as it corrodes the outdoor unit	J. Platt	Shielding can assist with that, but salt spray is very corrosive.
2	Question	We have a mall here in Barbados and the installers placed PV panels over the units and quoted 20%, is it true?	H. Archer	Yes, as some manufactures say 20% reduction , so our 10% reduction is conservative.
3	Comment	For companies renting buildings, there is no incentives to invest in energy savings as this doesn't benefit the landlord. If there is a mechanism where the tenant and landlord both benefit.	W. Hinds	This has been identified as a barrier to improve the EE measures in tenanted buildings, even in Japan. For reference, there are cases in US that tenants bring in the AC equipment and monthly power bill is also paid by tenants. This is one of the models for tenant buildings to raise incentive to introduce efficient equipment.
4	Comment	LEED and other energy efficient building certifications can be used to incentivize energy efficiency measures.	H. Archer	We thank you for this comment.
5	Comment	There are about 4 buildings that are focused on energy efficiency in Barbados and use this as a selling point for their tenanted buildings.	J. Platt	Thank you for this comment
6	Comment	The office of the MEB can have a reduction in lighting requirements as the light levels are about 900 Lux.	H. Archer	The retrofit from fluorescent to LED caused an increase of Lux in the office, and due to the lighting layout, it might be best to decrease the amount of lights installed .
7	Comment	The temperature variation is the highest from late night till midday. If we utilize the variations in temperature during the night and weather variations, we can boost energy efficiency in cooling in Barbados. (night parge)	W. Hinds	Thank you for this comment
8	Question	The CREEBC recommends motion sensors to further improve efficacy, what is JICA's take on sensors?	J. Platt	Sensors can be utilize to advance the progress of building control management to a greater efficiency.
9	Question	With reference to your presentation, what category would you place JICA in? The structure of BNSI is old and needs revamping. BNSI has changed into a project based company and would like to see examples of how to make government agencies more flexible to meet the energy goals of Barbados.	F.Scott	We are part of JICA's approach as we are executing a Joint-Venture project here with the project. We cannot speak directly about JICA's organization directly.
10	Comment	The avoidance of being dazzled by several possibilities is one key measure BNSI takes to progress the national standards.	J. Platt	We thank you for this comment.
11	Question	What is the purpose of communication?	H. Archer	The purpose of communication in this aspect is to boost relations between Government and Non-Governmental Organizations, and to promote energy efficiency and climate change mitigation.

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

EE Workshop on 24 Jan: Q&A

No	Item	Content	Name	Answer
12	Comment	The advent of COVID-19 globally has transformed the way in which we communicate in order to be more effective.	J. Platt	This is true, as it provides a myriad of ways to communicate.
13	Comment	There isn't a framework for communication as all of this tools that are available. Having a protocol for effective communication in organizations.	F.Scott	Having a framework for communication via a set suite of platforms would ensure efficacy.
14	Comment	There is a need for high level protocols for meetings to streamline lengthy meetings.	W. Hinds	Thank you for this comment
15	Comment	What is the structure for EV infrastructure in Japan? We at the BNSI would like to see what we can glean from JICA. BNSI was like to get information on battery standards and performance, along with information for a secondary battery market.	J. Platt	Thank you for this comment
16	Question	What information is available for SWAC for district level cooling in government buildings.	F.Scott	SWAC is not used in Japan, but has been demonstrated for district cooling in places like Hawaii. We do not have detailed information.
17	Comment	Energy Storage standards to ensure safety.	H. Archer	We thank you for this comment.
18	Question	What are the industry standards for module replacement as this is important for safety standards. We need to establish V2G tech standards as well.	F.Scott	The standards are highly dependent on the type of battery and can vary.

Technical Cooperation to Promote Energy Efficiency in Caribbean Countries

Progress and Discussion for RE and Grid Stabilization in Barbados

Jul 2022

Nippon Koei Co., Ltd.
PADECO Co., Ltd.

RE Team Agenda and Objective in Jul 2022 in Barbados

Agenda

- Activity and overall project schedule
- RE target, challenges, and activity of Technical Assistance
- Grid with large RE penetration
- Microgrid Concept for resilience

Objective of the visit in July 2022

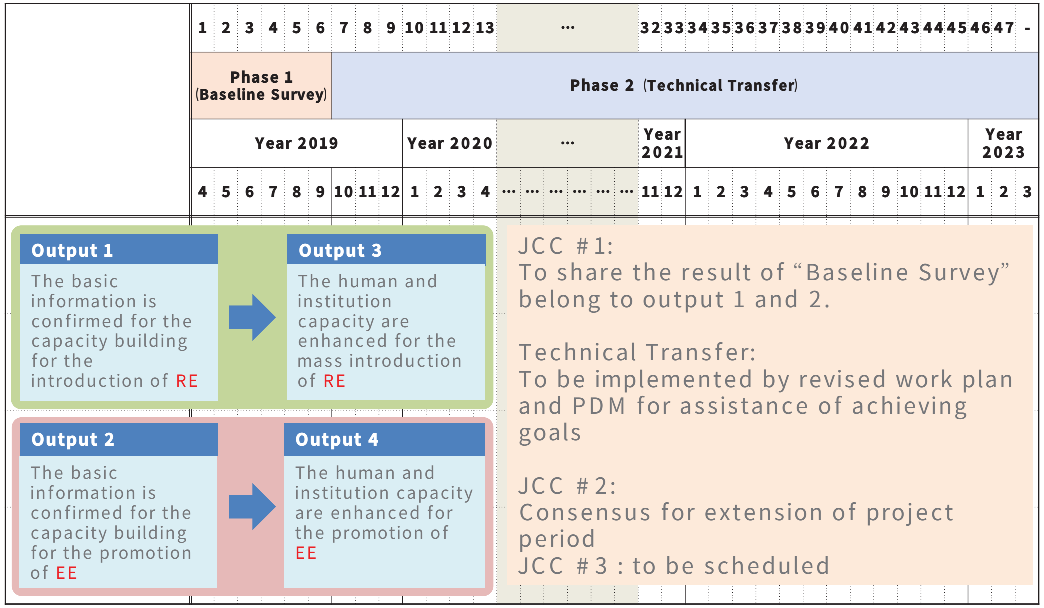
- To confirm and update generation & grid plan/status in Barbados
- To collect data for grid analysis and microgrid concept
- To conduct Workshop-1 (introduction) for grid analysis
- To discuss about recommendation about grid code and promotion policy for RE

Agenda for Workshop for Grid Stability with Large RE Penetration

Date/time: 13:00-15:00 27 Jul 2022
Venue: MEBD/ Online hybrid

13:00-13:10	Opening Remarks and Introduction
Session-1	General session
13:10-13:40	RE target in Barbados and Challenges, Recommendation for resilience (Microgrid and Asset Management)
13:40-14:00	Grid Stability: for Future Grid in Barbados
Session-2	Special session
14:00-14:45	Grid Stability: analysis method, tools
14:45-15:00	Discussion

Overall Project Schedule



Tentative Overall Schedule

Jul-22 | Aug | Sep | Oct | Nov | Dec | Jan-23 | Feb | Mar

Month	7	7	7	7	8	8	8	8	8	9	9	9	9	10	10	10	10	10	11
Date	4	11	18	25	1	8	15	22	29	5	12	19	26	3	10	17	24	31	7
EE Team										KN	B				B	KN	J		
RE Team				B							KN	B	KN	J					
											*1								

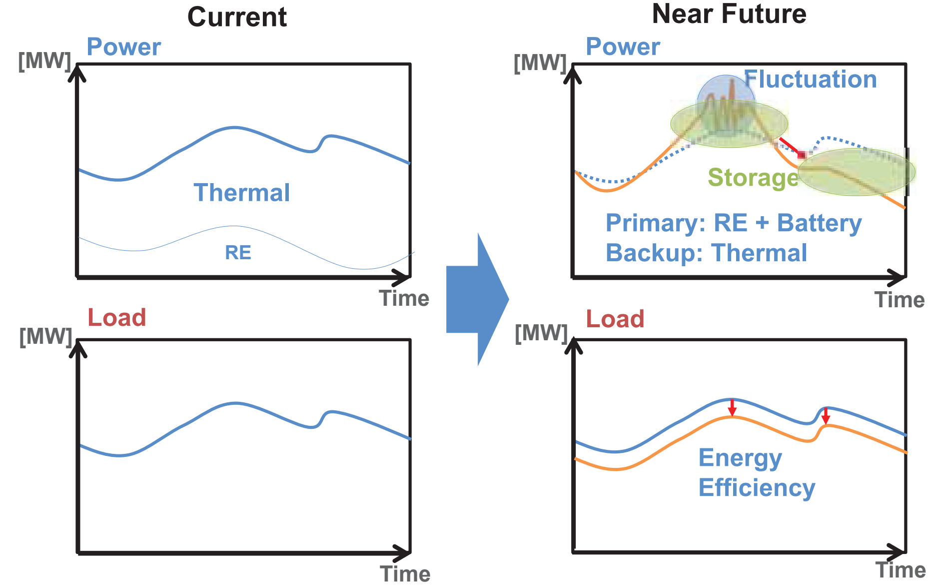
Month	11	11	11	12	12	12	12	1	1	1	1	1	2	2	2	2	3	3	3
Date	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	6	13	20
EE Team		B	KN	J					B	KN	J					*	*		
RE Team		J	B	KN					J	B	KN					*	*		

Note: Hurricane Season; Christmas Season; Training in Japan

- B Barbados
- J Jamaica
- KN St. Kitts and Nevis (Activity in Barbados or Saint Lucia with Virtual Meeting / depending on the restriction by JICA)
- * 3 Countries in 2 Weeks
- *1 To be discussed [1st RE activity of St. Kitts and Nevis), and also 1st EE/RE activities of Jamaica]

Possibility of training in Japan depends on COVID-19 situation.

Challenges



RE: Key T/C Activities for RE

Barbados

- Training for Grid stability analysis and simulation
- Micro-grid concept study at Coverley Village

Jamaica

- Training for grid simulation
- Introduction of network asset management
- Micro-grid concept study at Bogue area

St Kitts &Nevis

- Provision of Grid simulation software and training
- Introduction of network asset management

✓ Discussion for grid code

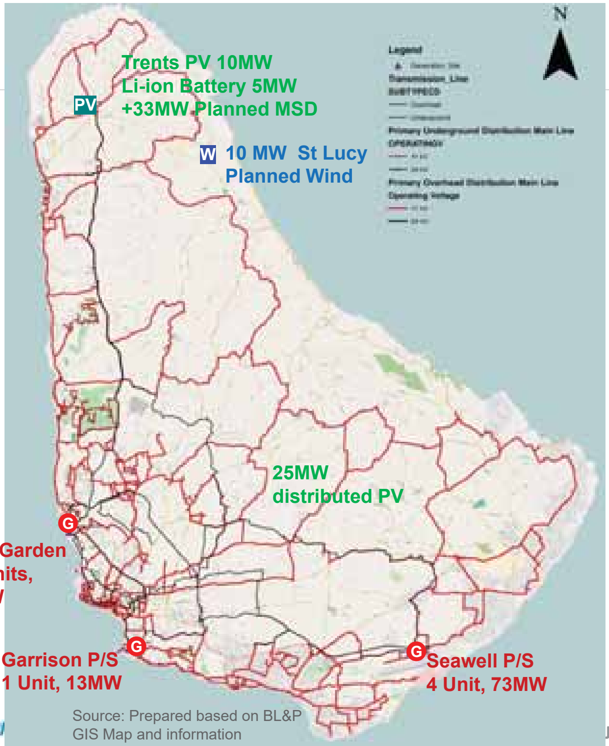
✓ Suggestion for policy and RE target with reviewing affordability of RE

Summary

B

Fields	Findings	Project Activities
1. Energy Efficiency	• Energy Source: Electricity (54%) , Oil (42%) • Load Curve: Bactrian camel type • Annual Peak Demand: about 150MW • Peak Period: 2pm - 3pm, 7pm-8pm	Priority 1: VRF Priority 2: BEMS Priority 3: Optimized operation with inverter
2. Renewable Energy	• 100% RE target incl. fuel by 2030 • 14% RE (generation), 2% of RE (energy base) • Good RE potential, but project plan not concrete • 10MW Trents PV + 12 MW Roof top	Confirmation of affordability and feasibility of 100% RE target Future project IP confirmation Training for grid simulation Micro-grid concept study
3. Grid Stabilization	• 5MW, 20 MWh BESS, 400 USD/MWh • 0.02 Hz with 1MW fluctuation, Ramp Rate 3MW/min • Fuel increase for spinning reserve	
4. O&M of Thermal Power Generation	• Thermal power plant: total 16 units (10 units for base load and 6 units for peak load • Installed Capacity: Total 255.5MW • Predictive Maintenance: Conducted twice a year	-
5. Human Resources and Capacity Building	• MEWE's Energy Conservation and Renewable Energy Unit: 3 employees • Most of capacity building is done by OJT • There is no systematic HR development.	JET experts select topics and develop the most suitable curriculum for technology transfer period

Barbados Grid and PS



Source: Prepared based on BL&P GIS Map and information

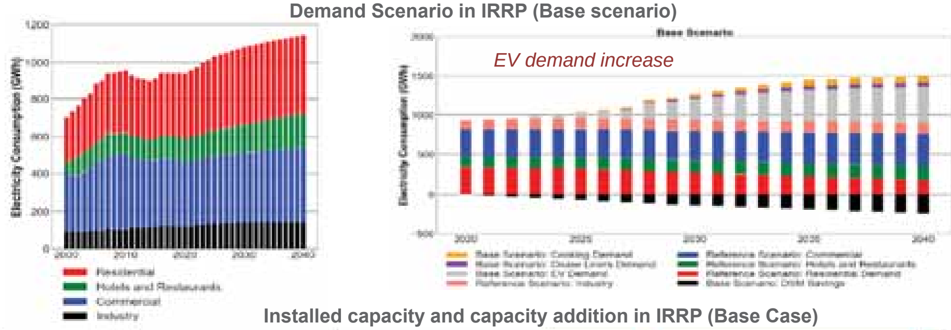
Location	MW/u	Qy	MW	Remark
Existing				
Total thermal power			232	
Spring Field	12	3	36	LSD Engine
Spring Field	12.5	1	12.5	LSD Engine
Spring Field	30	2	60	LSD Engine
Spring Field	20	2	40	Steam Turbine
Spring Field	17.5	1	17.5	Gas Tubine
Spring Field Total		9	166	
Garrison	13	1	13	Gas Tubine
Seawell	13	1	13	Gas Tubine
Seawell	20	2	40	Gas Tubine
Total PV			70	
Trents	10	1	10	PV
Distributed PV		LS	60	PV
Total Battery			5	
Trents	1	LS	5	BESS
Planned				
Total Planned RE			40	
Trents	33	1	33	CEB MSD Planned
St Lucy	10	1	10	Wind Planned
St Tomas	30	1	30	Vaucluse Biomass

Tentative. Please let us confirm the status and update if any.

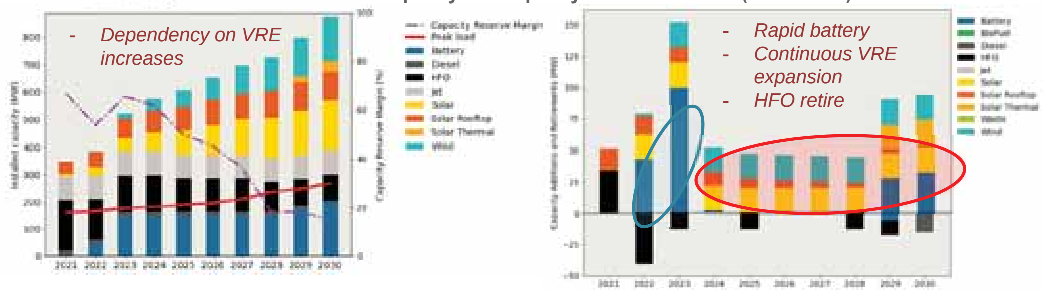
Barbados Demand&Installed capacity in IRRP

Source: IRRP Draft 2021, MottMacDonald

Demand Scenario in IRRP (Base scenario)



Installed capacity and capacity addition in IRRP (Base Case)



Challenges indicated in IRRP

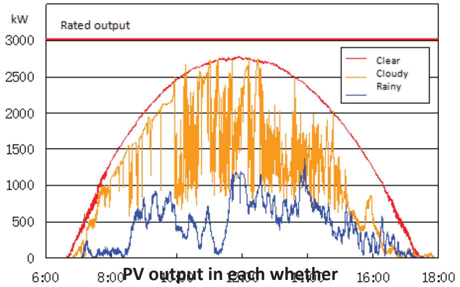
#	Item	Challenges	Solution/mitigation
1	Technical, reliability, operation	- Insufficient system reserve, diversification of generation, distribution generation& Storage, resilience and islanding - Lack of mid-term storage, smart EV system, - future asynchronous generation	Biomass, BESS, Incentive for distributed generation & storage, CAES, smart system
2	Land	Balancing competing users for land given for RE	Integrated town/land use planning
3	Fiscal	Large outflow of forex for oil	Diversify RE and BESS, storage
4	Environmental	- Decarbonization of energy system - Environmental impact of RE, cruise liners	Ditto, low-grad land utilization, RE to electrify cruise liners
5	Socio-economic	- Balancing socio-economic benefit, education and marketing benefits of customer RE	Tariff & financial incentives, market policy
6	Market/ regulatory	- Lack of market design, regulatory framework for fair RE industry, data access	GIS and data gathering
7	Capacity & resource	Capacity of IRRP transmission studies, skill in large bioenergy, on/off-shore wind,	Generation and transmission studies, university and experts
8	Cost	High cost of electricity	Diversify generation, increase energy storage

JICA T/C Items for RE and Grid Stability

IRRP #	Item	Details	Solution
1, 6, 7	Recommendation for Grid Stability with large RE penetration	Insufficient system reserve, spinning reserve and inertia, grid instability	- Planning with grid simulation, renewable synchronous generator/BESS, and new technology such as gird forming inverter - System stability cost sharing
1, 2, 4, 6, 7	Policy Recommendation for RE and grid stability, grid code	- Distributed RE - Investment plan, IPP, private - Grid code	- Smoothing effect by installation distributed PV at various places - Incentive for energy storage - SCR, inverter, etc.
1, 2, 5, 6	Recommendation for Demand side management	Demand increase especially due to EV and battery charging	- Incentive for demand side management for EV, efficient charging system
1, 4, 6, 8	Recommendation for Resilience and micro-grids	Damage to power system due to hurricane	Micro-grid, utilization of EV for V2H, asset management

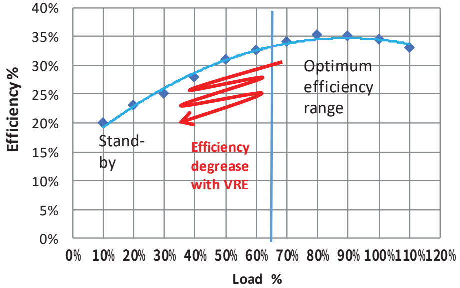
With Large RE Penetration

- VRE causes frequency and voltage fluctuation
- Load shedding due to fluctuation:
- Efficiency reduction
  - 10% DG efficiency reduction offsets 30% RE output in micro-grid without grid stabilization method
  - Increasing fuel consumption



PV output in each whether

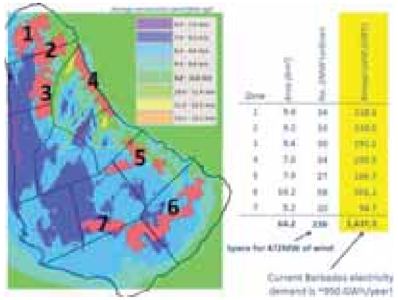
Source: http://www.kyuden.co.jp/effort_renewable-energy_photovoltaic.html



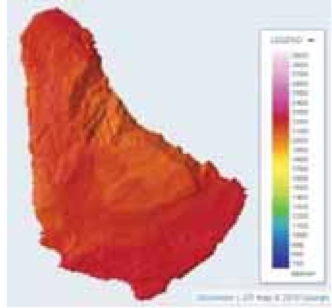
Load and efficiency of typical diesel generator

Status in Barbados

B



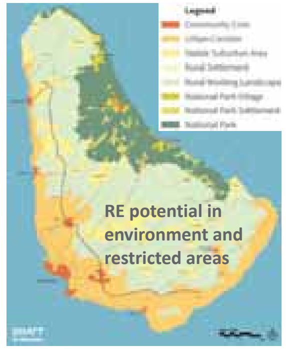
Measuring and mapping wind energy in Barbados 2016



Source: ESMAP

RE Potential

- ✓ Irradiation 4.4-4.7 kWh/kW, 2050-2240 kWh/m2/yr
- ✓ 472 MW wind potential identified but constrained by land availability



RE Projects

	Location	MW/u	Qy	MW	Remark
Existing					
Total PV				**70**	
	Trents	10	1	10	PV
	Distributed PV		LS	60	PV
Total Battery				**5**	
	Trents	1	LS	5	BESS
Planned					
Total Planned RE				40	
	St Lucy	10	1	10	Wind Planned
	St Tomas	30	1	30	Vaucluse Biomass

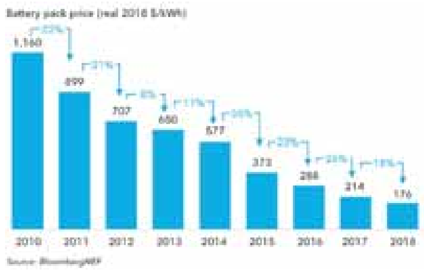
Challenges for RE

- ✓ Project implementation plans for 100% RE target for all energy
- ✓ Grid stability
- ✓ Bottle neck : land availability and environment
- ✓ Diversifying options: Biofuel, CSP

Recommendation for BESS cost reduction

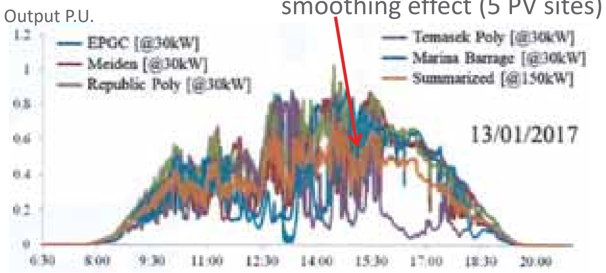
1) Output smoothing by overlaying different PV/wind locations
2) Battery at each site → Centralized battery storage system

Battery cost reduction, but still high cost



Cost reduction Example in Singapore

67% of battery capacity can be reduced by output smoothing effect (5 PV sites)



Source: Meidensha, Autonomous Micro-grid Conference, 2019

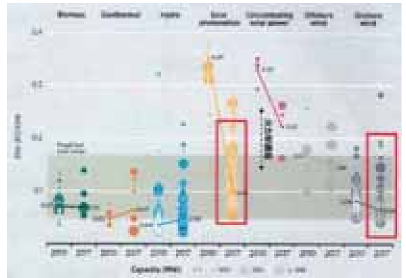
To reduce cost:
- Smoothing effect needs to be considered with distributed RE locationa
- Data analysis with solar irradiation/wind speed short interval necessary at several locations
- Speedy communication system advanced EMS control is necessary

Battery & control cost should be considered in Tariff

Way Forward for Large RE Penetration

Paradigm Shift
- VRE generation is low cost, promoted by market but cost is without stabilization
- Grid stabilization is necessary for large scale
- **Inertia** needs to be considered
  - Biomass, Biofuel, Biogas, CS
  - Grid-forming inverter
- Large cost for energy storage

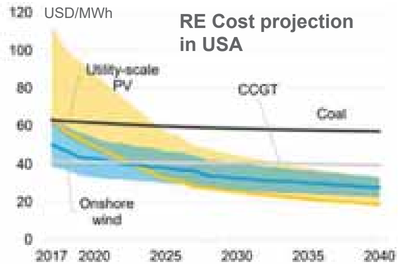
→ **Who owns the stabilization cost?**



Source: Mitsubishi Electrics, IRENA RE cost database

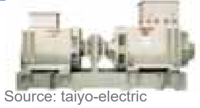
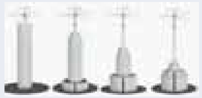
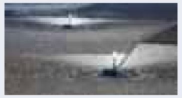
Necessary consideration in project activity

1) Grid Stabilization
2) Cost reduction of energy storage
3) Resiliency
4) Microgrid



Source: Power Markets Today, Broomberg 2018/ METI, Japan

Emerging technology for large RE with Grid stabilization : Promotion recommended

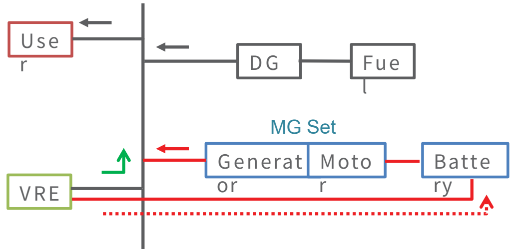
Type of Technology		Advantage	Develop stage
 Source: taiyo-electric	Motor generator (MG)	- Energy in battery provides synchronization and inertia - Small scale supply, for micro grid	- Used as frequency conversion - Commercial operation
 energyvault.com/gravity	Gravity Storage Battery	- Gravity of recycled Concrete block 35ton/nos - Provides inertia - Half cost of Li-ion battery	Pre-commercial, 35 MWh, 4MW per tower η = 85% 52.5GW planned in USA
 /www.nedo.go.jp/news/press/AA5_100756.html	CAES (Compressed air energy storage)	- Compressed high pressure air - (Liquid air may be developed) - Provides inertia	-demonstration by NEDO - 900 MW in California - η = 70-80%
 electrek.co/	CSP (concentrating solar power) Solar thermal	- With turbine, provides inertia and synchronization - Cost decrease expected, higher efficiency than PV, η = 50%	- Commercial operation at Ivanpah392MW 22 bil USD - Heat storage (molten solt, etc) under development
 Source: CIGRE	Grid-forming inverter	- Dynamic active/reactive power, FRT, frequency control, inertia - Applicable to existing PV - (Smart: FRT, VRT, voltage support)	- Under development - (Smart inverter by IEEE1547, Mandatory in Hawai)

Diversification of Technology: Battery Motor Generator set (MG Set)

Hateruma Island: Southern most island in Japan
- Area : 12.73 km2 , Population 527, hh 272 (2016)
- Peak power: 770 kW (2016)
- Generation: DG (Bunkar-A, total 1,250kW)
- Wind (245kW✕2, total 490kW)
- Lead-acid Batt (600kW/1,500kWh)
- **MG Set: Rated 300 kW**


Wind generator

Photo: https://www.kankyo-business.jp/news/011605.php

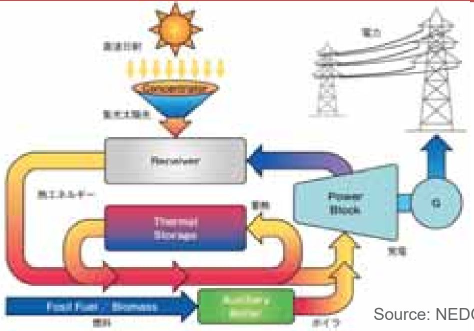


MG set is driven by battery charged from VRE and provides power with inertia → possible method to achieve 100% RE with inertia

https://www.okiden.co.jp/shared/pdf/news_release/2017/180328.pdf

Diversification of Technology : CSP

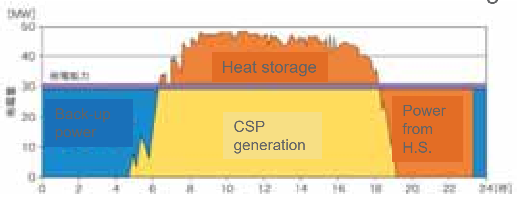
Concentrating Solar Thermal Power (CSP)



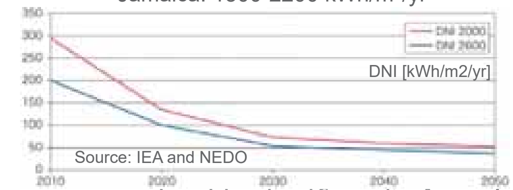
Source: NEDO


Photo: blog.eco-megane.jp/

- Inertial power can be supplied
- Combination with molten-salt heat storage
- Inertial power can be supplied
- Combination with molten-salt heat storage



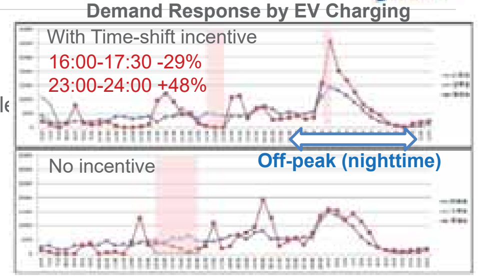
- DNI (Direct normal irradiation)
  - Barbados: 1600-2000 kWh/m^2/yr
  - St Kitts&Nevis:1600-2300 kWh/m^2/yr
  - Jamaica: 1300-2200 kWh/m^2/yr



Recommendation for EV

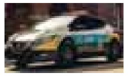
(1) TOU or Unit charge rate according to load curve and weather and PV output with EMS
(Ex.) Range-1 : Daytime, sunny , lowest
Range-2 : Daytime, sunny/cloudy / off-peak, middle
Range-4: Rain and evening, peak-time highest

Demand Response by EV Charging

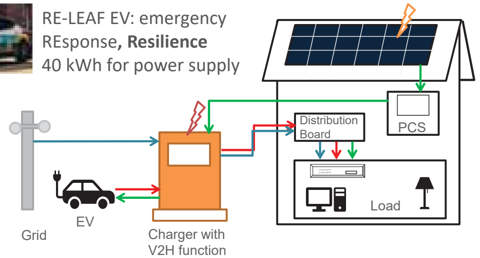


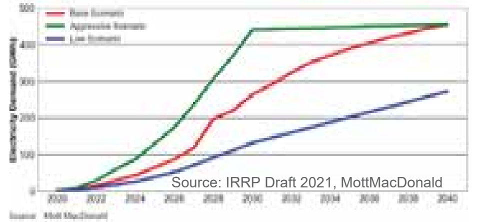
https://xtech.nikkei.com/dm/article/FEATURE/20150120/399714/?P=5

(2) Promotion of EV with Vehicle-to-Home (V2H), Vehicle- to-Grid (V2G)
- V2H is applicable for specific existing model of EV
- Emergency power supply to home



RE-LEAF EV: emergency REsponse, **Resilience**
40 kWh for power supply




Source: IRRP Draft 2021, MottMacDonald

(3) Promotion of solar assisted car
- 60 kWh, 400→725km , >47,600ASD (33,320 USD)
- Load to grid is mitigated


https://www.drive.com.au/

Resilience of RE

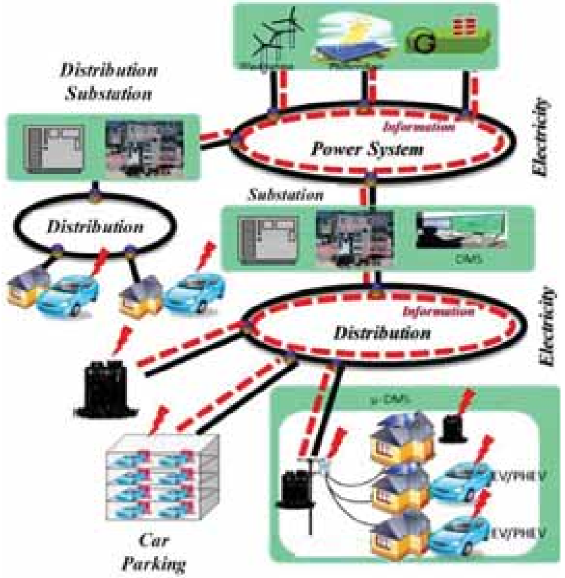
23 Aug 2018 Awaji, Japan
https://www.sankei.com/west/news/180828/wst1808280043-n1.html
600 kW, Fallen at 25.6m/s wind while 60m/s design
- Additional moment due to Excess of high speed
- Missing control power supply

9 Sep 2019 Kanto, Japan
@kadowaki_kozo
Damage of roof-top structure by high speed wind

26 Jul 2019 Himeji, Japan
https://www.dailyshincho.jp/article/2018/07260800/?photo=1
Landslide by a heavy rain

For enhancement of resilience:
- ✓ Design Standard with higher rank hurricane
- ✓ Compensation, third party Insurance coverage
- ✓ Safety Education for shock
- ✓ Fast recovery with **GIS and Asset management**
- ✓ **Micro-grid**

Recommendation for Micro-grid Concept

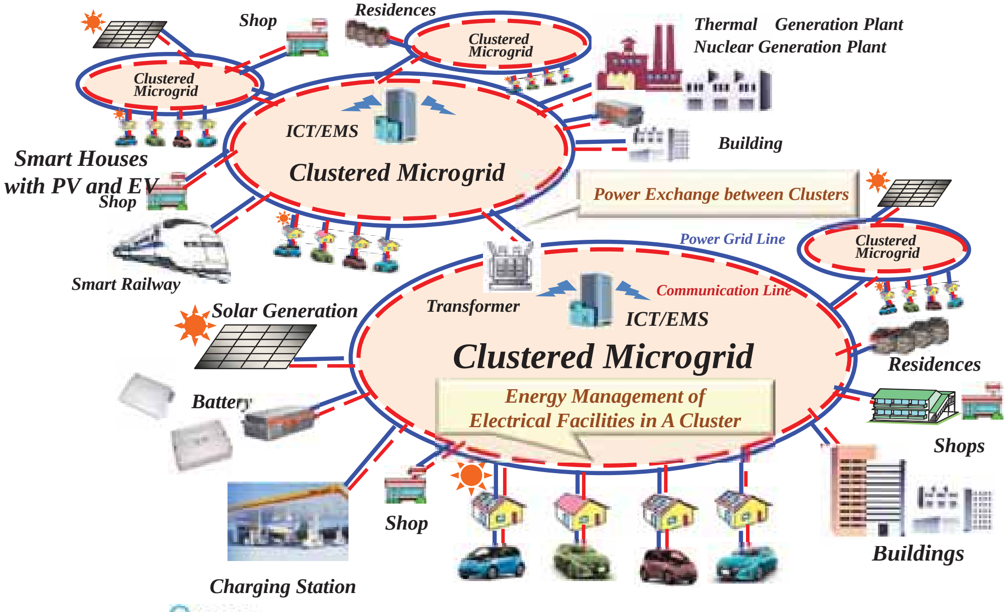


Concept of Micro-grid

- ✓ Respective Micro-grid is connected each other, and each Micro-grid can work independently
- ✓ Local energy production for local consumption
  - ✓ Generation: PV, wind, biomass, DG, GT, battery, etc.
  - ✓ Demand: industry, commercial, home, EV, etc.
- ✓ No transmission → loss saving
- ✓ With IoT, control system, EMS, demand response, smart meters
- ✓ Enhance resiliency

Source: Smart City Development and Recent trend in Electric Power Network, Waseda Univ.

Microgrid for Resilient System : Autonomous Micro Grid



RE: Large RE Example in Islands

40% RE: Hawaii

Hawaiian Electric Company: Expansion of distributed power sources
Nos of customers: 462,225, total 1,795 MW, VRE 673 MW
- Energy storage
- Output suppression of wind and solar
- 15% peak load reduction

Source: GE

100% RE: Samoa (USA)

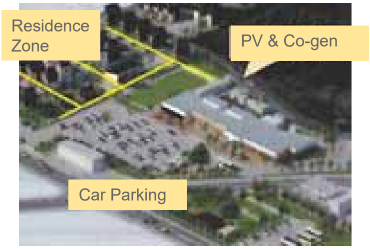
Source: JICA

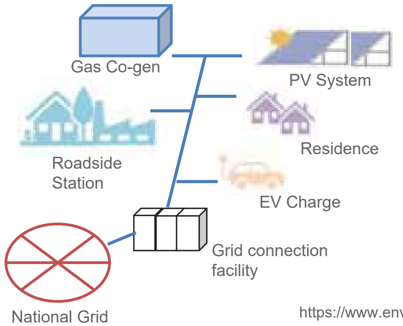
3 villages, 203 household, population 790
Peak **229kW**, Demand1300 MWh/yr, **3.6 MWh/day**)
RE: **1.4 MW PV (6.1 times than peak)**
Battery: **750kW/6 MWh** LIB, Tesla 20yrs guarantee
DG: 320kW✕3, 150kW✕1

Mon	Jan	Feb	Mar	Apr	May	Jun
RE%	98.4	97	99	91.2	89.9	99.6

Small demand, but huge RE and Battery
→ **Micro-grid**, Back-up DG is necessary

Microgrid for Resilience: Mutsuzawa Road Side Station





https://www.env.go.jp/press/files/jp/113284.pdf

Mutsuzawa Road Side Station

- Gas co-generation (80kWx2), PV system (20kW), Solar heating (37 kW) EV charger,
- Independent power supply for residence zone
- Thermal supply for hot spring by co-gen
- Microgrid area connected with grid
- Continuous supply during Typhoon (large scale regional power cut approx. 1 week) in Sep 2019
  - 1000 utilized power supply, shower, toilet for emergency
  - Regional Disaster-prevention facility
  - All power lines are underground

Micro-grid Concept: Coverley Village

Microgrid/Smart Grid Demonstration: Model study for 100% RE

Item	Data
Population	2,000, of which 1,300 are student
Household	1,000 houses
Expansion Plan	+300 houses
RE Status	100% solar thermal, 10% PV Panel

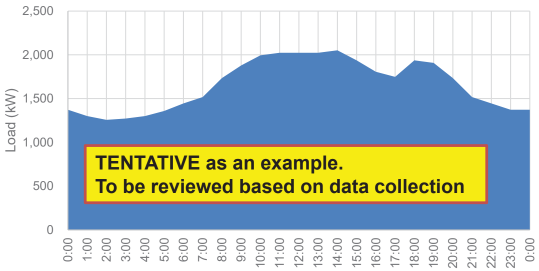
Requested Data

- Demand and facility data from BL&P
- 100%RE Scenario (RE source, BESS, EMS)
- Information for EV

Micro-grid Concept: Coverley Village

Microgrid/Smart Grid Demonstration: Model study for 100% RE

- 3 kW rooftop PV
- 5-7 MW additional PV (Grantley Adams AP?)
- BESS and EMS
- Data for load curve, transformer, distribution line information requested
- - Single line diagram
- - distribution line 11 kV (feeder length, size, type (ACRS or cable), impedance, resistance, capacitance, RLC
- - Transformer location, kVA



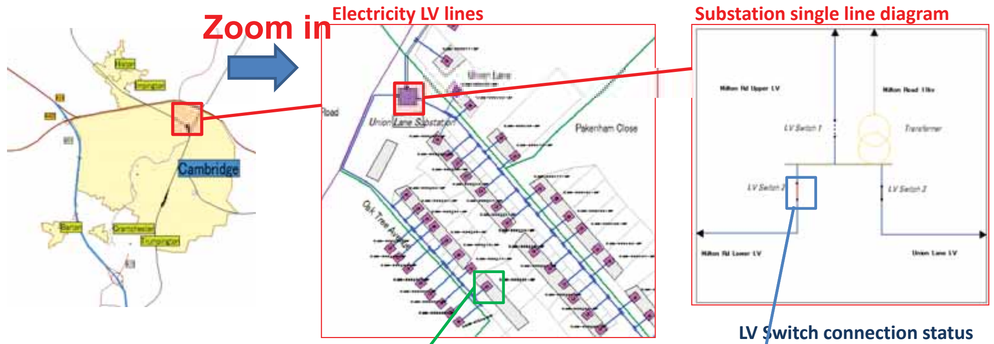
Load Curve in Coverly Village (assumed)

Example of system, to be reviewed

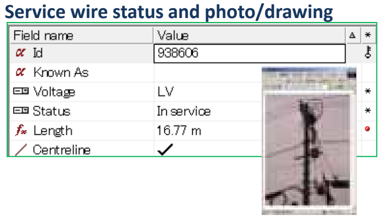
Nos of houses	1026	nos
Roof area for PV	30	m2/house
Commercial/official roof	300	m2 (6 facilities)
Total roof area	31,080	m2
PV Capacity	3108	kWp
Specific PV generation	4.917	kWh/kW/day
PV generation energy	15,282	kWh/day
Peak demand	4,104	kW
Electric energy demand	41,329	kWh/day
External PV	6,622	kWp
BESS capacity	80	MWh
BESS output	4	MWh

Resiliency Enhancement

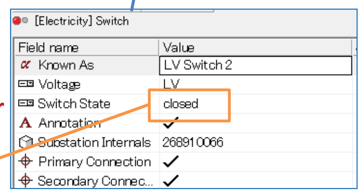
System infrastructure: GIS and Digitalized Data Model



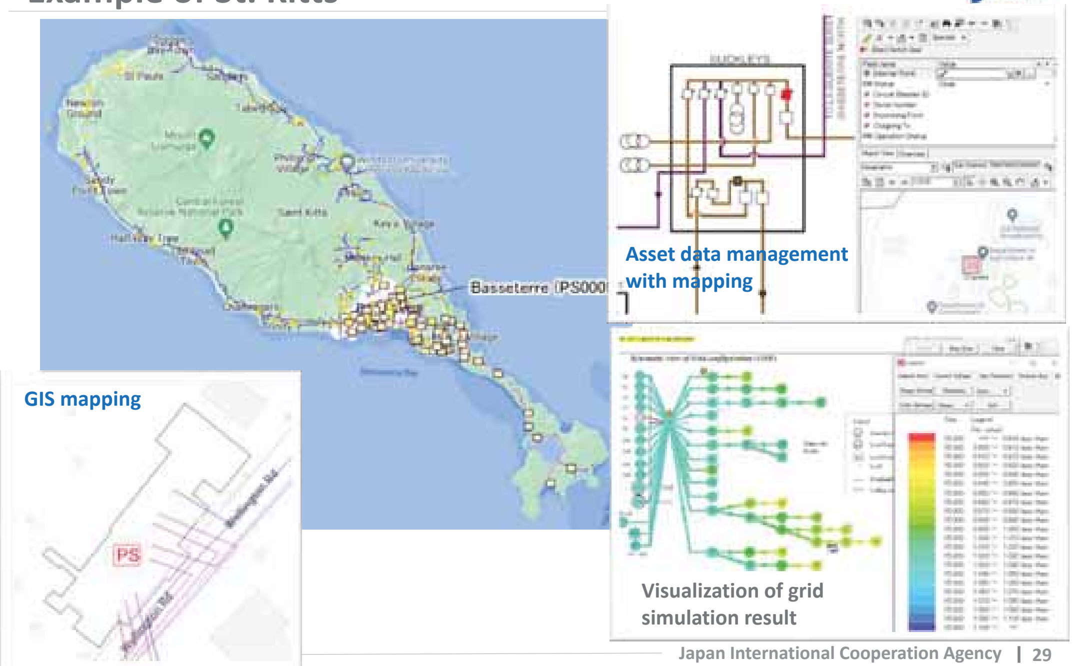
Service wire status and photo/drawing



The System judges if the feeder line is connected and power can be supplied with LV switch status in substation



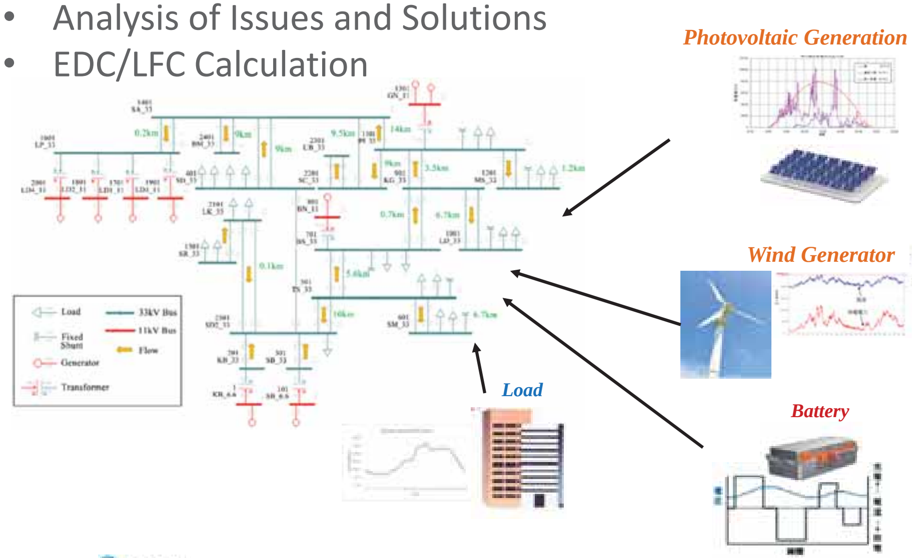
GIS, Asset Management with Grid Simulation Example of St. Kitts



Appendix : Grid Simulation

Grid Stabilization Simulation

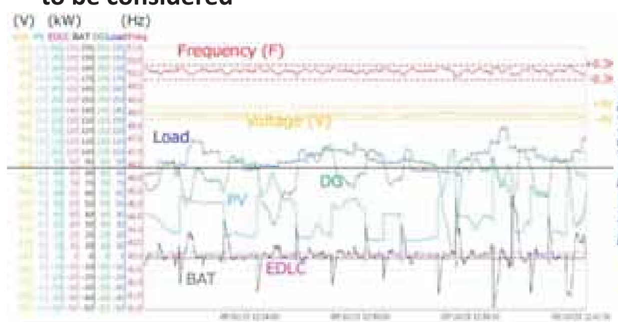
- Simulation of National Grid Model based on asset data
- Analysis of Issues and Solutions
- EDC/LFC Calculation



RE: Example of Grid Stabilization with RE and energy storage

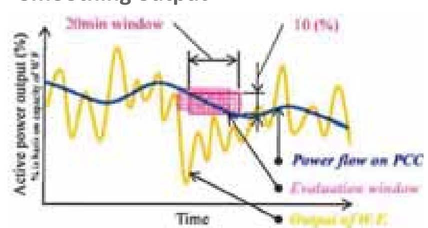
For Voltage and Frequency stabilization (below)

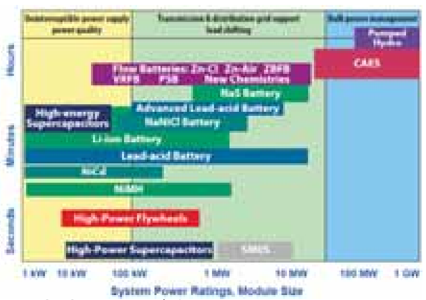
- ✓ Generation: PV, Wind, DG, GT, etc.
- ✓ Energy Storage: Battery (BAT), Capacitor (EDLC)
- ✓ Load /Demand control
- → **Grid Simulation is necessary**
- → **Various energy storage with inertia option needs to be considered**



Source: Meidensha, Autonomous Micro-grid Conference, 2019

Smoothing output





CAES: compressed air energy storage
Source: IRENA, Electricity Storage and Renewables, 2017

Grid Simulation: for Optimization of Power Flow Analysis

Microgrid Designer consists of tools of Economic Load Dispatch (ELD) and power flow analysis modules, developed by Energy & Environment Technology Research Institute, Japan (Venture company of Waseda Univ).

Module	Function
Single Stage Economic Load Dispatch Module	The determination of the optimal output of a number of electricity generation facilities, to meet the system load at the lowest possible cost subject to transmission and operational constraints
Multi Stage Economic Load Dispatch and LFC Module	Chronological determination of the optimal output of a number of electricity generation facilities, to meet time varying system loads at the lowest possible cost and load frequency control commands to maintain the system frequency within the permissible range.
Single Stage Power Flow Analysis Module	Steady-state analysis tool whose target is to determine the voltages, currents, and real and reactive power flows in a system under a given load conditions and planning ahead for various hypothetical situations
Multi Stage Power Flow Analysis Module	Chronological power flow analysis for time varying loads to determine the transitions of voltages, currents, and real and reactive power flows in a system over time horizon.

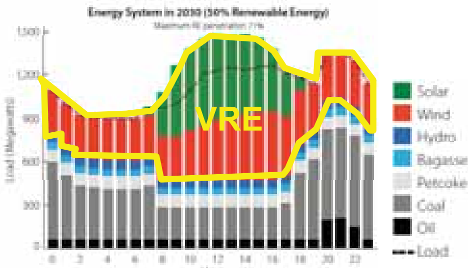
O&M of Thermal Power Generation(Barbados)

<List of Thermal Power Unit>

Country	Plant	Unit	Type	Fuel	Manufacture	Year Installed	Load	Rating Capacity(MW)
Barbados	Spring Garden	D10(Unit A)	LSD	HFO	MAN	1982	Base	12.0
		D11(Unit A)	LSD	HFO	MAN	1982	Base	12.0
		D12(Unit A)	LSD	HFO	MAN	1987	Base	12.0
		D13(Unit A)	LSD	HFO	MAN	1990	Base	12.5
		CG01	ST	heat from unit A	Peter Brotherhood	1985	Base	1.5
		D14(Unit B)	LSD	HFO	MAN	2005	Base	30.0
		D15(Unit B)	LSD	HFO	MAN	2005	Base	30.0
		CG02	ST	heat from unit B	SHINKO	2005	Base	2.0
		Unit S1	ST	HFO	GEC	1976	Base	20.0
		Unit S2	ST	HFO	GEC	1976	Base	20.0
			Olympos GT	Jet Fuel/ Diesel	CURTISS WRIGHT	1969-1970	Peak	17.5
	Garrison	G02	GT	Diesel	ABB	1990	Peak	13.0
	Seawell	G03	GT	Diesel	ABB	1996	Peak	13.0
		G04	GT	Jet Fuel	ABB	1999	Peak	20.0
		G05	GT	Jet Fuel	ABB	2001	Peak	20.0
		G06	GT	Jet Fuel	ABB	2002	Peak	20.0

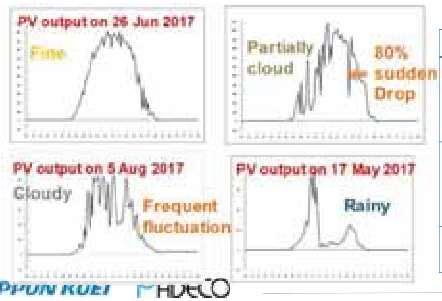
Total: 255.5MW

RE: Instability Caused by VRE



Source: Jamaica Sustainable Energy Roadmap 2013

Spinning reserve is necessary for RE fluctuation.



Grid instability
- Voltage and frequency fluctuation
- Shortage of Inertial power
- High cost for countermeasure

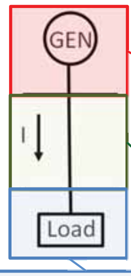
Fuel L/kW increase in diesel generator
- Low load operation
- Acceleration and deceleration
- Spinning reserve

→ **EMS and Battery Storage are necessary for grid stability and economic operation (expensive)**

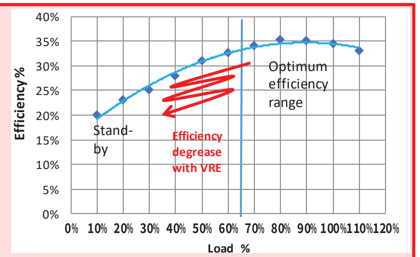
→ **It might need to optimize RE%**

VRE %	< 20%	20-60%	> 60%
Issue	Response by thermal poser	Voltage and frequency fluctuation, power failure increase	(in addition to left) harmonic wave, phase balance, synchronization, supplement of reactive power
Equipment needed for grid stabilization	Output restrain by PCS, EMS	EMS and high-speed charge-discharge battery or capacitor, quick-response thermal power	Power factor control PCS is needed. Special arrangement according to site is necessary.
Cost	Low	High (battery replacement is necessary)	Very high. Specific technical arrangement is necessary

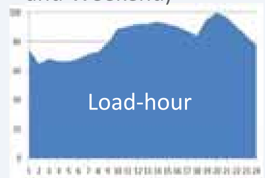
Input Data



Generators (DE,GT,ST,GE)
- Max. and min. output
- Ramp rate
- Load – cost curve or Load – efficiency curve



Load
- Average Load in each feeder
- Load Power Factor
- Load – hour curve (Weekday and Weekend)



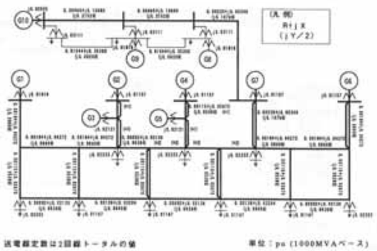
Transmission Line, Substation

[Common]
- Power flow limitation
- Voltage Magnitude

[Option 1]
- Impedance Map

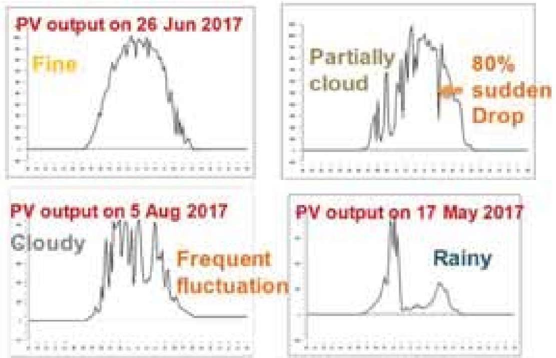
[Option 2]
- Shunt Capacitor
- Cable length
- Cable capacitance [μF/km]

Example of Impedance Map



Input Data

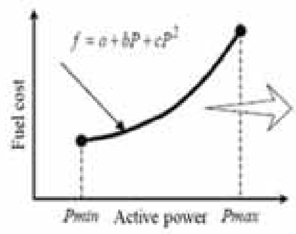
Necessary Data
- Fuel efficiency (heat rate) of each DG generator units at each load range
- PV generation 24 hr curve



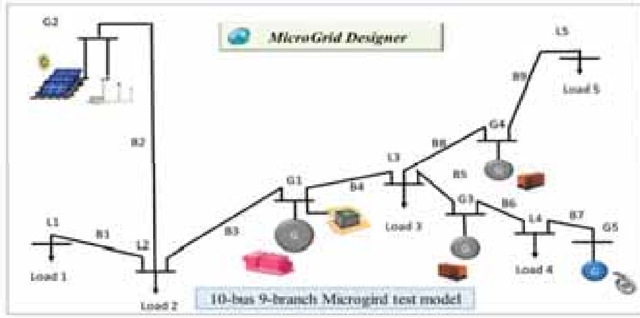
Battery
- Sum of MWh

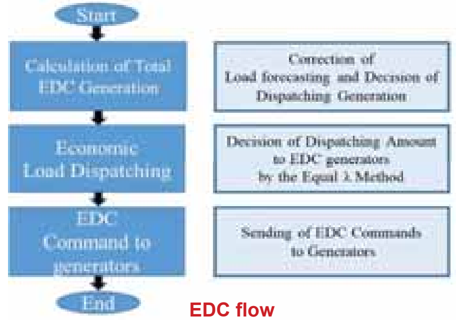
Battery A	5MWh
Battery B	3MWh
Battery C	1MWh
Sum of Battery Capacity	9MWh

EDC example with IEEE Microgrid Model

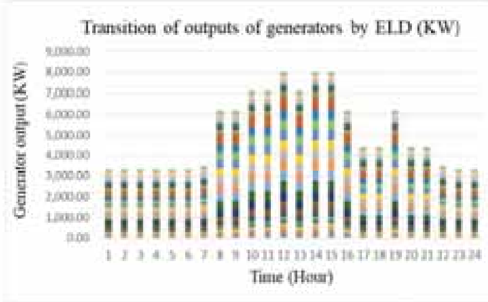


Load-fuel efficiency curve



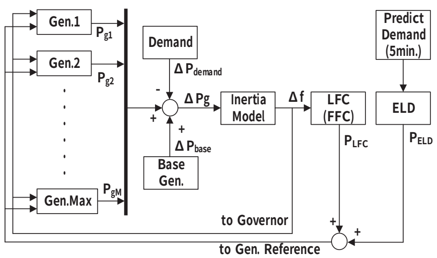


EDC flow

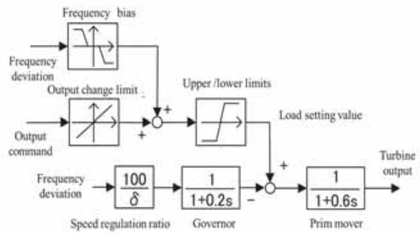


Optimum power output allocation of generators

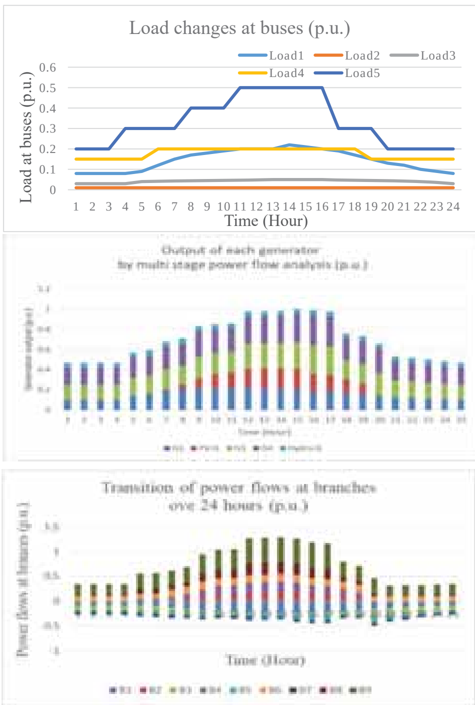
Load-flow Analysis



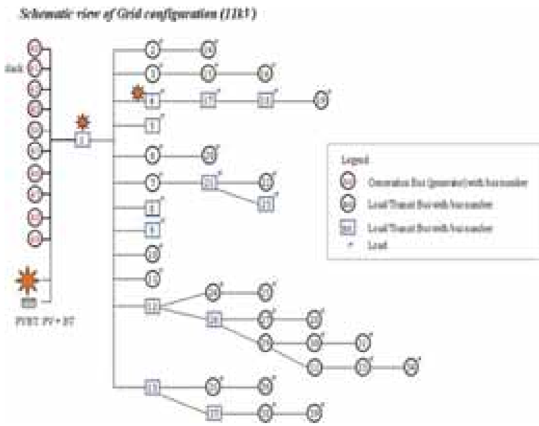
LFC model using EDC result



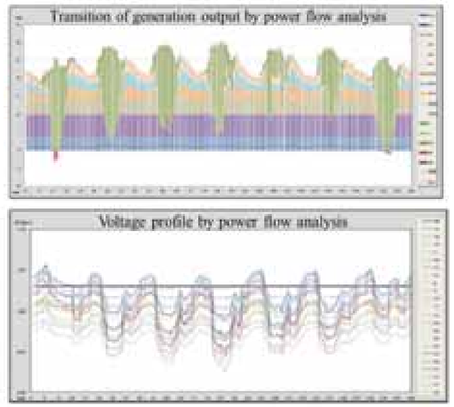
Output model of DG



Grid Analysis Model of Microgrid in St. Kitts



Example of micro-grid model (St. Kitts)



Grid analysis result (generator output, voltage, frequency)

Analysis result is viewed in geographical information system
Smallworld is applied to visualization for investment plan and design

Grid Stability: Future Grid in Barbados Brought by RE (Session-1 General)

Hisao Taoka

Why Grid Stability

- Responsibility of IBR(Inverter Based Resources) is faster than that of synchronous generator.
- The output of IBR can be controlled quickly.
- IBR has less or no inertia than synchronous generator.

↓

- Increase or add inertia function to IBR
  - Grid Forming Inverter
- Increase generator with large inertia.
  - Resources provided by Synchronous generators

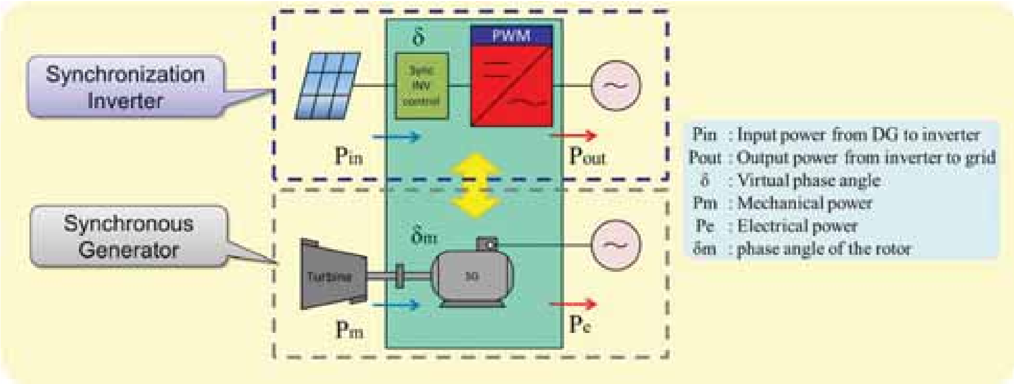
Keywords for Grid Stability

- **Virtual Inertia**
  - Grid Forming Inverter vs Grid Following Inverter
  - EV(Electric Vehicle) for V2G(Vehicle to Grid)
  - Virtual Power Plant
  - DR(Demand Response)
- Evaluation Index of Stability
  - **SCR**(Short Circuit Ratio)
  - **ATC**(Available Transmission Capacity)
- Grid Code from the Viewpoint of Stability
- Tools for Monitoring Power Grid
  - Load Flow Analysis
  - LFC(Load Frequency Control) and ELD(Economic Load Dispatching)
  - Stability Evaluation by EAC(Equal Area Criterion)
- Microgrid: One Solution for Stability
  - Decrease Power Flow of Utility Transmission Lines

IBR(Inverter Based Resources) Types

- Grid Following Inverter
  - Current Source Inverter
  - Control output current as adjusting voltage to grid's
- Grid Forming Inverter
  - Voltage Source Inverter
  - Virtual Synchronous Generator
  - Control output voltage and its frequency as adjusting power to grid's
  - Suppy Virtual Inertia to Grid
  - Source: PV, WP(Wind Power), EV(Electric Vehicle), Battery

Concept of Virtual Inertia



Source: M. Kawai, Y. Sakai, H. Sugiyama, H. Taoka "Frequency Improvement of a Power System with a Distributed Generator using Synchronization Inverter," 2015 International Symposium on Smart Electric Distribution Systems and Technologies (EDST), CIGRE SC C6 Colloquium, Sep. 2015.

Control Algorithm for Virtual Inertia

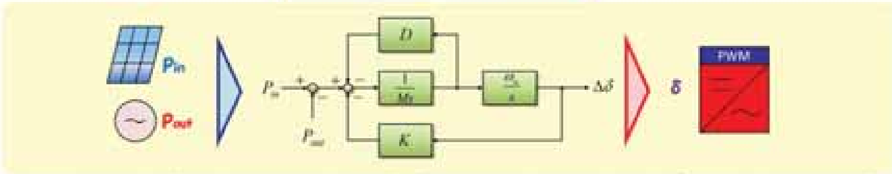
The control method of Synchronization Inverter is expressed by the swing equation. This equation is added damping term and synchronizing power term.

$$\frac{M}{\omega_n}\frac{d^2\delta_m}{dt^2}+\frac{D}{\omega_n}\frac{d\delta_m}{dt}+K\delta_m=P_m-P_e$$

This swing equation of the Synchronization Inverter is solved for virtual phase angle δ.

The transfer function of voltage value

$$\delta=\frac{\frac{1}{M}\omega_n}{s^2+\frac{D}{M}s+\frac{K}{M}\omega_n}(P_{in}-P_{out})$$



Source: M. Kawai, Y. Sakai, H. Sugiyama, H. Taoka "Frequency Improvement of a Power System with a Distributed Generator using Synchronization Inverter," 2015 International Symposium on Smart Electric Distribution Systems and Technologies (EDST), CIGRE SC C6 Colloquium, Sep. 2015.

SCR(Short Circuit Ratio)

- SCR is the factor to be considered for grid stability.
- SCR=AC System Capacity/Rated IBR Capacity
  - SCR>3 -------- High SCR, Stable
  - 3>SCR>2 ----- Low SCR
  - 2>SCR -------- Very Low SCR
- Discussed in IEEE Std 1204-1997(R2003)
  - IEEE Guide for Planning DC Links Terminating at AC Locations Having Low Short-Circuit Capacities
  - Recognized by ANSI(American National Standards Institute

Sources for High SCR Grid

- V2G(Vehicle to Grid) of EV(Electric Vehicle)
- BESS(Battery Energy Source System)
  - Battery with control circuits
- Biofuel Generator
- Solar Thermal Generator

  and
- Renewable Energy Resources (PV, WP) with Grid Forming Inverter
- These resources can supply inertia to grid.

ATC(Available Transmission Capacity)

- Transmission capacity needs to be calculated to see whether RE can be transmitted from source location to demand place.
- Swing Equation
  - $P = \frac{V_i V_j}{X} sin\delta$
- Synchronizing Force
  - $\frac{dP}{d\delta} = \frac{V_i V_j}{X} cos\delta$
- Maximum Transmission Capacity
  - $P = \frac{V_i V_j}{X}$

  or $P_{loss} = R * (\frac{V_i}{X})^2 < P_{lossmax}$----- from heat capacity limit

Spinning Reserve

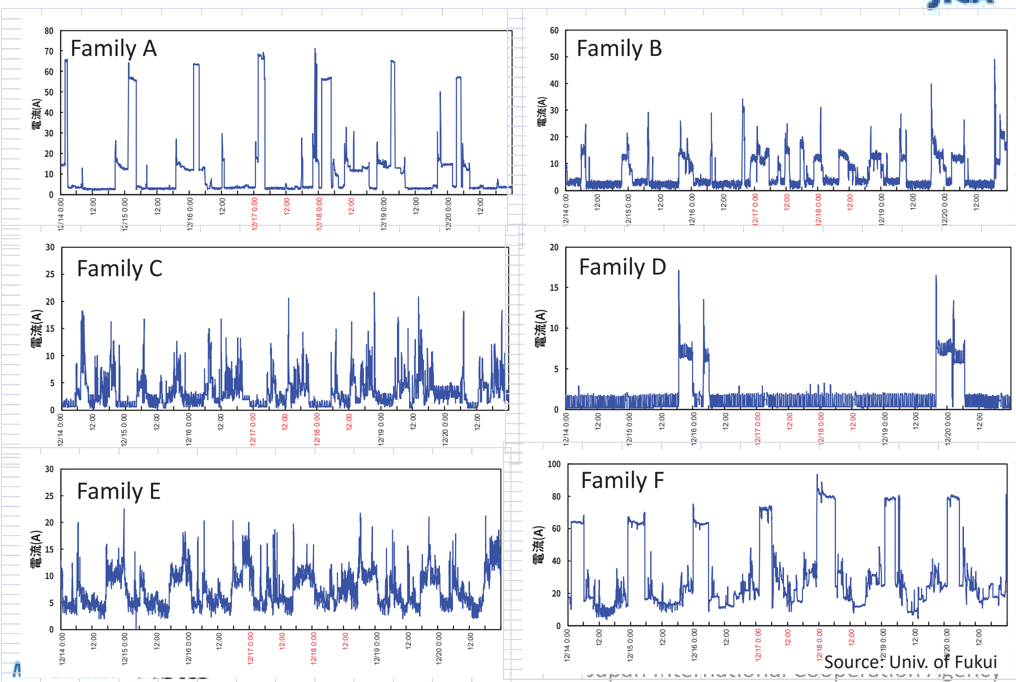
- In order to get electrical power under abnormal condition of grid, spinning reserve should be kept even if RE is installed. (under development)

- RE Sources for Spinning Reserve:
  - EV
  - Battery
  - Biofuel or Diesel Generator

etc.

Samples of Load (one week)

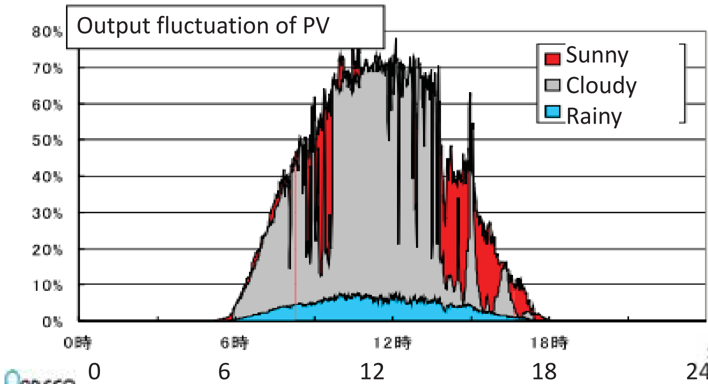
Confidential



Source: Univ. of Fukui

Generation Power of PV (Example)

- The range of PV output is 0 to max.
- Total power of renewable energy may be limited not to be over the spinning reserve of network.
- Battery and smoothing effect by PV in various place may cover short time fluctuation.



Source: Univ. of Fukui

Frequency and Voltage Control

- Frequency Control
  - Frequency Ride Through
  - Governor Control in Generation Side(PV, WP)
  - Load Frequency Control through Control Center/EMS
- Voltage Control
  - Voltage Ride Through
  - DVS(Dynamic Voltage Support) by Reactive Power in Generation Side (PV)

Recommendation for Grid Code

- The following items will be required from Grid Stability:
  - Virtual Inertia for IBR(Inverter Based Resources)
  - High SCR of Grid
  - Spinning Reserve from EV, Battery, etc.
- RE with these functions is key technology for grid stability.

Grid Code in EU and USA

- RfG(Requirements for Generators) : Grid Code in EU
  - The relevant TSO (Transmission System Operator) shall have the right to specify that power park modules [of type C and D] be capable of providing synthetic inertia during very fast frequency deviations.
- IEEE P2800 : Grid Code in USA
  - IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Grid Code Committee in Japan

Under discussion

- Short Term Target:2023/4
  - Criterion for Generator
- Middle Term Target:2025/4
  - Voltage Ride Through
- Long Term Target:2030/4
  - Inertia Market
  - RoCoF8rate of Change of Frequency)
  - Virtual Inertia
  - Stability
  - Black Start

Operating State of Power System

- Total Generation Power is to be normally 60〜70%.
- The fluctuation of load is 10〜20%, if load prediction is operated well.
- The fluctuation of renewable energy has to be about 10%, but already over 30% in Barbados.
- If total demand of grid becomes to 90% over of rated capacity of grid,
  - Spinning reserve will be decreased.
  - Synchronizing power will be very small not to be returned to stable state.
- Spinning reserve should be more than mixed fluctuation of load and renewable energy.

→RE, EV and Battery with inertia is required for large RE penetration.

→Energy mix of several resources will be helpful for improving grid stability.

Grid Stability: Future Grid in Barbados Brought by RE -Tools for Grid Stability- (Session-2 Special)

Hisao Taoka

Tools for Grid Stability

- Monitoring of Grid
  - Microgrid/VPP Designer (Software)
  - DC Flow Method (Manual calculation)
- Evaluation of Grid Stability
  - Equal Area Criterion (Manual calculation)
- Demand and Supply Control
  - Microgrid/VPP Designer (Software)
  - Plan of LFC and ELD
- Asset Management
  - Smallworld (Software)

VPP: Virtual Power Plant

Load Flow Analysis

- DC Flow Method (manual calculation)
  - Simplified Load(Power) Flow Calculation of Transmission Line
- Microgrid/VPP Designer (Software)
  - Newton Raphson Method
  - Load Flow Calculation to monitor current status of grid
  - Planning Tools for Demand and Supply Control
    - LFC(Load Frequency Control)
    - ELD(Economic Load Dispatching)

Stability Analysis

- Equivalent Area Criterion (Manual calculation)
  - Simplified Stability Calculation
- Transient Stability Program (Simulation Software)
  - Electro-Mechanical Transient Stability
    - Root Mean Square Value Calculation
    - PSS/E, ETAP, CYME, DigSILENT,,,
  - Electro-Magnetic Transient Stability
    - Instantaneous Value Calculation
    - EMTP, EMTDC, PSCAD,,,

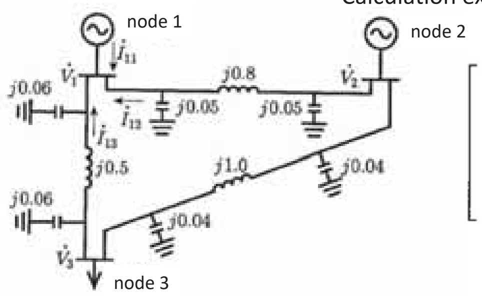
Load Flow(Power Flow) Analysis

Necessary items to consider Load flow Analysis
Buses are categorized to the following 3 types.

- Slack (Swing) Bus
  - The magnitude and phase angle of the voltage are specified.
  - This bus makes up the difference between the scheduled loads and generated power that are caused by the losses in the network.
- P-V Buses (Generator Buses)
  - The real power and voltage magnitude are specified.
  - The phase angles of the voltages and the reactive power are to be determined.
- P-Q Buses (Load Buses)
  - The active and reactive powers are specified.
  - The magnitude and the phase angle of the bus voltages are unknown.

Node Admittance Matrix to Describe Grid

Calculation example of power flow in 3 nodes network



$$\begin{bmatrix} \dot{I}_1 \\ \dot{I}_2 \\ \vdots \\ \dot{I}_N \end{bmatrix} = \begin{bmatrix} \dot{Y}_{11} & \dot{Y}_{12} & \cdots & \dot{Y}_{1N} \\ \dot{Y}_{21} & \dot{Y}_{22} & \cdots & \dot{Y}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \dot{Y}_{N1} & \dot{Y}_{N2} & \cdots & \dot{Y}_{NN} \end{bmatrix} \begin{bmatrix} \dot{V}_1 \\ \dot{V}_2 \\ \vdots \\ \dot{V}_N \end{bmatrix}$$

$$\dot{Y}_{11} = j0.05 + j0.06 + \frac{1}{j0.8} + \frac{1}{j0.5} = -j3.14$$
$$\dot{Y}_{22} = j0.05 + j0.04 + \frac{1}{j0.8} + \frac{1}{j1.0} = -j2.16$$
$$\dot{Y}_{33} = j0.04 + j0.06 + \frac{1}{j1.0} + \frac{1}{j0.5} = -j2.9$$
$$\dot{Y}_{12} = \dot{Y}_{21} = -\frac{1}{j0.8} = j1.25$$
$$\dot{Y}_{13} = \dot{Y}_{31} = -\frac{1}{j0.5} = j2.0$$
$$\dot{Y}_{23} = \dot{Y}_{32} = -\frac{1}{j1.0} = j1.0$$

$$Y = \begin{bmatrix} -j3.14 & j1.25 & j2.0 \\ j1.25 & -j2.16 & j1.0 \\ j2.0 & j1.0 & -j2.9 \end{bmatrix}$$

Power Flow Equation & Solution Method

Power Flow Equation of each node

$$P_k + jQ_k = \dot{I}_k^* \dot{V}_k = \sum_{m=1}^{N} \dot{Y}_{km}^* \dot{V}_m^* \dot{V}_k$$

$$P_{ks} = \mathrm{Re}\left\{ \sum_{m=1}^{N} \dot{Y}_{km}^* (e_m + jf_m)^* (e_k + jf_k) \right\}$$
$$Q_{ks} = \mathrm{Im}\left\{ \sum_{m=1}^{N} \dot{Y}_{km}^* (e_m + jf_m)^* (e_k + jf_k) \right\}$$
$$V_{ks}^2 = e_k^2 + f_k^2$$

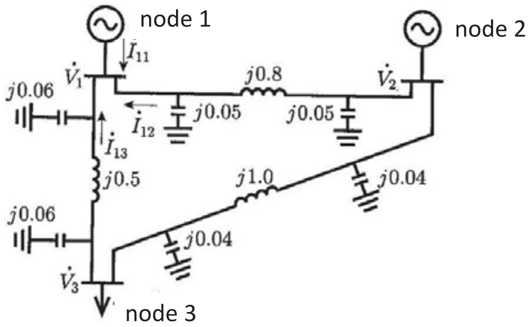
Solution Methods:

- Gauss-Seidel Method
- Newton-Raphson Method
- Fast Decoupled Method
- DC Flow Method

・・・

Power Flow Equation

(Example of 3 nodes network)



$$P_{2s} = \mathrm{Re}\{(j1.25)^*(e_1+jf_1)^*(e_2+jf_2) + (-j2.16)^*(e_2+jf_2)^*(e_2+jf_2) + (j1.0)^*(e_3+jf_3)^*(e_2+jf_2)\}$$
$$= 1.25e_1f_2 - 1.25e_2f_1 + e_3f_2 - e_2f_3$$

$$V_{2s}^2 = e_2^2 + f_2^2$$

$$P_{3s} = \mathrm{Re}\{(j2.0)^*(e_1+jf_1)^*(e_3+jf_3) + (j1.0)^*(e_2+jf_2)^*(e_3+jf_3) + (-j2.9)^*(e_3+jf_3)^*(e_3+jf_3)\}$$
$$= 2.0e_1f_3 - 2.0e_3f_1 + e_2f_3 - e_3f_2$$

$$Q_{3s} = \mathrm{Im}\{(j2.0)^*(e_1+jf_1)^*(e_3+jf_3) + (j1.0)^*(e_2+jf_2)^*(e_3+jf_3) + (-j2.9)^*(e_3+jf_3)^*(e_3+jf_3)\}$$
$$= 2.9e_3^2 + 2.9f_3^2 - 2.0e_1e_3 - 2.0f_1f_3 - e_2e_3 - f_2f_3$$

$$e_1 = V_{1s}, \quad f_1 = 0$$

Newton Raphson Method

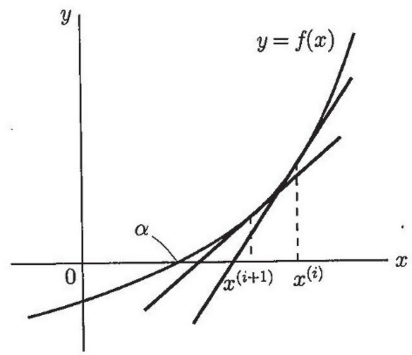
For computer model

This method is used in **Microgrid/VPP designer**.

This method can get solution, even if power flow is heavy.

$$\begin{bmatrix} \Delta P_2 \\ \Delta|\dot{V}_2|^2 \\ \Delta P_3 \\ \Delta Q_3 \end{bmatrix} = -\begin{bmatrix} \frac{\partial P_2}{\partial e_2} & \frac{\partial P_2}{\partial f_2} & \frac{\partial P_2}{\partial e_3} & \frac{\partial P_2}{\partial f_3} \\ \frac{\partial|\dot{V}_2|^2}{\partial e_2} & \frac{\partial|\dot{V}_2|^2}{\partial f_2} & \frac{\partial|\dot{V}_2|^2}{\partial e_3} & \frac{\partial|\dot{V}_2|^2}{\partial f_3} \\ \frac{\partial P_3}{\partial e_2} & \frac{\partial P_3}{\partial f_2} & \frac{\partial P_3}{\partial e_3} & \frac{\partial P_3}{\partial f_3} \\ \frac{\partial Q_3}{\partial e_2} & \frac{\partial Q_3}{\partial f_2} & \frac{\partial Q_3}{\partial e_3} & \frac{\partial Q_3}{\partial f_3} \end{bmatrix} \begin{bmatrix} \varepsilon_1^{(i)} \\ \varepsilon_2^{(i)} \\ \varepsilon_3^{(i)} \\ \varepsilon_4^{(i)} \end{bmatrix}$$

$$\begin{bmatrix} e_2^{(i+1)} \\ f_2^{(i+1)} \\ e_3^{(i+1)} \\ f_3^{(i+1)} \end{bmatrix} = \begin{bmatrix} e_2^{(i)} \\ f_2^{(i)} \\ e_3^{(i)} \\ f_3^{(i)} \end{bmatrix} + \begin{bmatrix} \varepsilon_1^{(i)} \\ \varepsilon_2^{(i)} \\ \varepsilon_3^{(i)} \\ \varepsilon_4^{(i)} \end{bmatrix}$$



DC Flow Method

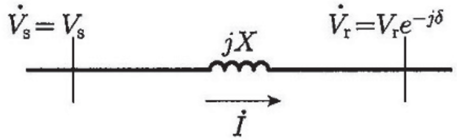
Manual method to calculate power flow.

Easy to calculate in manual.

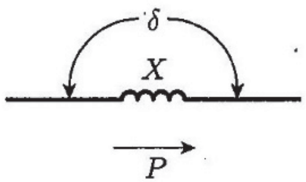
$$P_r + jQ_r = V_r e^{-j\delta} \dot{I}^*$$
$$= V_r e^{-j\delta}\left(\frac{V_s - V_r e^{-j\delta}}{jX}\right)^*$$
$$= \frac{V_s V_r e^{-j\delta} - V_r^2}{-jX}$$
$$= \frac{V_s V_r}{X}\sin\delta + j\frac{V_s V_r \cos\delta - V_r^2}{X}$$

$$P_r = \frac{V_s V_r}{X}\sin\delta$$

$$P_r = \frac{\delta}{X}$$

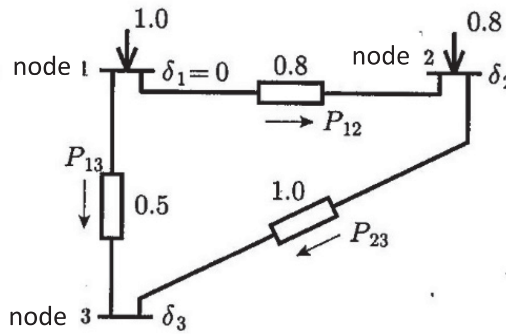


Simplified and Similar to DC circuit solution



DC Flow Method

(Example of 3 nodes network)



$$1.0 = \frac{0-\delta_2}{0.8} + \frac{0-\delta_3}{0.5}$$

$$0.8 = \frac{\delta_2 - 0}{0.8} + \frac{\delta_2 - \delta_3}{1.0}$$

$$\delta_2 = 0.104$$

$$\delta_3 = -0.565$$

$$P_{12} = \frac{0-0.104}{0.8} = -0.130$$

$$P_{13} = \frac{0-0.565}{0.5} = 1.13$$

$$P_{23} = \frac{0.104+0.565}{1.0} = 0.669$$

Per Unit Method:

Rated or base voltage and power in grid are set to 1.0

Microgrid/VPP Designer

- Calculate large scale power grid including microgrid
- From power flow solution till demand and supply control
- Based on Microsoft Excel Macro
  - Easy to install into PC

<Functions>

- Load Flow solution
- LFC(Load Frequency Control)
- ELD(Economic Load Dispatching)

VPP: Virtual Power Plant

Starting Window of Load Flow

Power Flow Calculation

Step

Set node data and branch data

Click "Calculation" button

Node max 200, Branch max 400

Jump to NodeData input sheet

Specification

Maximum iteration	20
Convergence criterion (pu)	0.0001
Acceleration factor	1

Jump to BranchData input sheet

Calculation

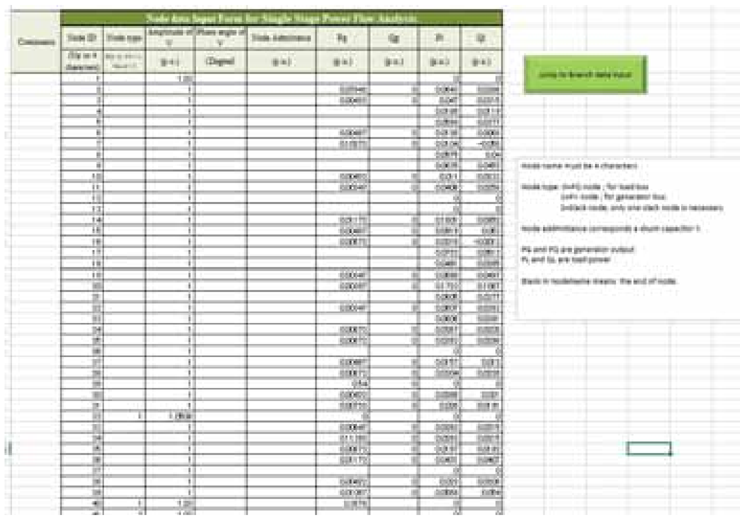
Explanation

1) Capacity base is not shown here, it is assumed by user.
2) Newton-Raphson method is applied as the solver.
3) Convergence criterion is applied to the amplitude of node voltage.
4) Line addmittance is Y/2 in branch data, not Y.
5) Maximum branch number connected a node must be less than 39.

Node Data

Node data Input Form for Single Stage Power Flow Analysis

Node ID	Node type	Amplitude of V	Phase angle of V	Node Admittance	Pg	Qg	Pl	Ql
(Up to 4 characters)	PQ=0, PV=1, Slack=2	(p.u.)	(Degree)	(p.u.)	(p.u.)	(p.u.)	(p.u.)	(p.u.)

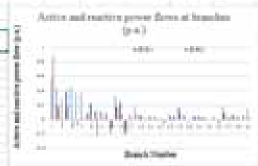


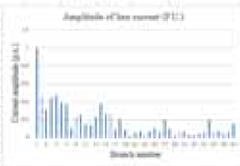
Branch Data

Branch data Input Form for Single Stage Power Flow Analysis

Branch ID	Sending node	Receiving node	No. of circuits	Resistance R	Reactance X	Admittance Y/2	Tap ratio
(Up to 5 integers)	(Up to 4 chracters)	(Up to 4 chracters)	default =1	(p.u.)	(p.u.)	(p.u.)	default = 1.0

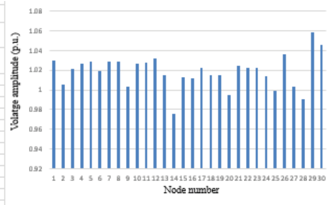
Calculation Results of Branch

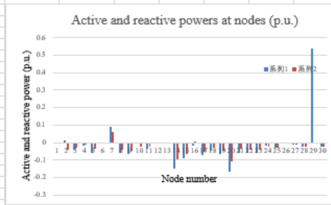




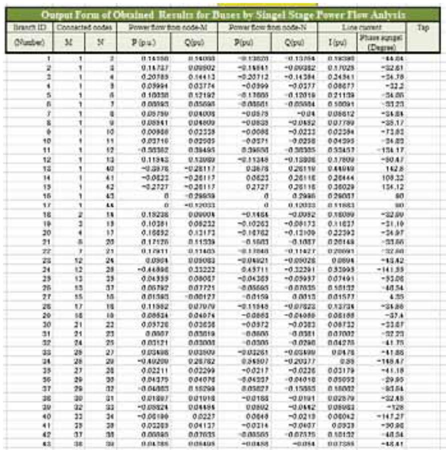
Calculation Results of Node

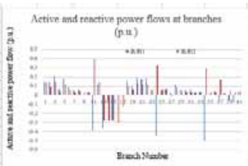
Output Form of Obtained Results for Nodes by Singel Stage Power Flow Anlysis										
Node ID	Node type	Specified voltage	Obtaiened value		Specified P&Q		Obtained P&Q		Injection current	
(Up to 4 characters)	PQ=0, PV=1, Slack=2	V (p.u.)	V (p.u.)	(Degree)	P (p.u.)	Q (p.u.)	P (p.u.)	Q (p.u.)	I (p.u.)	Angel (Degree)
1	0	1.03	1.02997	0	0	0	-0.00002	-0.00181	0.00175	90.53
2	0	1	1.00576	0.03	0.0141	-0.0386	0.0141	-0.0386	0.04086	69.96
3	0	1	1.02141	-0.16	-0.0428	-0.0315	-0.0428	-0.0315	0.05203	143.49
4	0	1	1.02704	-0.02	-0.0186	-0.0119	-0.0186	-0.01191	0.0215	147.35
5	0	1	1.02913	-0.01	-0.0599	-0.0377	-0.0599	-0.0377	0.06877	147.8
6	0	1	1.0194	-0.15	-0.0076	-0.0068	-0.0076	-0.0068	0.01	138.03
7	0	1	1.02831	-0.02	0.0923	0.058	0.0923	0.05801	0.10601	-32.16
8	0	1	1.02826	-0.01	-0.0575	-0.04	-0.0575	-0.04	0.06812	145.16
9	0	1	1.00329	0.28	-0.0635	-0.0452	-0.0635	-0.0452	0.07769	144.83
10	0	1	1.02686	0.1	-0.0068	-0.0233	-0.0068	-0.0233	0.02364	106.37
11	0	1	1.02815	-0.01	-0.0371	-0.0258	-0.0371	-0.0258	0.04395	145.17
12	0	1	1.03142	1.83	0	0	0	0	0	176.87
13	0	1	1.01492	0.12	0	0	0	0	0	149.38
14	0	1	0.97575	-0.31	-0.1484	-0.0952	-0.1484	-0.0952	0.18069	147.01
15	0	1	1.01319	-0.21	-0.0869	-0.063	-0.0869	-0.063	0.10594	143.84
16	0	1	1.01138	-0.32	-0.0159	0.0013	-0.0159	0.0013	0.01577	-175.65
17	0	1	1.02284	-0.05	-0.0722	-0.0513	-0.0722	-0.0513	0.08659	144.55
18	0	1	1.01542	-0.54	-0.0491	-0.0285	-0.04911	-0.0285	0.05592	149.33
19	0	1	1.01468	-0.55	-0.0663	-0.0497	-0.06629	-0.04969	0.08165	142.6
20	0	1	0.99437	-0.81	-0.1683	-0.1087	-0.1683	-0.1087	0.20149	146.34
21	0	1	1.02423	-0.06	-0.0605	-0.0377	-0.06049	-0.0377	0.06959	148.01
22	0	1	1.02262	-0.07	-0.0572	-0.0383	-0.0572	-0.0383	0.06732	146.13
23	0	1	1.0224	-0.07	-0.0606	-0.0381	-0.0606	-0.0381	0.07002	147.77
24	0	1	1.01367	2.2	-0.018	-0.0202	-0.018	-0.0202	0.02669	133.91
25	0	1	0.99894	2.49	-0.0306	-0.0298	-0.0306	-0.0298	0.04276	138.25
26	0	1	1.0365	3.21	0	0	0	0	0	-43.03
27	0	1	1.00342	4.96	-0.0107	-0.012	-0.0107	-0.012	0.01602	136.69
28	0	1	0.99025	5.26	-0.0217	-0.0228	-0.0217	-0.0228	0.03179	138.84
29	0	1	1.05802	13.04	0.54	0	0.53999	0	0.51038	13.04
30	0	1	1.04584	12.86	-0.0244	-0.021	-0.0244	-0.021	0.03078	152.14
31	0	1	1.03906	13	-0.0188	-0.0191	-0.0188	-0.0191	0.02579	147.55
32	1	1.0508	1.05081	16.53	0	0	0.00003	-0.11399	0.10847	106.51
33	0	1	1.05793	17.25	-0.0228	-0.0215	-0.0228	-0.0215	0.02962	153.94
34	0	1	1.08536	18.47	0.0846	-0.0215	0.0846	-0.0215	0.08042	32.73
35	0	1	0.98754	0.56	-0.011	-0.0182	-0.011	-0.0182	0.02153	121.71
36	0	1	0.96089	1.37	-0.0314	-0.0407	-0.0314	-0.0407	0.0535	129.02
37	0	1	1.0023	0.21	0	0	0	0	0	-29.21
38	0	1	0.98932	0.54	-0.0178	-0.0208	-0.0178	-0.0208	0.02767	131.1
39	0	1	0.96146	1.29	-0.0458	-0.054	-0.0458	-0.054	0.07365	131.59
40	1	1.03	1.03	0	0.3678	0	0.3678	0.28148	0.44966	-37.43
41	2	1.03	1.03	0	0	0	0.0823	0.28147	0.28472	-73.7
42	1	1.03	1.03	0	0.2727	0	0.2727	0.28148	0.3805	-45.91
43	0	1.03	1.03	0	0	0.3	0	0.29958	0.29085	-90
44	0	1.03	1.02998	0	0	0.12	0	0.12053	0.11703	-90

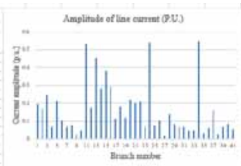




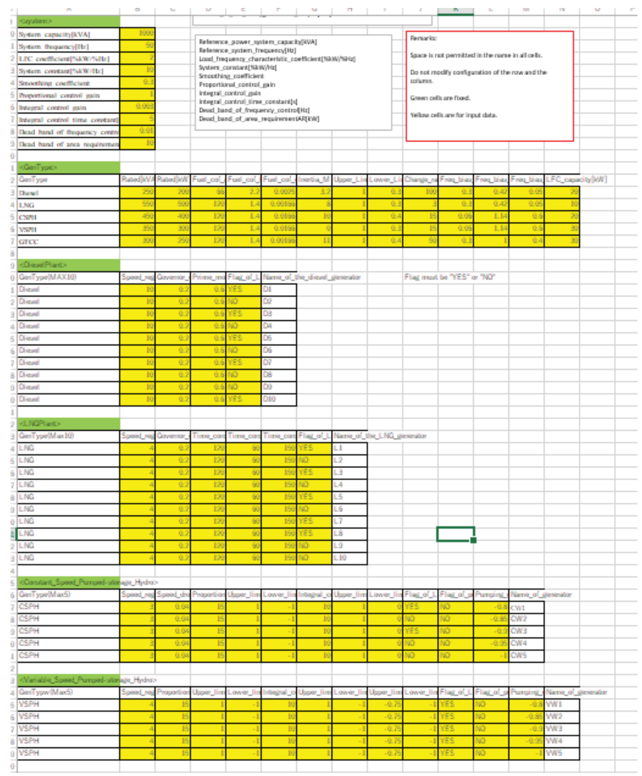
Calculation Results of Branch



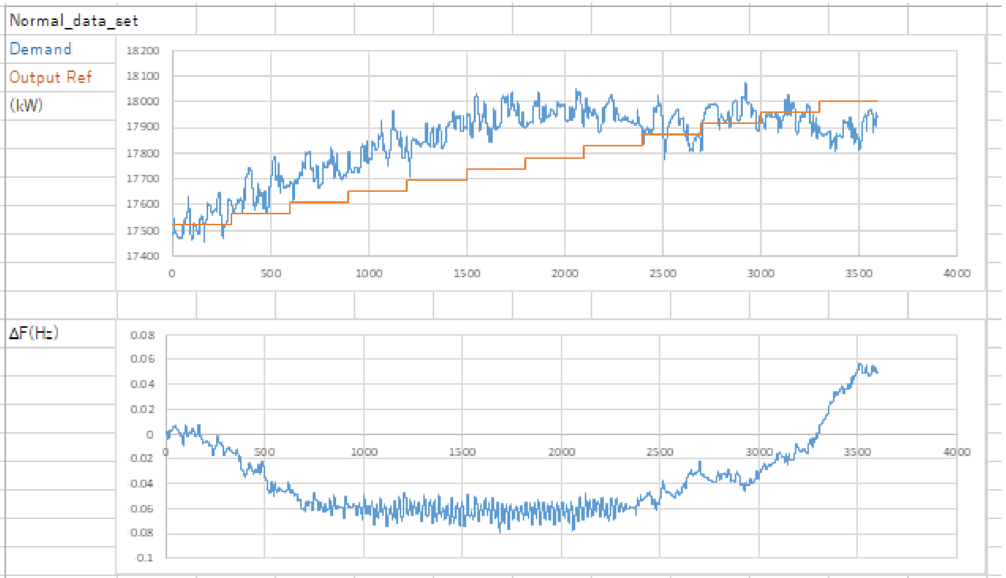




LFC Calculation -Input Data-



Demand and Frequency -LFC result-



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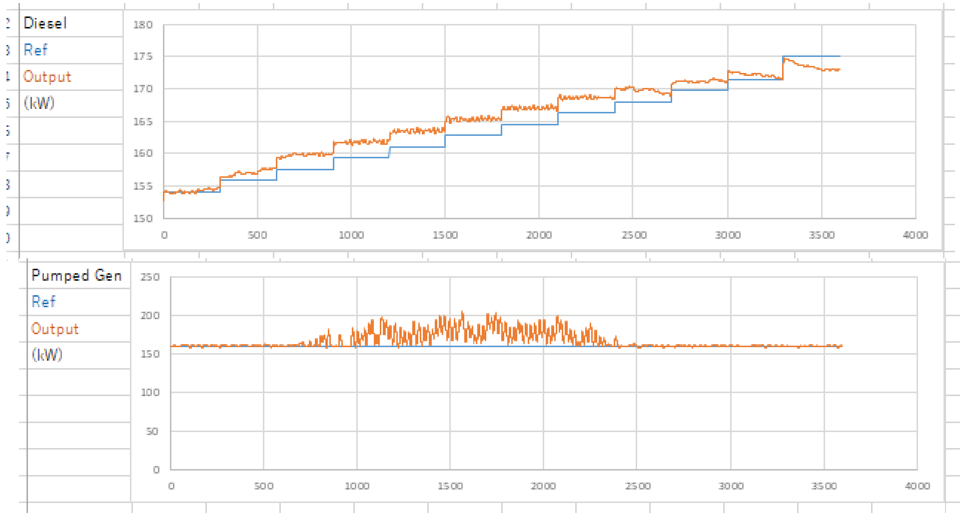
Generator Output -LFC result-



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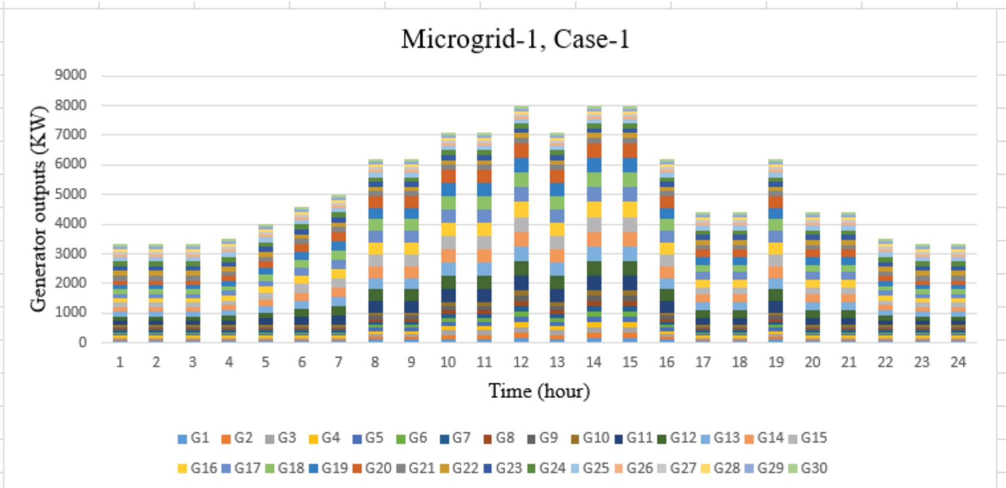
ELD Calculation Results



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Stability Analysis -Swing Equation-

M: Inertia capacity

- M $d^2\delta/dt^2 = P_m - P_e = \Delta P$
  - This equation describes relationship between power and frequency.
  - Power will swing according to disturbances caused by unbalance between generation power and consuming load.
- P_m: Generation Power
  - Synchronous Generator: Controllable
  - Renewable Energy Generator:
    Uncontrollable? -> Control,,,
    Uncertainty? -> Predict,,,
- P_e: Load
  - Customer: Uncertainty-> Predict,,,
  - Fault: Uncertainty, Unpredictable (Of course)

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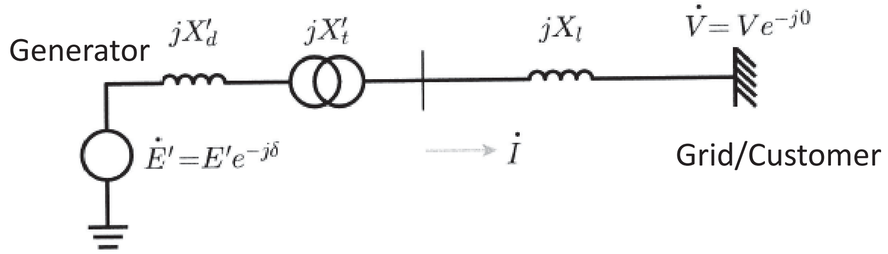
Simplified Grid Model



P-δ Equation

$$P = \frac{\dot{V}E'}{X}\sin\delta$$

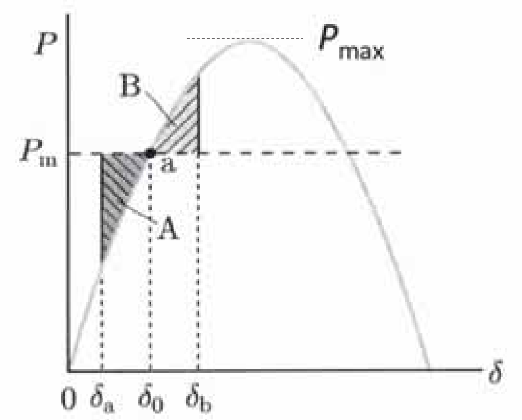
$$\begin{aligned} P + jQ &= \dot{V}\dot{I}^* \\ &= \dot{V}\left\{\frac{E'e^{-j\delta} - \dot{V}}{j(X'_d + X_t + X_l)}\right\}^* \\ &= \frac{\dot{V}E'}{X'_d + X_t + X_l}\sin\delta + j\frac{\dot{V}E'\cos\delta - \dot{V}^2}{X'_d + X_t + X_l} \end{aligned}$$

$$X = X'_d + X_t + X_l$$

Equivalent Area Criterion for Stability Analysis

- $P = \frac{V_iV_j}{X} sin\delta$
  Uncertainty of Pm
  It will be caused by load and renewable energy.
- $\frac{dP}{d\delta} = \frac{V_iV_j}{X} cos\delta$
  Synchronizing Force
  Gradient of Power Curve
  If Pm reaches to Pmax, synchronizing force will be lost.

Pmax=>ATC



A: Acceleration Energy
B: Deceleration Energy

ATC(Available Transmission Capacity)

- Transmission capacity needs to be calculated to see whether RE can be transmitted from source location to demand place.
- Swing Equation
  - $P = \frac{V_iV_j}{X} sin\delta$
- Synchronizing Force
  - $\frac{dP}{d\delta} = \frac{V_iV_j}{X} cos\delta$
- Maximum Transmission Capacity
  - $P = \frac{V_iV_j}{X}$

  or $P_{loss} = R * (\frac{V_i}{X})^2 < P_{lossmax}$----- from heat capacity limit

Operating State of Power System

- Total Generation Power is to be normally 60〜70%.
- The fluctuation of load is 10〜20%, if load prediction is operated well.
- The fluctuation of renewable energy has to be about 10%, but already over 30% in Barbados.
- If total demand of grid becomes to 90% over of rated capacity of grid,
  - Spinning reserve will be decreased.
  - Synchronizing power will be very small not to be returned to stable state.
- Spinning reserve should be more than mixed fluctuation of load and renewable energy.

→RE, EV and Battery with inertia is required for large RE penetration.

→Energy mix of several resources will be helpful for improving grid stability.

Appendix 4-3-2 Attendant list, and Q&A, of the 1st RE & Grid Stability Seminar (Barbados)

Workshop for RE and Grid Stability on 27 Jul 2022: List of Participants

	Name	Organisation	Position
1	Destine Gay	MEBD	Project Manager
2	Horace Archer	MEBD	Senior Technical Officer
3	William Hinds	MEBD	Senior Technical Officer
4	Robert Harewood	BLPC	
5	Rohan Seale	BLPC	
6	Johann Greaves	BLPC	
7	Stephen Worme	BREA	
8	Dr. Gary Jackson	CCREEE	Director
9	Jean-Michel Parle	CCREEE	
10	Danielle Evanson	CERMES, UWI	Researcher
11	Heather Sealy	GEED	
12	Baidy Diallo	HDF	Business Developer
13	Jeffrey Kiyoshi Chen	Massy	
14	Dwight Grannum	Willams Renewable Energy	
15	Gleeson Roach	Williams Solar	
16	Natasha Davis	Williams Solar	
17	Nida R	WREL	
18	Aria Goodridge		
19	D. Coombs		
20	Jamal J		
21	Lawson Benard		
22	Owen Reader		
23	Tyrone White		
24	Dudley Williams		
25	Ron Farley		
26	Prof. Hisao Taoka	JET	Energy Model Expert
27	Yuka Nakagawa	JET	
28	Alex Harewood	JET	Technical Assistant

Workshop for RE and Grid Stability on 27 Jul 2022: Question and Answers

	Question	Placed by	Response
1	Is this a project being done on behalf of the Ministry of Energy?	Stephen Worme	We are JICA (Japan International Cooperation Agency) team providing technical assistance to MEBD in this project. MEBD is our counterpart for this project.
2	Does the grid model presented incorporate RE production and energy consumption?	Rohan Seale	The model will incorporate RE production and demand. This is an introductory workshop and if we receive data from BLPC, we will produce accurate models based on BLPC data for the selected microgrid area.
3	Are these presentations going to be available to participants after this presentation.	Stephen Worme	We will provide the slides via chat.
4	Is Grid Forming Inverter technology at a point where it can be applied to a Grid the size of Barbados? Or are these only available at the Distributed Micro Grid Scale?	Jeffrey Kiyoshi Chen	The size of Grid Forming Inverter is from home size to utility size. But the cost will be high. So utility size including microgrid will be better.
5	This is very technical and even as an engineer, a lot of it is over my head. However, I gather these are all of the things you are going to be examining and will be advising on. A lot of PV has already installed. What is going to happen between now and when they come back with their final report?	Stephen Worme	Today is an introductory session. The detailed session for input and analysis with the simulator will be held in the next session in Sep 2022. Final Report will be submitted in Mar 2023.
6	Could you further discuss the fluctuation of renewable energy?	Horace Archer	Generally, acceptable fluctuation level is less than 10% of grid capacity, but in Barbados, it is already significantly beyond that figure as 30MW in demand swings are seen routinely while demand was 130 MW. According to IRRP, utility will need to install Synchronous Condensers , in addition to battery, to mitigate this problem.
7	My concern is that already our grid is unstable and we continue to add more PV and the expectation of PV owners is that their systems will be installed in a reasonable time frame. Is this going to be possible to continue installing systems and if we do what is going to be the impact on the grid?	Stephen Worme	According to increase of PV, the output fluctuation will be increased, while demand is kept same. Then, voltage and frequency goes up and down. In case of frequency drops due to sudden output decrease without any stabilization measurement, under frequency relay (UFR) operates at the source of feeder, and the feeder is tripped to cut the load, and power cut will happen for the feeder. At the worst case, it will bring black out of the country. Battery installation is needed as soon as possible. Large PV installations can work, but energy management system with weather prediction AI will be necessary. Some ideas to solve this problem are as follows. (1)Install Batteries to substations. It can control all PV at substations. (2)Utility controls output of PV's using smart meters or other metering and control equipments. (3)Install PV with Grid Forming Inverter (future application)
8	It is my understanding that the Utility will not be able to get batteries for many months. What do we do in the interim?	Stephen Worme	Black-outs is an significant issue as risk increases with a greater influx of variable PV. Significant PV curtailment can be a tentative solution. Utility should use some of current diesel generators as LFC generator to control and keep frequency in stable state.
9	The use of concentrated solar heat power	Horace Archer	IRRP suggests to introduce concentrated solar heat generation (CSP) after 2028 as base case. It can be used to mitigate issues with intermittency since it can provide inertia. A study indicates irradiation level more than 2000 DNI will result in cost range of 6-8 c/kWh. It is still not sure if it is economic as it has not been deployed in places like Barbados.