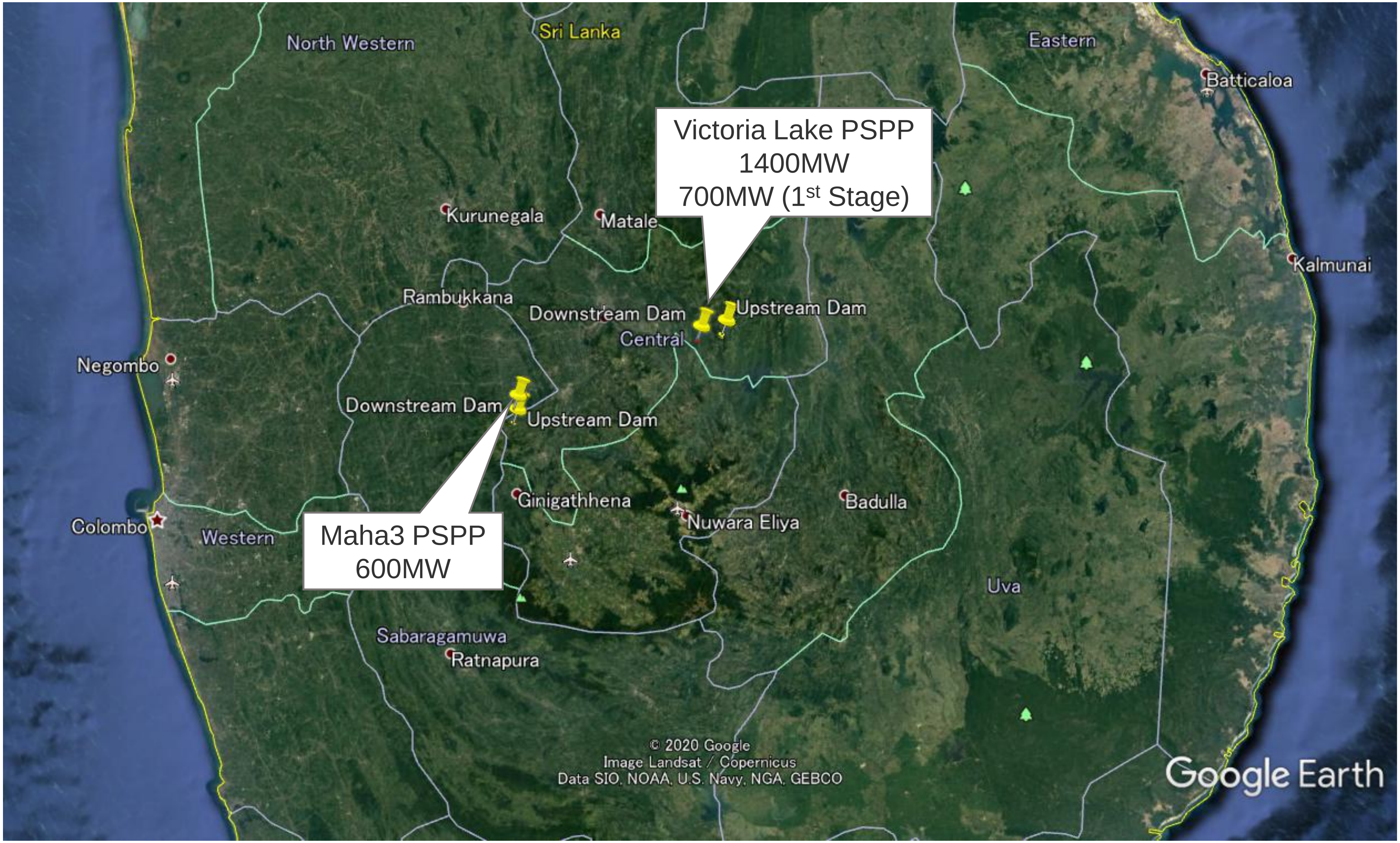
# 1st Technical Seminar
（Issues of PSPP）

15th December, 2020

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Maha3 and Victoria Lake PSPP: Locations




*Source: Google Earth*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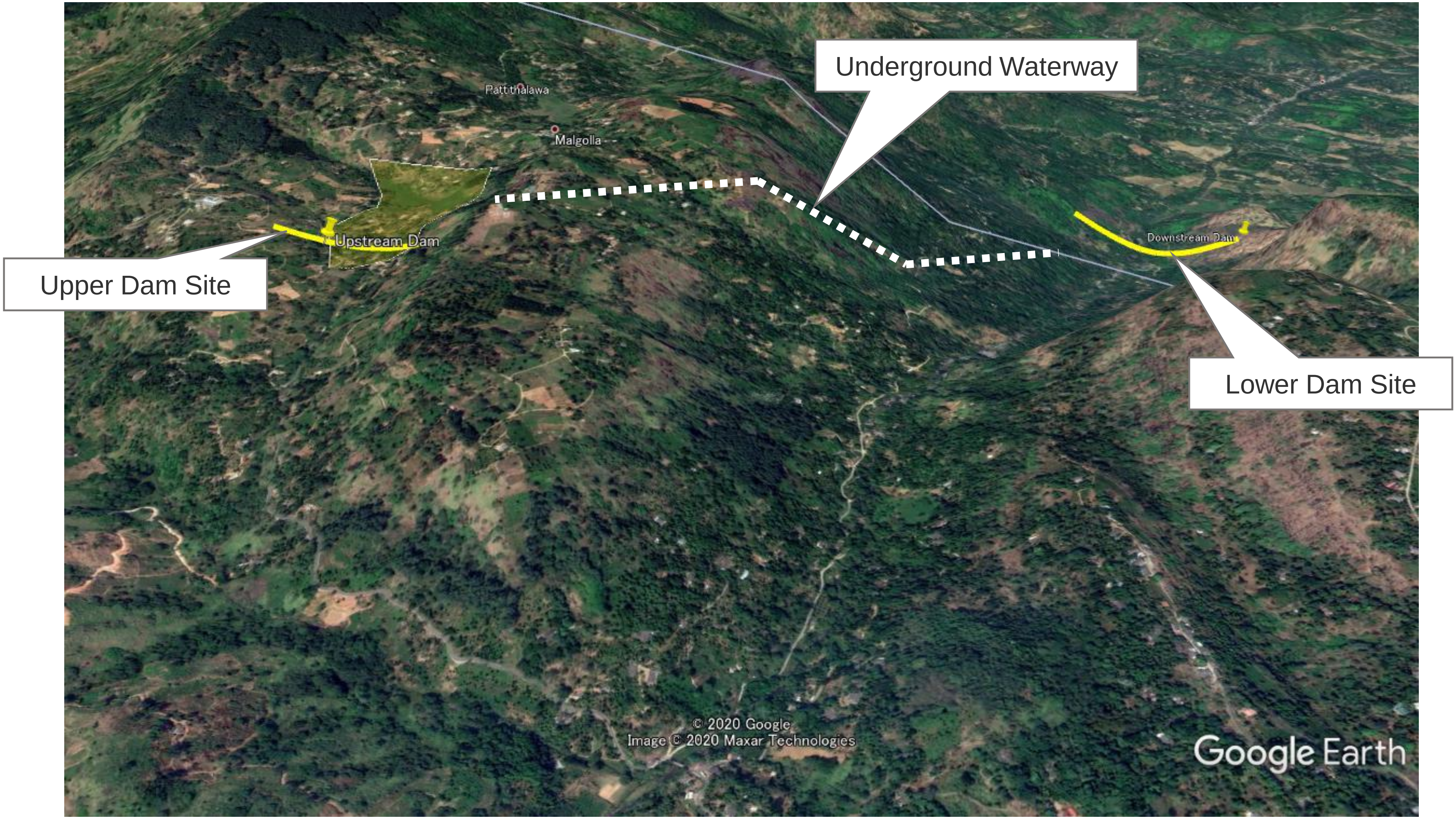
# Maha3 PSPP: General Layout Image




*Source: Google Earth*



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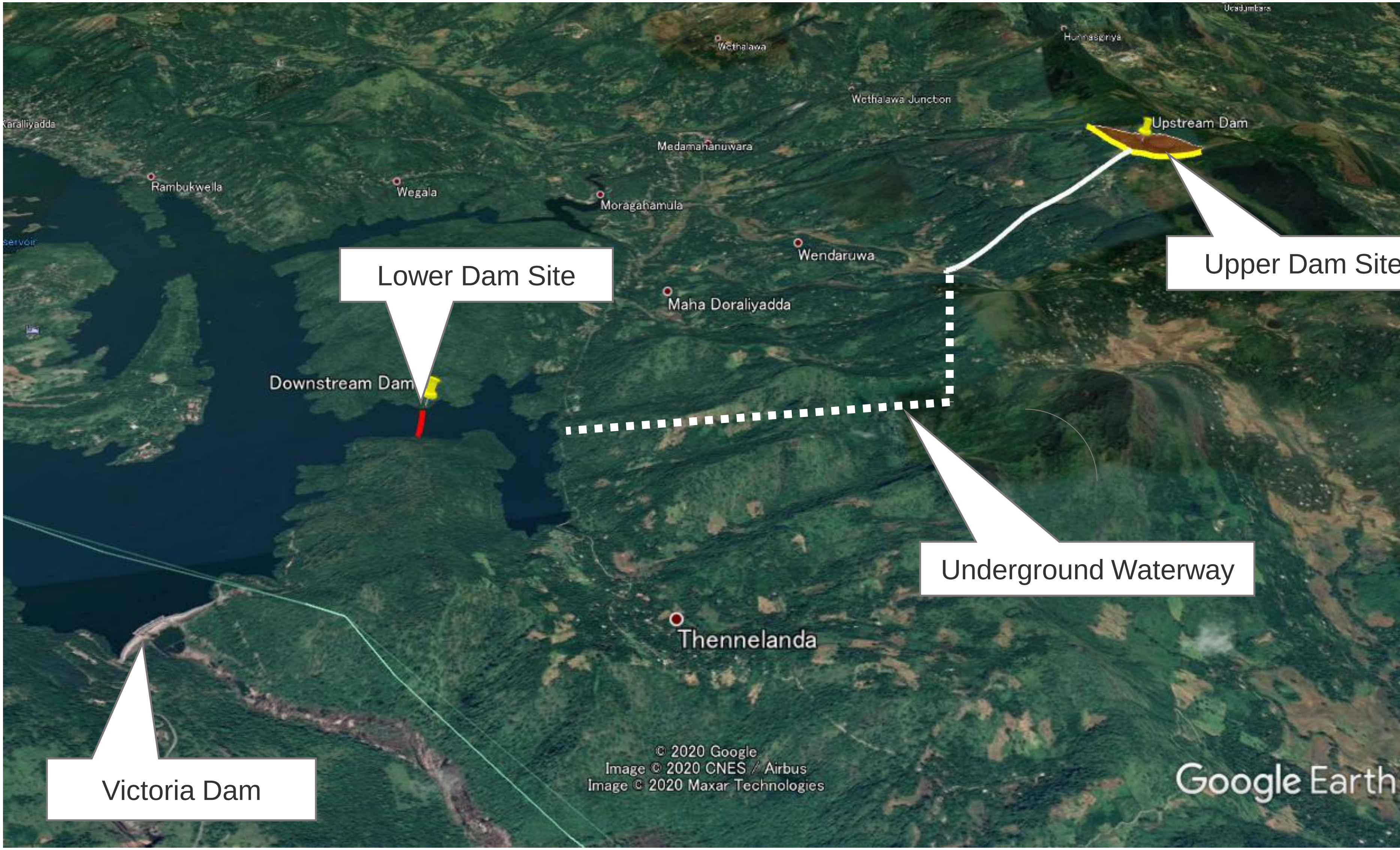
# Victoria Lake PSPP: General Layout Image




*Source: Google Earth*



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# Key Features of Reservoirs

| | Maha 3 PSPP | | Victoria Lake PSPP | |
|---|---|---|---|---|
| | Upper Reservoir | Lower Reservoir | Upper Reservoir | Lower Reservoir |
| HWL | EL. 815 m | EL. 292.5 m | EL. 1160 m | EL. 438 m |
| LWL | EL. 794.4 m | EL. 276.4 m | EL. 1125 m | EL. 407 m |
| Drawdown | 20.5 m | 16.1 m | 35 m | 31 m |
| Gross Capacity | 3.71 mil. $m^3$ | 6.22 mil. $m^3$ | 5.5 mil. $m^3$ | 10.0 mil. $m^3$ |
| Available Capacity | 3.15 mil. $m^3$ | 3.20 mil. $m^3$ | 5.1 mil. $m^3$ | 5.1 mil. $m^3$ |
| Reservoir Area | 0.22 $km^2$ | 0.24 $km^2$ | 0.17 $km^2$ | 0.3 $km^2$ |
| Dam Height | 59 m | 74 m | 40 m | 42 m |

*Source: JICA Reports*


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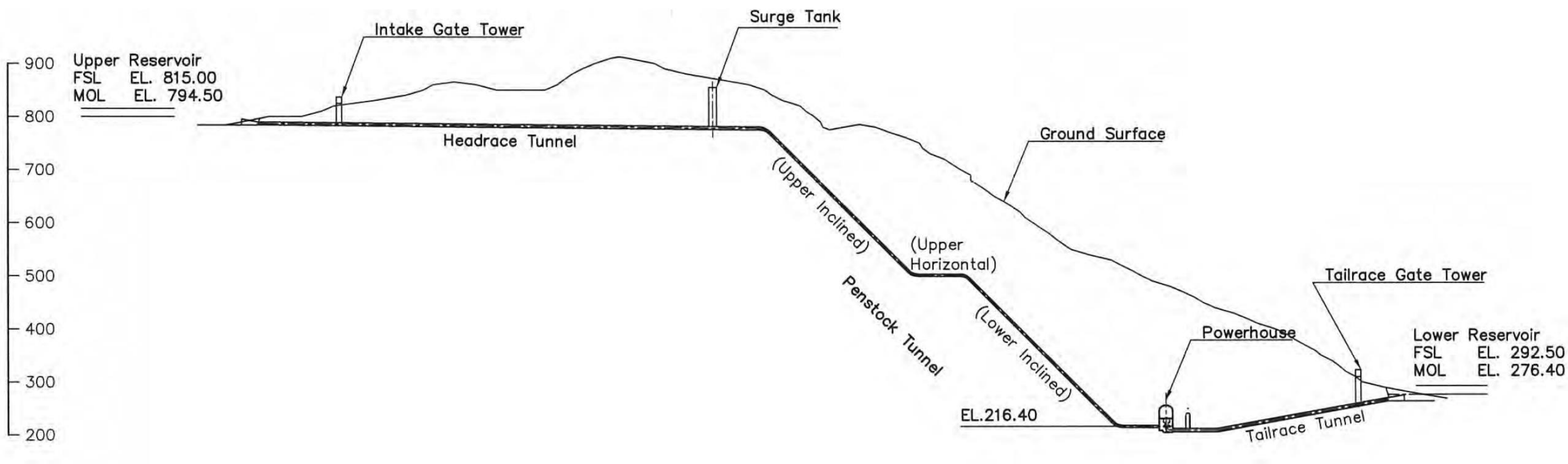
# Maha3 PSPP: Longitudinal Profile of Waterway




*Source: Development Planning on Optimal Power Generation for Peak Demand in Sri Lanka, 2015, JICA*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# Issues of Geology on Maha 3 Site

| Structures | Check points | Major considerable issues |
|---|---|---|
| Upper storage dam | • Safety of dam foundation<br>• Water tightness | • Thick talus deposits/highly weathered rocks on left bank<br>• Impermeable layer seems to be deep on left bank (more than 50 m in depth) |
| Reservoir | • Landslide risks<br>• Water seepage risks | • No information, but daily fluctuation of water level might thick weather zone on the left bank might trigger landslides especially on left bank covered with thick overburden.<br>• No information, but seepage risks on left bank are anticipated. |
| Water way | • Landslide risks of portals<br>• Rock condition along water ways | • No information<br>• Geological structures nearly parallel to the waterway route.<br>• NE-SW lineaments (possible faults) were identified. |
| Underground powerhouse | • Rock condition | • Biotite gneiss according to existing geological map.<br>• No critical issues according to the Report (2015) |
| Lower storage dam and reservoir | • Same as upper storage dam and reservoir<br>(Safety of dam foundation, Water tightness, Landslide risks and Water seepage risks) | • No critical issues according to the Report (2015) |


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# Maha3: Layout of the Structures and Geological Issues

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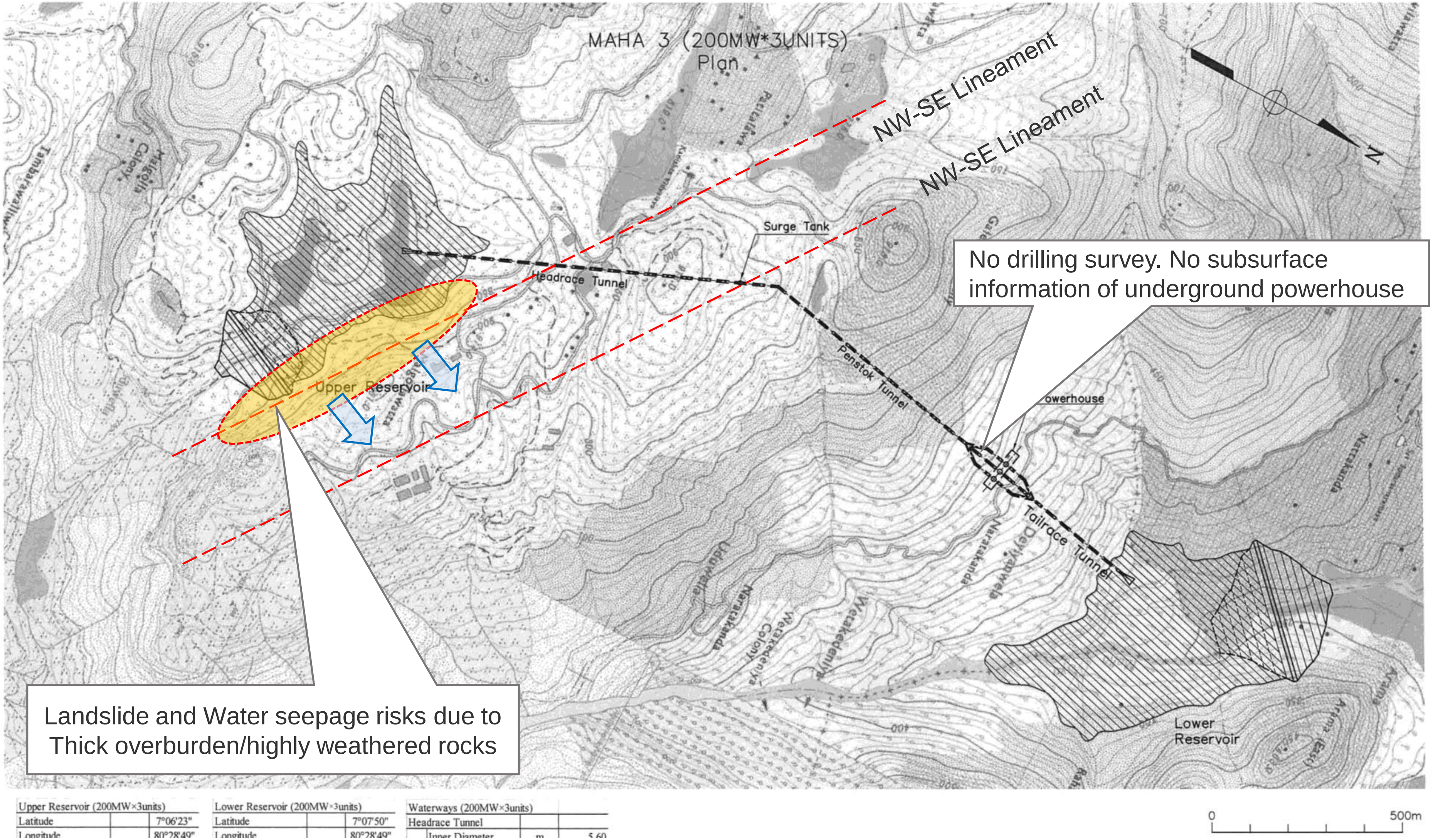


*Source: Development Planning on Optimal Power Generation for Peak Demand in Sri Lanka, 2015, JICA, JICA Study Team added the geological information.*


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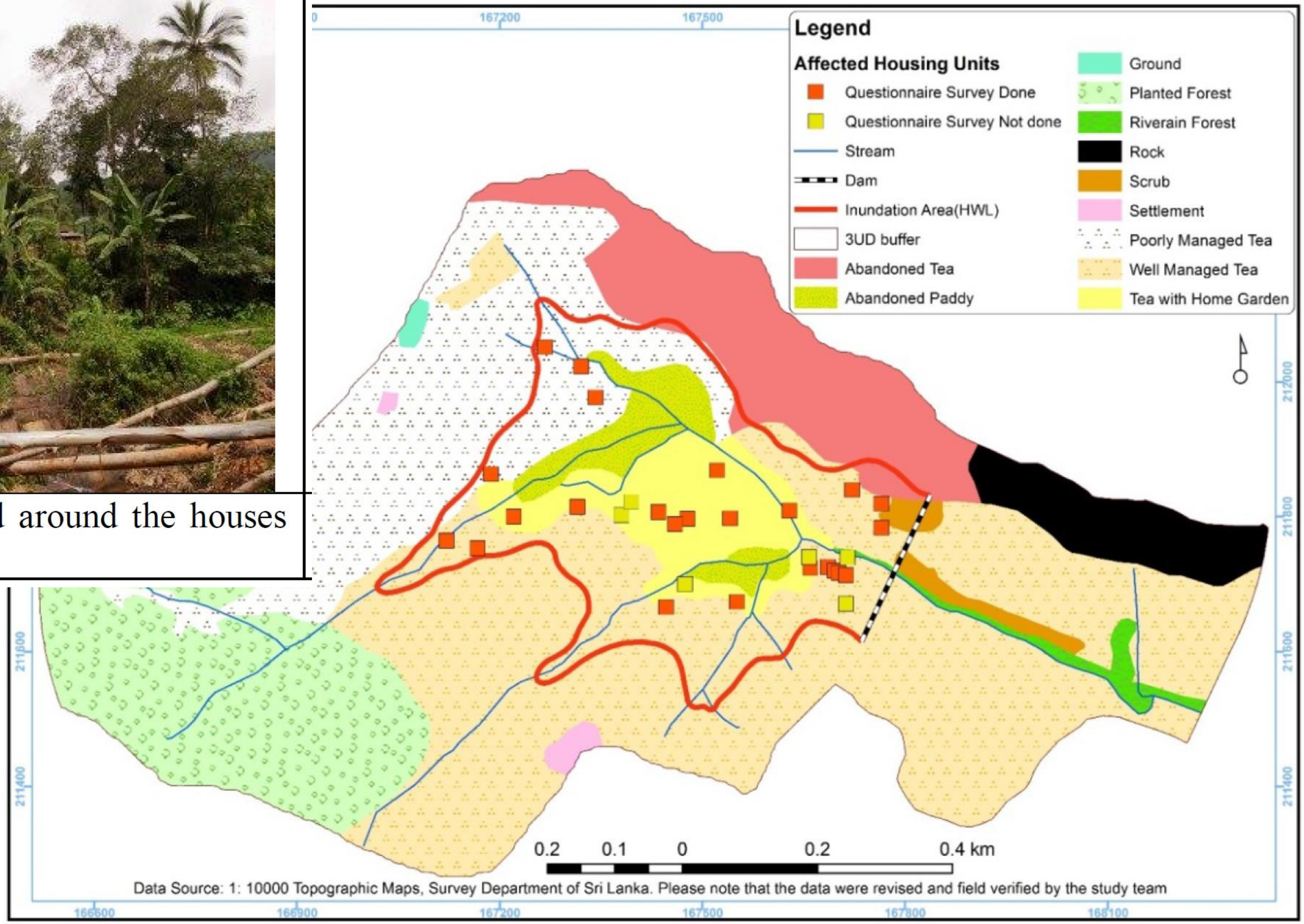
# Maha3: Land Use and Location of Houses in Upper Reservoir

Home gardens are developed around the houses with some tea plantation.




*Source: Development Planning on Optimal Power Generation for Peak Demand in Sri Lanka, 2015, JICA*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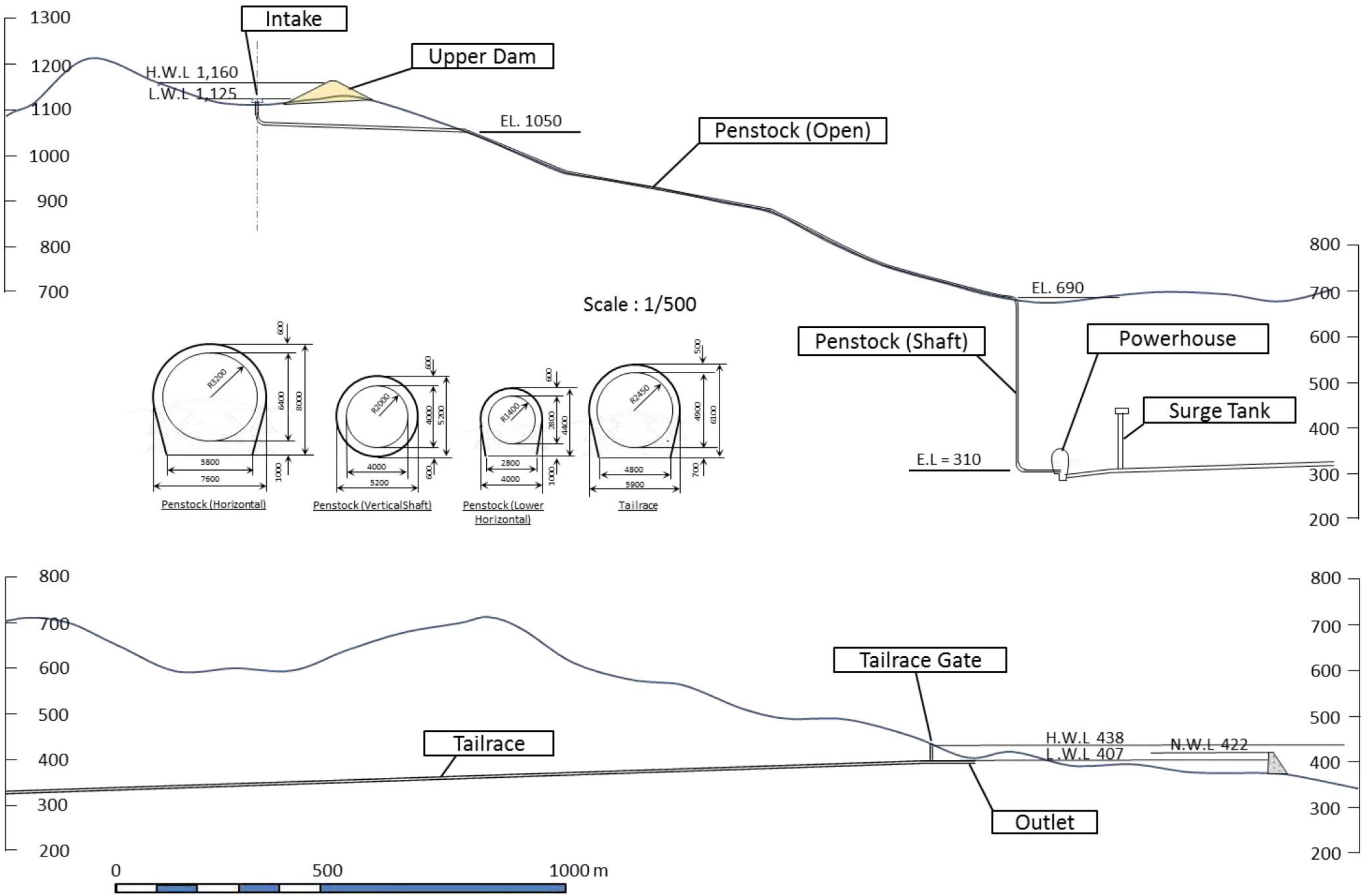
# Victoria Lake PSPP: Longitudinal Profile of Waterway




*Source: Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, 2018, JICA*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# Issues of Geology on Victoria Lake Site

| Structures | Check points | Major considerable issues |
|---|---|---|
| Upper storage dam | • Safety of dam foundation<br>• Water tightness | • Possibility of landslide risks<br>• No information |
| Reservoir | • Landslide risks<br>• Water seepage risks | • Ditto<br>• No information |
| Water way | • Landslide risks of portals<br>• Rock condition along water ways | • No information<br>• One lineament (possibly fracture zone) crossing the tunnel. |
| Underground powerhouse | • Rock condition | • No information |
| Lower storage dam and reservoir | • Safety of dam foundation, Water tightness, Landslide risks and Water seepage risks | • No information |


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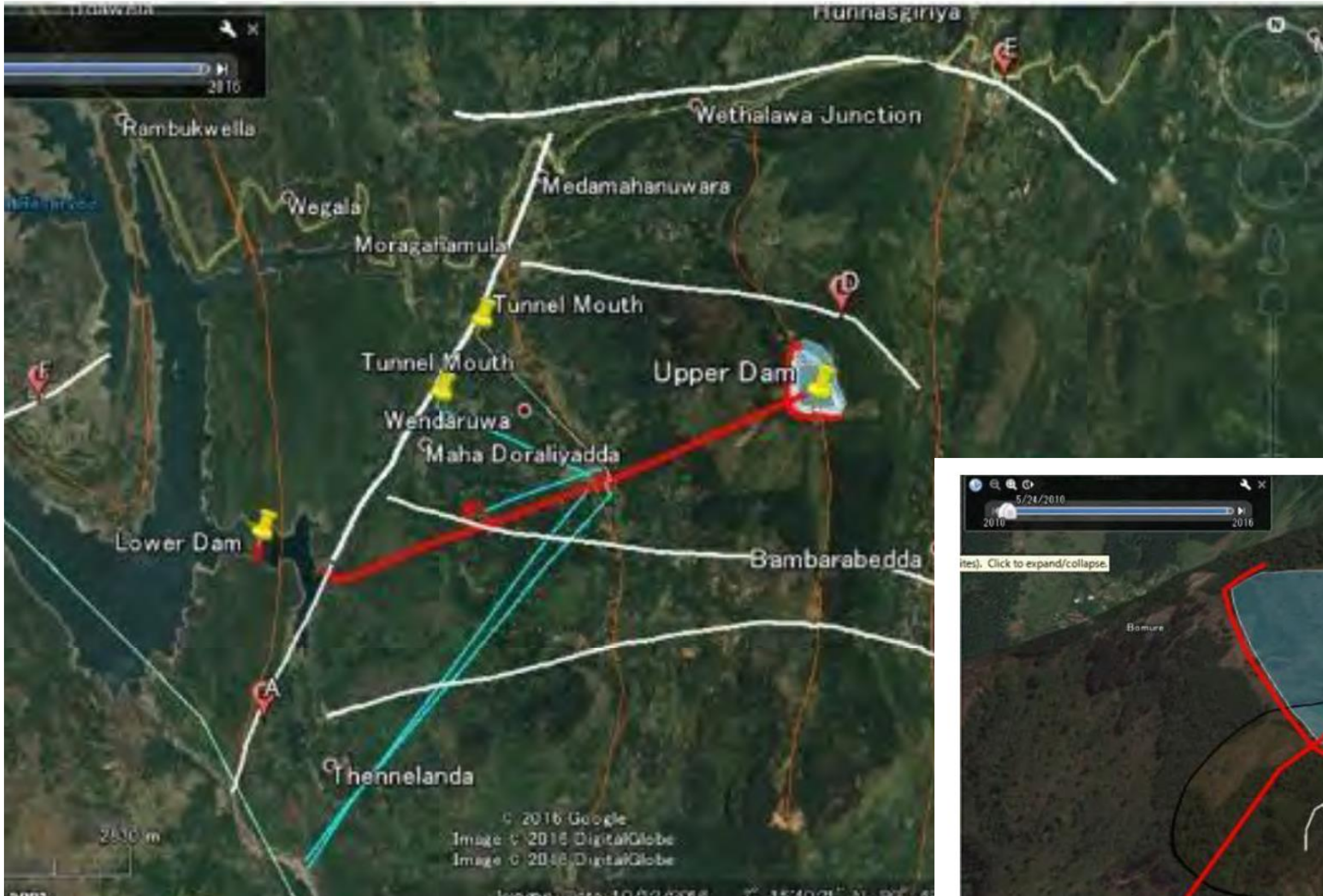
# Victoria Lake PSPP: Geological Lineament and Landslide




Lineaments (white line)


Upper reservoir and Possible landslide (black line)

*Source: Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, 2018, JICA*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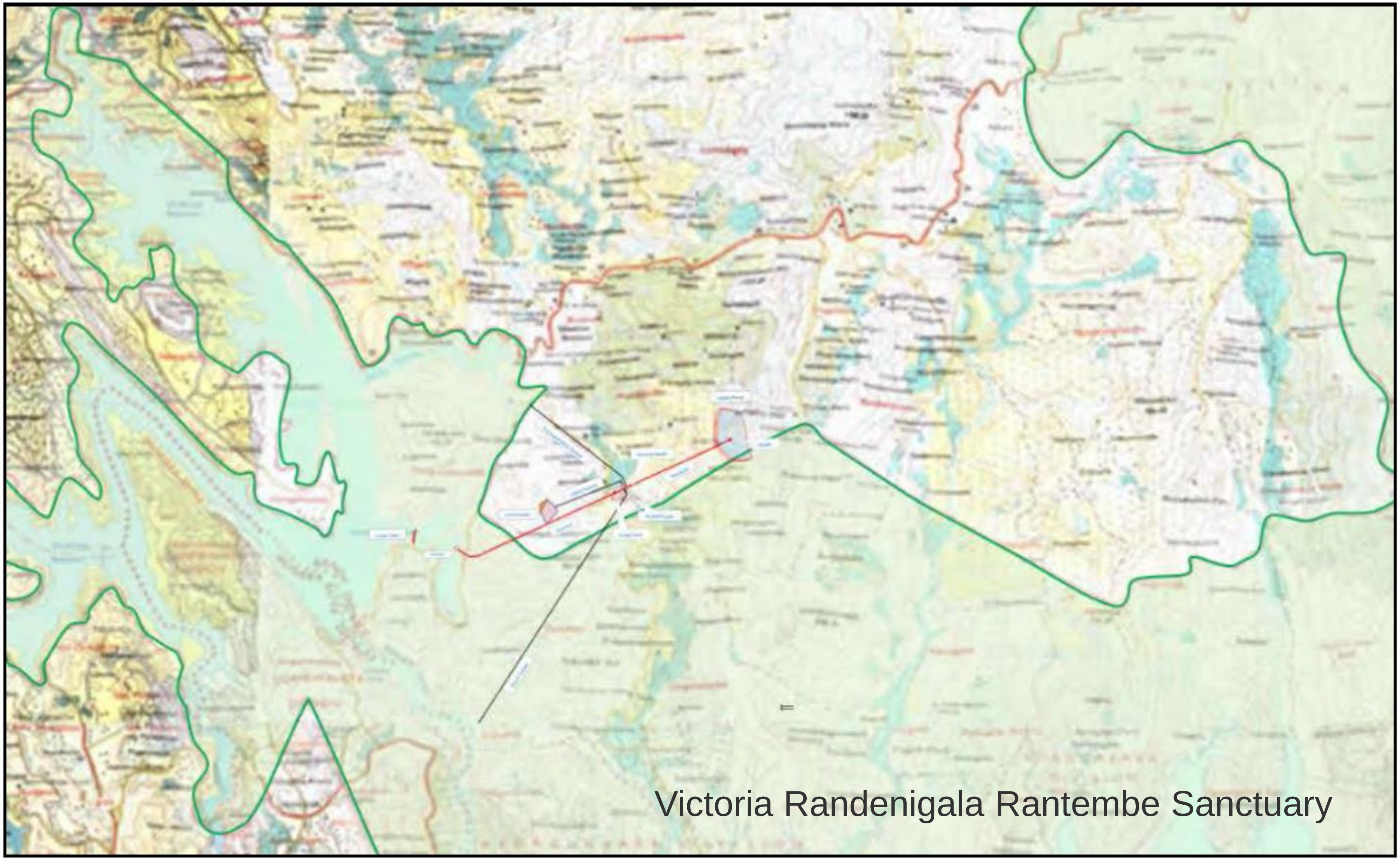
# Victoria Lake PSPP: Protection Area




*Source: Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, 2018, JICA*



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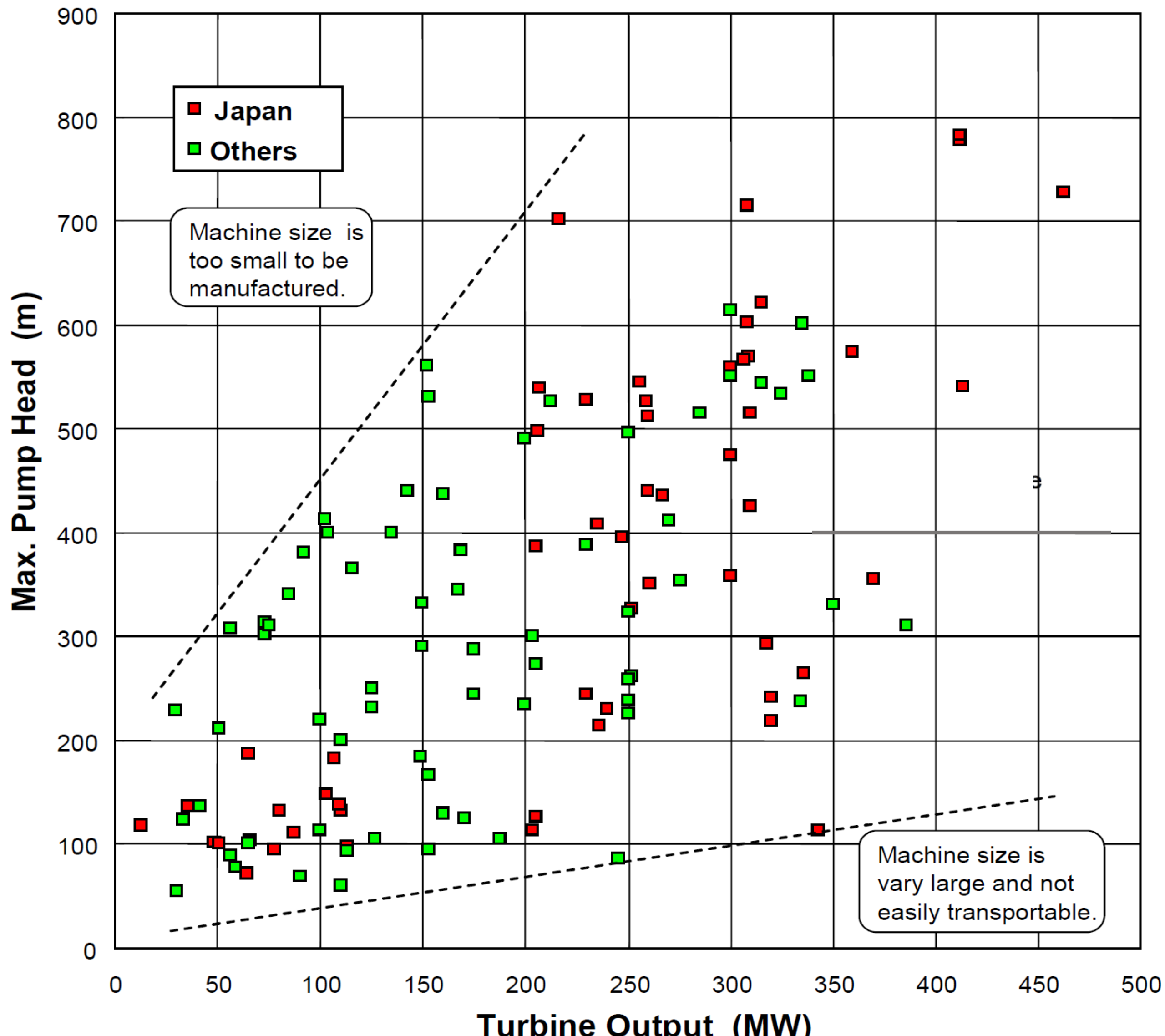
# Record of Francis Type Reversible Pump Turbine




*Source: Development Planning on Optimal Power Generation for Peak Demand in Sri Lanka, 2015, JICA*



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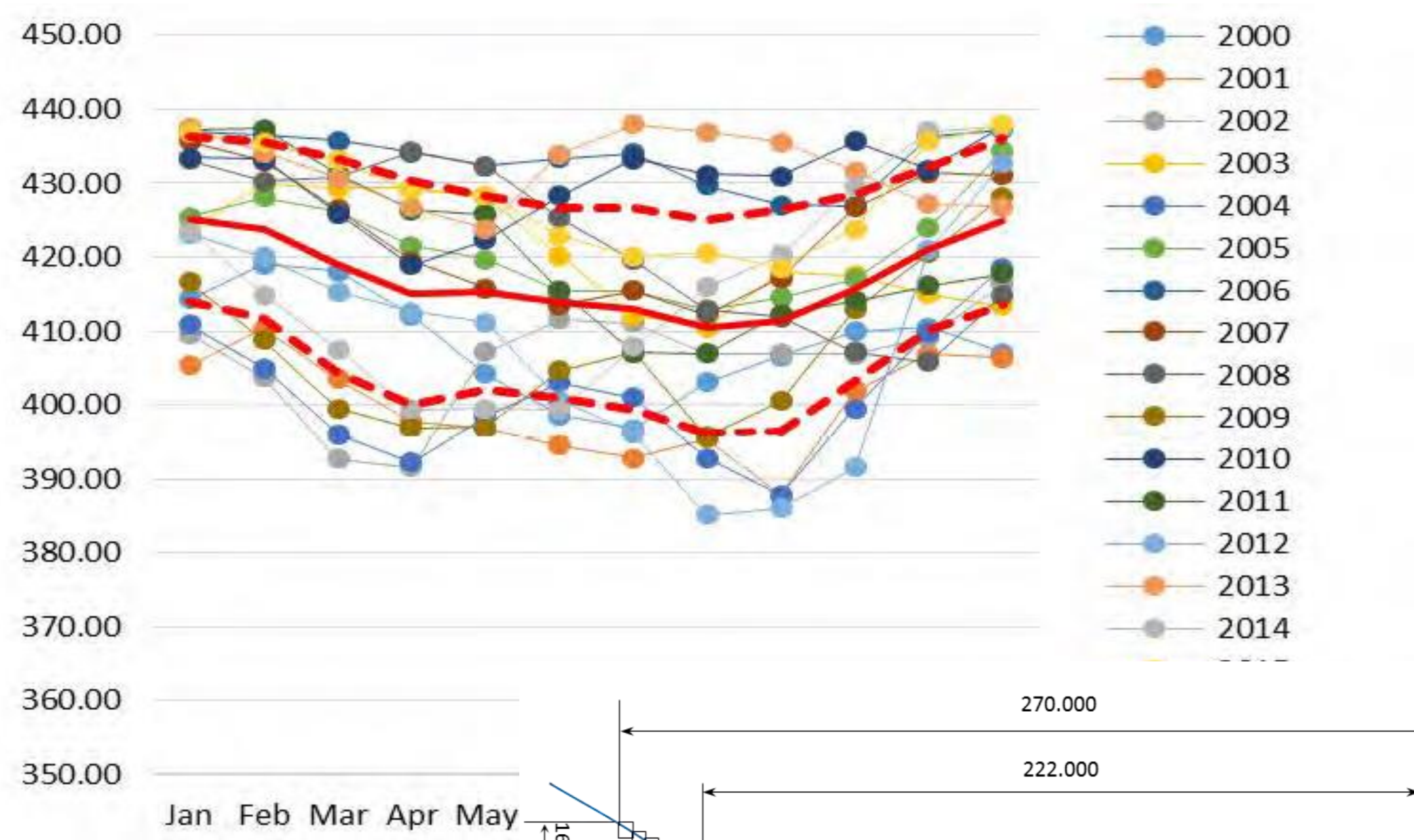
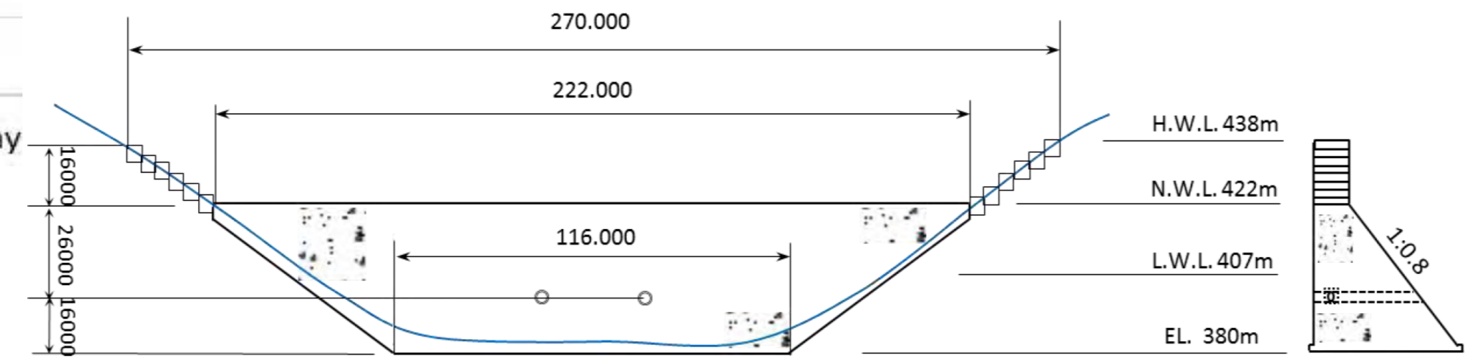
# Victoria Lake PSPP: Lower Dam




*Source: Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, 2018, JICA*



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# Issues of Maha3 and Victoria Lake PSPPs

| | Maha3 PSPP | Victoria Lake PSPP |
|---|---|---|
| Source of Info. | • Development Planning on Optimal Power Generation for Peak Demand in Sri Lanka, 2015, JICA | • Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, 2018, JICA |
| Geology | • Site investigation: in 2015<br>• **Upper dam: thick deposit on the left bank of the talus**<br>• Lower dam: no critical issue<br>• Waterway: layers nearly parallel to the water route | • Site reconnaissance: in 2018<br>• **Upper dam: possibility of existence of landslide**<br>• Lower dam: unclear<br>• Waterway: lineament |
| Environment | • Environmental study: in 2015<br>• Natural: out of the protection area<br>• **Social: resettlement of 28 households within the inundated area**. | • Site reconnaissance: in 2018<br>• **Natural: lower dam within the protection area.**<br>• Social: direct impacts on the village may not be substantial. |
| Technical Aspect | | • **Pumping head: more than 700m**<br>• **Lower dam: construction in the Victoria Lake** |


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# Project Cost of PSPP

| | Installed Capacity | Project Cost Base Year 2014 | USD per kW | Source |
|---|---|---|---|---|
| Maha3 PSPP | 600MW | USD 638 mil. | USD 1,060/kW | 2015, JICA |
| Victoria Lake PSPP | 700MW (1st Stage) | USD 590 mil. | USD 840/kW | 2018, JICA |

- Investigation is more advanced in Maha 3 PSPP compared to Victoria Lake PSPP, especially for geological information.
- For Victoria Lake PSPP, there are critical aspects on which further examination is needed in the next stage, such as upper reservoir geology, lower dam construction in Victoria Lake and construction in forest sanctuary.
- Therefore, at this stage it is adequate to consider the Maha3 PSPP's cost as the benchmark of PSPP cost for comparison with the battery option.
- The said Maha3 PSPP's cost is escalated with annual price escalation at 2% to obtain 2020 price; thus **USD 1,200/kW** is considered as the benchmark of PSPP cost for comparison with battery.


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# 1st Technical Seminar

（Comparison of the cost merit between PSPP and storage battery）

15th December, 2020

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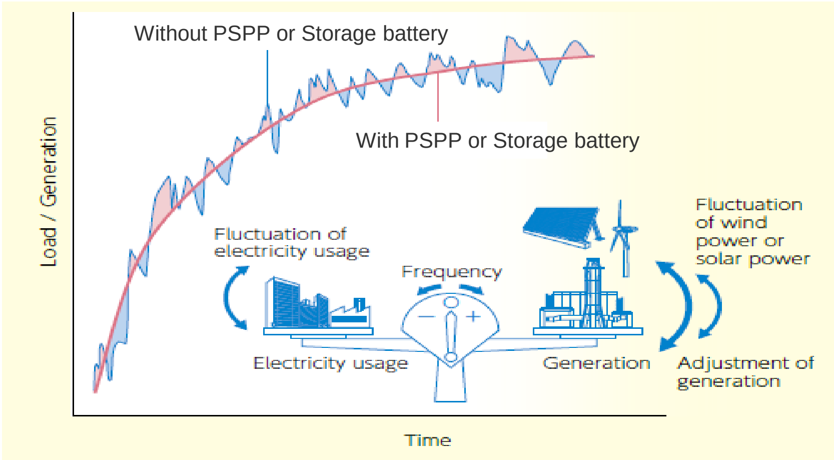
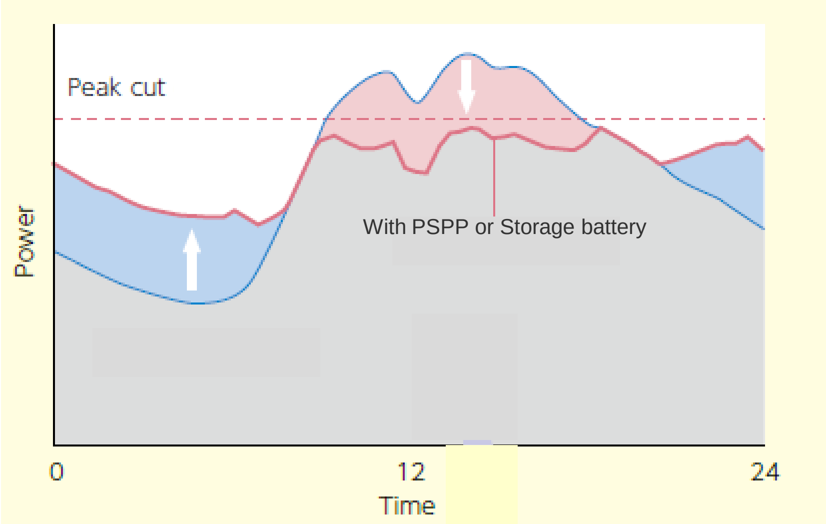
# Purpose of power storage technology

| Purpose | Explanatory diagram | Utilization contents |
|---|---|---|
| **Measures for frequency fluctuation** |  | **Imbalance between demand and supply could cause frequency fluctuation. Utilizing storage technology can achieve minimization of frequency fluctuation by utilizing their high-speed response.** |
| **Measures for surplus electricity** |  | **It stores surplus electricity such as solar power generation and utilizes the stored electricity when needed.** |

# Types of power storage technology

| Technology of Storage Energy | Shape of storage | Method |
|---|---|---|
| Storage battery | Chemical energy | NAS, Li (Lithium-ion battery)<br>Vanadium redox flow |
| CAES<br>(Compressed Air Energy Storage) | Pressure energy | compress air at night, using it daytime to generate power |
| Hydrogen storage | Chemical energy | Use for fuel battery |
| PSPP<br>(Pumped storage power plants) | Hydro energy | Pumping water with surplus electricity, discharge when needed |

Comparison

We would like to propose the best method for Sri Lanka.



source: NEDO(new energy and industrial technology development organization) renewable energy technology white book ver.2

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# Type of storage battery

Three types of batteries that can replace pumped storage power generation.

| Battery name | | Energy density／Output density | Charge and discharge efficiency | Replace cycle (year) | Characteristics | Price |
|---|---|---|---|---|---|---|
| NAS |  | ○／△ | ○ (75～80%) | △ (15) | Heater loss | ○ |
| Li (Lithium-ion battery) |  | ○／△ | ○ (80～90%) | △ (10～20) | None | △ |
| Vanadium redox flow |  | △／△ | △ (70～80%) | ○ (20) | Pump loss | △ |

 source: NEDO(new energy and industrial technology development organization) renewable energy technology white book ver.2

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# NAS Battery

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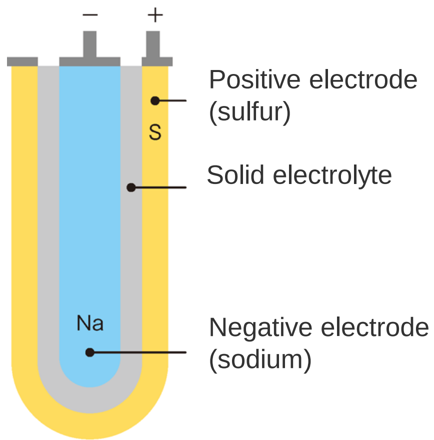


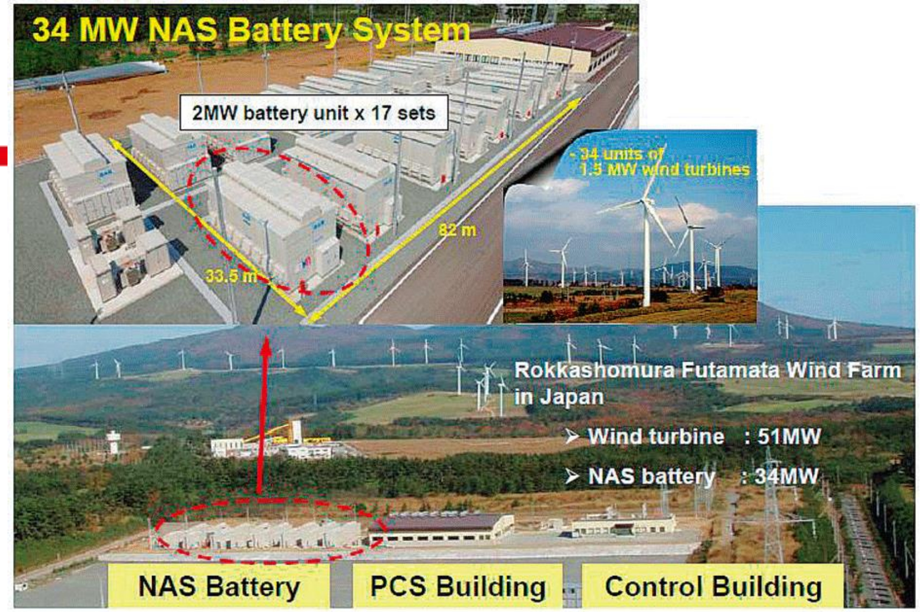


| | |
|---|---|
| Charge and discharge speed | 0.2~0.5C |
| Efficiency of charge and discharge | 75~80% |
| Replace cycle | 15 years（4500cycle） |
| Construction period | 1~2year |
| Characteristics | ・The equipment price is cheaper than other batteries.（1,800 USD/kW（300 USD/kWh））<br>・The operating temperature is 300 to 340 degrees, and it can be installed regardless of the external temperature.<br>・Suitable for measures against surplus power that requires a large capacity. |

source: NEDO(new energy and industrial technology development organization) renewable energy technology white book ver.2


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# Lithium-ion (Li) battery

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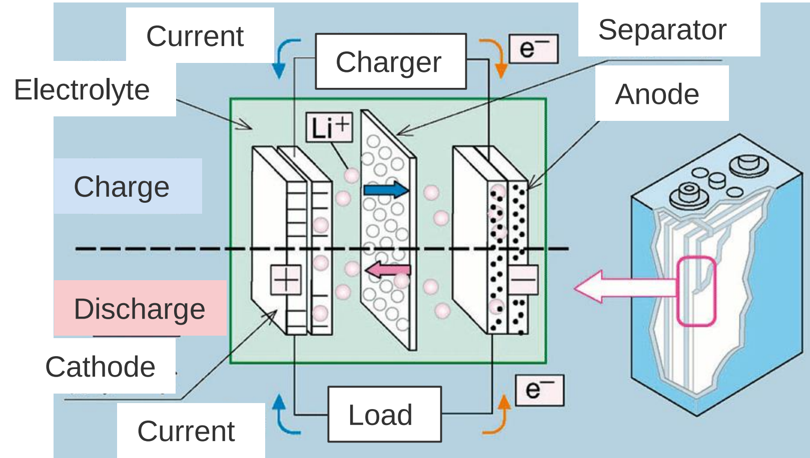
ESS(Energy Storage System)


| | |
|---|---|
| Charge and discharge speed | Max 3C |
| Efficiency of charge and discharge | 80~90% |
| Replace cycle | 10~20 years |
| Construction period | 1~2year |
| Characteristics | ・It can output 3 times the rated capacity in a short time and is suitable for frequency fluctuation measures.<br>・Fast charging is possible (approx. 80% charge in 6 minutes)<br>・Charge / discharge efficiency is higher than other storage batteries. |



source: NEDO(new energy and industrial technology development organization) renewable energy technology white book ver.2

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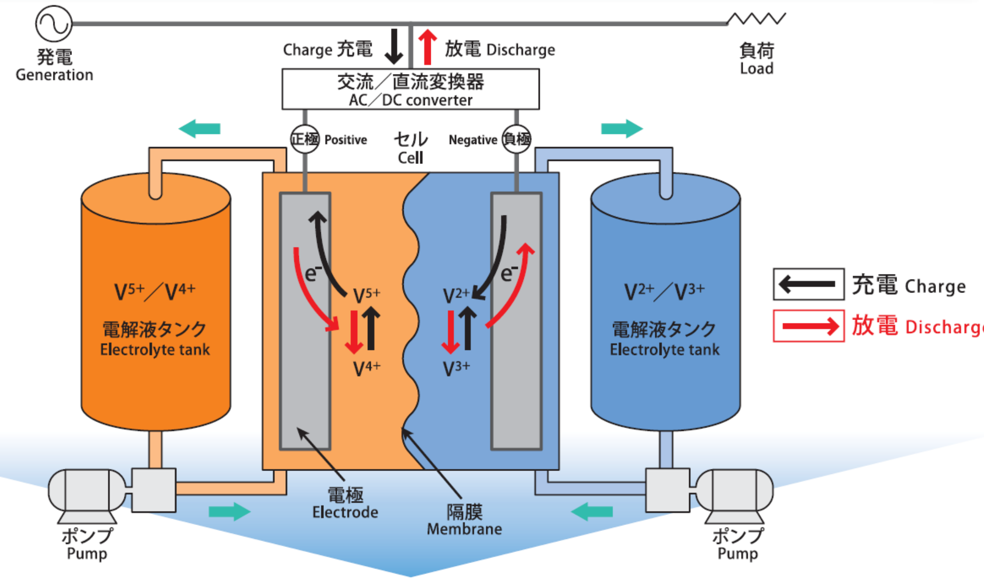
# Vanadium redox flow




redox: reduction and oxidation

| | |
|---|---|
| Charge and discharge speed | max 1C |
| Efficiency of charge and discharge | 70~80% |
| Replace cycle | 20 years (electrolyte is usable permanently) |
| Construction period | 1~2year |
| Characteristics | ・Since the electrolyte can be used permanently with no limit on the number of times, maintenance costs are low. (Equipment needs to be updated every 20 years)<br>・There is no risk of fire because it uses non-flammable materials. |



source: NEDO(new energy and industrial technology development organization) renewable energy technology white book ver.2

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# Comparison of PSPP and Storage battery①

| | | PSPP （Assuming Maha3 （※1）） | | Storage Battery （NAS） | | | |
|---|---|---|---|---|---|---|---|
| | | | | Current | | Around 2030 year | |
| ① | Condition | Output:600MW<br>Generation / Discharge Time: 6hours<br>Storage capacity: 3,600MWh | | | | | |
| | Constriction (MUSD) | 720 | | 1,080 | | 378 | |
| | Constriction Cost (US cents／Wh) | 20 | | 32 | | 11 | |
| | Constriction Cost／Replacement cycle （US cents ／Wh／year）<br>PSPP：40year<br>Storage Battery：20year | 0.5 | ○ | 1.6 | △ | 0.6 | ○ |
| ② | Condition | Days of operation: 250day<br>Times of operation: 1,500h／year | | | | | |
| | (A)Power generation cost for equipment (US cents／kWh)<br>(Annual expense ratio: **%) | 4.8<br>(6%) | | 12.0<br>(10%) | | 4.0<br>(10%) | |
| | (B)Power generation cost for PSPP operation or Storage battery operation (US cents／kWh) | 10.0 | | 10.0 | | | |
| | (C)Power generation efficiency (loss) (US cents／kWh) | 3.0<br>（PSPP efficiency: 70%) | | 1.0<br>( Storage Battery efficiency: 90%) | | | |
| | Power generation Cost (US cents／kWh): (A)+(B)+(C) | 17.8 | ○ | 23.0 | △ | 15.0 | ○ |

Source: Potential Capacity and Cost of Pumped-Storage Power in Japan Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies （January 2020 Japan Science and Technology Agency）

# Comparison of PSPP and storage battery②

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| | | PSPP | | NAS Battery | | Li Battery | | Redox flow | |
|---|---|---|---|---|---|---|---|---|---|
| ③ | Construction period (Year) | 8～10 | △ | 1～2 | | | | | ○ |
| ④ | Replacement cycle (Year) | 40 (※2) | ○ | 15 | △ | 10~20 | △ | 20 | △ |
| ⑤ | Advantages | ・Suitable for surplus electricity countermeasures.<br>・Large scale development<br>・Long-term usage | | ・Suitable for frequency fluctuation countermeasures.<br>・Staged develop is possible<br>・Low loss (10-30%)<br>・Significant price decline<br>・The construction period is short. | | | | | |
| | Disadvantages | ・Development sites is limited.<br>・Staged development is impossible.<br>・Loss is bigger than storage battery: about 30% | | ・The replacement cycle of the storage battery (10~20 year) is shorter than PSPP. | | | | | |

[Notices]

(※1) The comparison target of the storage battery was the PSPP of Maha3. Because Victoria Lake's investigation has many uncertainties.

(※2) The replacement cycle of PSPP (40year) is described from the Maha3 report.
(Average 40year : Civil works 50year, Hydro-mechanical and electro-mechanical equipment 35year)

source: Potential Capacity and Cost of Pumped-Storage Power in Japan Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies (January 2020 Japan Science and Technology Agency)

# Suggestion from JICA Expert Team

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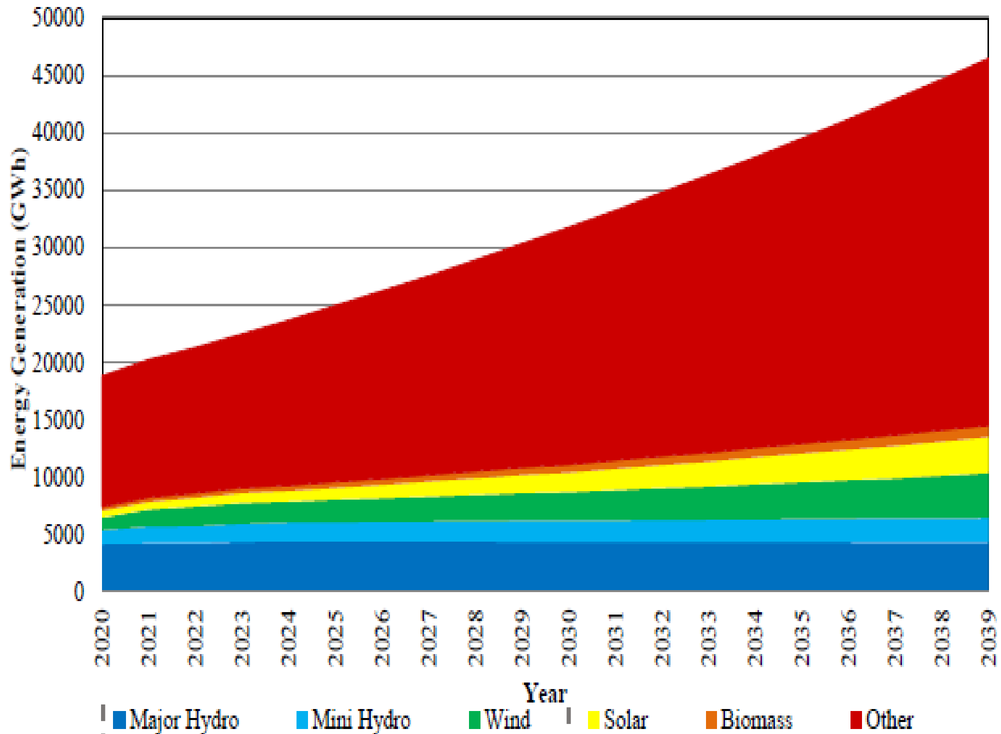
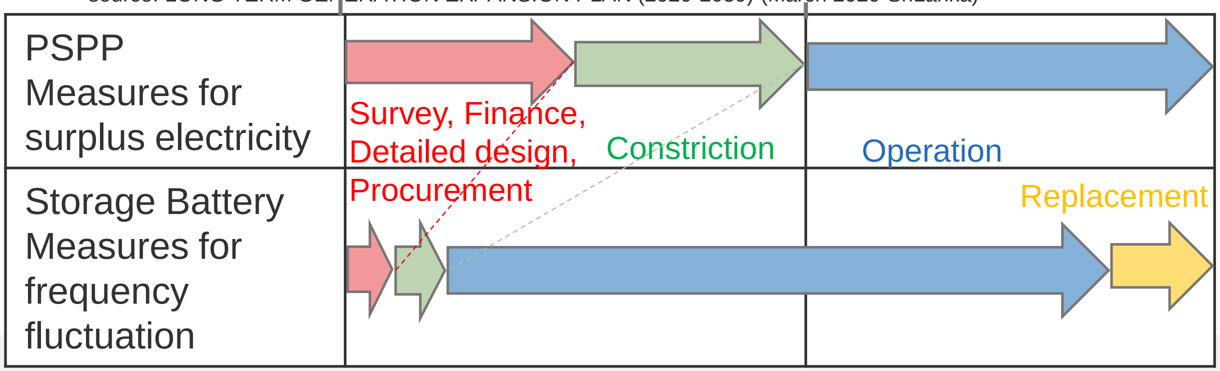



*ure 8.7 –Renewable Contribution over next 20 years based on energy resource*

source: LONG TERM GENERATION EXPANSION PLAN (2020-2039) (March 2020 SriLanka)




- PSPP takes a lot of time to complete.
- Renewable energy will gradually increase.

(Recent years)
When gradually introducing renewable energy, it is necessary to take measures against frequency fluctuations.
(Storage battery will be used as a measure against frequency fluctuations.)

(10 years later)
When a large amount introducing renewable energy， it is necessary to take measures against surplus electricity.
(PSPP will be used as a measure against surplus electricity.)

**We would like to take measures against renewable energy by best mixing PSPP and storage battery.**

Thank you for attention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# Democratic Socialist Republic of Sri Lanka

# The Project for Capacity Development on the Power Sector Master Plan Implementation Program

# 1st Technical Seminar

December 15th, 2020

Japan Weather Association

# Contents





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# Development of VRE output Forecast model

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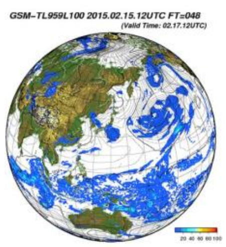
## ◆ Overview of Forecast for VRE Output

- Weather forecast for VRE can be calculated based on the weather models of the Japan Meteorological Agency and the Meteorological Organizations of each country.
- The output of PV and wind power can be predicted from weather forecast results and specifications of facilities.

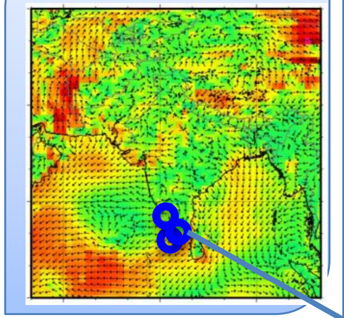
Output from Weather model



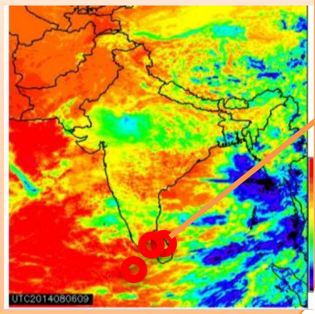

Statistical model

Forecast for VRE at power plant

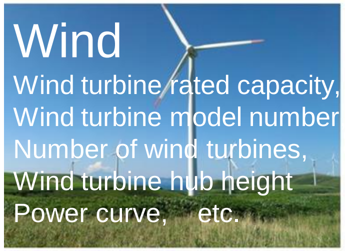
[ Wind speed ]

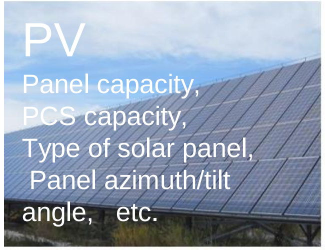


[Solar irradiation]



Facility information



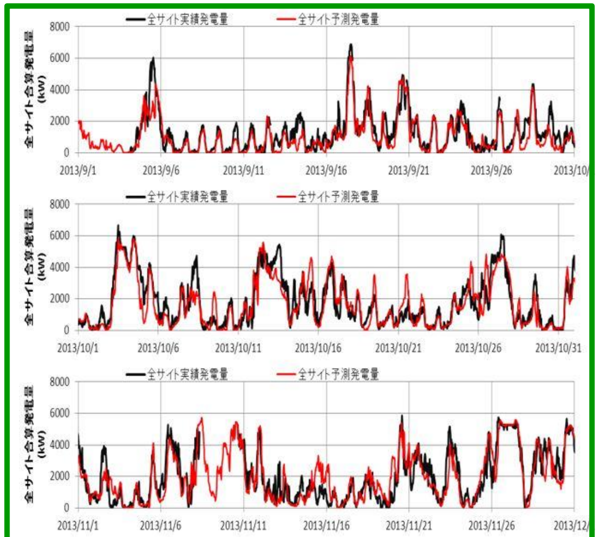

Wind speed at wind power plant

Solar irradiation at PV power plant

Wind power generation at the plant

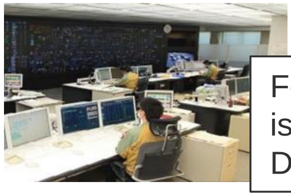
PV power generation at the plant

Statistical model




X_axis: timeline [year/month/day]
Y_axis: total amount of all power output(wind + PV) [kW]
legend: historical result (black); forecast for power generation output (red)

※Specification should be considered in detail at the time of design



Forecast system of PV output is installed at Central Load Dispatching Center in CEPCO.



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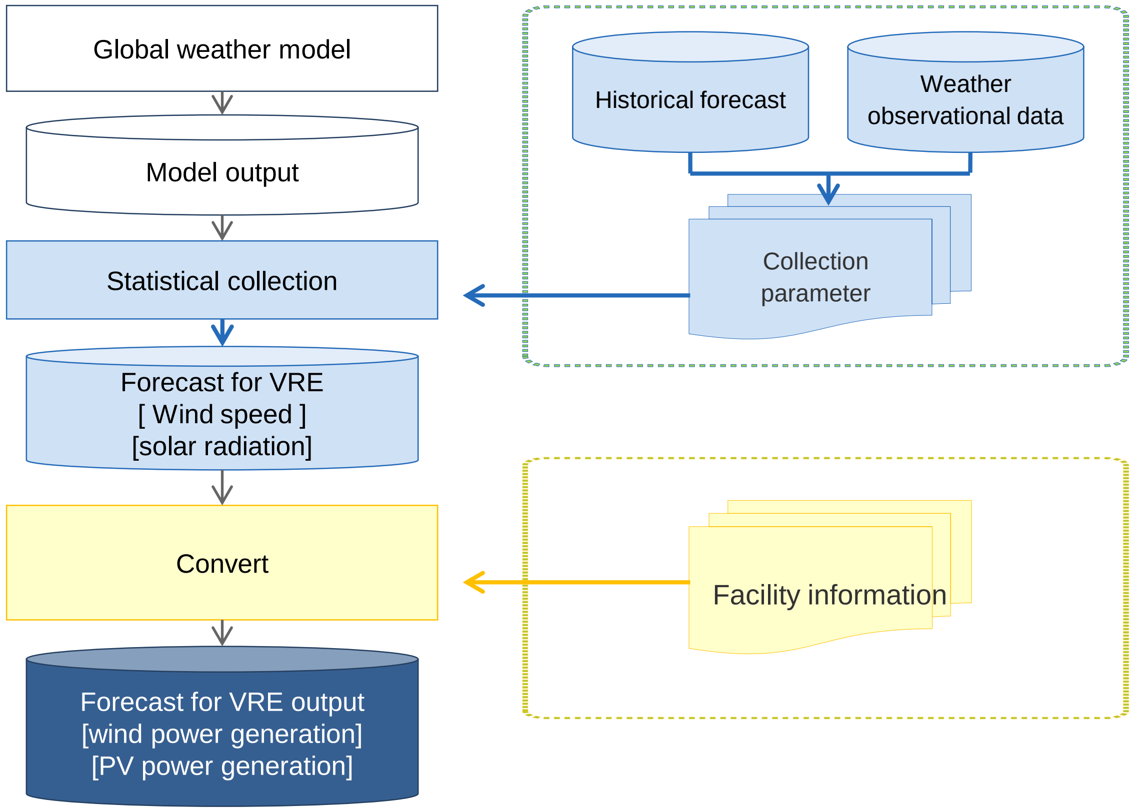
# Development of VRE output Forecast model

## ◆ Process of the Forecast for VRE output

This flow shows an example approach for predicting power output using weather forecasts. The overall flow is the same for PV and wind power. Facility information is mandatory to output power generation.





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# Development of VRE output Forecast model

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## ◆ PV facility information:sample(Utility-scale)

Using the following facility information, solar radiation is converted into Rooftop PV power generation per resident(household). These information should be organized by area.

| PV facility information | example |
|---|---|
| Site name | Saga PV Site |
| Location(latitude/longitude) | Lat: 7.94YYYYY,　Lon: 81.25XXXX |
| Period of installation | 1 year and 3 months since installation |
| panel azimuth angle | 180°　　(due south) |
| panel tilt angle | 10° |
| type of installation | Utility-scale |
| types of PV module | Monocrystalline Silicon,<br>Polycrystalline Silicon, etc |
| Total amount of panel capacity（kW） | 100,000kW |
| PCS series-name（manufacturer） | PCS-ABC1200E (produced by ABC solar Co.,Ltd.) |
| Total amount of PCS rated capacity（kW） | 100,000kW |


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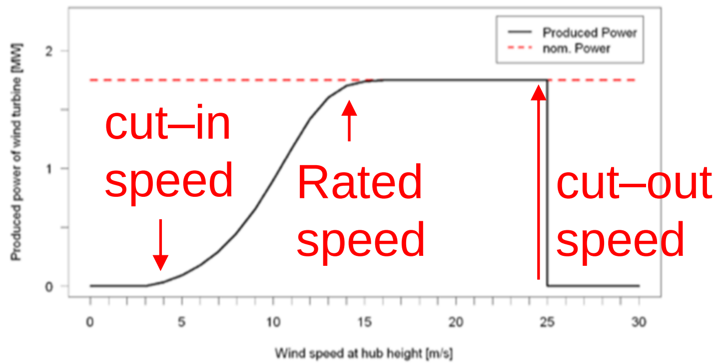
# Development of VRE output Forecast model

## ◆ Wind facility information:sample

Using the following facility information, wind speed and direction is converted into Wind power generation output. These information should be organized by site.

| Wind facility information | example |
|---|---|
| Site name | ZZZZ WPP Site |
| Location(latitude/longitude) | Lat: 7.94YYYYY, Lon: 81.25XXXX |
| Period of installation | 8 months since installation |
| number of wind turbines | 11 |
| wind turbine rated capacity per unit（kW） | 1,700 kW |
| Total amount of wind turbine capacity（kW） | 18,700 kW |
| wind turbine hub height | 60m |
| power curve<br>(includes cut–in, rated, cut–out wind speed)<br><br>※please refer to product catalog of wind turbine. |  |





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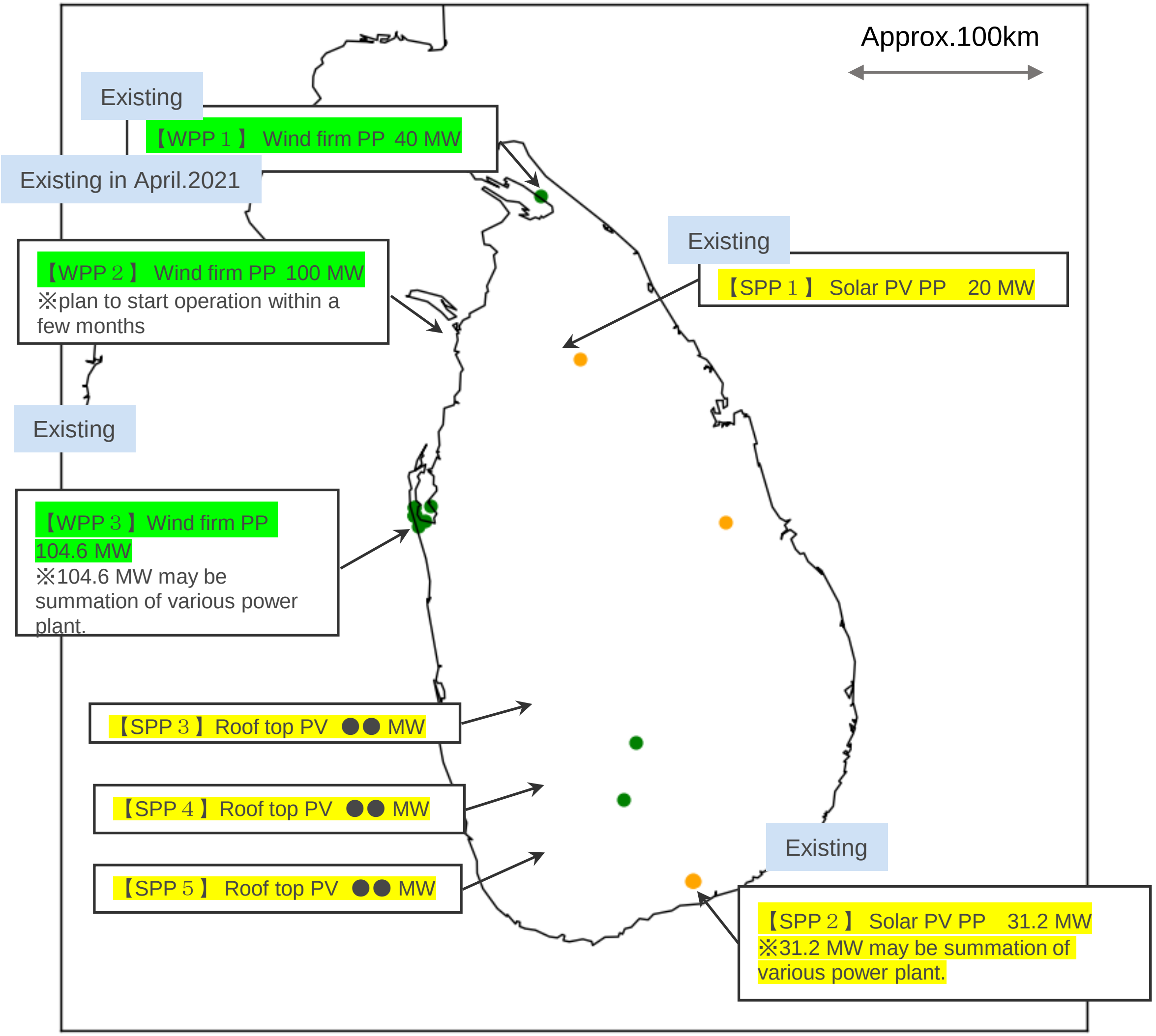
# Development of VRE output Forecast model

## ◆ Candidate points decided in the activity so far




| # | Solar Power Plant |
|---|---|
| Existing Power Plant | |
| SPP1 | Solar PV PP 20 MW |
| SPP2 | Solar PV PP 31.2 MW |
| Existing Rooftop(RT) | |
| SPP3 | Roof top PV ●● MW |
| SPP4 | Roof top PV ●● MW |
| SPP5 | Roof top PV ●● MW |

| # | Wind Power Plant |
|---|---|
| Existing Power Plant | |
| WPP1 | Wind firm PP 40 MW |
| WPP2 | Wind firm PP 100 MW (plan to start operation within a few months) |
| WPP3 | Wind firm PP 104.6 MW |



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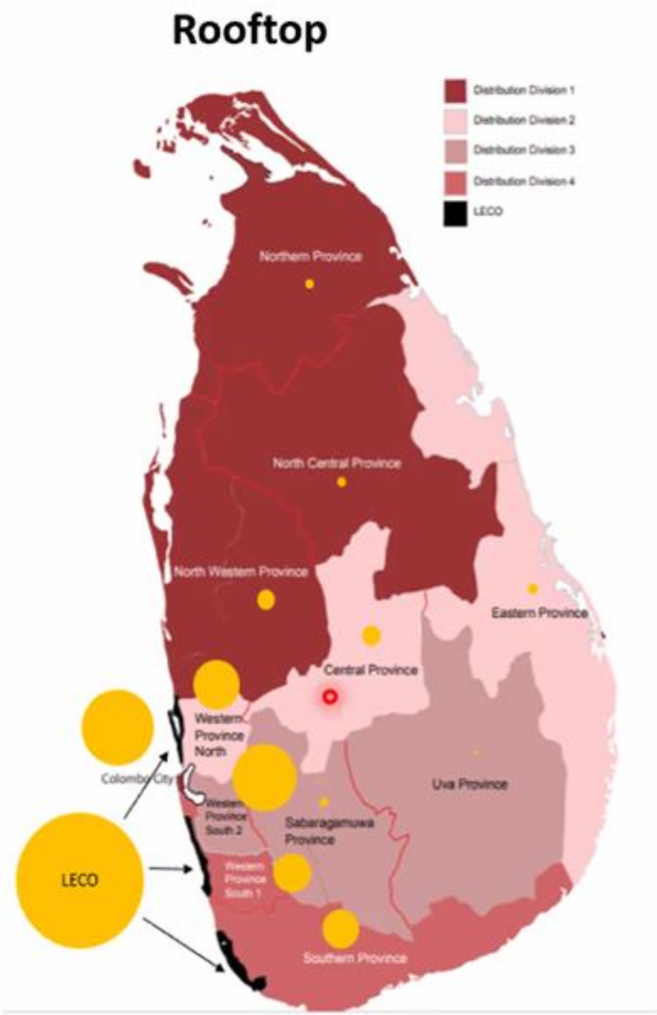
# Development of VRE output Forecast model

## ◆ How the Solar Roof Top is important




| Other Renewable Energy Technology | No of Projects | Capacity (MW) |
|---|---|---|
| Mini Hydro Power | 210 | 394 |
| Biomass | 12 | 37 |
| Solar Power- Parks | 8 | 51 |
| Wind Power | 15 | 128 |
| Solar Roof Top (Approx.) | | 170 |
| **Total** | | **780** |

**Quoted from materials provided by CEB**

Concern required to reconsider is rapid-growing Rooftop PV, especially in south-west area.



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# Evaluation of VRE output forecast model

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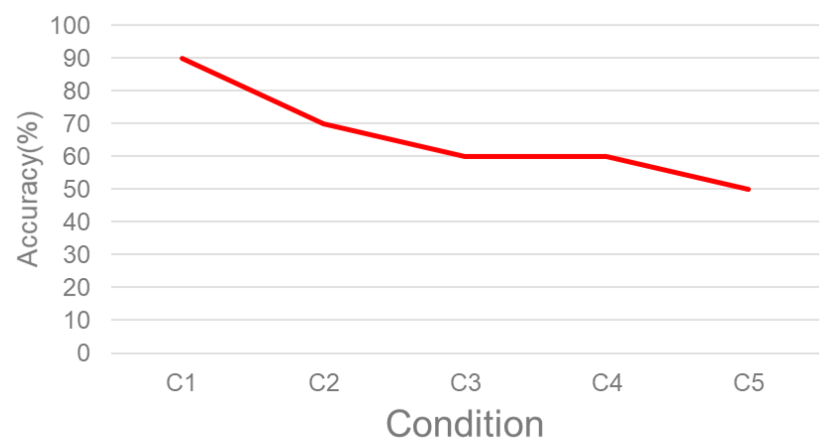
## ◆ Approach to the accuracy improvement

| Condition | Weather data（CEB,IPP) | Weather data（DOM) | Output data of VRE | Facility information |
|---|---|---|---|---|
| C1 | ○ | × | ○ | ◎ |
| C2 | × | ○ | ○ | ◎ |
| C3 | × | × | ○ | ◎ |
| C4 | × | ◎ | × | ◎ |
| C5 | × | × | × | ◎ |

◎：Mandatory,○：Available,×：Not available

The accuracy of the forecast is dependent on the collected data

VRE Forecast Accuracy




Above chart is presented for illustrative purposes only.



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# Evaluation of VRE output forecast model

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◆ Accuracy verification indicators and future goals

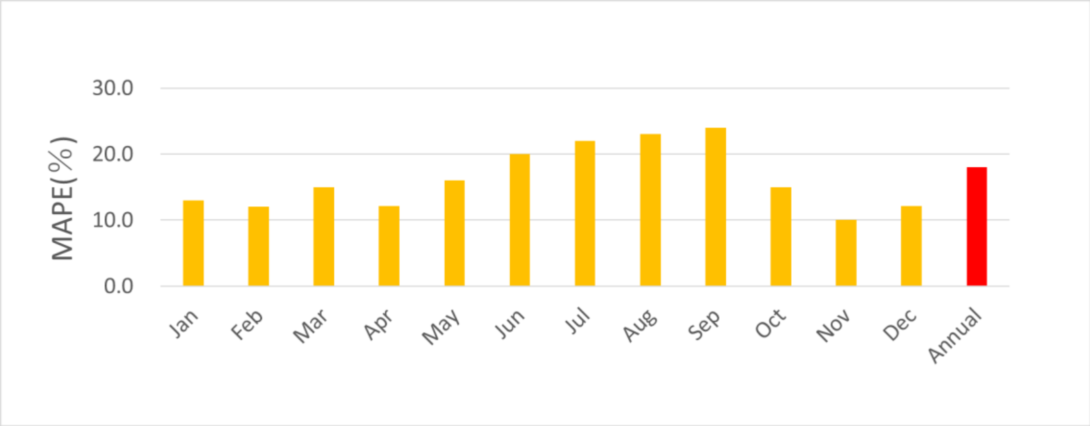
## Mean Absolute Percentage Error(**MAPE**)

The Index showing the accuracy of the forecast model is shown below:

$$MAPE = \frac{\sum_{i=1}^{N} \left| R_{fcst,i} - R_{obs,i} \right|}{\sum_{i=1}^{N} R_{obs,i}} \times 100$$

$R_{obs,i}$: Observed value,
$R_{fcst,i}$ : Forecasted value
$N$ : Sample number of targeting period

Targeting VRE **(the sum of PV and WF),** Mean Absolute Percentage Error **(MAPE)** between the forecasted value and the observed value is aimed at below **20%** of the **monthly or yearly average**.



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# Future plan of the project

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- Determine VRE forecast model development points based on meteorological data and facility information.
- Determine the delivery method of the forecast data.
- Construct VRE forecast system within about 3 months after the delivery method is decided and the facility information is received.
- After constructing VRE forecast system, create a tool to convert from weather data to VRE output with MS Excel.


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# Annex3-5-4a VRE_location (Solar Power)

## Existing Solar Power Plant

| | Developer Name | Solar Plant Name | Capacity | Location | | |
|---|---|---|---|---|---|---|
| | | | (MW) | Connected GSS | Latitude | Longitude |
| 1 | Japan Solar Plant (SEA) | Gonnoruwa Phase I SPP | 0.737 | Hambanthota | 6°13'31.31"N | 81°4'38.07"E |
| 2 | Korean Solar Plant (SEA) | Gonnoruwa Phase II SPP | 0.5 | Hambanthota | 6°13'34.94"N | 81°4'31.86"E |
| 3 | Saga Solar | Saga (Baruthankanda) SPP | 10 | Hambanthota | 6°13'53.59"N | 81°5'8.85"E |
| 4 | Iris Eco Power Lanka (Pvt) Ltd | Iris (Baruthankanda) SPP | 10 | Hambanthota | 6°13'57.19"N | 81°4'43.77"E |
| 5 | Anorchi Lanka (Private) Ltd | Anorchi Lanka (Baruthankanda) SPP | 10 | Hambanthota | 6°13'39.72"N | 81°4'50.40"E |
| 6 | Solar One Ceylon (Pvt) Ltd | Solar One Ceylon Power (Pudukadumalai) Solar PV PP | 10 | Valachchenai | 7°58'31.22"N | 81°14'9.89"E |
| 7 | Vydexa (Lanka) Power Corporation (Pvt) Ltd | Nedunkulam Solar PV PP | 10 | Vauniya | 8°46'16.69"N | 80°31'40.50"E |
| | **Total** | | 51.237 | | | |

## Development Plan for Solar Power Plant

| | Developer Name | Solar Plant Name | Capacity | Location | | | Year of | Present Status |
|---|---|---|---|---|---|---|---|---|
| | | | (MW) | Connected GSS | Latitude | Longitude | Operation | |
| 1 | | Rooftop Solar Power Programs | | | | | | |
| 2 | | 37x1MW Solar Park | 37 | | | | 2021 | Under Construction |
| 3 | | 90x1MW Solar Park | 90 | | | | 2021 | Awarded/under Construction |
| 4 | | 2x10MW Solar Park | 29 | | | | | |
| 5 | | 150MW Dist. Solar Park | 150 | | | | 2022 | Bidding stage |
| 6 | | Utility Scale Solar Park | 100? | | | | 2020 | Prefeasibility is being done |
| | **Total** | | | | | | | |

※e.g. AxB: A:Location, B: Capacity


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# Annex3-5-4a VRE_location (Wind Power)

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## Existing Wind Power Plant

| | Developer Name | Solar Wind Name | Capacity | Location | | |
|---|---|---|---|---|---|---|
| | | | (MW) | Connected GSS | Latitude | Longitude |
| 1 | Senok Wind Power (Pvt) Ltd | Mampuri WPP | 10 | Puttalam | 8°0'36.37"N | 79°43'24.09"E |
| 2 | Seguwantivu Wind Power (Pvt) Ltd | Seguwantivu WPP | 10 | Puttalam | 8° 3'30.43"N | 79°48'12.98"E |
| 3 | Vidatamunai Wind Power (Pvt) Ltd | Vidatamunai WPP | 10 | Puttalam | | |
| 4 | Vallibel Willwind (Pvt) Ltd | Willpita WPP | 0.85 | Balangoda | 6°37'22.36"N | 80°44'37.80"E |
| 5 | Nirmalapura Wind Power (Pvt) Ltd | Nirmalapura WPP | 10 | Norochcholei PP | 7°57'14.73"N | 79°44'27.14"E |
| 6 | Ace Wind Power (Pvt) Ltd | Ambewela WPP | 3 | Nuwara Eliya | 6°54'4.68"N | 80°48'4.12"E |
| 7 | Powergen Lanka (Pvt) Ltd | Uppudaluwa WPP | 10 | Norochcholei PP | 7°58'49.37"N | 79°46'32.87"E |
| 8 | Daily Life Renewable Energy (Pvt) Ltd | Madurankuliya WPP | 10 | Norochcholei PP | 8°0'45.40"N | 79°43'36.69"E |
| 9 | Pavan Danavi (Pvt) Ltd | Kalpitiya WPP | 9.8 | Norochcholei PP | 8°2'55.19"N | 79°43'7.84"E |
| 10 | Nala Dhanavi (Pvt) Ltd | Erumbukkudal WPP | 4.8 | Norochcholei PP | 8°2'55.19"N | 79°43'7.84"E |
| 11 | Senok Wind Energy (Pvt) Ltd | Mampuri II WPP | 10 | Norochcholei PP | 8°0'36.37"N | 79°43'24.09"E |
| 12 | Senok Wind Resource (Pvt) Ltd | Mampuri III WPP | 10 | Norochcholei PP | 8°0'36.37"N | 79°43'24.09"E |
| 13 | Joul Power (Pvt) Ltd | Puloppalai WPP | 10 | Kilinochchi | 9°33'54.05"N | 80°20'21.87"E |
| 14 | Beta Power (Pvt) Ltd | Vallimunai WPP | 10 | Kilinochchi | | |
| 15 | Musalpetti Wind Power (Pvt) Ltd | Musalpetti WPP | 10 | Puttalam | 8°0'36.37"N | 79°43'24.09"E |
| | **Total** | | 128.5 | | | |

## Development Plan for Wind Power Plant

| | Developer Name | Wind Plant Name | Capacity | Location | | | Year of | Present Status |
|---|---|---|---|---|---|---|---|---|
| | | | (MW) | Connected GSS | Latitude | Longitude | Operation | |
| 1 | | Mannar WPP Phase 1 | 100 | | | | 2020 | Under Construction |
| 2 | | Mannar WPP Phase 2 | 100 | | | | 2023 | Procurement process yet to start |
| 3 | | Mannar WPP Phase 3 | | | | | | |
| 4 | | 240MW WPP at Pooneryn | | | | | | |
| | **Total** | | | | | | | |



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# 1st Technical Seminar

## Supply-demand Balancing Operation Considering VRE Output Forecast

15th December, 2020

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Introduction & Operation Overview


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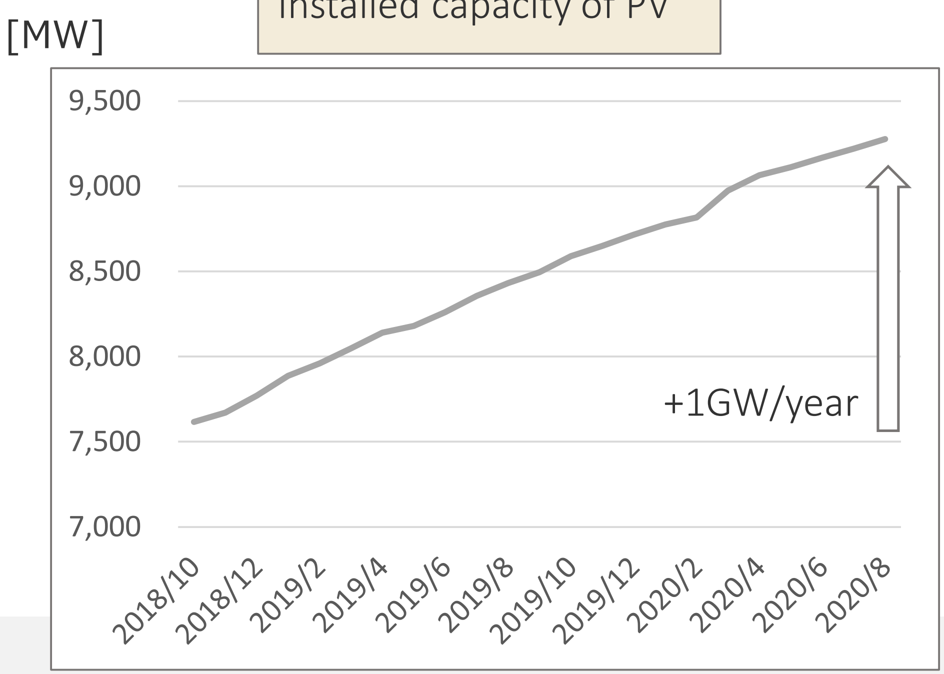
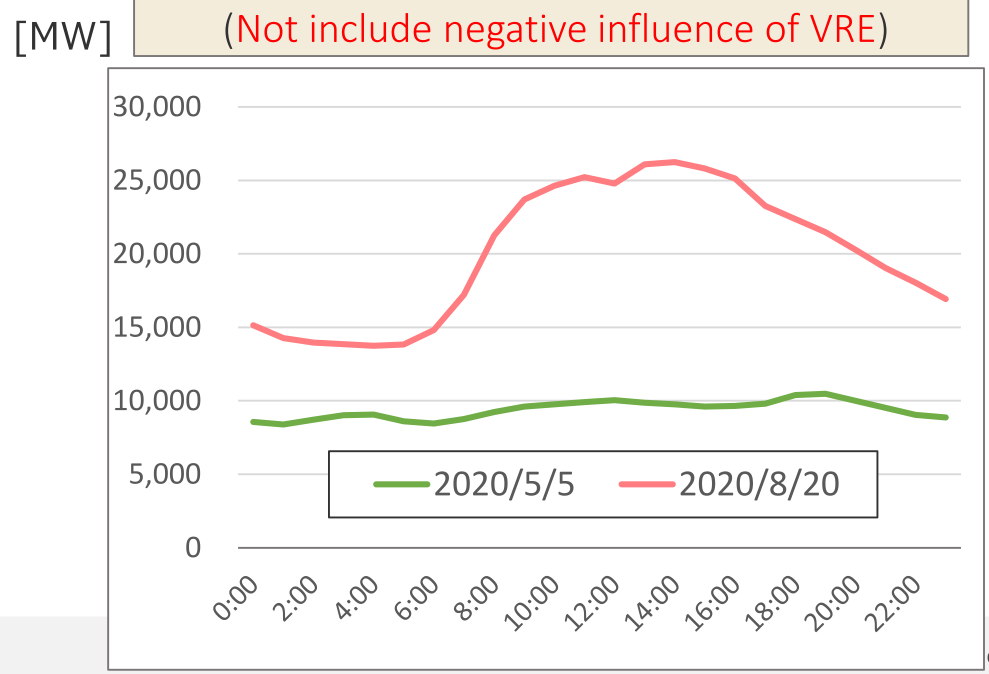
# Introduction

- Supply-demand balancing operation is being more difficult due to a large amount of PV installation in Chubu area.
- In such a situation, **VRE output forecast is being more important and flexibility of PSPP or battery, too**.
- In this material, we focus on the day ahead operation in Chubu area, because CEB is planning to receive day ahead forecast data of VRE output from JWA in this project.

Installed capacity of PV




"Real" Demand Curve in Chubu Area (Not include negative influence of VRE)



# Timeline of day ahead operation

- Central Load Dispatching Center(CLDC) of CEPCO receives updated weather forecast data per 3 hours. (▽ in the table below)
- **The highlighted contents are the key operations for supply-demand balancing.**

D-1 11:00 ▽ D-1 14:00 ▽ D-1 17:00 ▽

| | | | |
|---|---|---|---|
| • Area demand prediction | • Area demand prediction | • Area demand prediction | • Area demand prediction |
| • VRE output forecast | • VRE output forecast | • VRE output forecast | • VRE output forecast |
| | • Plan submission of non–dispachable (IPP units etc) power plant from generation entities | • Considering forecast error of VRE output | • Same as on the left<br>Content No.1 |
| | | • PSPP scheduling and reserve margin (for generation) considering reservoir level | • Same as on the left<br>Content No.2 |
| | | • Unit scheduling of thermal power plant(TPP)<br>• Instruction to TPP | • Change instruction<br>Content No.3 |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# 02 Operation for VRE output reduction


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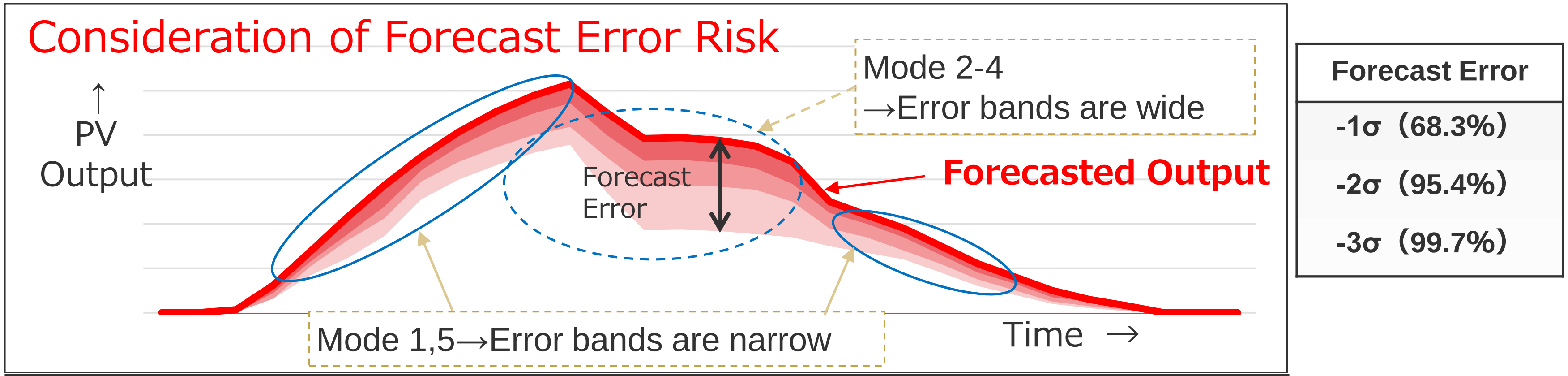
# No.1 Considering forecast error of VRE output

- Solar forecast error is considered in day ahead operation in CLDC.
- The **“modes”** are classified by the “clearness index” ” based on  weather forecast.
- In the case of Mode 1 and 5, the downside forecast error is relatively small, meanwhile greater in the case of Mode 2-4.

| **Mode** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Clearness Index** | 1～0.71 | 0.71～0.62 | 0.62～0.43 | 0.43～0.21 | 0.21～0 |
| **Weather** | Clear Sunny | Sunny | Little cloudy | Cloudy | Rainy |




| Mode | 5 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | - |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|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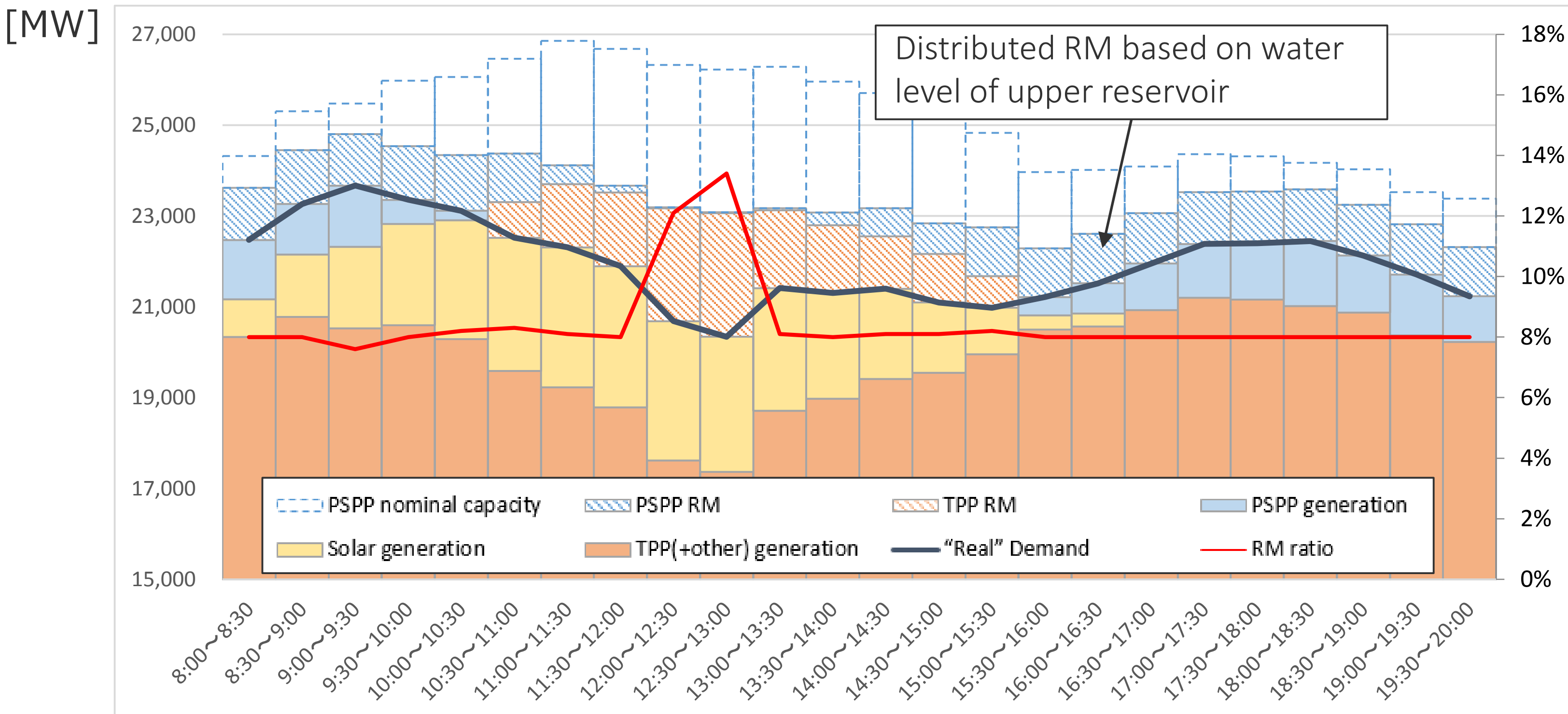
## No.2 PSPP RM distributed based on reservoir level

- There is kWh constraint of upper reservoir of PSPPs, therefore they do not keep their nominal capacity all time.
- CLDC evaluates **their RM for generation** by distributing kWh based on upper reservoir water level to equalize the ratio of "RM / predicted demand" each time.





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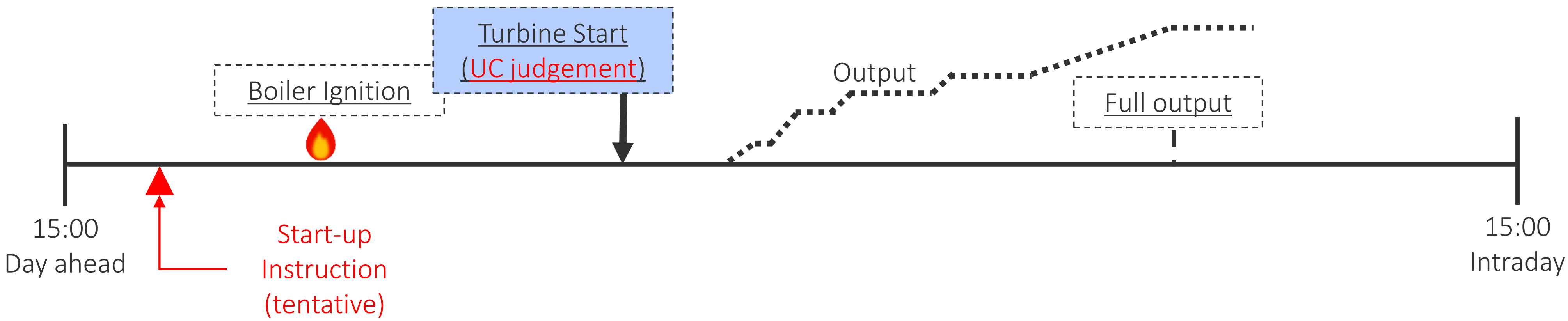
# No.3 Tentative Instruction to TPP

To deal with the forecast error, **CLDC uses "tentative start-up instruction" to TPPs that enables CLDC to extend the final judgement of unit commitment** until their turbine start.

Schedule of TPPs Start-up (Cold Start-up)



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# Case study (Considering PV forecast error)

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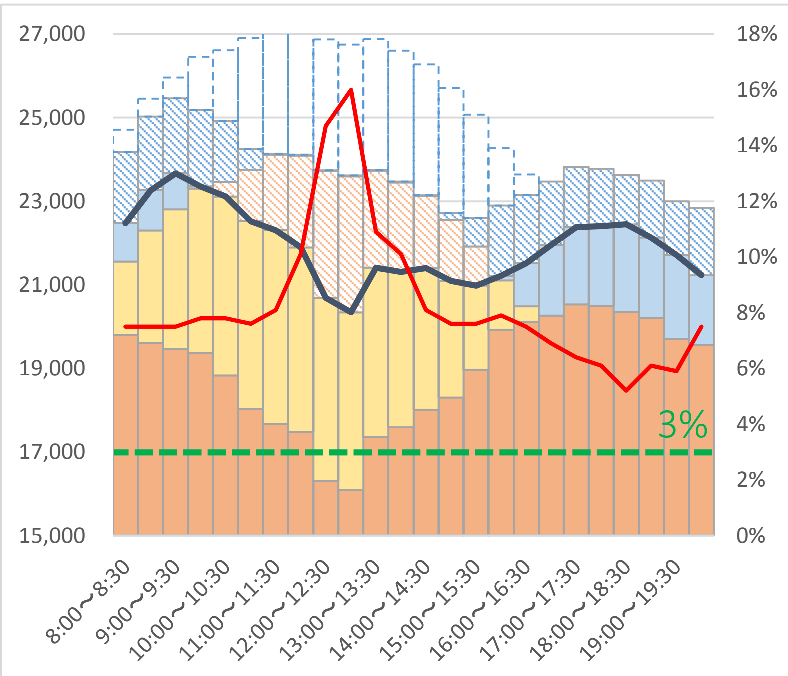
- 3% indicated with green lines is the criterion of the least RM ratio of CEPCO.
- RM goes down below 3% when the -3σ forecast error occurs.

D-1 17:00 (PV forecast: normal)
Original TPP scheduling

[MW]

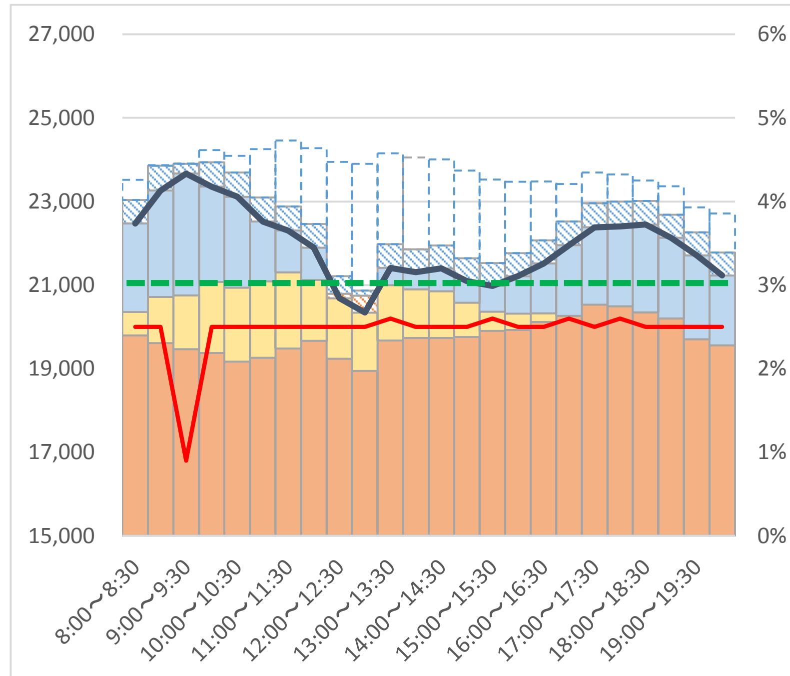



(No.1)
Considering forecast error

(No.2)
PSPP RM re-distribution

D-1 17:00 (PV forecast : -3σ)
Original TPP scheduling

[MW]




PSPP nominal capacity | PSPP RM | TPP RM | PSPP generation
Solar generation | TPP(+other) generation | "Real" Demand | RM ratio



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# Case study (Tentative start-up instruction on TPP)

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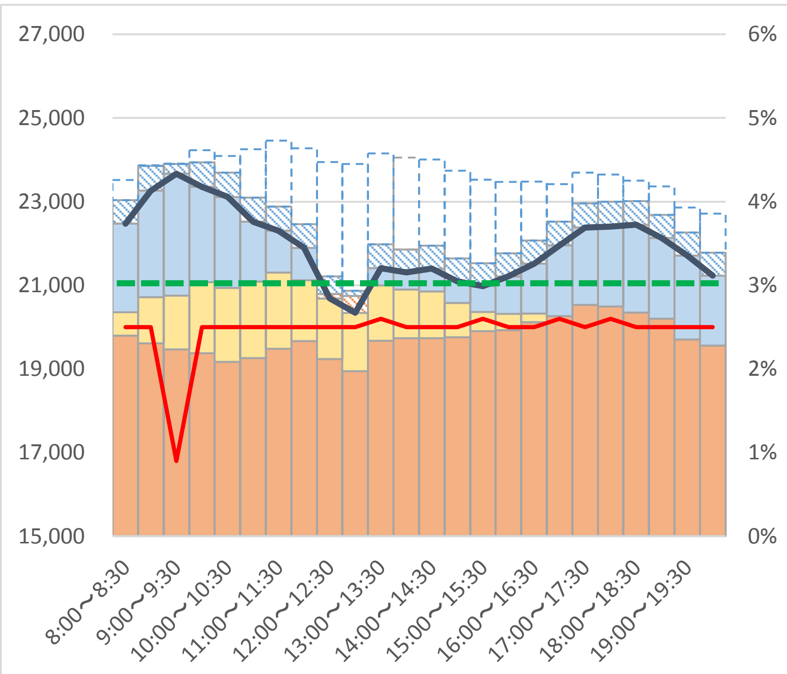
CLDC gives the tentative start-up instruction to an additional 700MW TPP and RM ratio recovers over 3%.

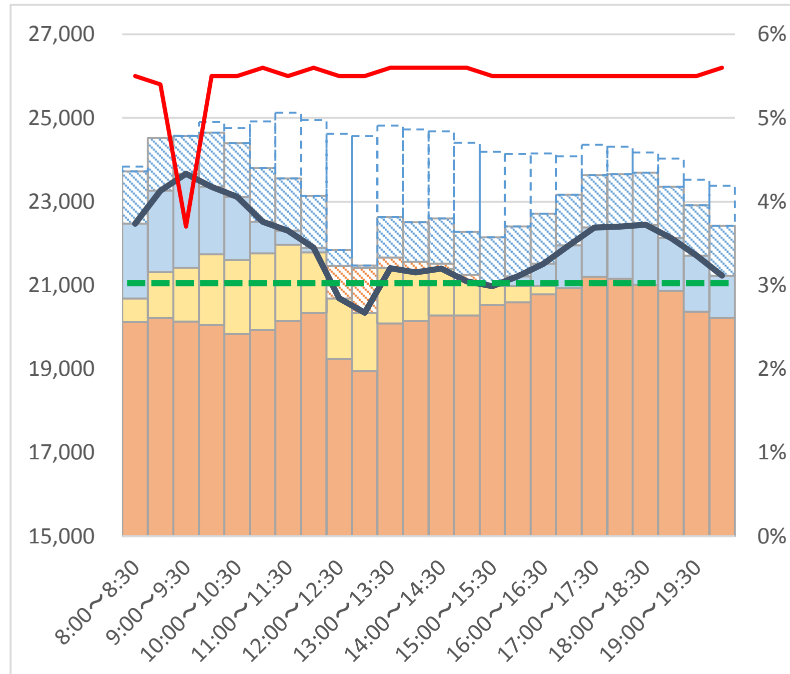
D-1 17:00 (PV forecast : -3σ)
Original TPP scheduling

[MW]

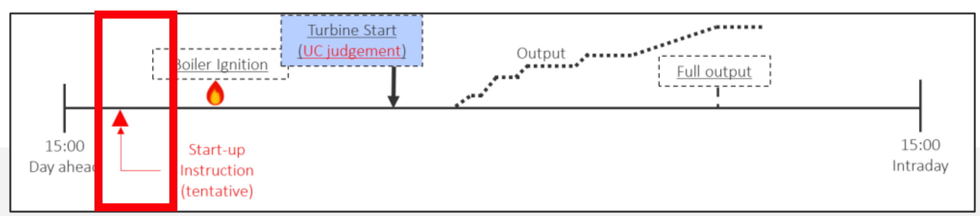



(No.3)
Tentative TPP start-up

D-1 17:00 (PV forecast : -3σ)
Additional 700MW TPP start-up (tentative)



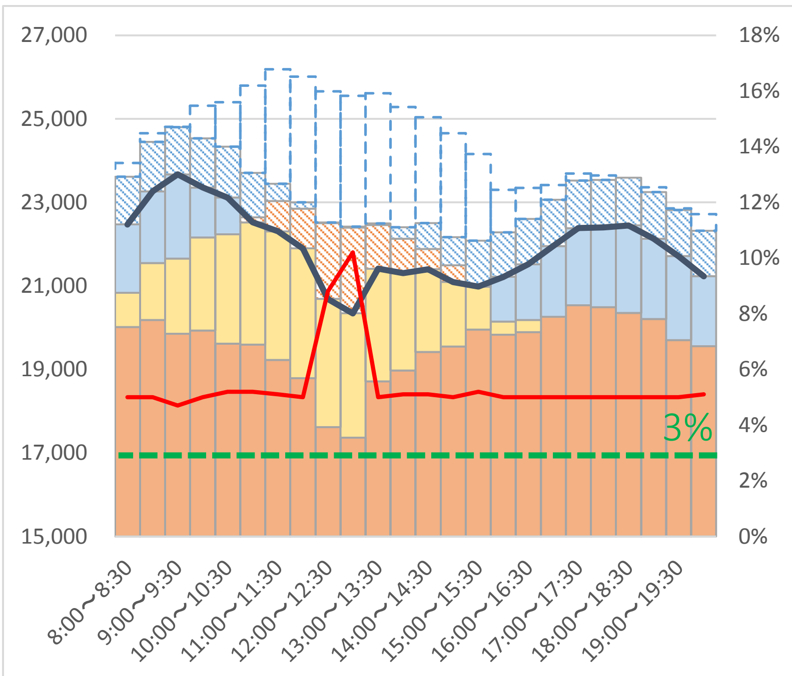

<Schedule of TPPs tentative Start-up>

# Case study (Judgment of TPP start-up)

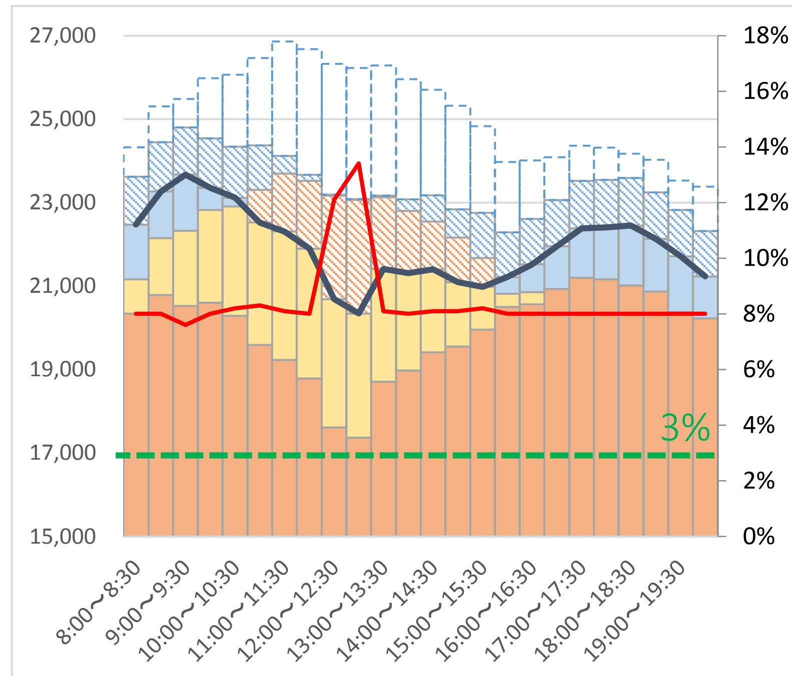
At D-1 23:00, the forecasted PV output reduction from D-1 17:00 is observed and RM becomes close to 3%, then CLDC determines an additional 700MW TPP start-up.

D-1 23:00 (PV forecast : normal)
Original TPP scheduling



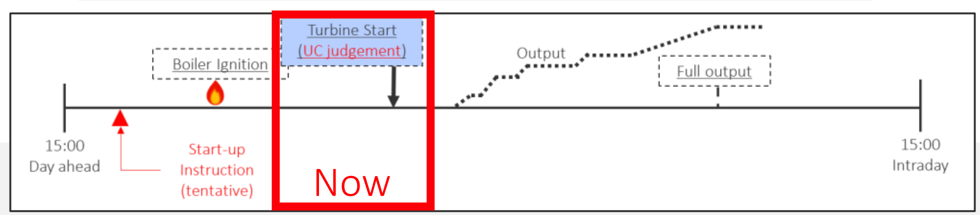

(No.3)
TPP start-up

D-1 23:00 (PV forecast : normal)
Additional 700MW TPP start-up (determined)




<Schedule of TPPs tentative Start-up>

PSPP nominal capacity
PSPP RM
TPP RM
PSPP generation
Solar generation
TPP(+other) generation
"Real" Demand
RM ratio



# 03 Operation for VRE surplus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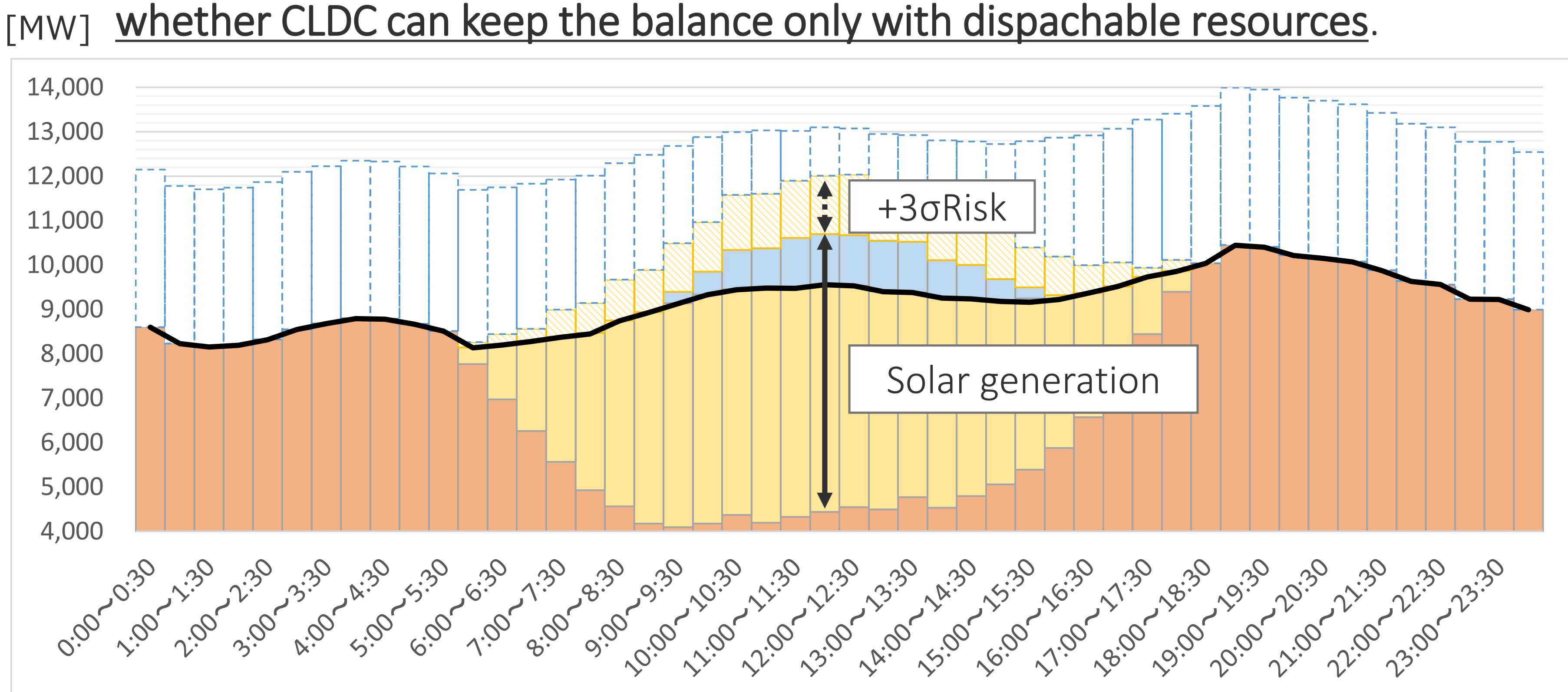
# How to consider VRE surplus in CEPCO

- CLDC pumps lower reservoir water up to keep the supply-demand balance in day time during spring and autumn.
- In the day ahead operation, <u>**CLDC considers +3σ PV forecast error to confirm whether CLDC can keep the balance only with dispachable resources**</u>.





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# Operation based on the Rule of "Priority Dispatch"

- When CLDC can't keep the balance only with dispachable resources, <u>CLDC controls non-dispachable ones etc. based on "Priority Dispatch"</u>.
- The order of control of the output is determined by the cost of power generation and technical characteristics of the generating system.

The order in which the output is suppressed

① Output control of thermal power and water pumping operations (Dispachable)

② Ditto(Non-dispachable except for biomass and VRE, day ahead instruction)

③ Export to other regions using interconnected lines(day ahead instruction)

④ Biomass output control(day ahead instruction)

⑤ Solar and wind power control(day ahead instruction)

⑥ Output control of long-term fixed power sources (hydro, nuclear, geothermal)

Source: Agency for Natural Resources and Energy



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# 04 PSPP Utilization Purposes


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# PSPP Utilization Purposes

(dashed red box) Today's content

| | Purpose | Note |
|---|---|---|
| Generation | **Reserve Margin** | kWh distribution of Reservoir |
| | **Upward Balancing Reserve** | |
| | → Load Frequency Control | Time Range < 5 min (From Stop Mode) |
| | → Governor Free Capability | • Time Range < 10 sec (During Running)<br>• Chubu Criterion = 3% × Area Demand |
| Pump up | → Keep Frequency in N-1 Contingency by Shedding PSPP | • Time Range ≒ instant (During Running)<br>• Chubu Criterion = Keeping 59.5Hz in N-1 Contingency |
| | **Downward Balancing Reserve** | |
| | VRE Curtailment Reduction | Time Range > 15 min(From Stop Mode) |
| Pump up ↓ Generation | **Economical Operation** | Marginal Cost for Pumping up Divided by 70%<br>vs<br>Substituted Marginal Cost by PSPP Generation after Pumping up |
| Other | **Voltage Control** | Operation of Voltage Control Mode |
| | **Black Start** | – |

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# Democratic Socialist Republic of Sri Lanka
# The Project for Capacity Development on the Power Sector Master Plan Implementation Program

## Improvement of Supply Reliability in Distribution System

### Introduction of Time Sequential Sectionalizer
### - From the first step to the Future -

December 15, 2020

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Contents

Improvement of Supply Reliability in Distribution System
Introduction of Time Sequential Sectionalizer - From the first step to the Future -




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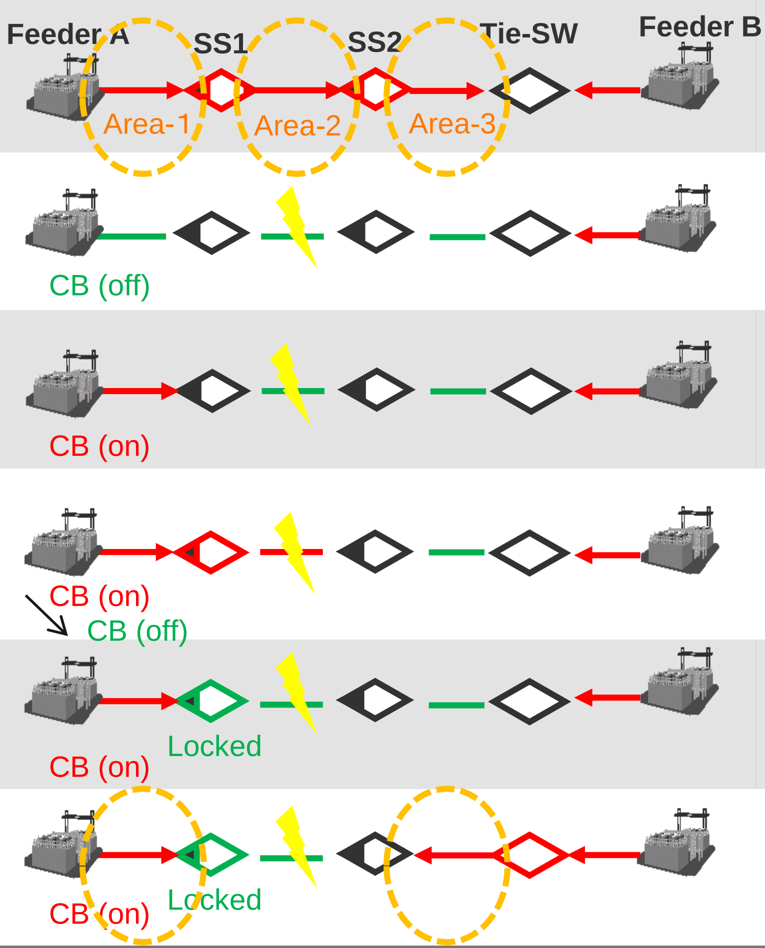
# TSS sectionalizes a fault section area automatically. (detects and isolates)

**Power Flow**




| Process | Automatic Action |
|---|---|
| (1) Normal | Suppose, Feeder-A is divided into 3 section areas by 2 section switches (SS). Feeder-A is tied to Feeder-B via Tie SW. |
| (2) Trip | If a fault occurs in Area 2, the relay at S/S detects a fault and makes the circuit breaker (CB) trip at S/S.<br>All SSs also get opened as their powers get off. |
| (3) Reclose | In 60 seconds after the fault detection,<br>the CB gets closed automatically and Area1 gets energized. |
| (4) Re-Trip | In 9 seconds after Area1 gets energized. SS1 gets closed automatically and Area2 gets energized. However, the CB trips again because Area 2 has the fault. At this time, SS1 memorizes that Area 2 is a fault area and keeps its own state off (Locked). |
| (5) Reclose again | In 60 seconds after the second fault detection, the CB gets closed automatically and Area1 is energized. But SS1 never re-close. |
| (6) Inverse | If the Feeder A side of Tie-SW is kept off in a certain time, Tie-SW closes automatically, and Area 3 gets energized.<br>Thanks to TSS, Area 1 and 3 can be supplied power automatically. |



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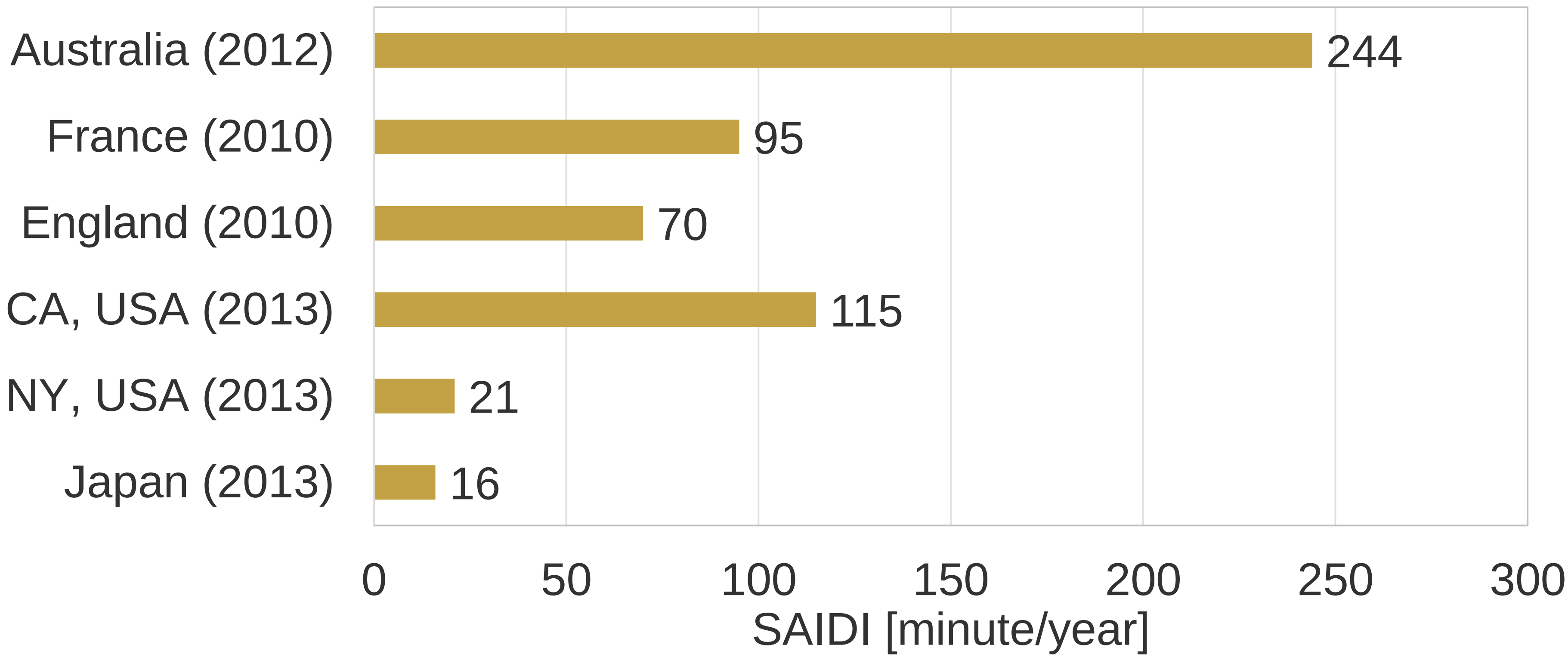
# Time-Proven in Japan and Standardized in IEC

Time Sequential Sectionalizer (TSS), having been working in all the Japanese electric power companies, has time-proven performance.

TSS was standardized as IEC 61850-90-6 in 2019.





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# Whole Configuration of Time Sequential Sectionalizer

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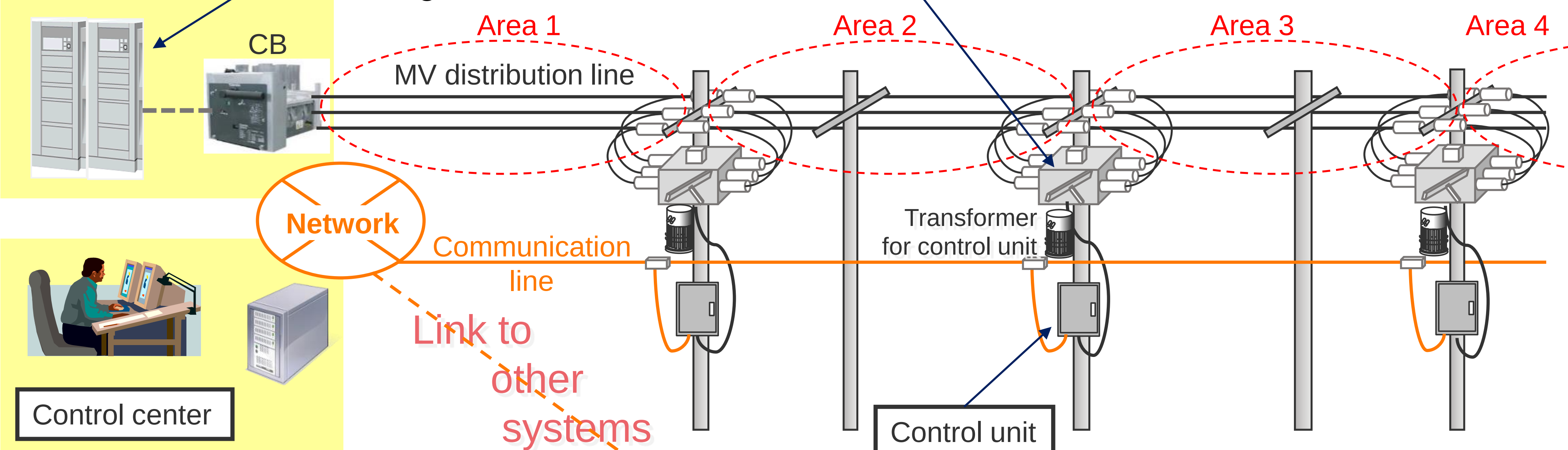
## Protection relay

- Protect distribution line against OC, DG, etc.

## Automatic section switch

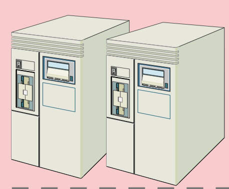
- Switch to sectionalize distribution line




**Master station for TSS**

- Detect and recover a fault outage
- Supervise and control of distribution grid and equipment
- Link to other systems

Other systems



**Slave station for TSS**

- Turn on/off S.S. by local control from slave station itself

*Through communication network*

- Turn on/off S.S. by remote control from master station through slave station



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# TSS Introduction Steps from the First to the Future

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TSS can be upgraded step by step, according to progression of other infrastructures of communication line, smart meter system, etc.

| Step | Available method | Data transfer | Remote supervisory and control | Remarks |
|---|---|---|---|---|
| 1 | Time sequential sectionalizer | No need (Work by themselves) | Will be possible by upgrading | To be verified in the pilot project |
| 2 | Remote supervisory and control | Utilization of existing N/W (Low speed) | Possible by manual operation remotely from control center | No restriction by existing infrastructure |
| 3 | Automatic supervisory and control | Need of progression （High speed and Large capacity） | Possible by automatic operation from control system Furthermore, possible to enhancement of power quality as well as supply reliability by linking to other systems | Link to other systems such as smart meter system |



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## Step 1

◎Improvement of power supply reliability

by operation of equipment itself without communication network


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# Step 1: Improvement of power supply reliability by TSS

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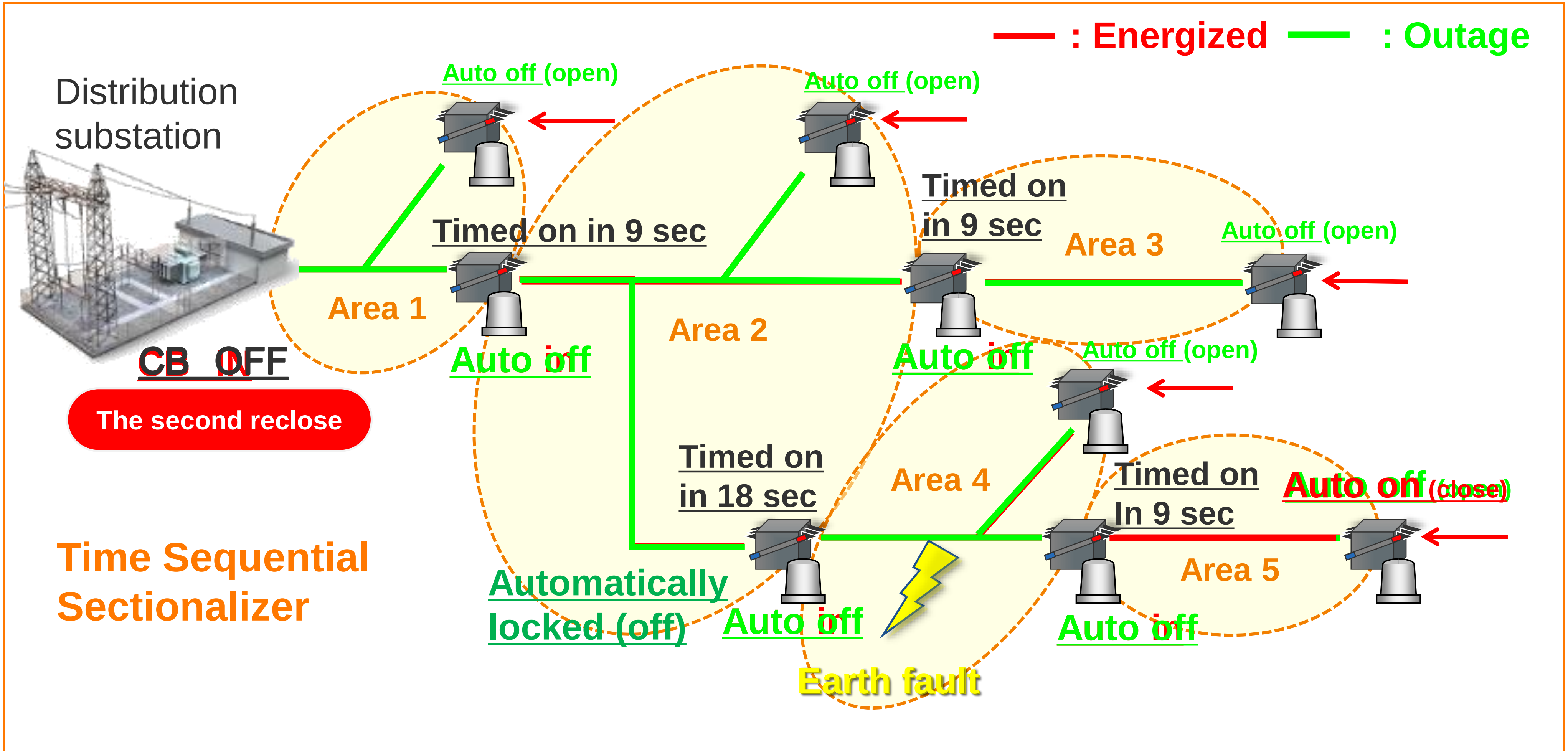


TSS can detect and isolate a fault outage section and can supply power to some other sections automatically without communication network.



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# From Step 1 to Step 2

## Step 1

◎Improvement of power supply reliability

by operation of equipment itself without communication network

## Step 2

◎Further improvement of ordinary operation

by supervisory and remote control of section switches with existing communication networks


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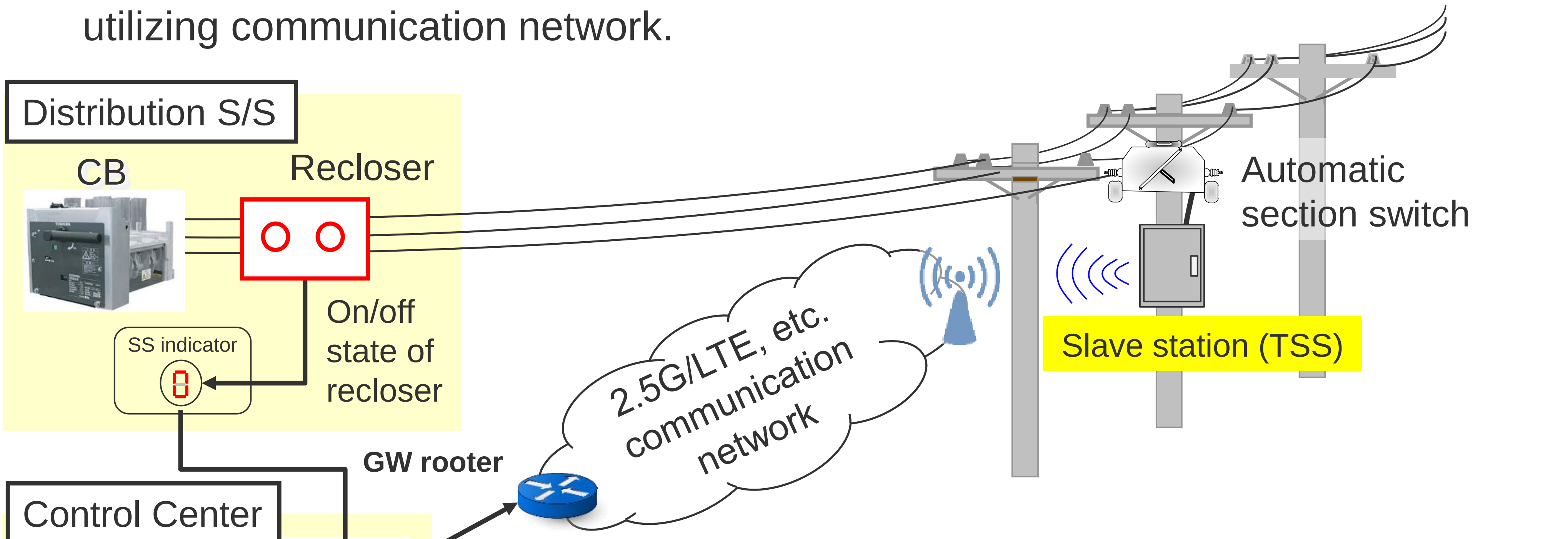
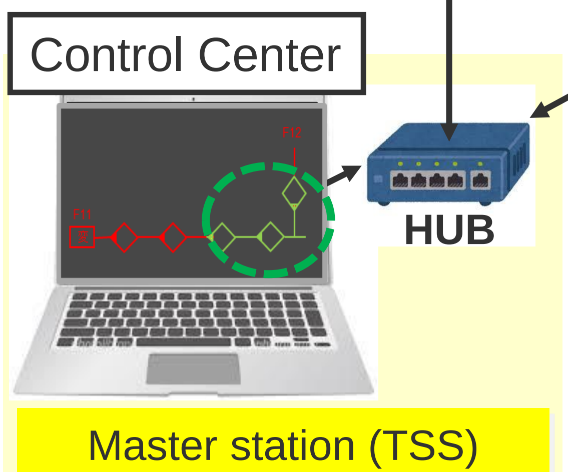
# Step 2: Further Improvement by TSS Upgrade

TSS of step1 will be used continuously and can be upgraded by utilizing communication network.




| Case | Contents | Features |
|---|---|---|
| Ordinary operation | Control section switch remotely<br>Monitor present status of distribution grid and equipment | Efficient operation such as remote grid change-over, etc. |
| Emergency | Be informed of outage section automatically | Early exact outage information, etc. |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## Step 2

◎Further Improvement of ordinary operation

by supervisory and remote control of section switches with existing communication network

## Step 3

◎Sophistication of **power supply reliability**

◎Sophistication of **power quality** in preparation for VRE

by linkage to other systems
with conditions of high-speed and large-capacity data transfer infrastructure


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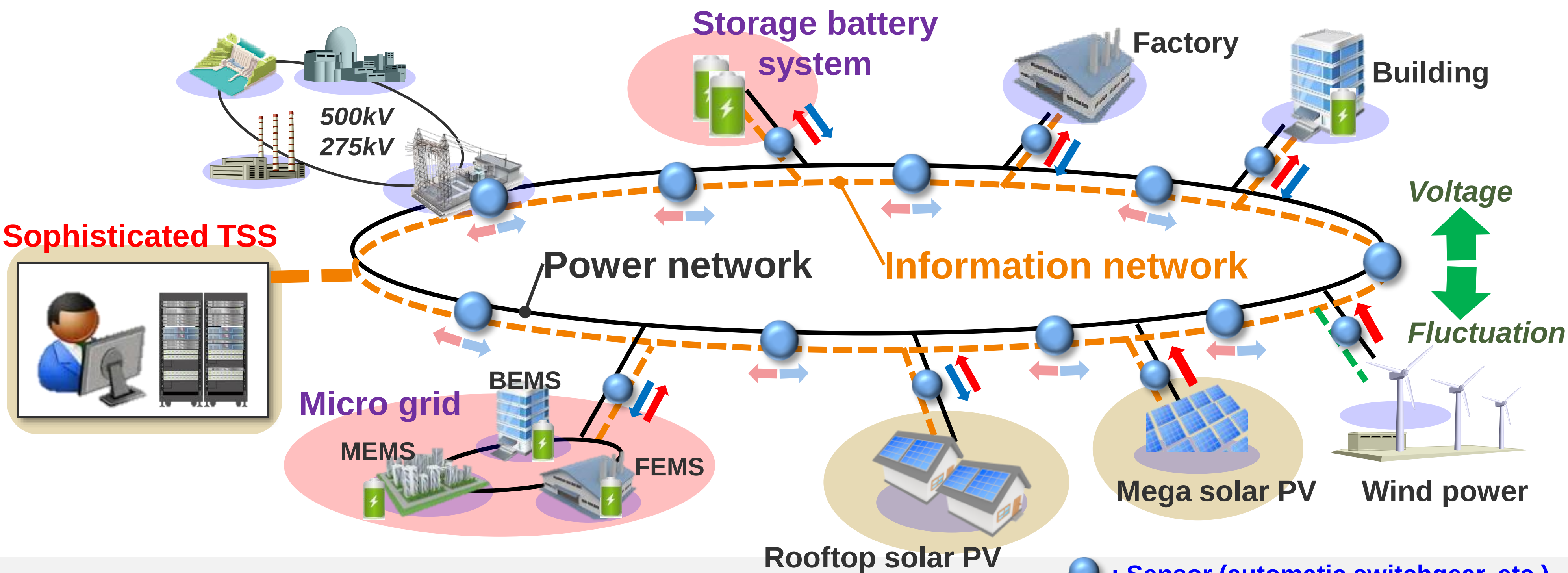
# Step3: Power Quality Problems by Mass VRE Interconnection

Voltage fluctuations and rises are getting more pronounced by mass introduction of VRE.

Electricity usage is getting more diversified by attracting microgrids, demand response, etc.

There is concern that **voltage management** in distribution systems will be getting more and more complicated in the future.

Therefore, to ensure and keep power quality as well as power supply reliability will be strongly requested in the future.



# Step 3: Future Image of Sophisticated TSS

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**Voltage supervisory and regulation**

Supervise grid and equipment conditions by monitored data, and control voltage automatically by voltage regulation facility

➥ **Possible to regulate proper voltage**

**Current estimation**

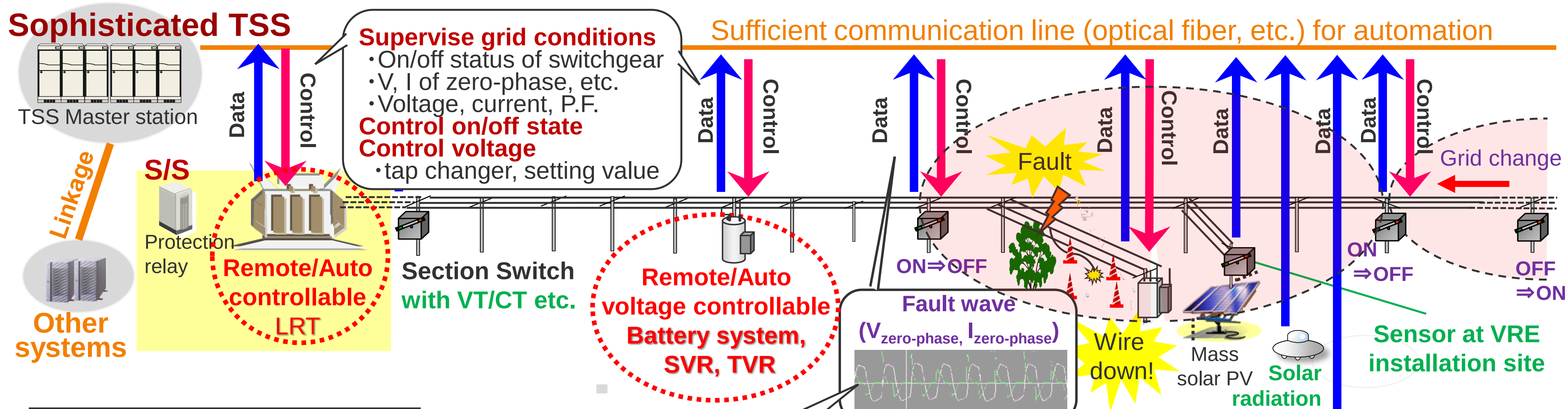
Estimate actual load current and switchover grids, based on measured data such as solar radiation, VRE output, smart meter information.

➥ **Possible to judge best grid formation**

**System sophistication**

-System upgrade preparing for disaster, etc.
-Security enhancement

➥ **Risk aversion in case of disaster, cyberattack, etc.**

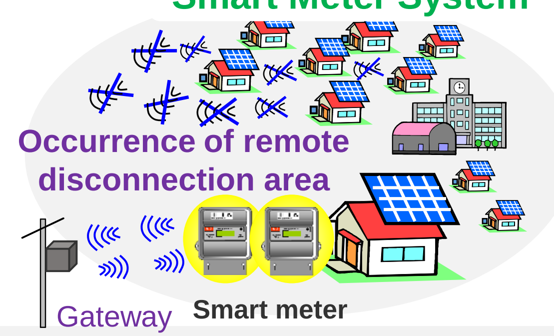



**Fault dealing and recovery**

| | | |
|---|---|---|
| Detect fault by protection relay ⇨ | • Estimate fault point and cause<br>• Control section switches automatically ⇨ | Removal of fault cause and recovery even without identification of fault point and causeon-site |
| Even in case of wire breaking which might not be detected by protection relay at substation, estimate the outage area by utilizing data measured by S.S. sensor and/or information of smart meter network conditions. ⇨ | | |

⇨ Keep high supply reliability by early recovery of any faults

**Smart Meter System**



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# The Project for Capacity Development on the Power Sector Master Plan Implementation Program

## 2nd Technical Seminar

December 22th, 2021

Japan Weather Association

# Contents





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# Constructing VRE forecast model

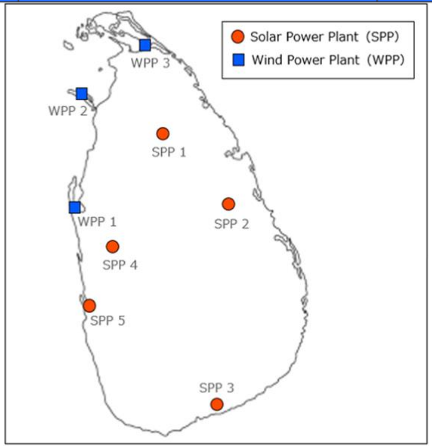
- System of VRE forecast model started operation in July, 2021.
- Construct VRE forecast model using the facility information provided by CEB.

| Category | Contents |
| --- | --- |
| Data distribution periods | From July 1, 2021 to March 31, 2023 |
| Forecast range | Up to maximum 78 hours ahead from initial time |
| Frequency | Twice a day<br>(6 AM and 4 PM in Sri Lanka Standard Time) |
| Timestep | Every 15 min (※Interpolated value) |
| Data variables | PV ①Total amount of solar irradiation(W/㎡)<br>②PV power output(kW)<br>WF ③wind speed(m/s) and direction<br>④WF power output (kW) |
| Forecasting point | 8 points set by Latitude/longitude |
| File format | XML(two files, weather and VRE output) |
| Data access | HTTP-GET |

Specifications of VRE forecast model

Site information and capacity

| No. | Information/Site | Total capacity (kW) |
| --- | --- | --- |
| SPP1(Utility) | Vydexa solar power | 10,000 |
| SPP2(Utility) | Solar One Ceylon power | 12,500 |
| SPP3(Utility) | SAGA solar power | 10,000 |
| SPP4(Roof-top) | Kuliyapitiya | 179 |
| SPP5(Roof-top) | Rooftop PV Colombo | 90,855 |
| WPP1 | Vallimunai 10MW Wind Power plant | 10,000 |
| WPP2 | Thambapavani Wind Power plant | 103,500 |
| WPP3 | Mampuri Wind Power Plant– Stage I | 10,000 |




Forecast target points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# Accuracy of the forecasted points

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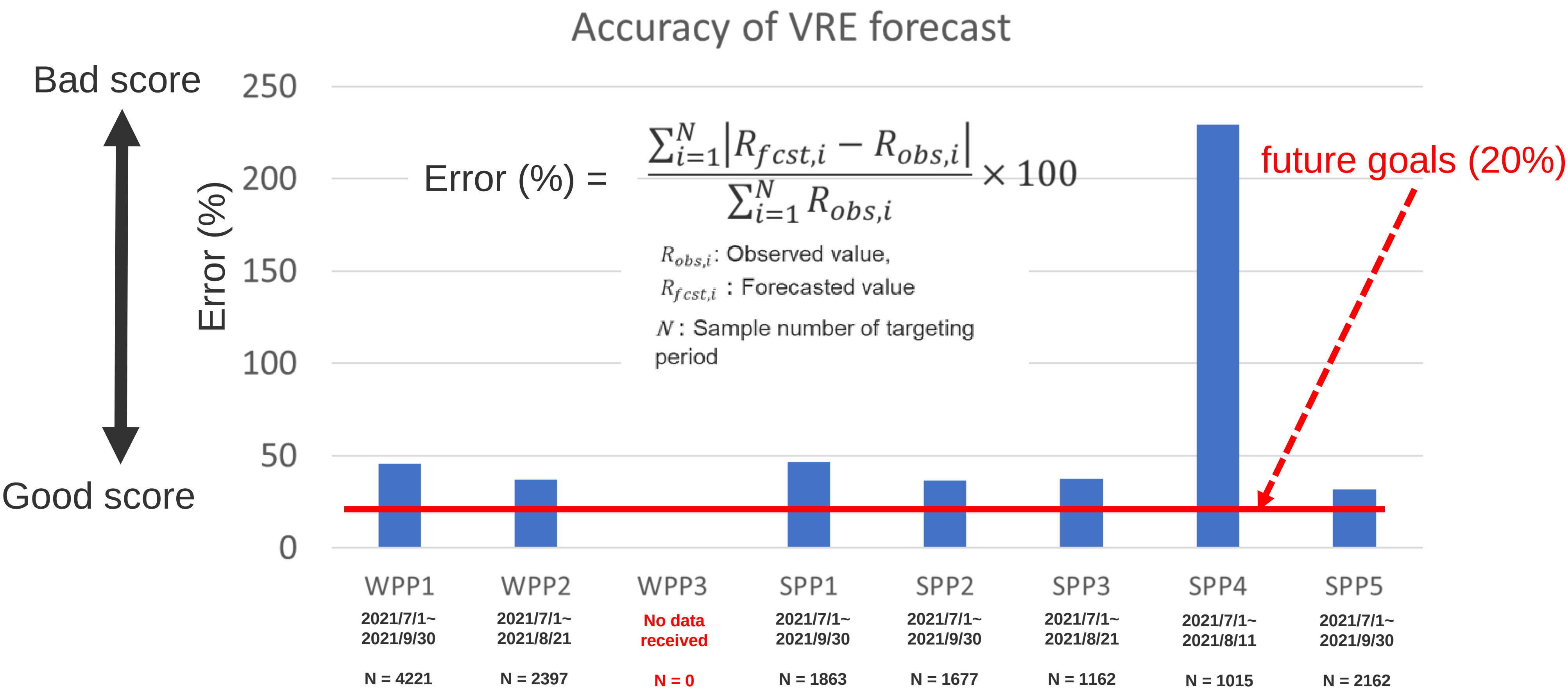
We confirmed the current VRE forecast accuracy based on the observed data we received.





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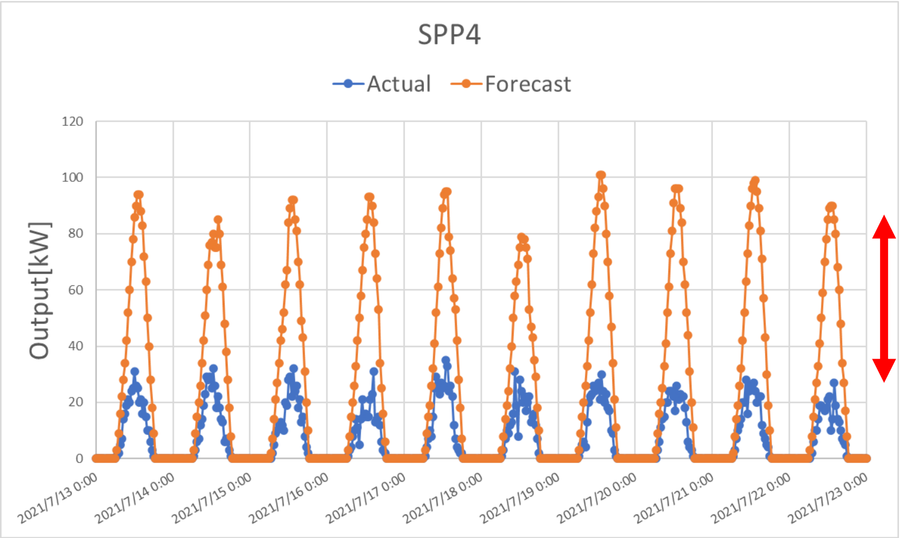
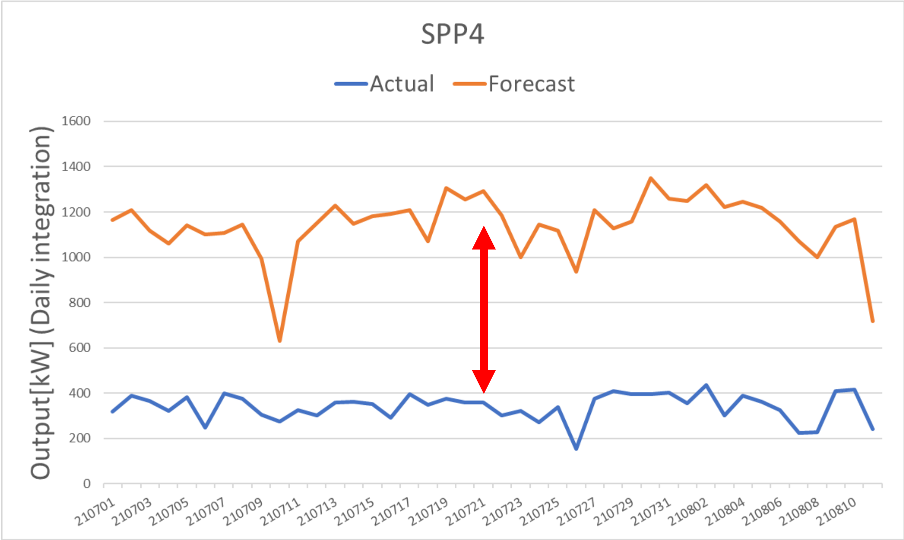
# Accuracy of the forecasted points (SPP4)

About SPP4,

Error is large compared to other points of SPP.
Forecasted VRE output data tend to be overestimated.
It is necessary to review the rated output of VRE forecast model.




Daily fluctuations




Daily integration,
Time series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# Accuracy of the forecasted points (SPP)

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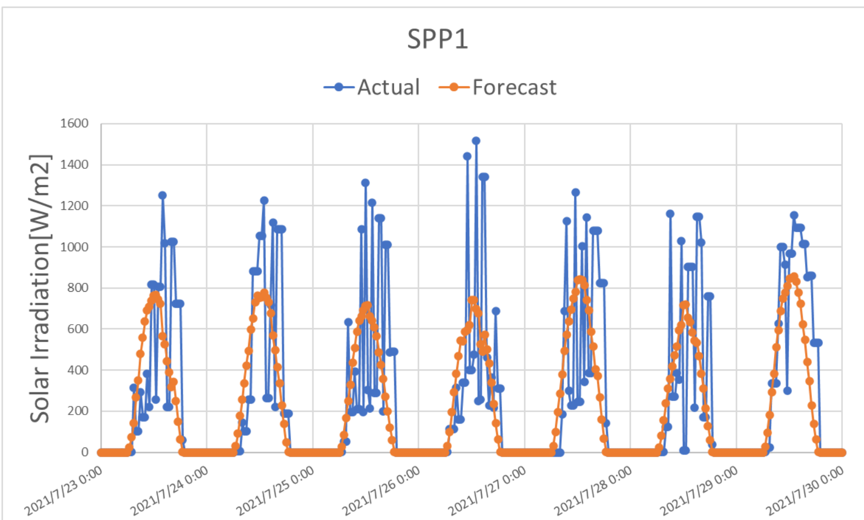
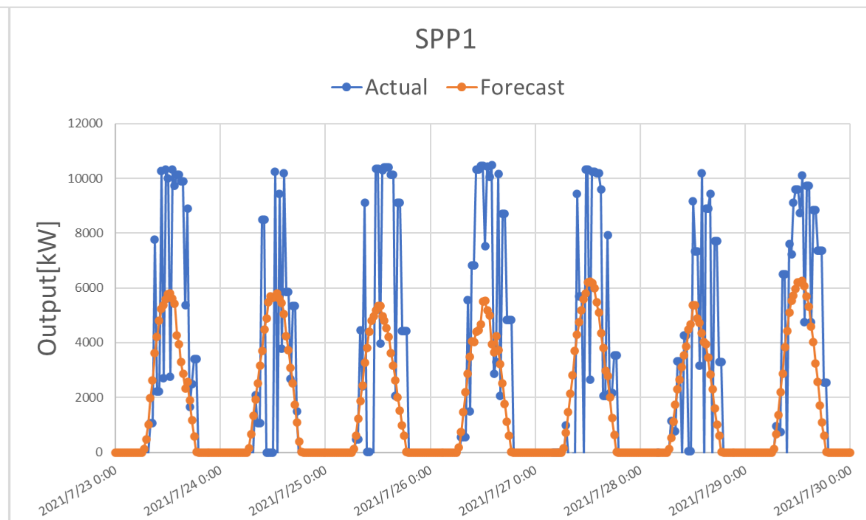
## For SPP1 (Time series comparison)

① Forecasted Solar Irradiation and VRE output data tend to be underestimated.
② The Daily fluctuation of forecasted both data tend to be smaller than Actual data.





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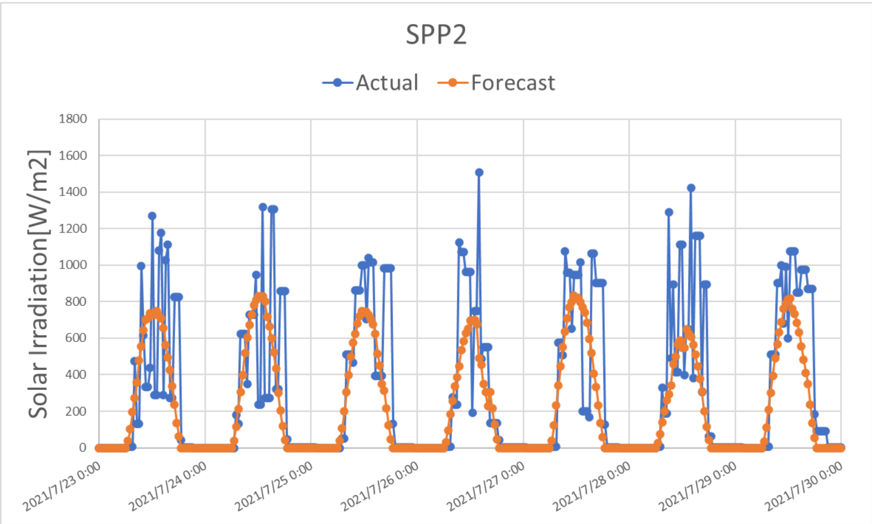
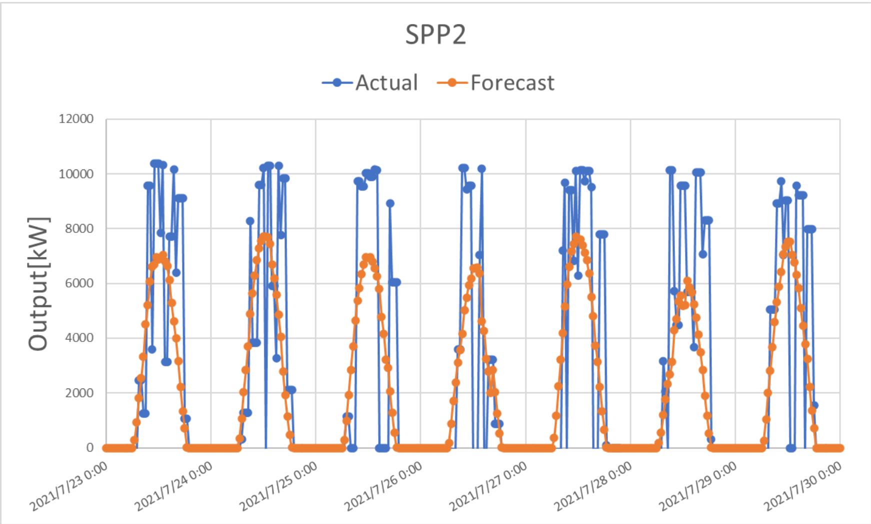
Accuracy of the forecasted points (SPP)

## For SPP2 (Time series comparison)

① Forecasted Solar Irradiation and VRE output data tend to be underestimated.
② The Daily fluctuation of forecasted both data tend to be smaller than Actual data.





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# Accuracy of the forecasted points (WPP)

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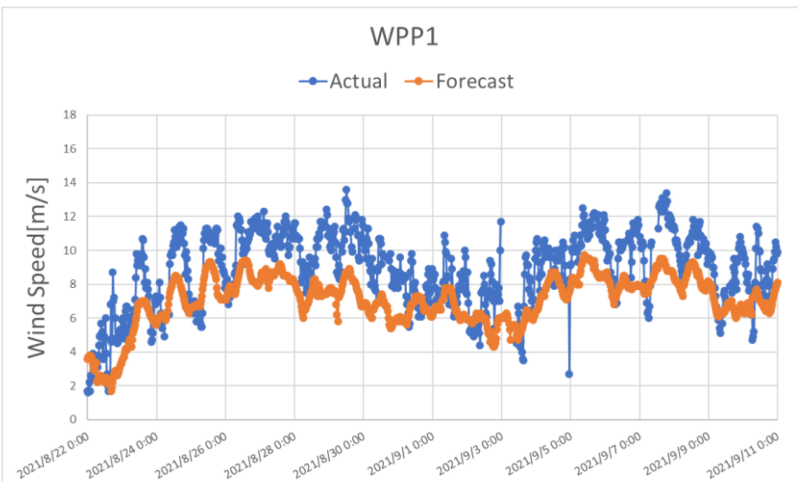
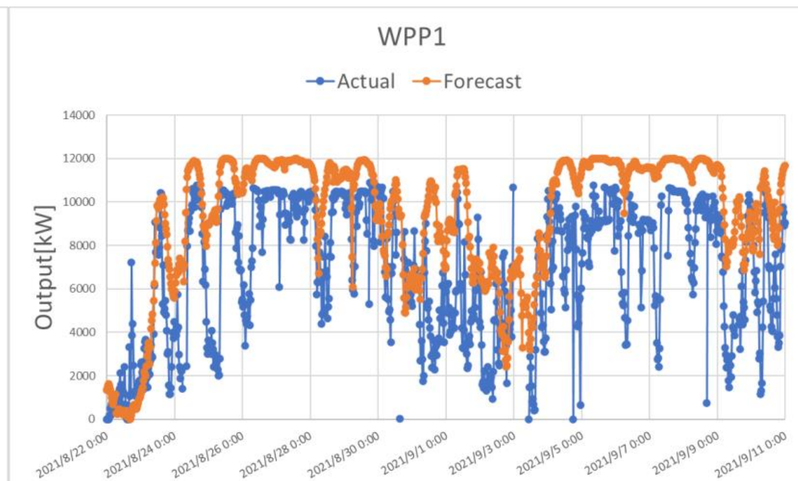
## For WPP1 (Time series comparison)

① Forecasted <u>Wind Speed</u> data tend to be <u>underestimated</u>.
② Forecasted <u>VRE output</u> data tend to be <u>overestimated</u>.





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# Accuracy of the forecasted points (WPP)

## For WPP2 (Time series comparison)

① Forecasted Wind Speed data tend to be generally correct.
② Forecasted VRE output data tend to be overestimated.



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# Accuracy of the forecasted points (WPP)

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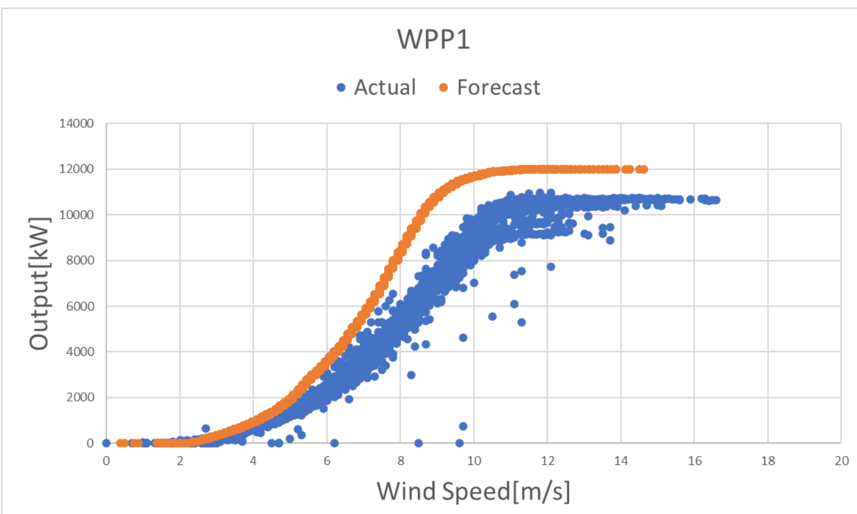
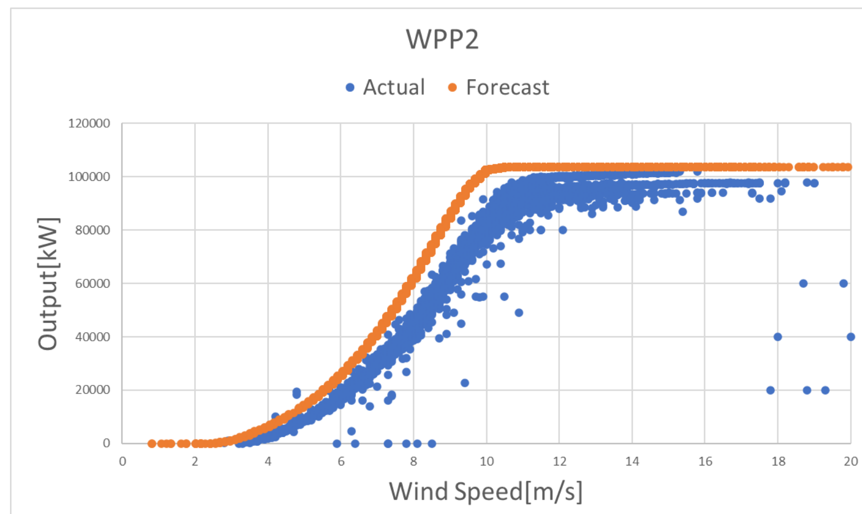
## For WPP1 and WPP2 (Power Curve comparison)

① About WPP1 and WPP2,

VRE forecast model was constructed based on similar power curve, because the power curve information was not available.
Create a power curve based on the measured values (Wind Speed and Output) and apply it to the VRE forecast model.



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# Future plan of the project

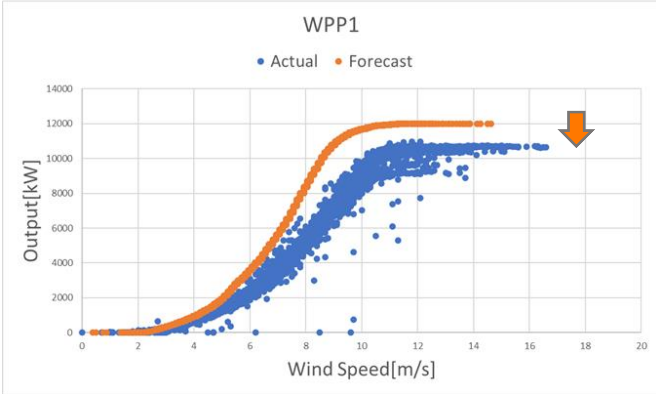
## Efforts to improve the accuracy of VRE forecast model

### For WPP & SPP

- To calculate Error rate(%) correctly, exclude outliers in the data.
- **Create correction coefficient to reduce Error from the relationship between the Actual data and the Forecast data.**

### For WPP

- Confirm the number of actual working wind turbines.
- Apply the power curve created by actual data to VRE forecast model.




Applied image.

### For SPP

- Confirm each facility information. Especially rated output about SPP4.
- Investigate the cause of underestimation and difference of daily fluctuation.
- Check the quality of observation (Actual) data (Solar Irradiation and VRE output ).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# Future plan of the project

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## Continued data accumulation and examination of correction methods

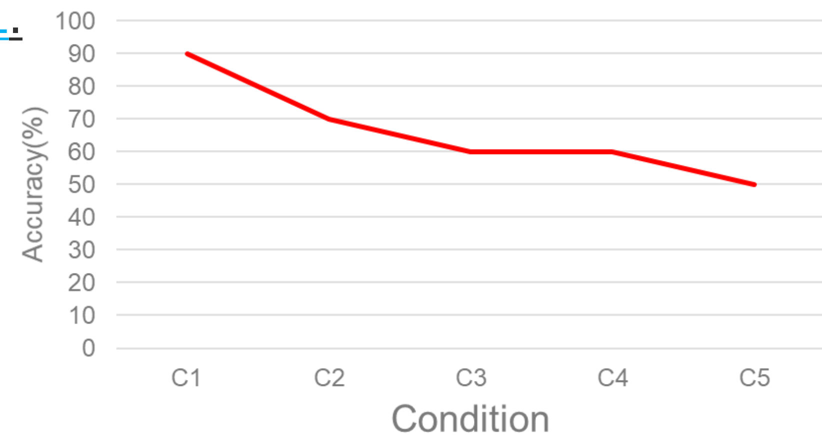
| Condition | Weather data（CEB,IPP) | Weather data（DOM) | Output data of VRE | Facility information |
|---|---|---|---|---|
| C1 | 〇 | × | 〇 | ◎ |
| C2 | × | 〇 | 〇 | ◎ |
| C3 | × | × | 〇 | ◎ |
| C4 | × | ◎ | × | ◎ |
| C5 | × | × | × | ◎ |

◎：Mandatory,〇：Available,×：Not available

① Some of the Forecasted points are in condition C1.
Analyze the data further and examine correction methods to improve VRE forecast model.

② Continue to collect data about forecasted point with low data in condition C2 or C5.

VRE Forecast Accuracy




Above chart is presented for illustrative purposes only.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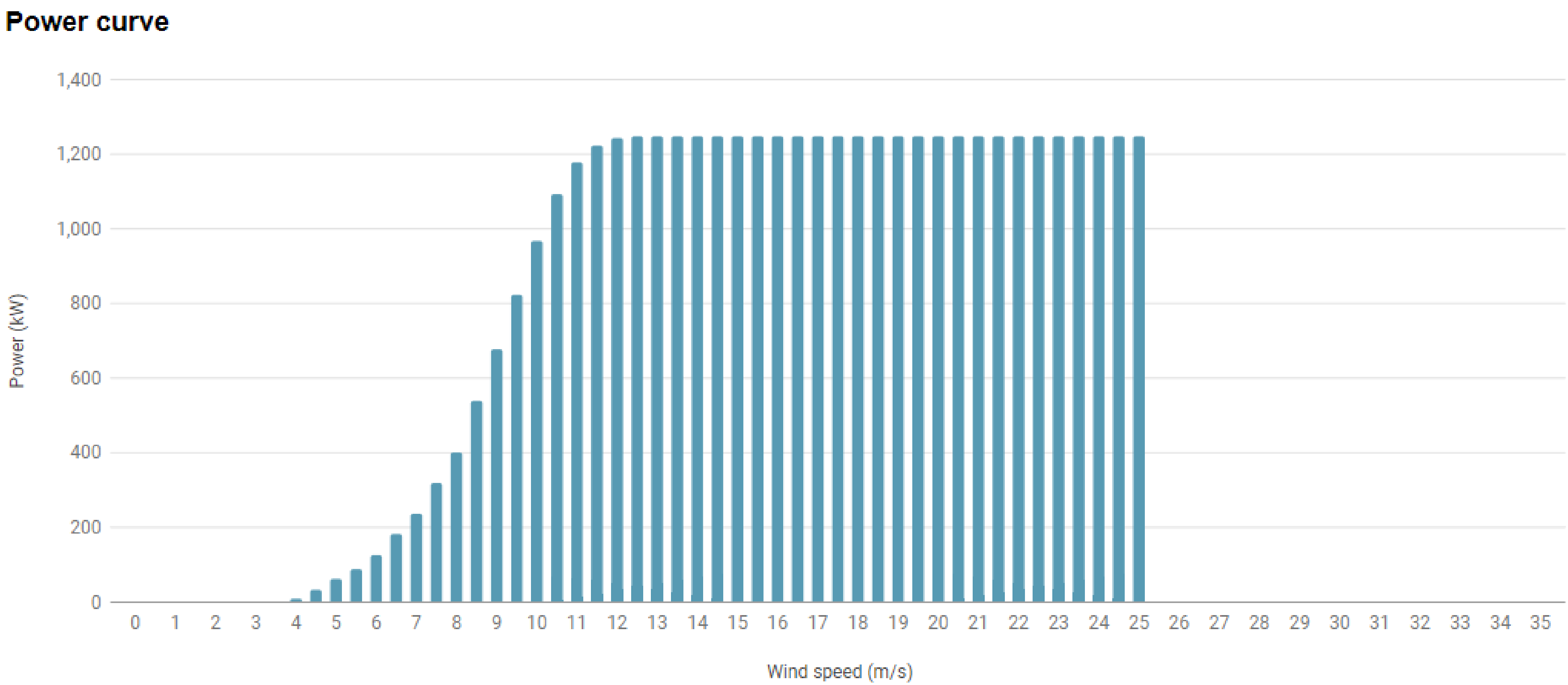
# Appendix

## Example of official Power curve(WPP3)





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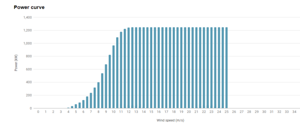
# Appendix:
# Facility Information of VRE forecasted (WPP)

| | WPP1 | WPP2 | WPP3 |
|---|---|---|---|
| Facility No. | Facility 3 | Facility 2 | Facility 1 |
| Information | Northern Wind power plant | Mannar Wind power plant | Wind plant from cluster in Puttalam |
| Site | Vallimunai 10MW Wind Power plant | Thambapavani Wind Power plant (CEB) | Mampuri Wind Power Plant– Stage I |
| Area | Jaffna | Mannar Island | Puttalam |
| Premises | Beta Power (Pvt) Ltd | Thambapavani Wind Power plant | Mampuri Wind Power Plant |
| Location (Lat/lon) | 9.556760792037888, 80.35954521288103 | 9.050124, 79.792038 | 8°0'36.37"N, 79°43'24.09"E |
| Period of Installation | December 2014 | End 2020- Being Commissioned | 2010 |
| Number of wind turbines | 8 | 30 | 8 |
| Wind turbine rated capacity per unit | 1,500 kW (ReGen VENSYS 82V82) | 3,450kW | 1,250kW |
| Total amount of wind turbine capacity | 10 MW or 40MW? | 100 MW | 10 MW |
| Wind turbine hub height | 85m | 80 m | 60m |
| Power curve (includes cut-in, rated, cut-out wind speed) | Cut-in wind speed: 2.5 m/s<br>Rated wind speed: 13 m/s<br>Cut-off wind speed: 22.5 m/s<br>http://www.regenpowertech.com/104/wind-turbine | Rated power: 3,450 kW<br>Cut-in wind speed: 3 m/s<br>Cut-out wind speed: 22.5 m/s<br>Re cut-in wind speed: 20 m/s<br>Wind class IEC IIIA/IEC IIB<br>https://www.vestas.com/en/products/4-mw-platform/v136-_3_45_mw#!technical-specifications | <br>Power Curve Data-<br>https://www.thewindpower.net/turbine_en_220_suzlon_s64-1250.php |
| Past Data availability (If possible) | | | |

Important items for Building VRE forecast model

Request more information



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# The Project for Capacity Development on the Power Sector Master Plan Implementation Program

## 2nd Technical Seminar

Evaluation on Geological Investigation Result at Victoria PSPP site

December 22nd, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Basic Sequence of Overall Schedule

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**Step 1 (2021)**
**C/B by JICA Expert**

**Geo Inv. on Victoria PSPP**

Current Stage

**Step 2 (2022-2023)**
**F/S with ADB Fund**

**Step 2-1**
**Prioritization**

**Step 2-2**
**Full-swing F/S**


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# Victoria Lake PSPP: Longitudinal Profile of Waterway

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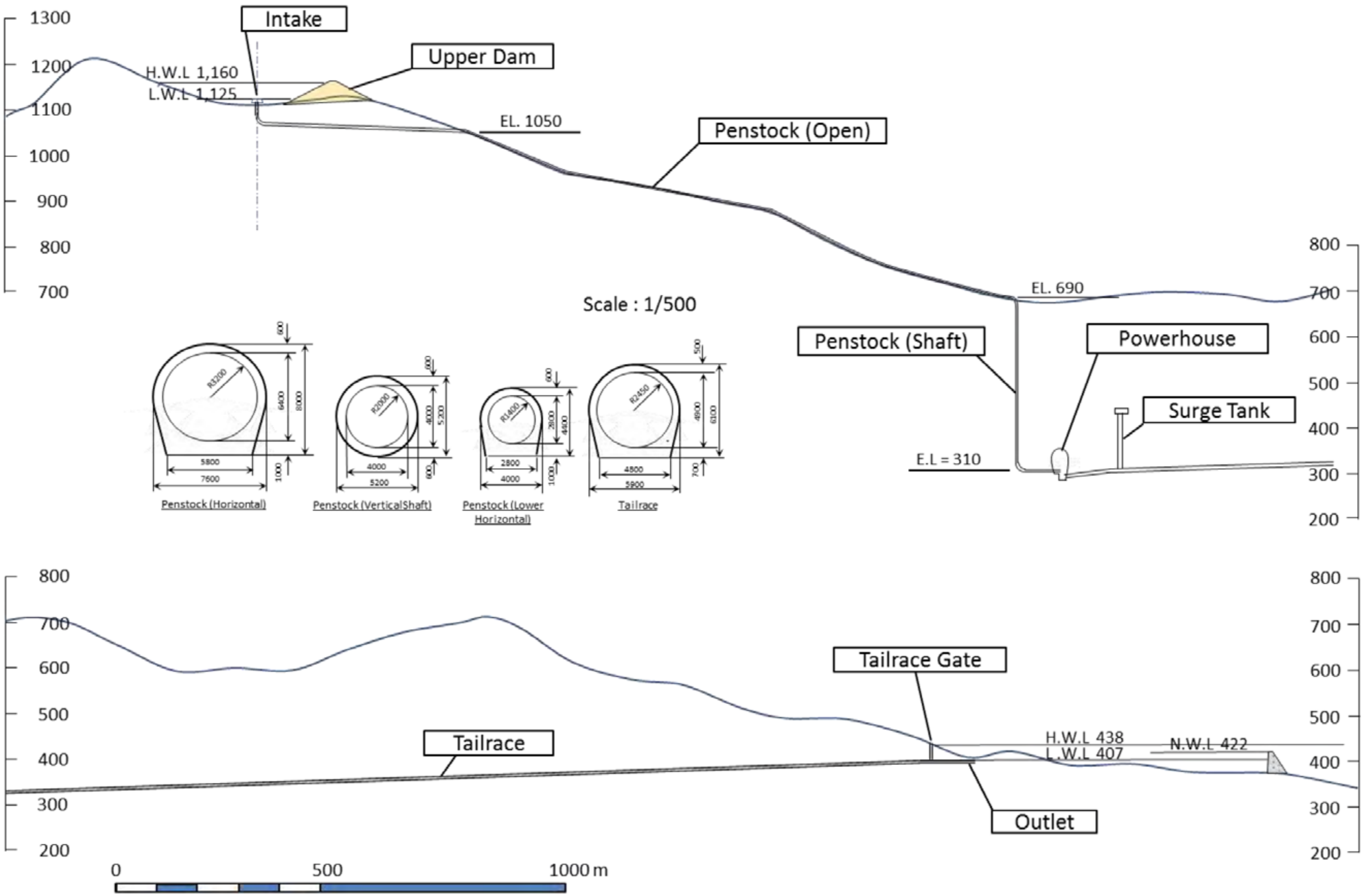


*Source: Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, 2018, JICA*



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# Geological Investigation: Plan of Mapping

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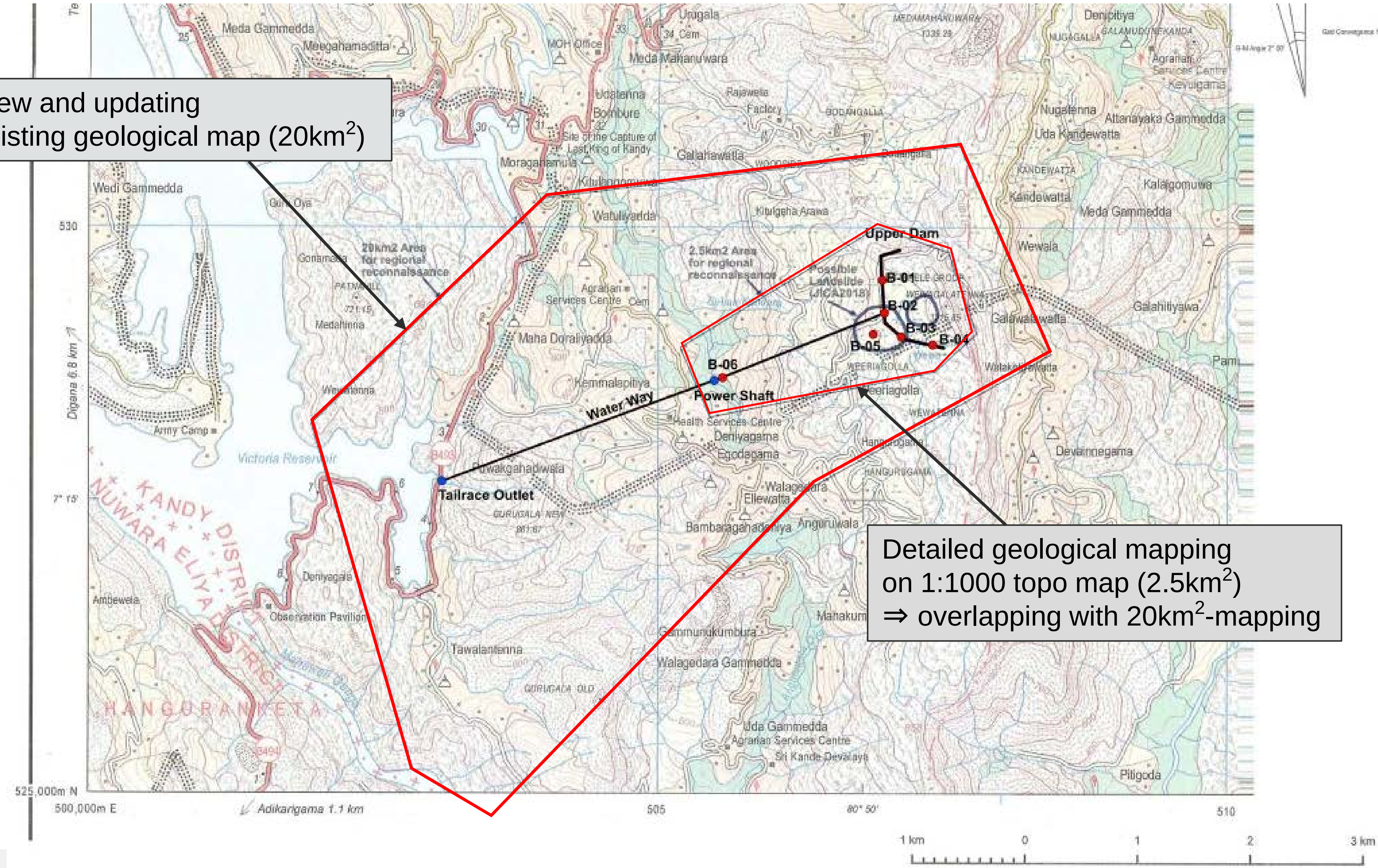
Review and updating
of existing geological map (20km$^2$)




Detailed geological mapping
on 1:1000 topo map (2.5km$^2$)
⇒ overlapping with 20km$^2$-mapping

# Geological Mapping

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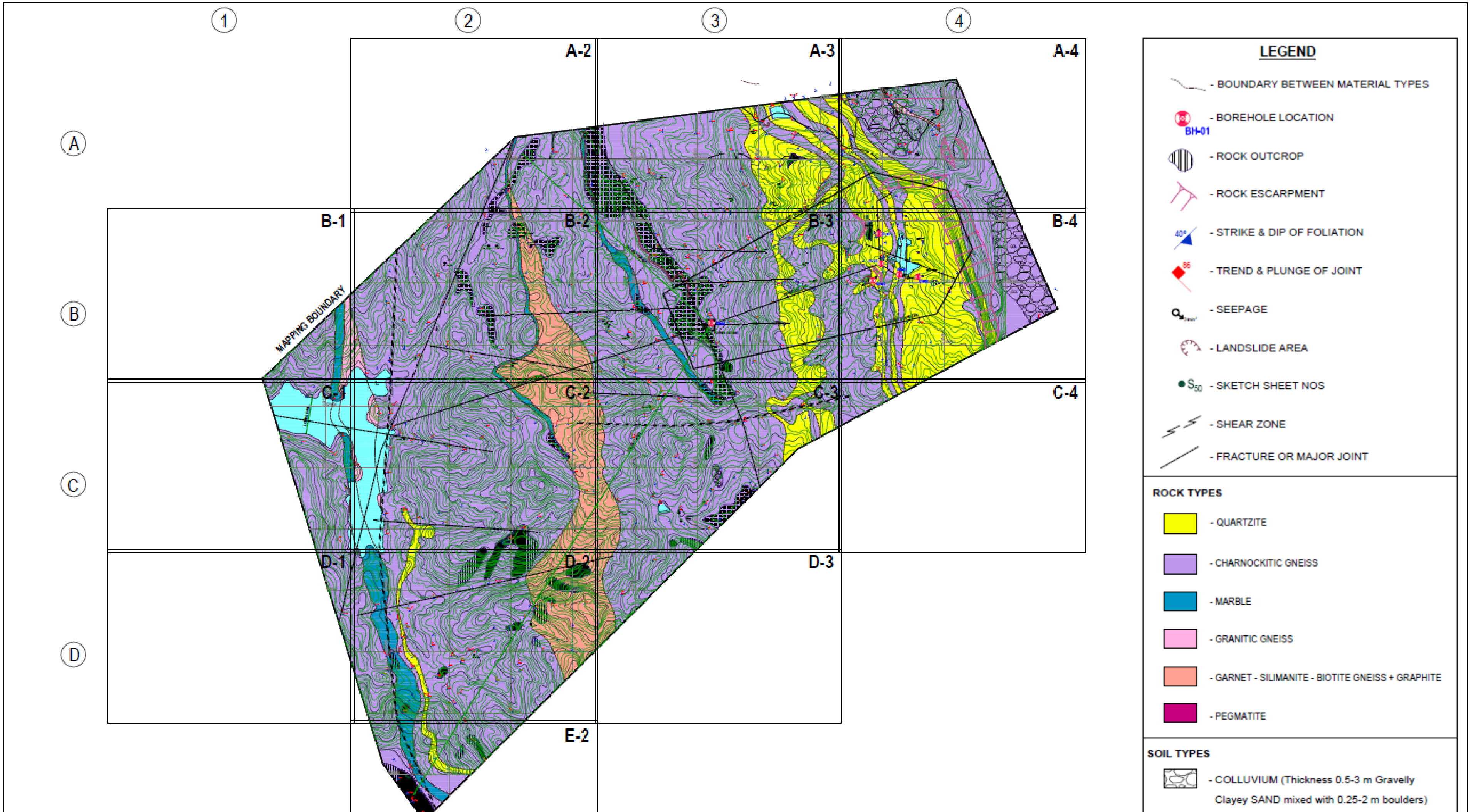


Note: Geology between lower part of the penstock and outlet of the waterway including underground powerhouse site is not only Charnokitic gneiss but possibly composed of various type of gneisses due to its mineral compositions. The Charnockitic gneiss associated with powerhouse shows more acidic features. Geology and rock condition especially for underground powerhouse site need to be confirmed by core drilling survey in next stage.



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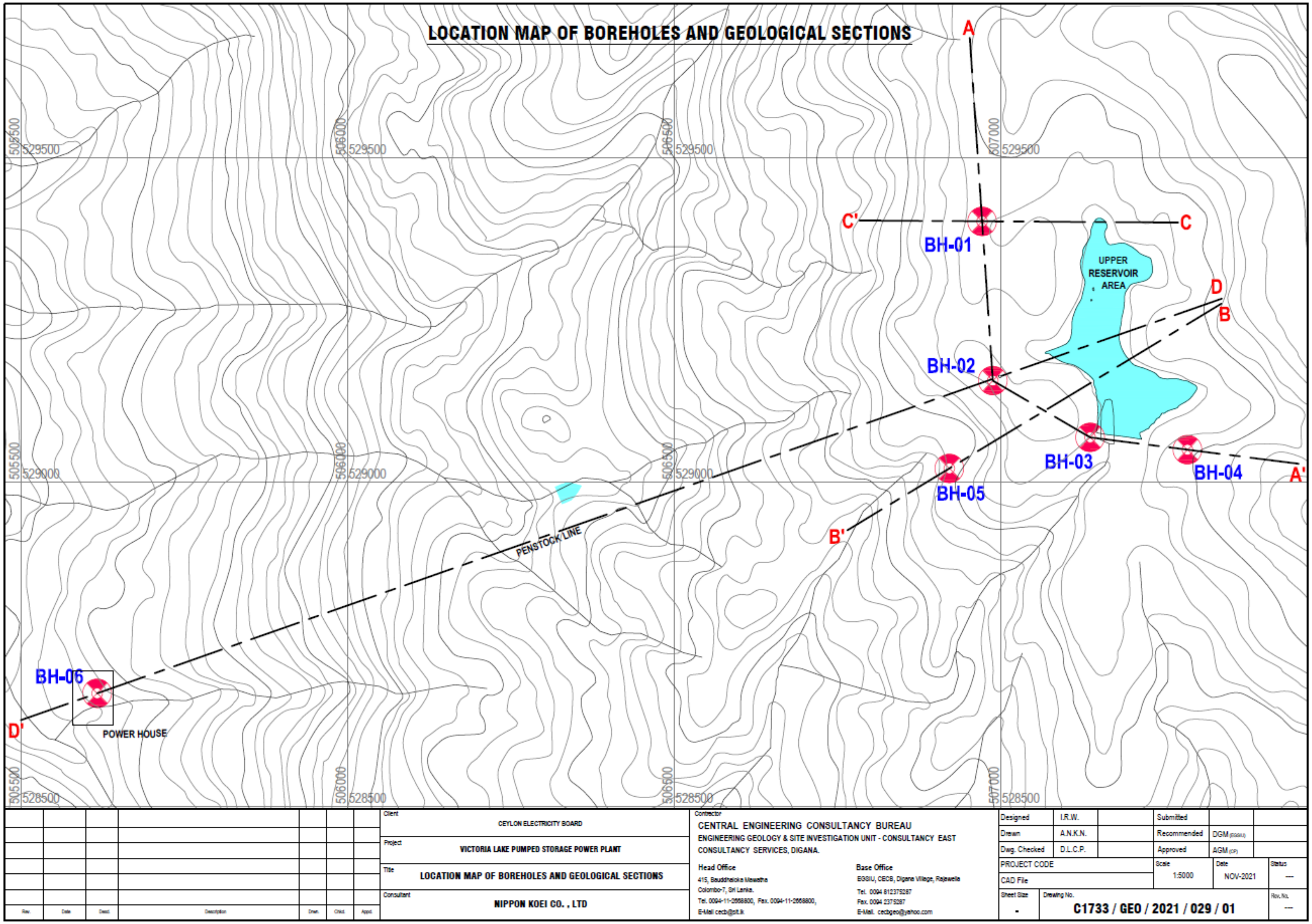
# Geological Investigation: Plan of Core Boring



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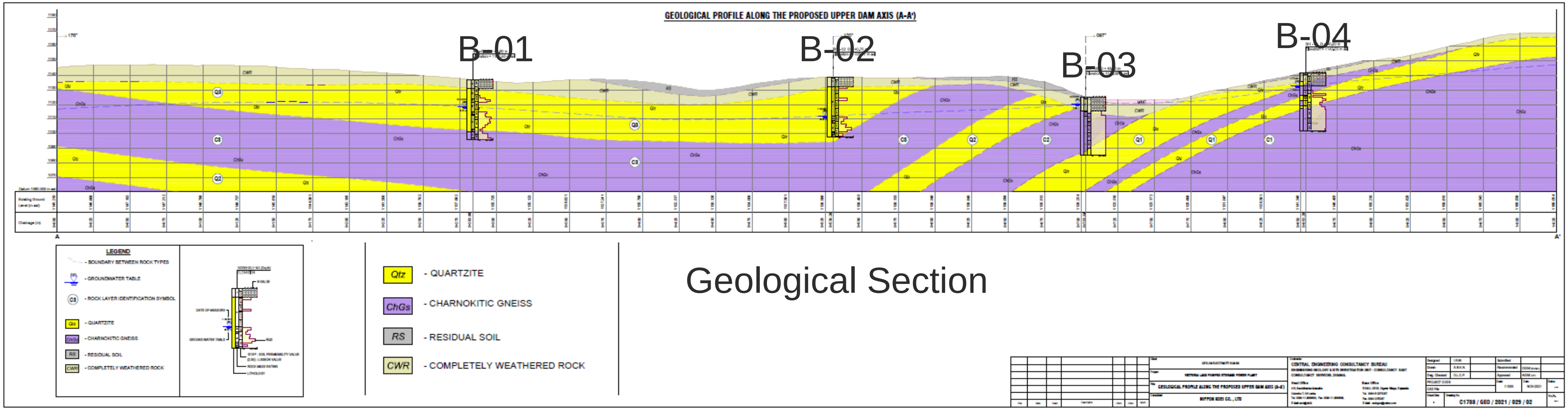
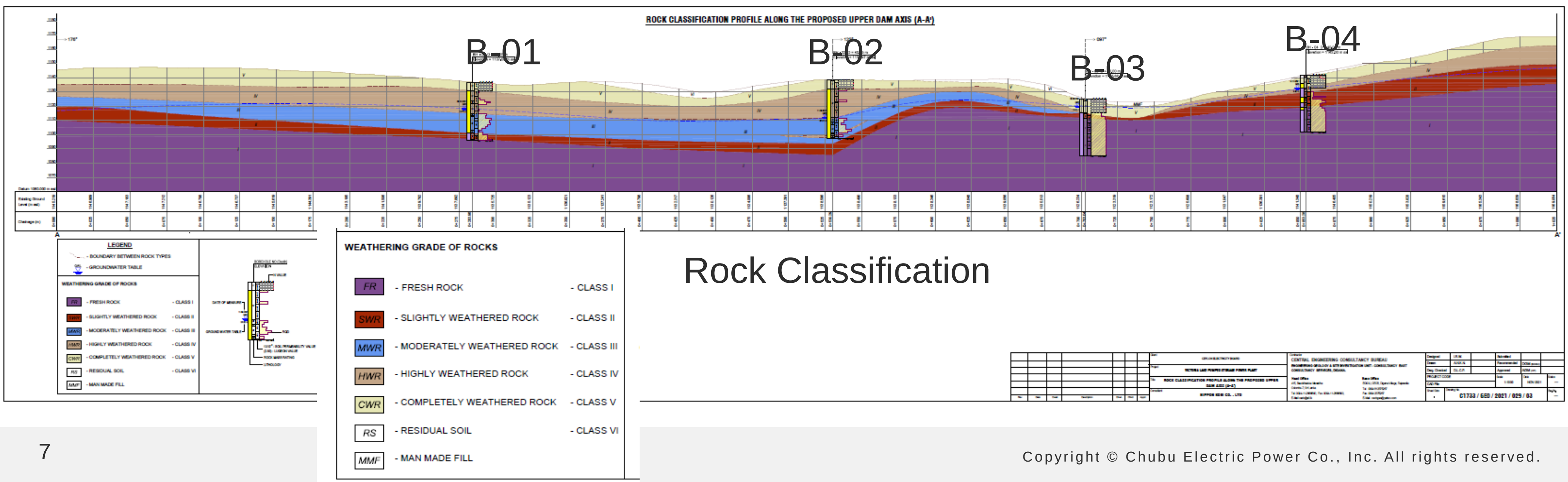
# Geological Sections A-A



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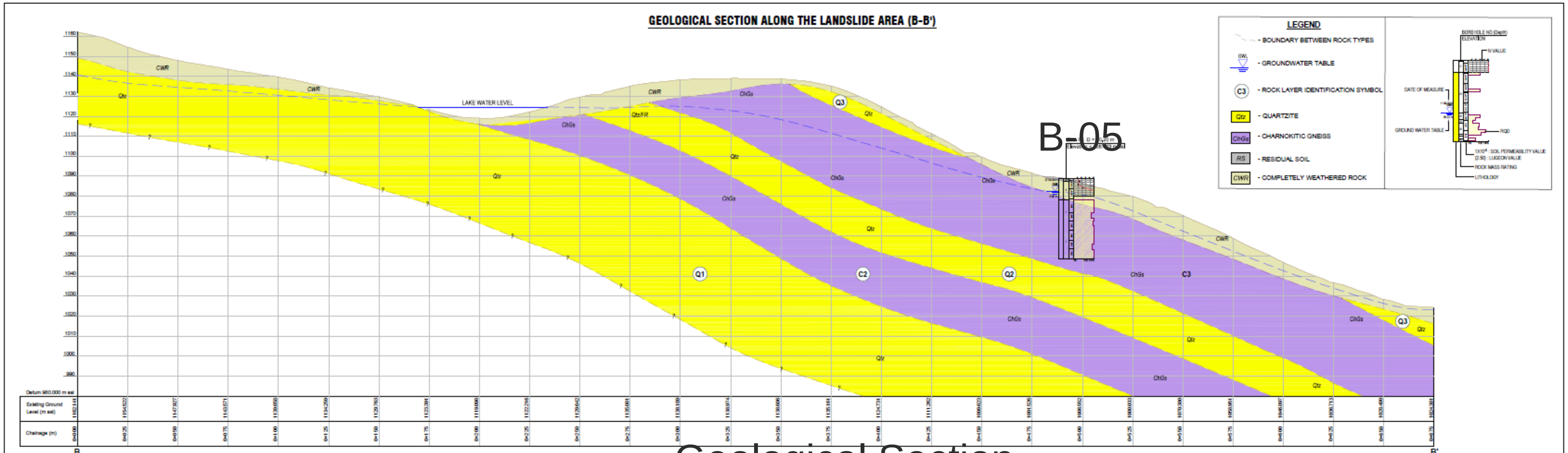
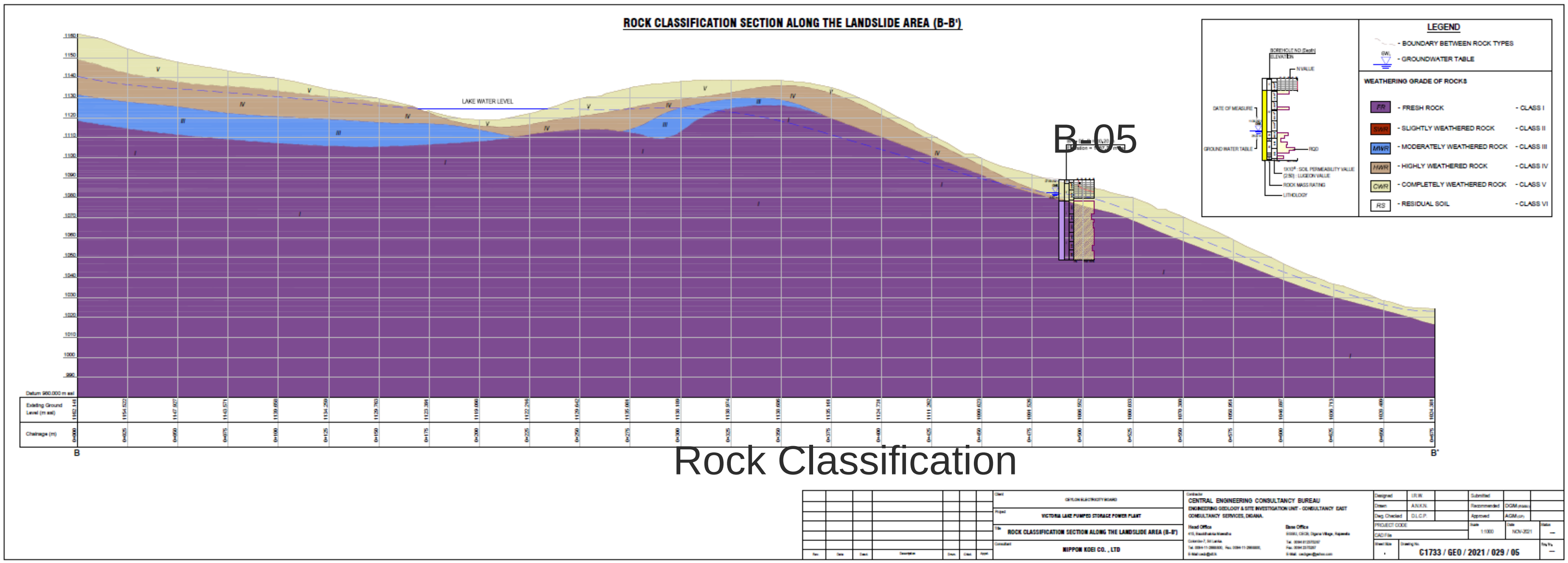
# Geological Sections B-B



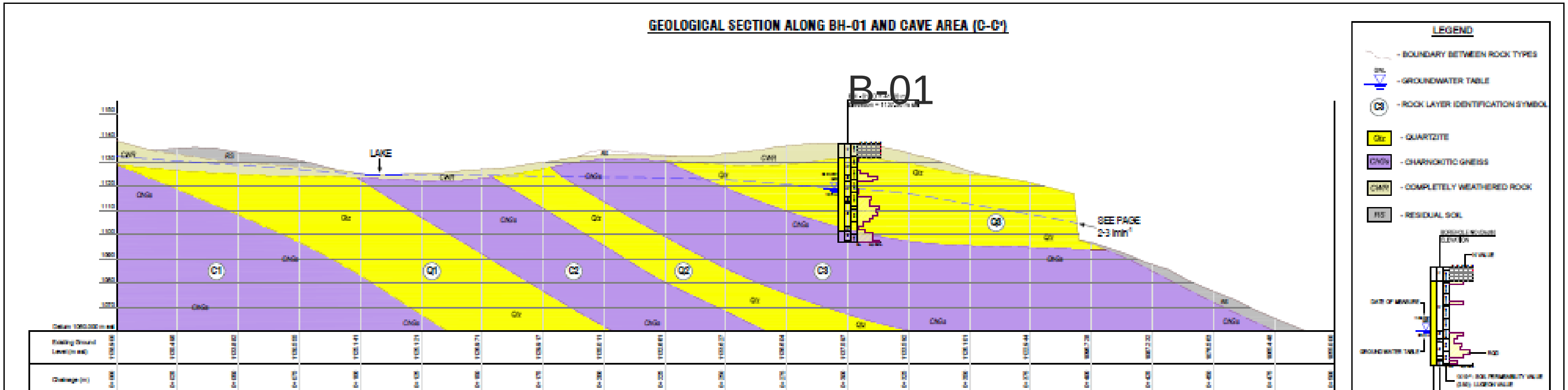

Geological Section



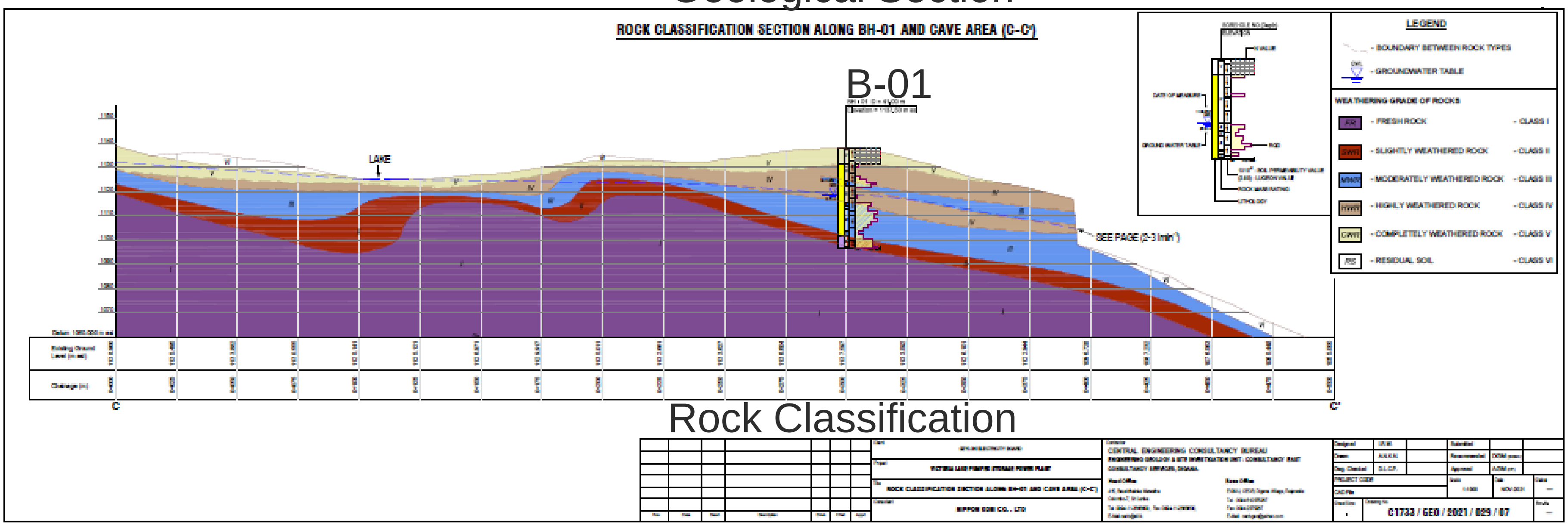

Rock Classification


erved.

# Geological Sections C-C




Geological Section




Rock Classification



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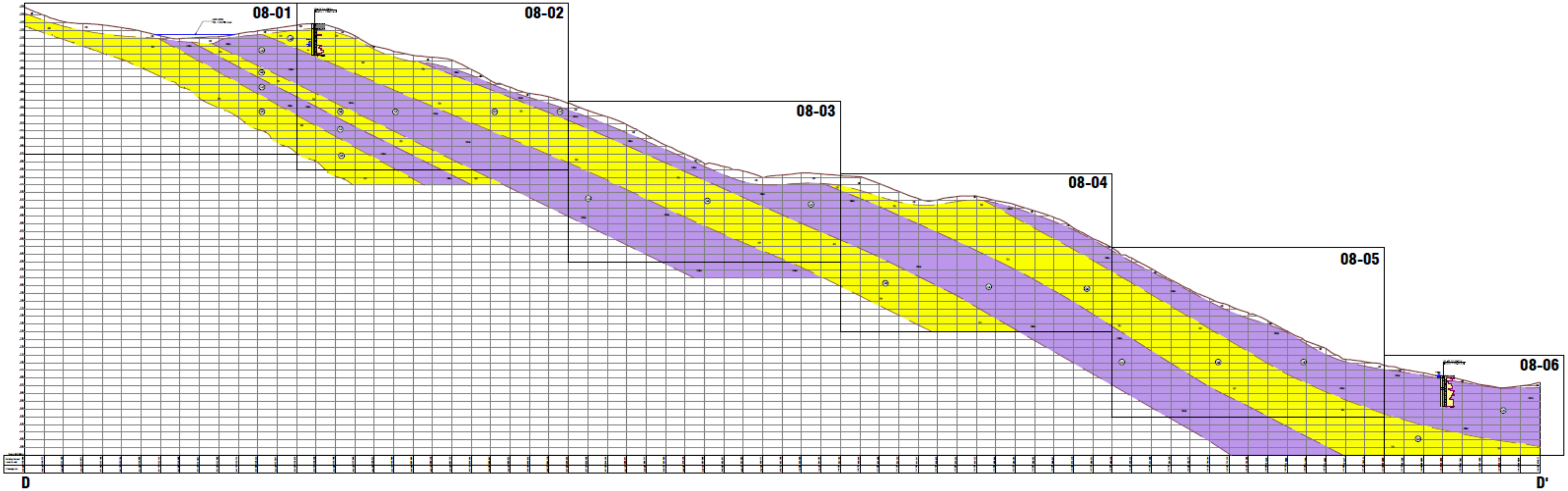
# Geological Sections D-D

B-02




Geological Section



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# Evaluation of Investigation Result (1/3)

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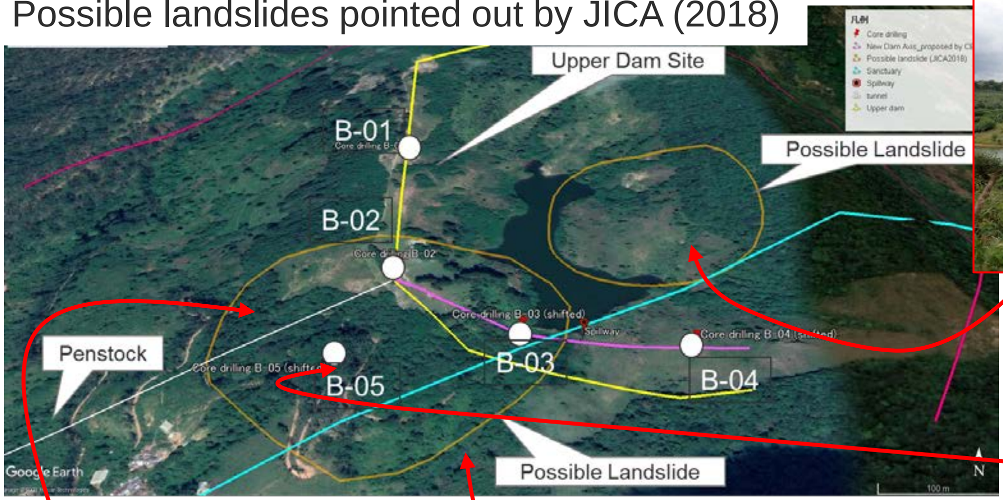
For upper area of Victoria PSPP site, fatal geological risks seem not exist, based on investigation results in this stage (2021)

- Possibility of landslide risks seem low around upper dam site and penstock areas → need final confirmation in F/S 1st stage

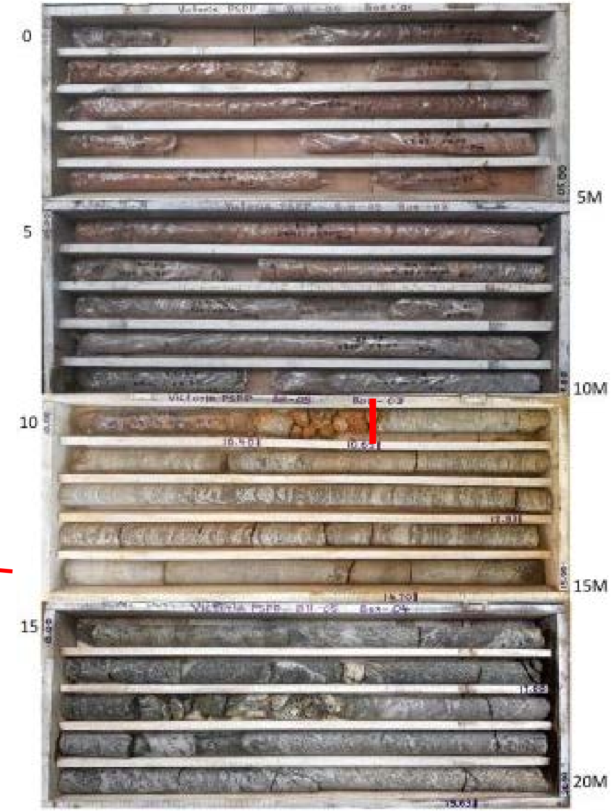
Possible landslides pointed out by JICA (2018)




Many fresh outcrops exists inside slope, without any disturbing direction of rock foliation

Large outcrop of fresh rock inside possible landslide block

No identical phenomena of landslide around slope




Encountering hard rock at shallow depth (10.60m) in drill No.BH-05



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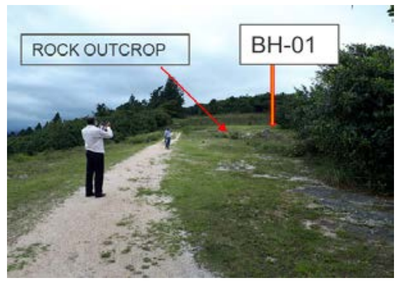
# Evaluation of Investigation Result (2/3)

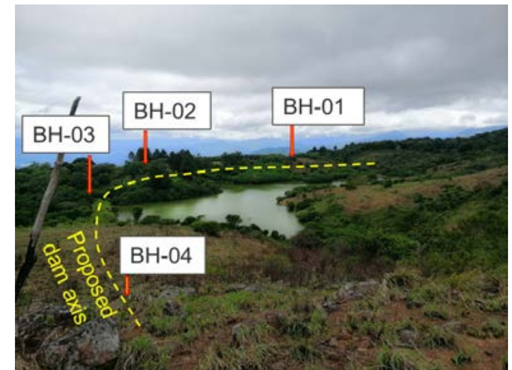


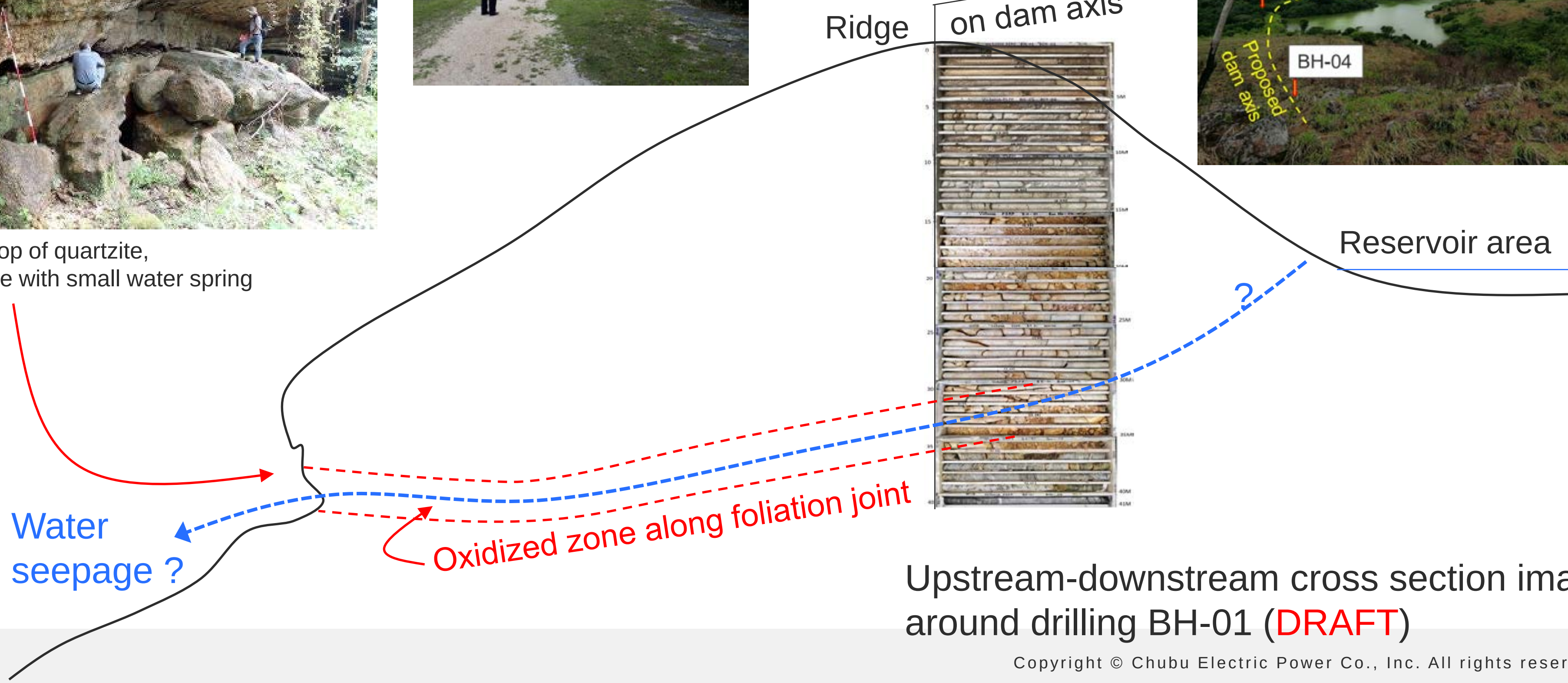
## However, some considerable issues are identified for upper area of Victoria PSPP site

- Basically, water permeability seems low around upper dam site and reservoir area, but possible minor seepage should be considered at right bank → need evaluation in F/S stage

Large outcrop of quartzite, forming cave with small water spring




Upstream-downstream cross section image around drilling BH-01 (DRAFT)



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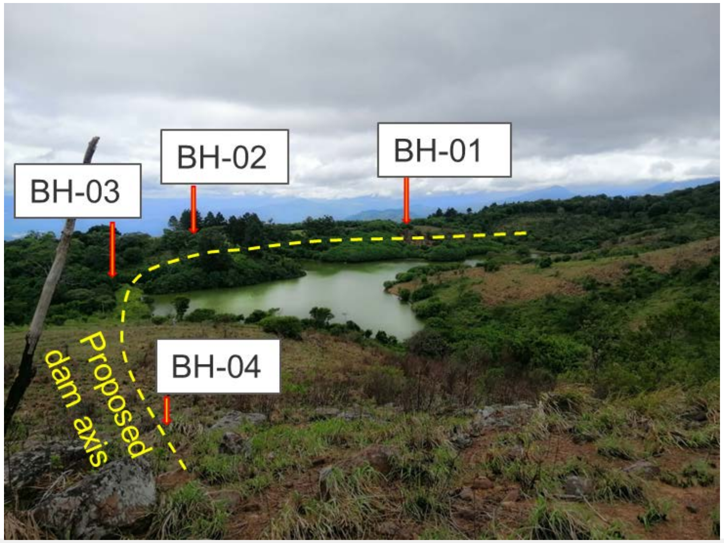
# Evaluation of Investigation Result (3/3)

- Quartzite around right bank of upper dam foundation seems fragile in core sample, while seems hard in outcrop. → caused by drilling operation inside tight-joint rich zone ? →difficult to estimate geotechnical parameters → recommending adit observation with in-situ tests, such as rock shear test and loading test in F/S stage

Fragile core sample (BH-02: 15-20m)




Hard outcrop of quartzite
around right bank of upper dam site

EXAMPLE: adit in other project



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# Conclusion (1/2)

| Structures | Check points | Major conceivable issues | |
|---|---|---|---|
| | | Focused by JICA (2018) | Based on this investigation (2021) |
| Upper storage dam | 1. Safety of dam foundation<br>2. Water tightness | 1. Possibility of landslide risks<br>2. No information | 1. Possibility of landslide risks seem low.<br>2. Basically tight, but possible minor seepage at right bank.<br>3 Quartzite at right bank seems. moderately weak, need to check strength of quartzite.<br>4 Original dam axis should be slightly shifted to upstream side in consideration of creep length and stability of foundation rock. |
| Reservoir | 1. Landslide risks<br>2. Water seepage risks | 1. Possibility of landslide risks<br>2. No information | 1. No landslide risks.<br>2. Seepage risks seem low, but need check narrow ridges condition surrounding reservoir. |
| Upper water way | 1. Landslide risks of portals<br>2. Rock condition along water ways | 1. No information<br>2. No information | 1. Possibility of landslide risks seem low.<br>2. No identified risks along penstock.<br>3 Quartzite around intake seems moderately weak, need to check strength of quartzite.<br>4 Possibility of minor water inflow. |



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# Conclusion (2/2)

| Structures | Check points | Major conceivable issues | |
|---|---|---|---|
| | | Focused by JICA (2018) | Based on this investigation (2021) |
| Underground Powerhouse | 1. Rock condition | 1. No information | 1. No information, but<br>- possibly marble layer is not so thick, based on the regional geological mapping<br>- weak and permeable sheared zone and anisotropic biotite gneiss described in published geological map |
| Lower water way | 1. Landslide risks of portals<br>2. Rock condition along water ways | 1. No information<br>2. Two lineaments (possibly fracture zone) crossing the tunnel. | 1. No information<br>2. Two lineaments (possibly fracture zone) crossing the tunnel. |
| Lower storage dam and reservoir | Safety of dam foundation, water tightness, landslide and water seepage risks | No information | No information, but following issues are described in published geological map<br>- permeable marble<br>- weak and permeable shared zone<br>- anisotropic biotite gneiss |

No geotechnical investigation were conducted in this stage (2021)


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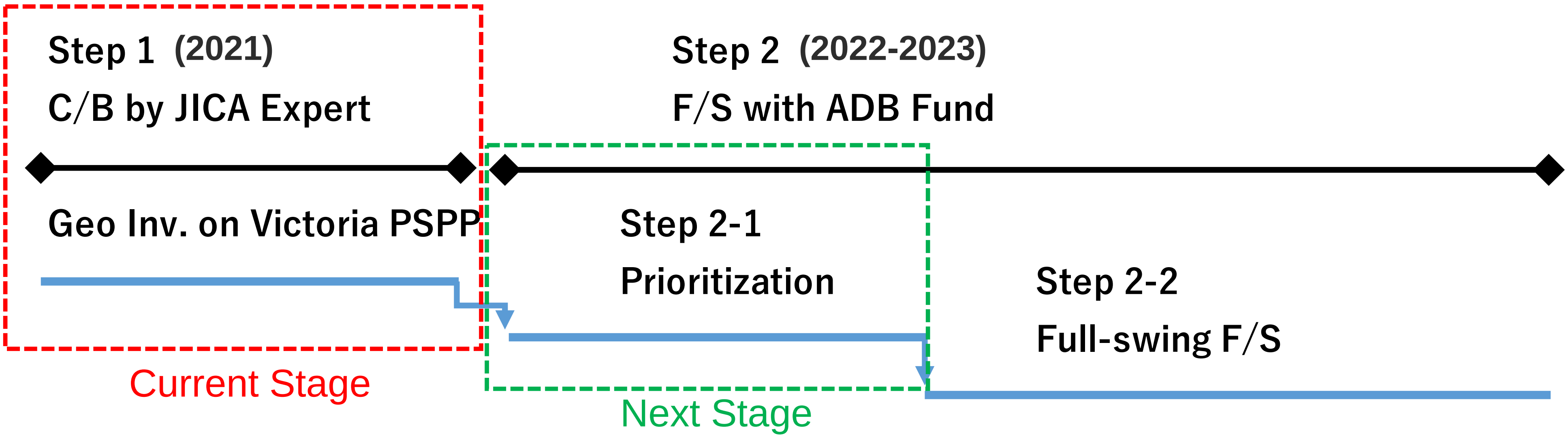
# Basic Sequence of Overall Schedule



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# Recommendation in Next F/S 1st Stage

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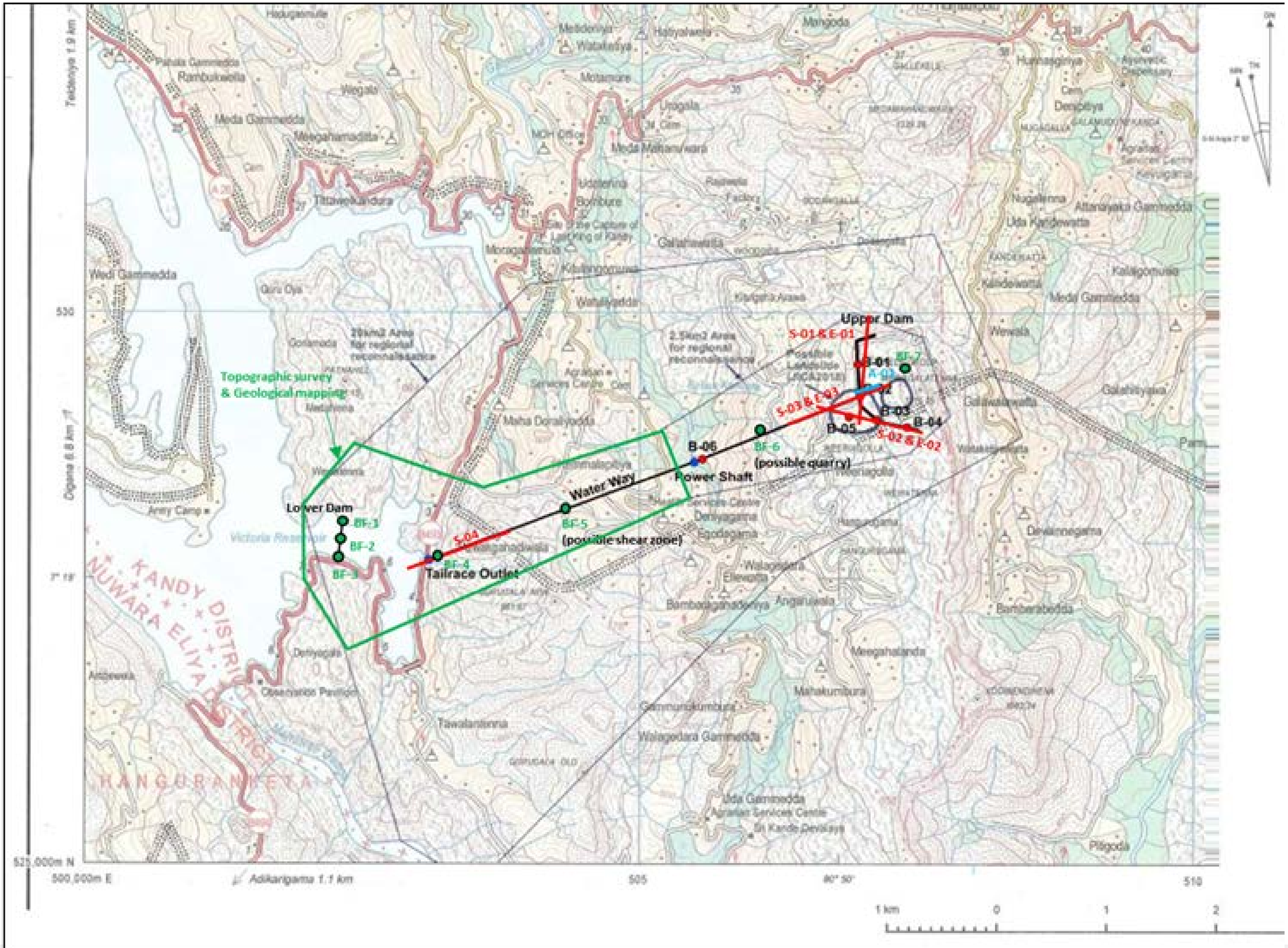
## Proposed layout of geological investigation for Victoria Lake site in Next F/S 1st stage




Completed drilling location (2021):

- Drilling ( B-01 to 06 )
- Topographic survey & Geological mapping

Proposed layout of investigation for F/S 1st stage:

- Drilling ( BF- )
- Seismic prospecting ( S- )
- Electrical resistivity prospecting ( E- )
- Test Adit ( A- )
- Topographic survey & Geological mapping



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# JICA CAPACITY DEVELOPMENT ON THE POWER SECTOR MASTER PLAN IMPLEMENTATION PROGRAMME-WG3-1

Estimation of SAIFI/SAIDI at the pilot sites to be improved

by countermeasure facilities


N.H.Chamil Janaka

Group Leader-WG3-1

# COUNTERMEASURE DEVICES FOR DD’S

| | |
|---|---|
| • Over Currenct Indicator (OCI) |  |
| • Abrasion Resistor Cover(ARC) |   |
| • Ground Fault Detector |  |

# 1. Over Current Indicator (OCI)

[Overview]
This product is with a function to detect and display the overcurrent (short-circuit current) flowing in the overhead distribution lines, and to automatically recover after a certain period of time.

[Benefits]
・Maintenance free (no batteries are required due to electromagnetic induction operation)
・Applicable to bare conductors

Image of attachment to a conductor

Rating

| | 300A | 600A |
|---|---|---|
| Rated operating current | 300A | 600A |
| Min. detection current | 250±30A | 550±40A |
| Indicates retractor current | 2A or more | |
| Indicates retreat time | 5hours | |
| Overcurrent strength | 12.5kA | |
| Rated frequency | 50Hz | |
| Operating temperature range | -20~40℃ | |



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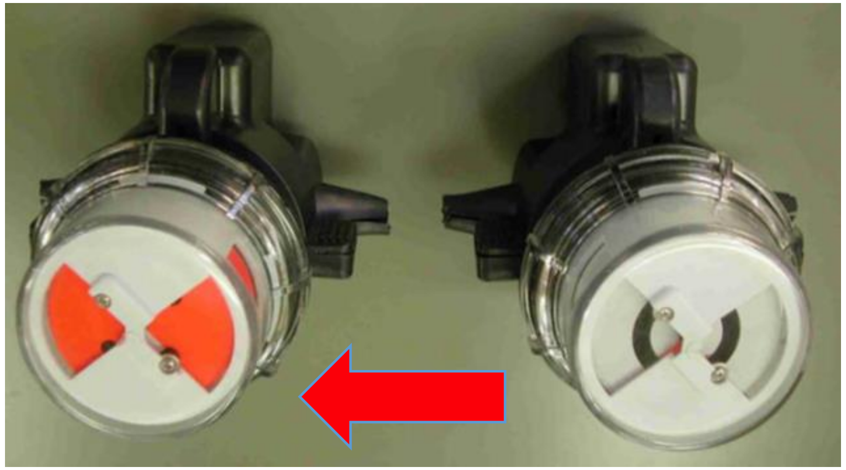
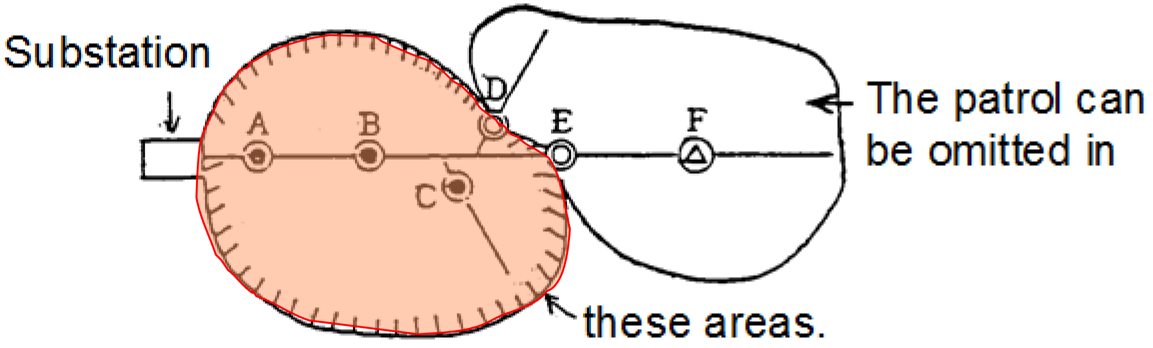
# 1. Over Current Indicator (OCI)




The patrol should be performed in these areas.

Over current indicator legend

- Color change (A, B, C)
- White (D, E)
- No need of checking (F)

The color at bottom of the indicator is changed from white to red by the passage of short-circuit current through the parts behind the installation point.

So, The patrol should be performed in these red areas since there is no need to look at the latter part of the distribution line.
In this case patrol time can be cut in half.



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# 2. Abrasion Resistance Cover for Conductor

[Overview]

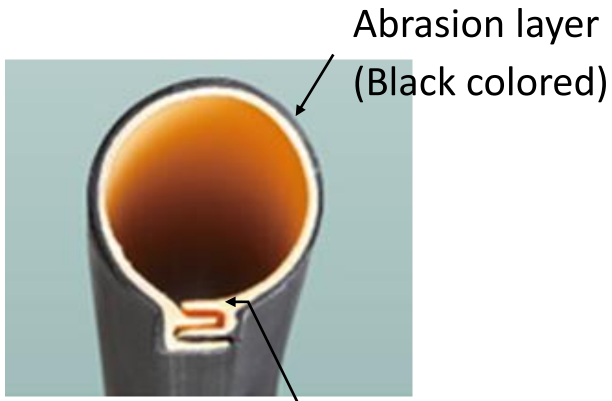
This product is used to protect electric conductors from trees, etc. by attaching it to electric conductors that are adjacent to trees, etc.

[Benefits]

-This product is made of flame-retardant materials. (V-0 class)

-The two-layer construction (outer layer: black, inner layer: yellow) makes it possible to visually check the time of replacement due to abrasion.

-A locking mechanism is provided at the bottom of the joint to prevent it from opening.



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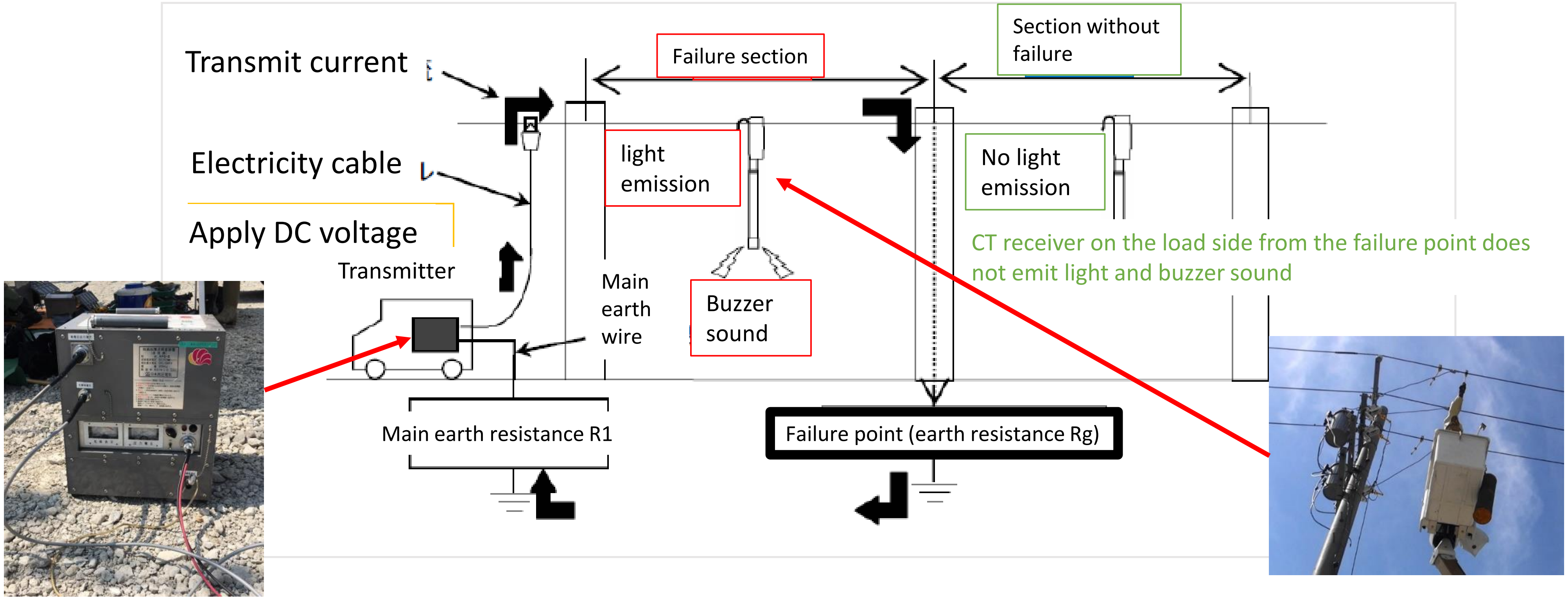
# 3. Ground Fault Detector (GFD)

DC voltage (5 to 15 kV) is applied to the MV line in the power failure section by the fault detector, and the ground fault current is received. The cause of the failure is identified by the light emission and buzzer sound of the receiver. This makes it possible to identify damages and internal failures of the arrester, which are difficult to check with the naked eye.



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# 3. Ground Fault Detector (GFD)

[Verification of Technical Issues on Real Lines]

-The applied voltage to the actual line path

→this device can be applied to a complete ground fault on the 11kV/33kV distribution line.

-The detection range of the charging system and the applicability of the distribution line length.

→It is effective to divide the distribution line into 30km or less .



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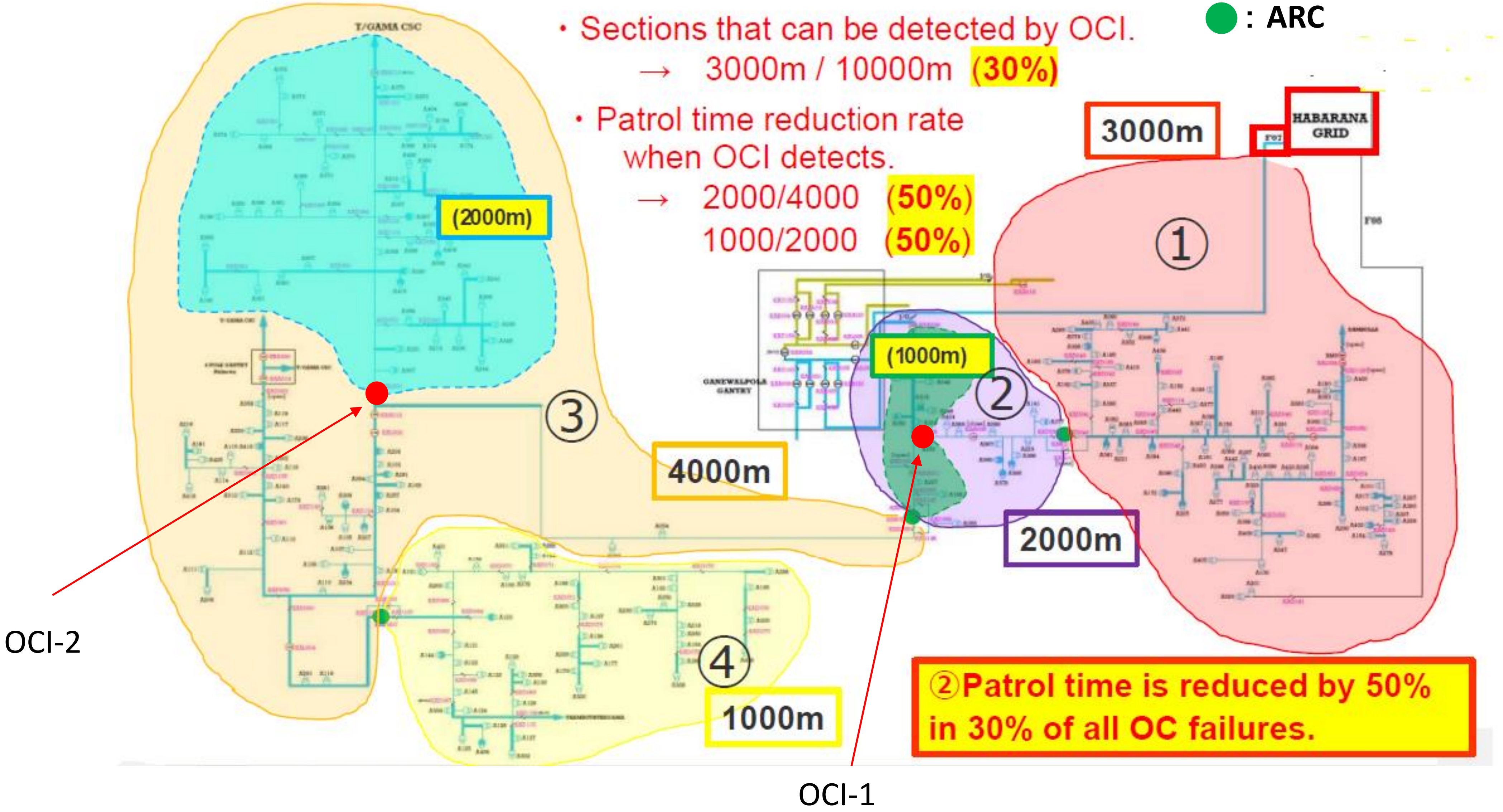
# COUNTERMEASURE DEVICES- DEPLOYMENT PLAN

| Location | OCI (Pieces) | ARC (Pieces) (2m/piece) | GFD (Sets) |
|---|---|---|---|
| DD1 | 6 | 135 | 1 |
| DD2 | 6 | - | 1 |
| DD3 | 6 | - | 1 |
| DD4 | 6 | 125 | 1 |
| LECO | 6 | 240 | 1 |

Estimation of effectives of OCI – Habarana Feeder No.7 of DD1

（DD1:OCI-1：Habarana F07）



# PDM Calculation

## DD1:OCI-1: Habarana F07

**BEFORE (2019)**

| | OC | EF | Both | Total |
|---|---|---|---|---|
| 2019 | 31 | 49 | 92 | 172 |
| % | 18.0 | 28.5 | 53.5 | 100 |

**71.5%**

| Patrol Duration |
|---|
| 100 |

Total patrol duration (2019)
172 x 100 = 17,200 min/year

| SAIDI (min) |
|---|
| 4,620 |

**AFTER (ESTIMATION)**

1. Effective in 71.5% of power failures
2. Patrol time is reduced by 50% in 30% of OC failures

Total patrol duration (min/year)

- OC: (172 x 71.5% × 30%) × (100min x 50%)

  + (172 x 71.5% x 70%) x 100min

  = 10,453 min/year
- EF: (172 x 28.5%) x 100 min = 4,900 min/year

Total patrol duration (Estimation)
= 15,353 min/year

| Difference |
|---|
| 10.7% |

| PDM - SAIDI (min) |
|---|
| 4126 |

# Estimation of effectives of ARC – Poojanagaraya 11kV feeder of DD1

DD1:ARC: Pooja Nagaraya

**BEFORE (2019)**

Number of power failures per year

| | OC | EF | Both | Total |
|---|---|---|---|---|
| 2019 | 2 | 9 | 4 | 15 |

Number of tree/etc contact

| Tree/etc Contact |
|---|
| 10 |

Total number of power failure = 15 per year

| SAIFI |
|---|
| 10 |

**AFTER (ESTIMATION)**

1. Effective in 10/15 = 66.6% of power failures
2. No more tree contact

Total number of power failure

- 15 – 10 = 5 per year

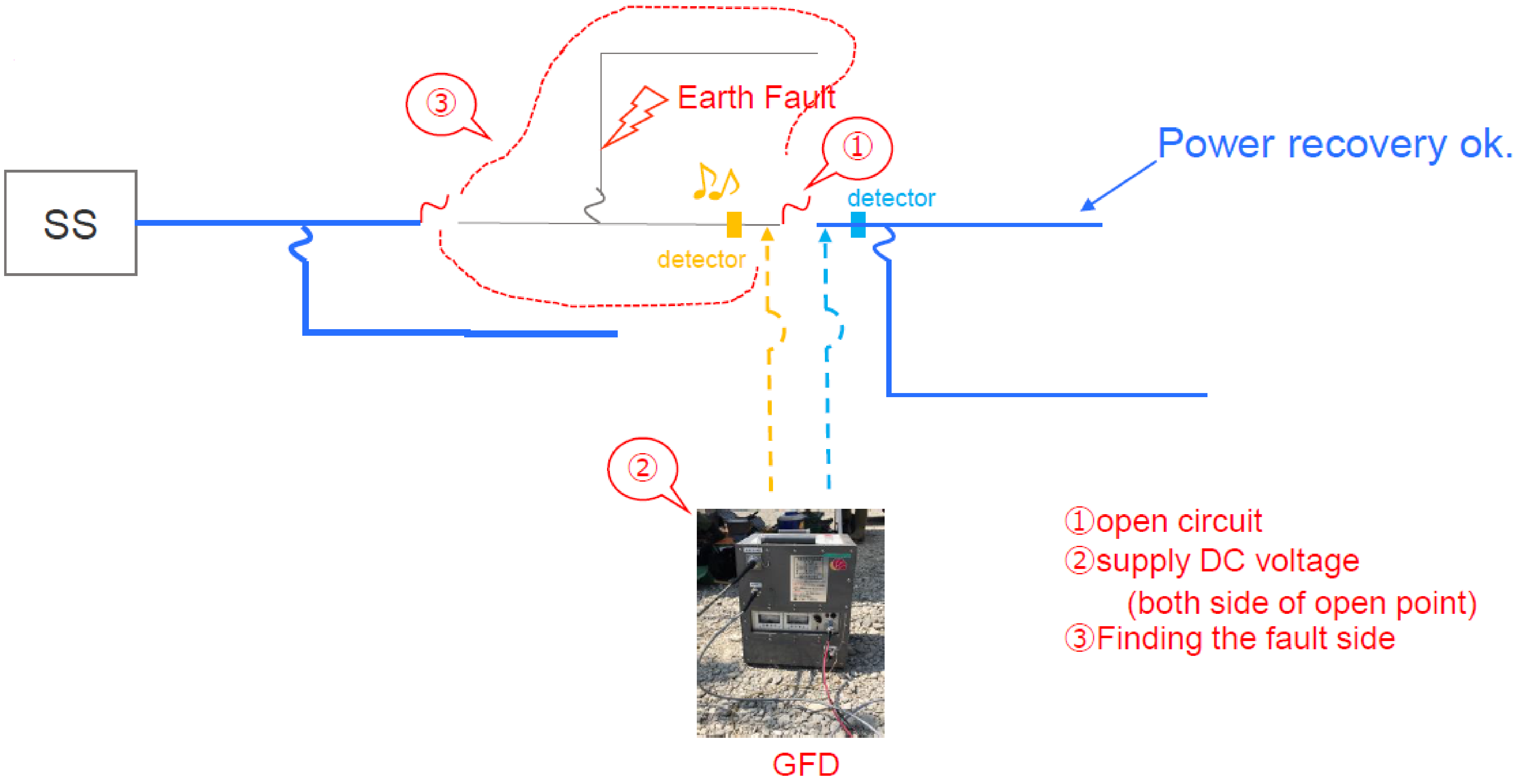
Total number of power failure = 5 per year

| PDM - SAIFI |
|---|
| 3.82 |

Difference-61.8%

Estimation of effectives of GFD – Norochcolei feeder No.2 of DD1

# GFD Installation



# DD1:GFD: Norochcholai F2

**BEFORE (2019)**

Number of power failures per year

| | OC | EF | Both | Total |
|---|---|---|---|---|
| 2019 | 2 | 14 | 0 | 16 |

Patrol duration min/failure

| Before | After |
|---|---|
| 41 | 20 |

Total patrol duration (min/year) = 16 x 41 = 656

| SAIDI |
|---|
| 490 |

**AFTER (ESTIMATION)**

1. Effective in 14/16 = 87% of power failures
2. Patrol time for EF failures is reduced by 50%

Total number of power failure

- EF: (16 x 87%) x (41min x 50%) = 285.36 min/year
- OC: (16 x 13%) x 41min = 85.28 min/year

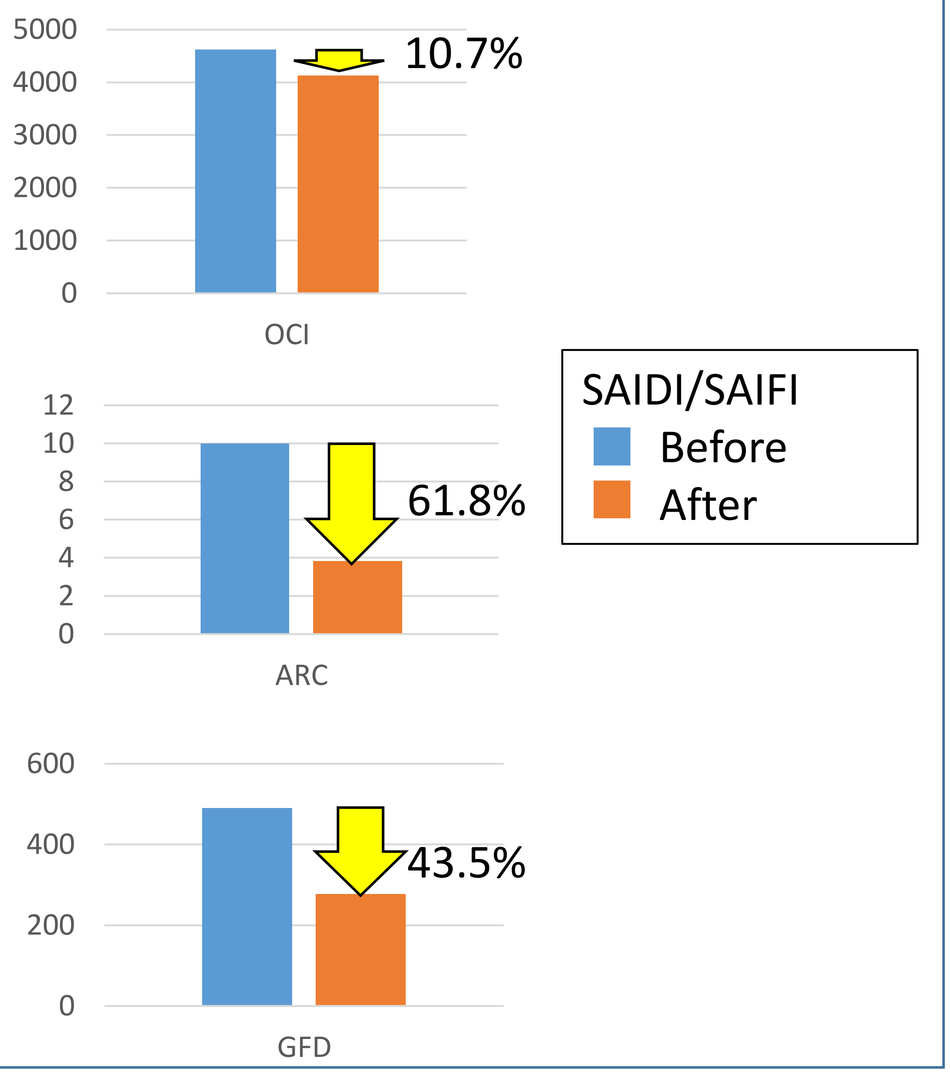
Total patrol duration (min/year) = 370

**Difference 43.5%**

| PDM - SAIDI |
|---|
| 277 |

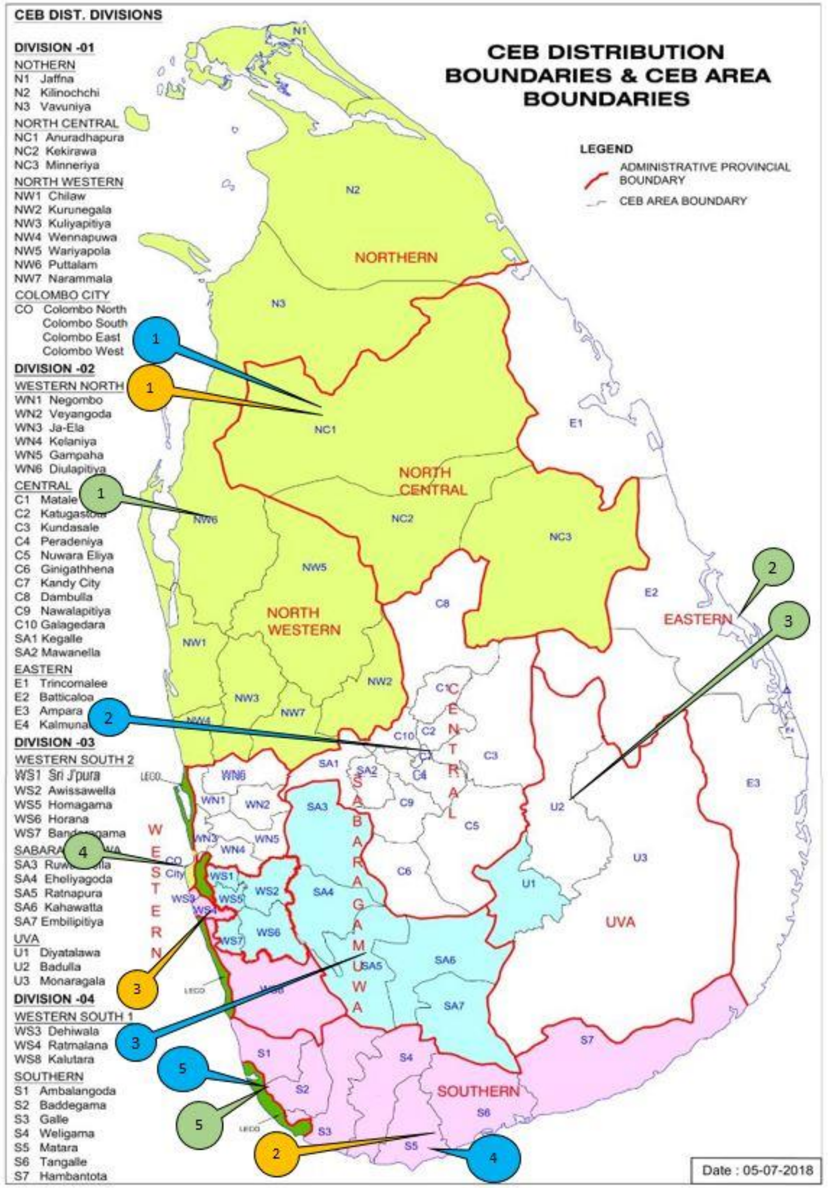
# Conclusion

| Countermeasure Device | SAIDI (Min)/SAIFI | | Improvement (%) |
|---|---|---|---|
| | Before | after | |
| OCI | 4620 | 4126 | 10.7 |
| ARC | 10 | 3.82 | 61.8 |
| GFD | 490 | 277 | 43.5 |

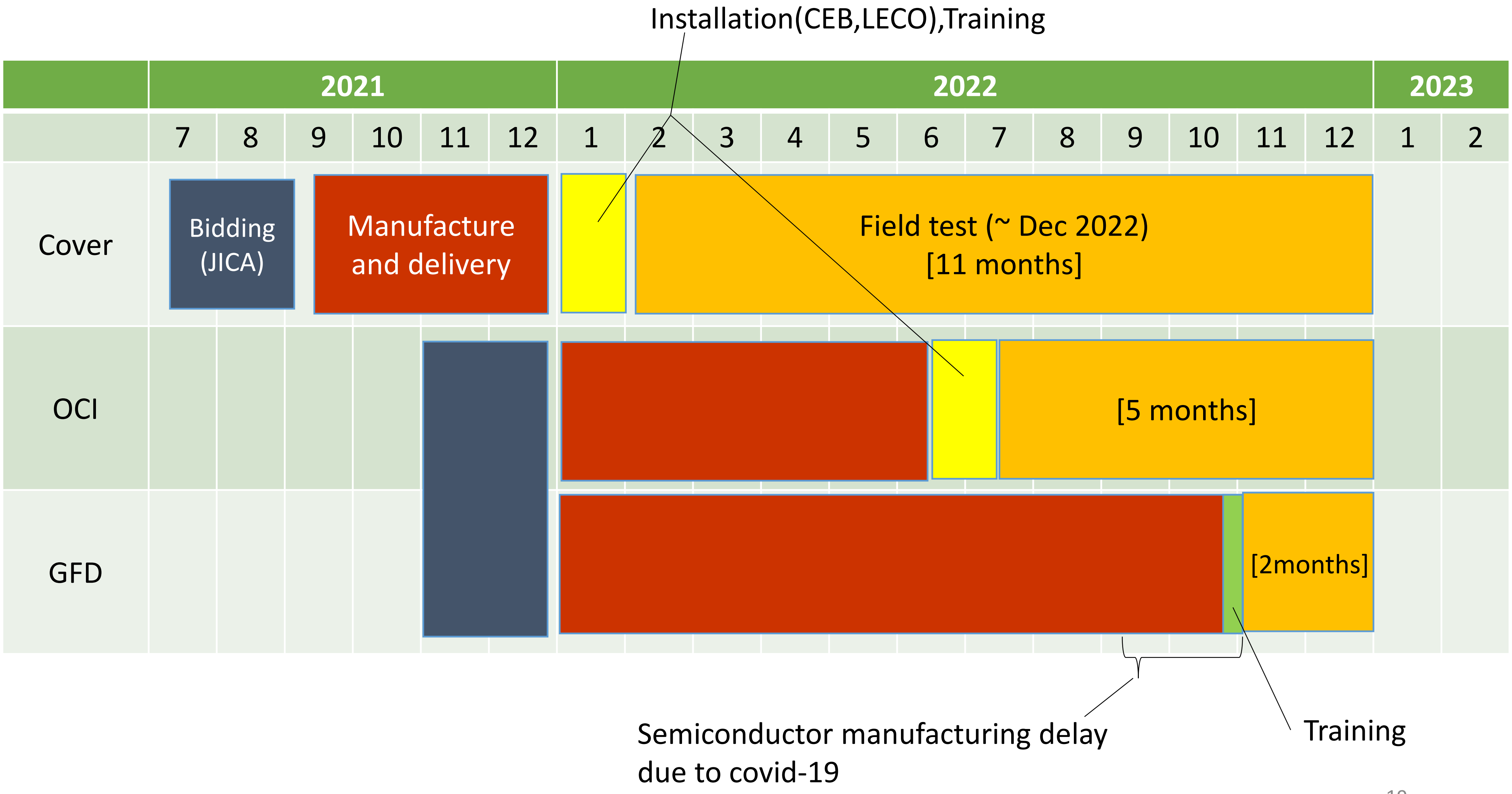


# Map of Pilot Project Site

| countermeasure | area | province | district | Substation | Map |
|---|---|---|---|---|---|
| Over Current Indicator (OCI) | DD1 | NCP | Anuradhapura | Habarana Feeder 07 (karawilagala) | 1 |
| | DD2 | Central | Kandy | Kiribathkumbura GSS to Kadugannawa (KI-F9) | 2 |
| | DD3 | Sabaragamuwa | Rathnapura | Ratnapura GSS,feeder 2 (Ratnapura town) | 3 |
| | DD4 | Southern | Matara | Deniyaya GSS,F4,Neluwa | 4 |
| | LECO | Southern | Galle | Beligaha PSS - Boossa feeder | 5 |
| Abrasion Resistance Cover for Conductor | DD1 | NCP | Anuradhapura | Pooja Nagaraya 11kV feeder from Town primary | 1 |
| | DD2 | - | - | - | - |
| | DD3 | - | - | - | - |
| | DD4 | Southern | Matara | Matara PSS (Rahula PSS),F1(Kalidasa Road) | 2 |
| | LECO | Western | Kalutara | Kaluwamodara PSS - Moragalla feeder | 3 |
| Ground Fault Detector | DD1 | NWP | Puttlam | Norochcholai Feeder 02 (Palakuda to Kalpitiya) | 1 |
| | DD2 | Eastern | Batticaloa | 33kV ,Valaichchenai GSS to Eravur ( F06) | 2 |
| | DD3 | Uva | Badulla | Mahiyanganaya GSS ,33 kV Feeder 3(Adaulpotha) | 3 |
| | DD4 | WPSI | Colombo | Rathmalana GSS, F2 | 4 |
| | LECO | Southern | Galle | Hikkaduwa PSS - Wewalamilla feeder (Galle branch area) | 5 |



# Pilot Project schedule (OCI, Cover, GFD)



# Thank You

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Democratic Socialist Republic of Sri Lanka

# The Project for Capacity Development on the Power Sector Master Plan Implementation Program

## 2st Technical Seminar

Virtual Power Plant Demonstration Project in Toyota City (Introduction)

22th December, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Contents

1. What is Virtual Power Plant (VPP)?
2. Outline of the VPP Demonstrated in Toyota City
3. Outline of BESS Control in MV Distribution NW
4. Some Results of Power/Voltage Fluctuation Control
   - Power Flow Control
   - Constant Target Voltage Control
   - Possibility of Rational Distribution NW Formation (SVR Saving, etc.)
5. Conclusions


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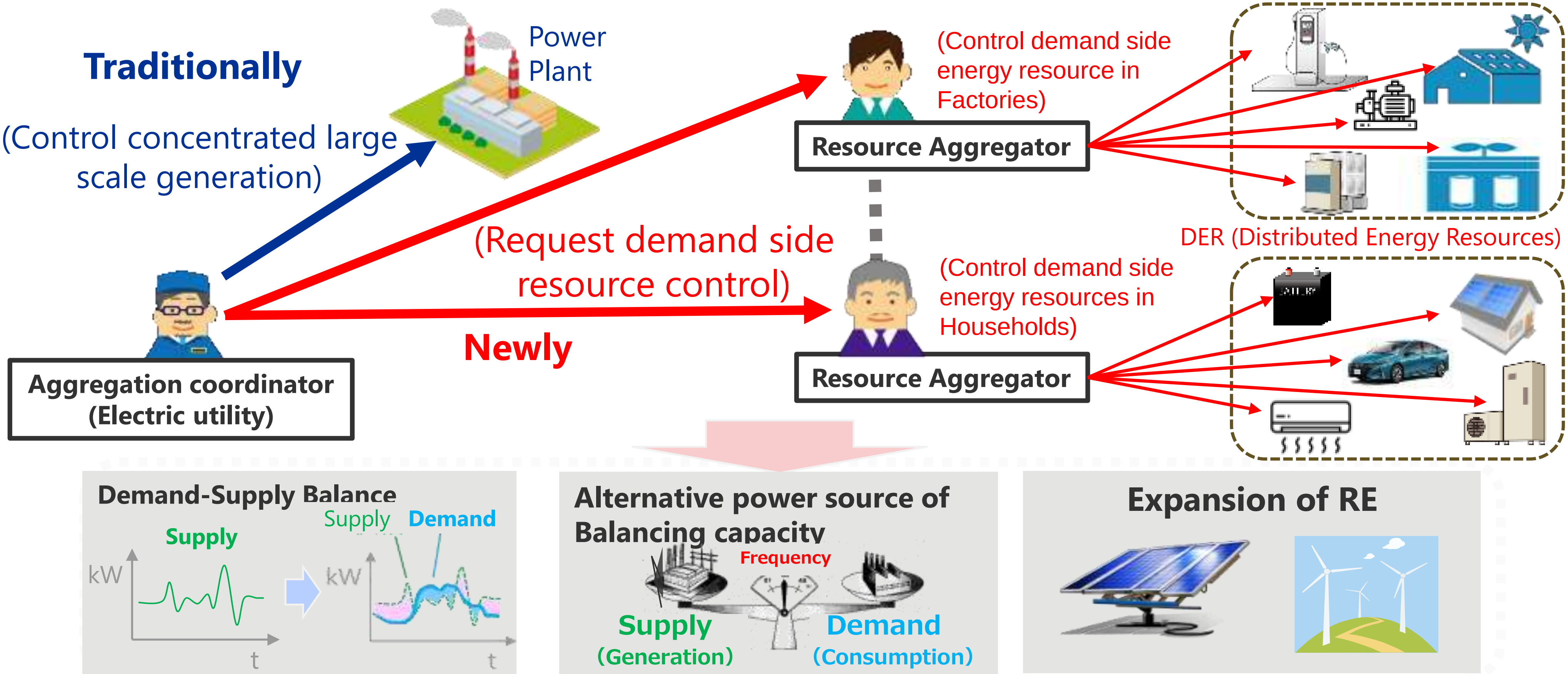
# What is Virtual Power Plant (VPP)

VPP means aggregators (retailers) integrate and optimally control distributed energy resources (PV, air conditioners, storage batteries, EVs, etc.) as “Energy creation", "Energy conservation" and “Energy storage" on customer sides by utilizing IoT, and makes them function as if they were one power plant.




- **Decarbonize**
- **Reduce energy cost**
- **Improve energy self-sufficiency rate**



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# Theme of VPP Projects in Toyota city

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| | A : Control of distributed energy resources | | B : Control of MV NW |
|---|---|---|---|
| | **I. Utilization of DER to realize local production for local consumption** | **Ⅱ. Provision of balancing control power to TSO/DSO** | **Ⅲ. Advancement of distribution network** |
| Purpose | ● Balancing supply and demand locally | ● Providing balancing control power to TSO/DSO | ● Optimization of equipment formation<br>● Optimization of network operation |
| Method | ● Controlling distributed energy resources such as BESS, PHVs, heat pumped water heaters, cogeneration units | ● Controlling demand side energy resources to provide TSO/DSO with balancing control power | ● Controlling demand side energy resources to accommodate a large amount of VRE |
| Remarks | ● Toyota Motor Corp. participate as an aggregator and utilizes batteries in PHVs as distributed energy sources. | ● Try to provide 3 types of balancing control power to TSO/DSO.<br>● Conduct verification test of DR to create demand | ● Achieve the optimal distribution system with using voltage adjusting equipment<br>● Consider optimal quantity and allocation of storage batteries |


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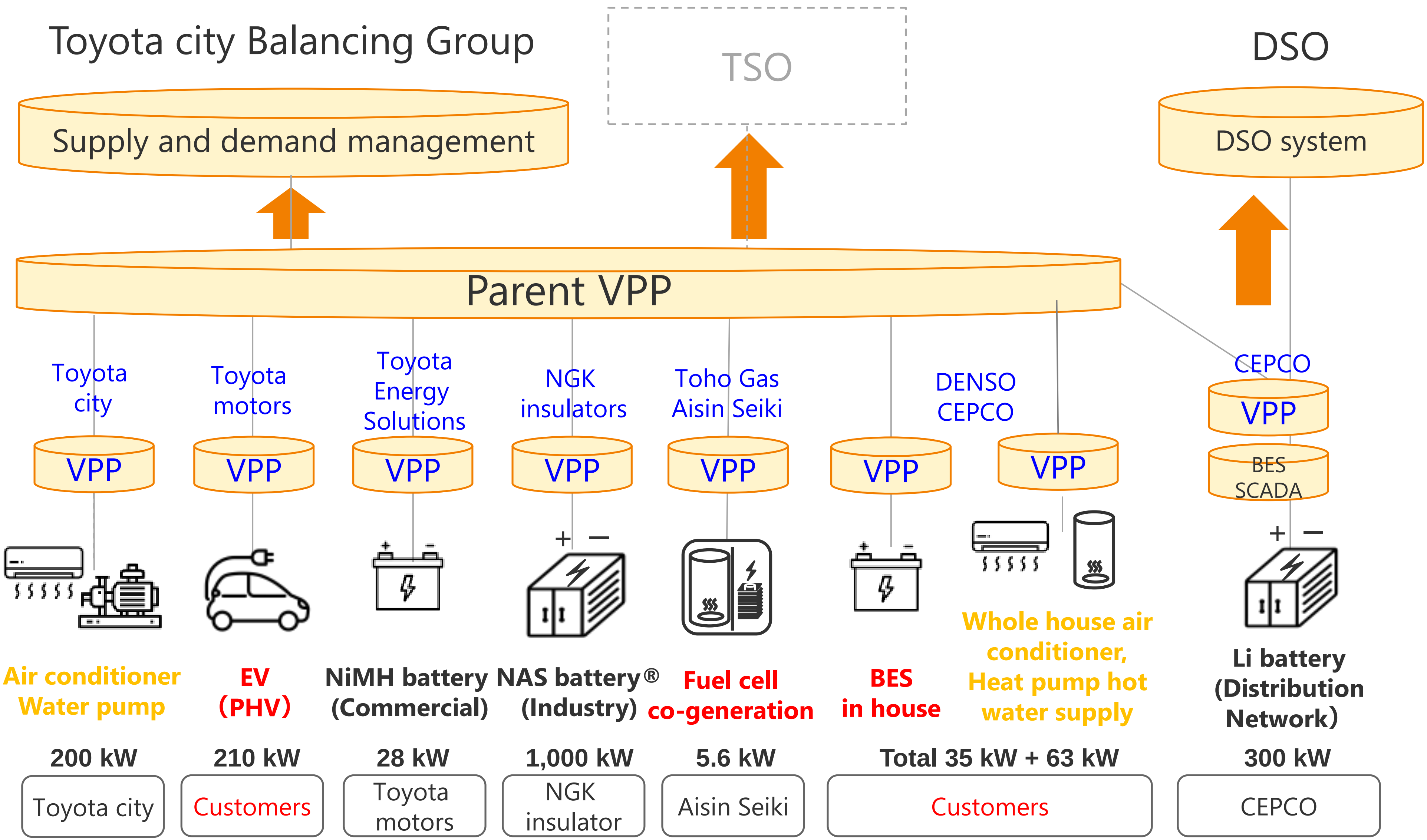
# Scheme of VPP Demonstration in Toyota City



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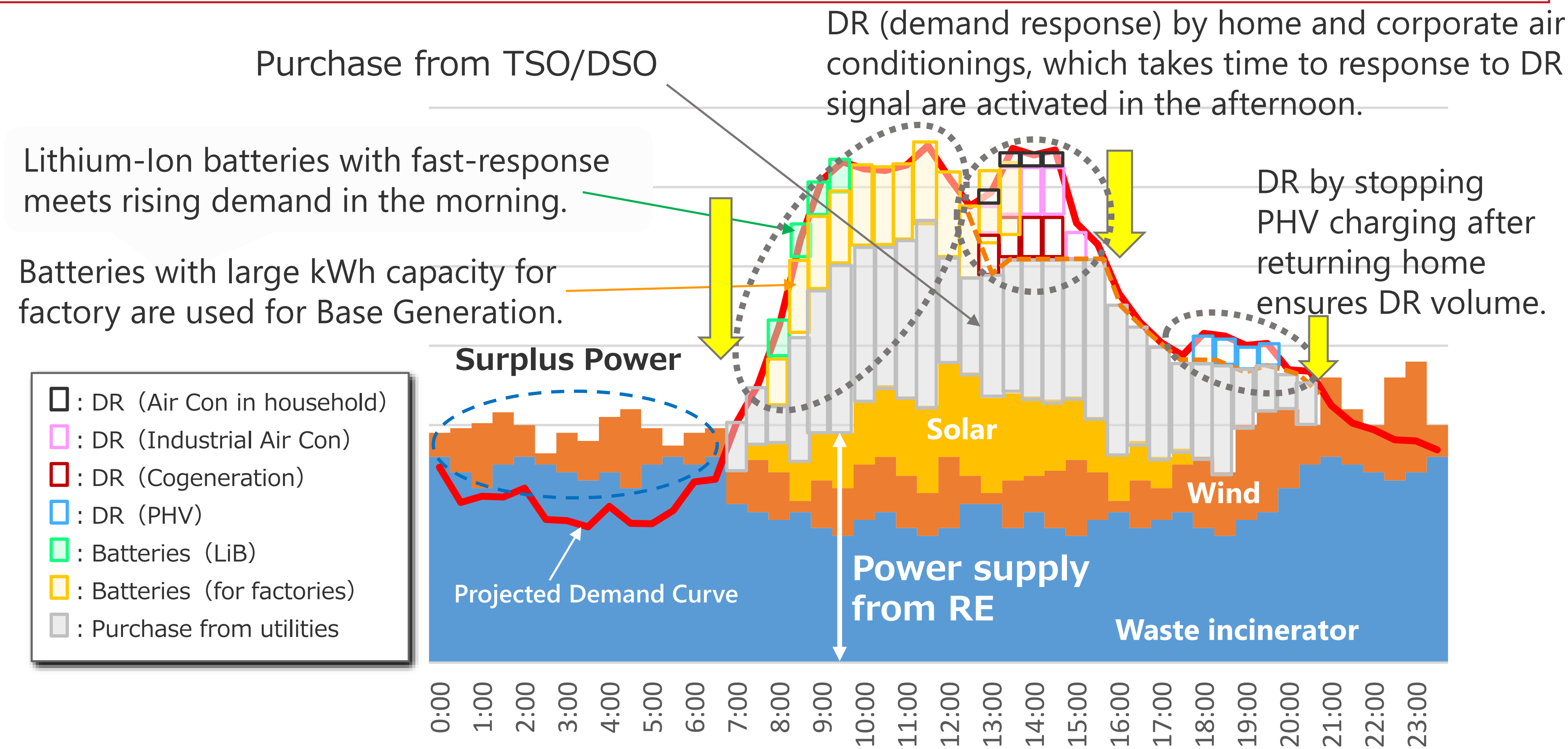
# Utilizing DER for Achieving “local production for local consumption”

- To increase “local production for local consumption,” try to balance supply and demand locally and mainly from RE.
- To adjust the gap between supply and demand, need to utilize distributed energy resources.





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# Theme B: Control of MV Distribution Network

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| | A : Control of distributed energy resources | | B : Control of MV NW |
|---|---|---|---|
| | **I. Utilization of DER to realize local production for local consumption** | **Ⅱ. Provision of balancing control power to TSO/DSO** | **Ⅲ. Advancement of distribution network** |
| **Purpose** | ● Balancing supply and demand locally | ● Providing balancing control power to TSO/DSO | ● Optimization of equipment formation<br>● Optimization of network operation |
| **Method** | ● Controlling distributed energy resources such as BESS, PHVs, heat pumped water heaters, cogeneration units | ● Controlling demand side energy resources to provide TSO/DSO with balancing control power | ● Controlling demand side energy resources to accommodate a large amount of VRE |
| **Remarks** | ● Toyota Motor Corp. participate as an aggregator and utilizes batteries in PHVs as distributed energy sources. | ● Try to provide 3 types of balancing control power to TSO/DSO.<br>● Conduct verification test of DR to create demand | ● Achieve the optimal distribution system with using voltage adjusting equipment<br>● Consider optimal quantity and allocation of storage batteries |



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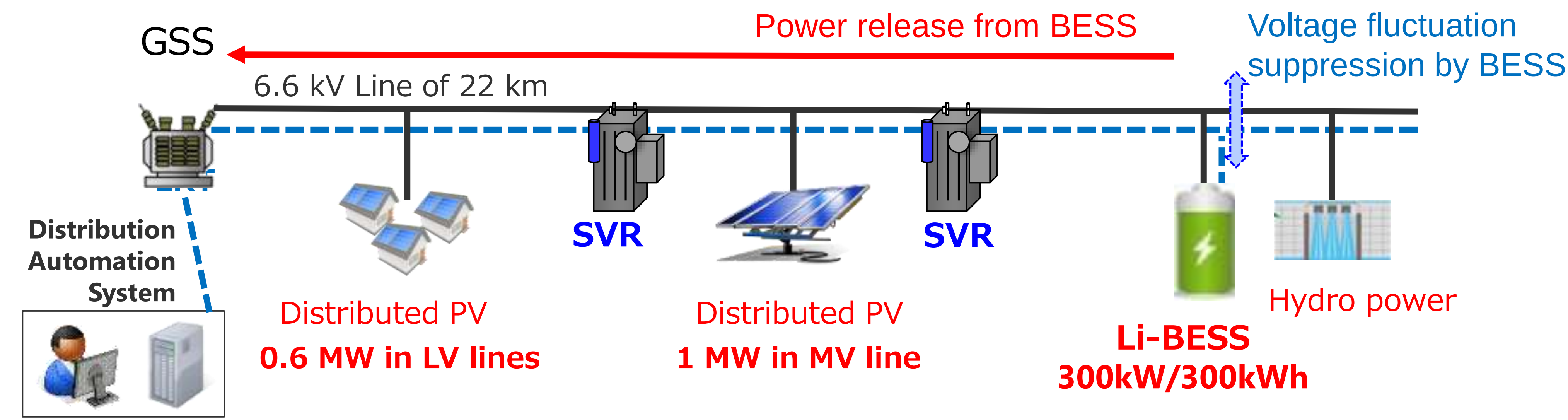
# Demonstration Plan for BESS Utilization

## Demonstration policy

Verification of
the possibility of advanced rational distribution network formation
as well as the effect of suppressing power overload and voltage fluctuation by controlling BESS.

## Demonstration Flow

1. Planning of use case scenarios
2. Modeling of the demonstration feeder
3. Simulation of the feeder
4. Carrying out of the BESS operation
5. Assessing the BESS operation





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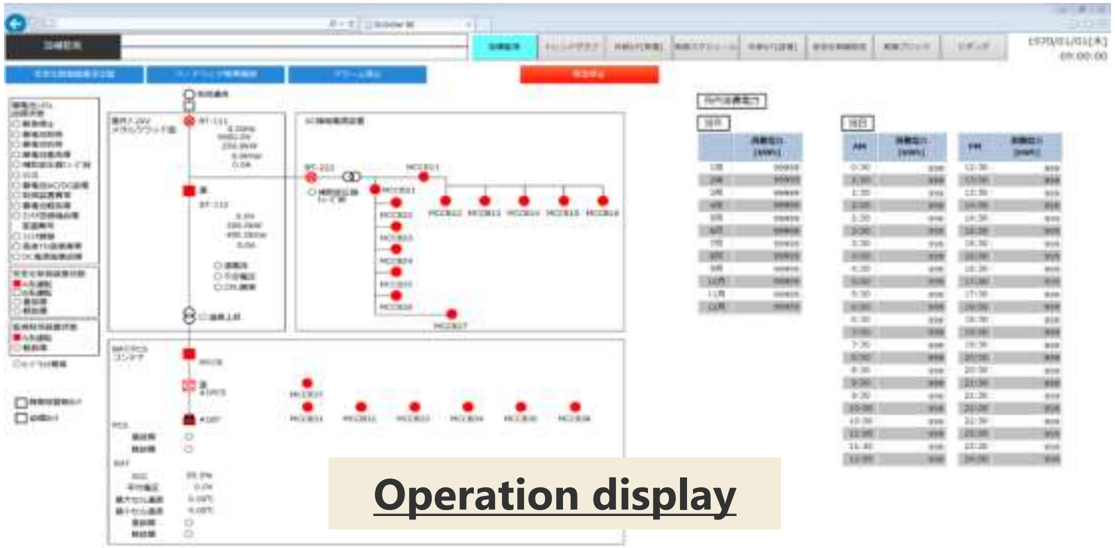
# BESS interconnected in the Demonstration Feeder









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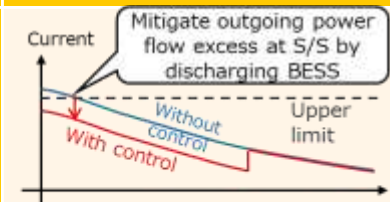
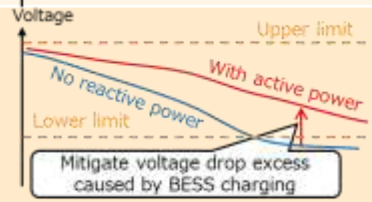
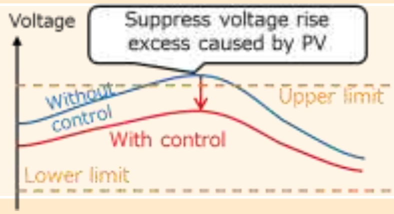
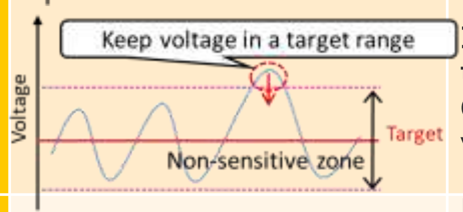
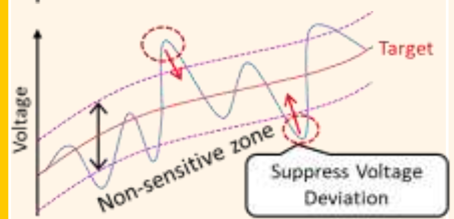
# Use Cases for Demonstration of BESS Control

| | Use Case | Control image | Use Case Scenario |
|---|---|---|---|
| ① | Power Flow Control |  | A current overload occurs at the outgoing feeder at the S/S, when a part of the section of the next feeder is switched to the next feeder due to a failure.<br>A reverse current overload occurs at the outgoing feeder at the S/S, when a large amount of RE is generated. |
| ② | Reactive Power Control |  | Direct control of reactive power from BESS to avoid peak voltage excursions. |
| ③ | Constant Power Factor Control |  | In case of the battery dispatch the active power to adjust SOC and this may have a bad influence on the feeder.<br>In order to avoid the voltage deviation, BESS carry out the constant power factor control. |
| ④ | Constant Target Voltage Control |  | In order to mitigate the voltage deviation due to the fluctuation of PV output, the BESS carry out the reactive power control to keep constant voltage. Confirming the possibility whether this solution contribute to reduce a voltage violation, or frequency of SVR tap change. |
| ⑤ | Voltage Violation Control |  | Likewise Constant Voltage Control, confirming the possibility whether the utilizing battery control contribute to reduce a voltage violation, or actuating cycle of SVR tap.<br>With respect to the target voltage, by executing the moving average processing for the past 10 minutes, it is an object of the present invention to perform control for outputting the reactive power to the short term voltage fluctuation and suppressing the short period voltage fluctuation. |



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# ① Result of Power Flow Control

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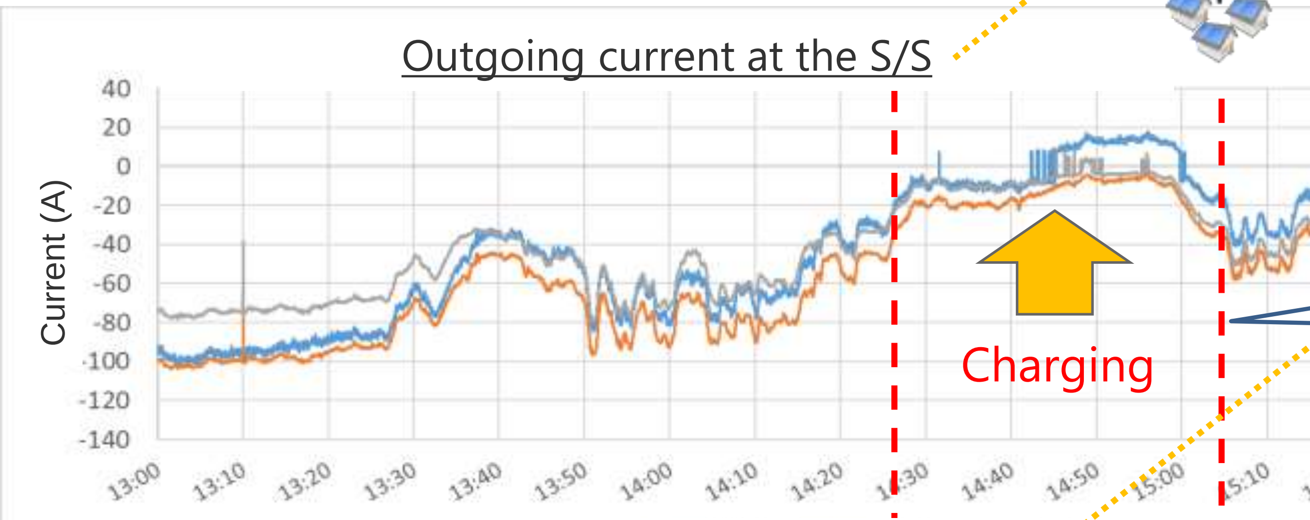
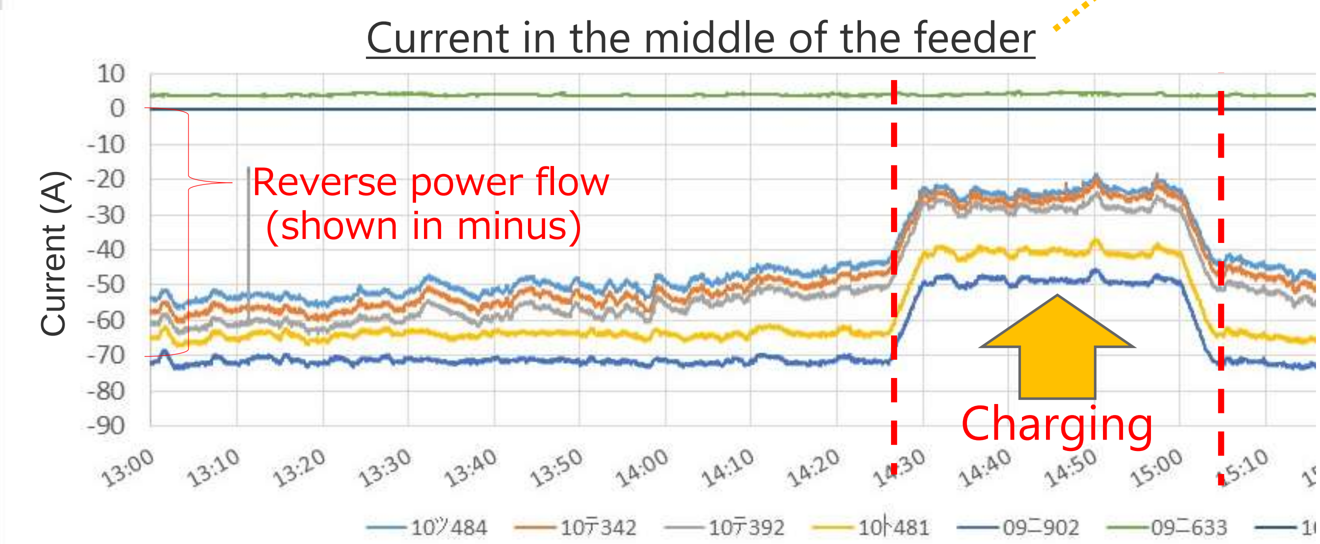



Reverse power flow was decreased by BESS charging.




- 100 kW charging to the BESS from 14:30 to 15:00 Control the BESS in P.F.-0.8
- Decrease of the reverse power (current) was observed by BESS charging in the 6.6 kV feeder.



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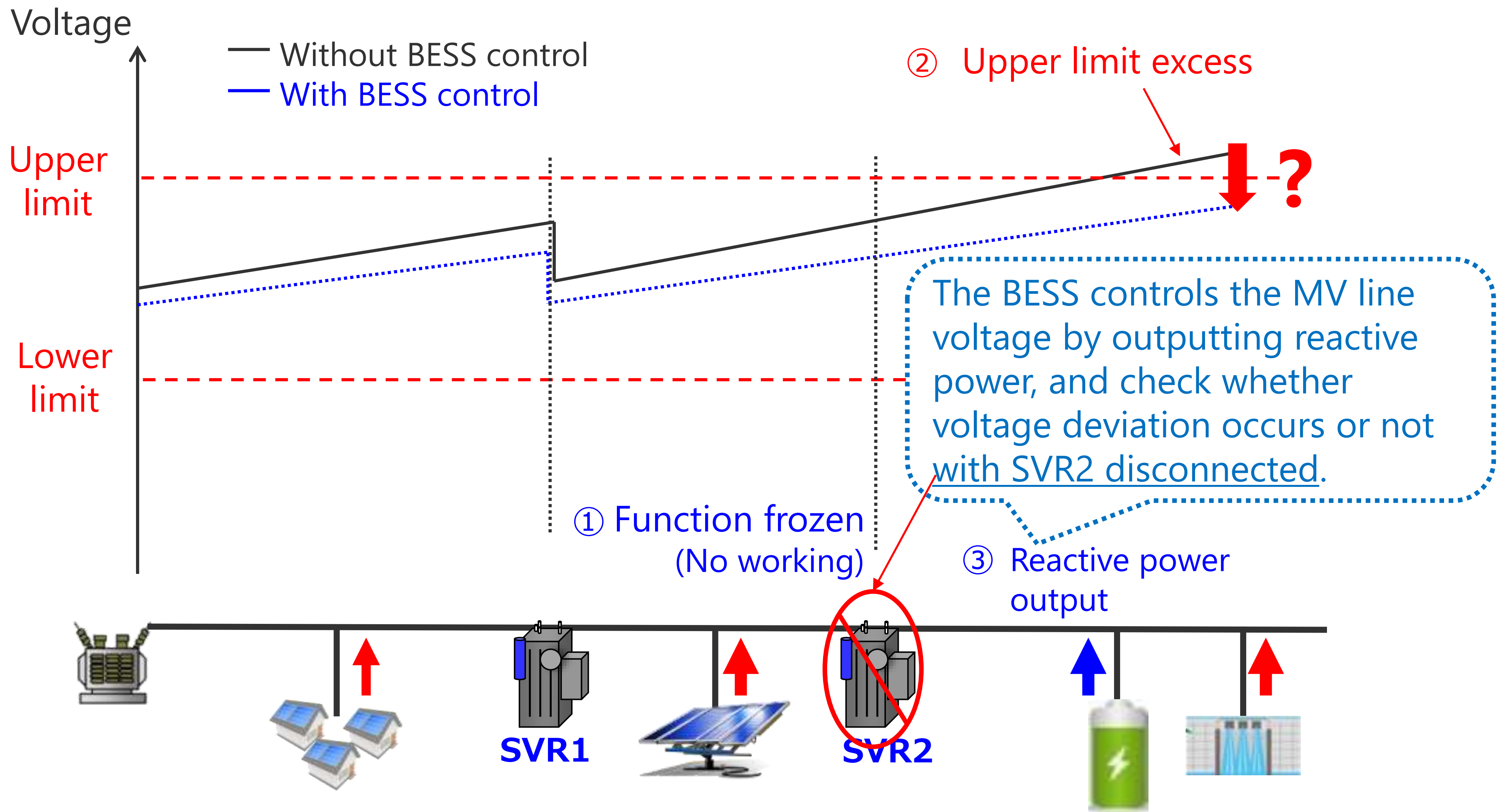
# ④ Additional Case Scenario of Constant Target Voltage Control
## - Potential of SVR Saving -



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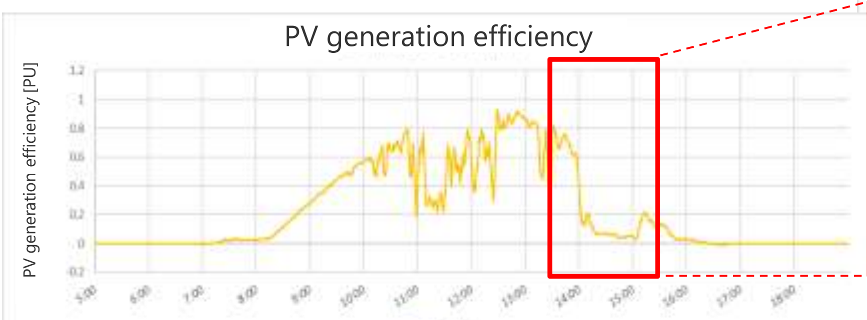
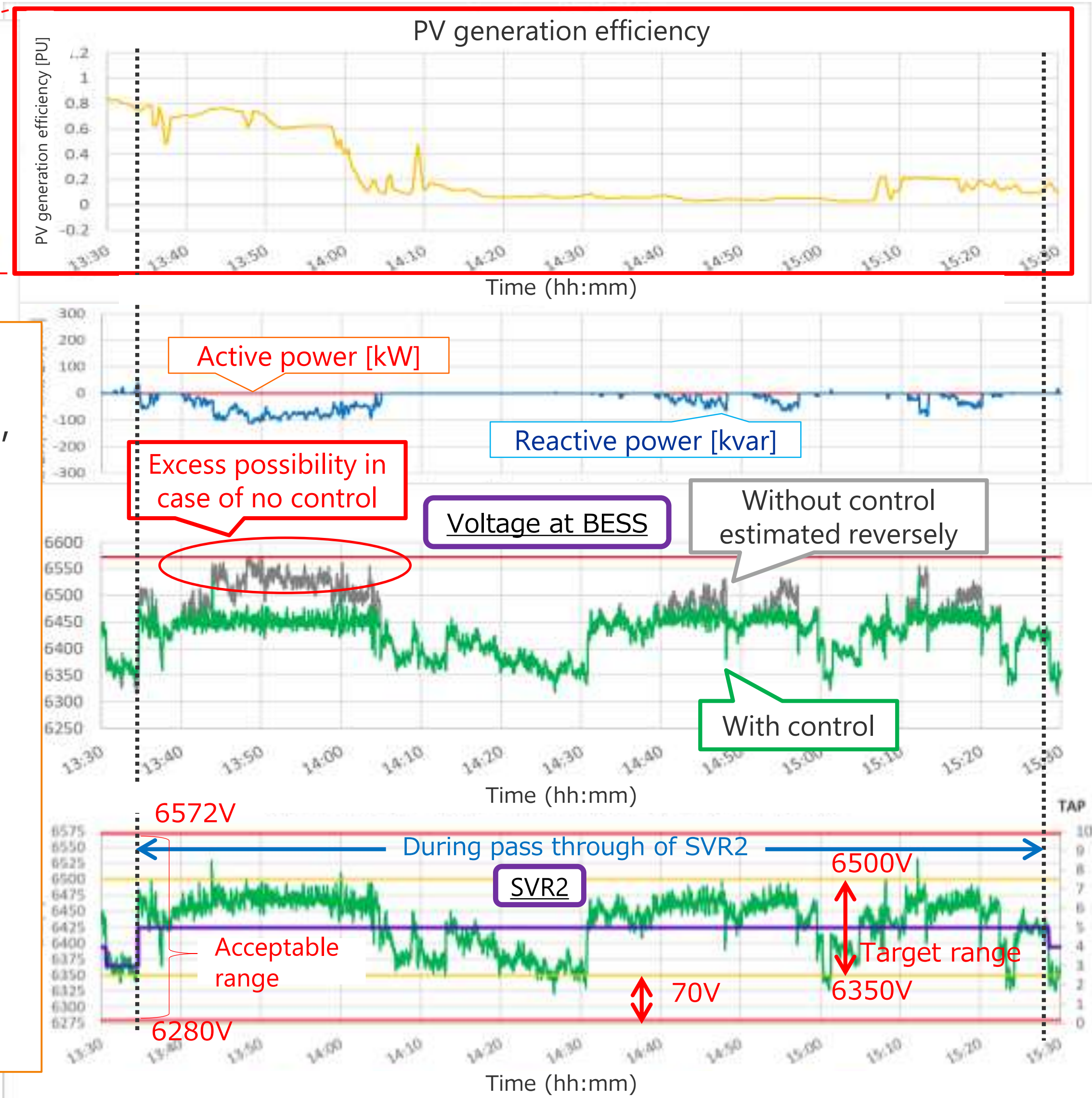
# ④ Result of Constant Target Voltage Control
## - Verification of SVR Saving -




- From 13:30 to 15:30, SVR2 was set to pass through (no regulation of passing voltage), and the target voltage was tried to control to be constant.
- The parameter of constant target voltage control was set so that the SVR2 voltage was kept within the target range (6350 to 6500V). As a result, it was kept within the acceptable range (6280 to 6571 V).
- It was confirmed that the distribution line voltage can be kept within the operating range and SVR2 could be saved by controlling the target voltage of the BESS within the constant target level.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# Conclusions

In a distribution network, the demonstration was conducted for the purposes of not only eliminating overload and suppressing voltage fluctuations but also rationalizing equipment by controlling the BESS.

## Verification results:

- **As for power flow control, by charging/discharging from the BESS, the MV line current could be controlled to eliminate the overloading.**
- **As for target range voltage control, by outputting reactive power from the BESS, the MV line voltage could be kept stable against the fluctuations of solar PV output.**
- **Furthermore, even in the conditions of the BESS on but the nearest SVR off, the MV line voltage could be kept stable, that verified a potential of equipment rationalization with BESS.**

## In the future:

- **The studies for the actual operation of advanced distribution systems using BESS, etc. will be studied further.**


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# Rational Formation of Distribution Network

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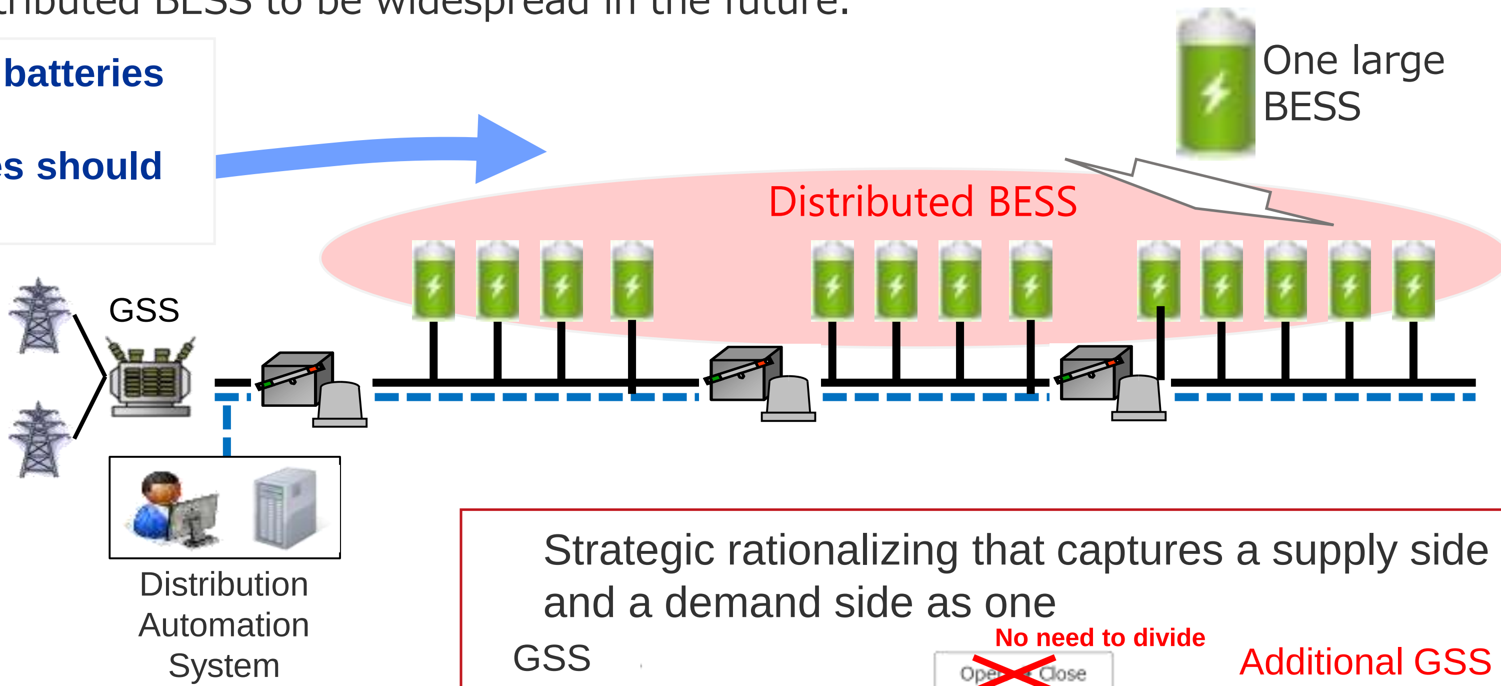
Based on the measurement data of power flow and voltage controlled by BESS, the optimal capacities and allocation of BESS required for rational formation of distribution network will be studied, expecting the possibilities of distributed BESS to be widespread in the future.

**How many quantity of batteries should be controlled?**
**Which located batteries should be controlled?**

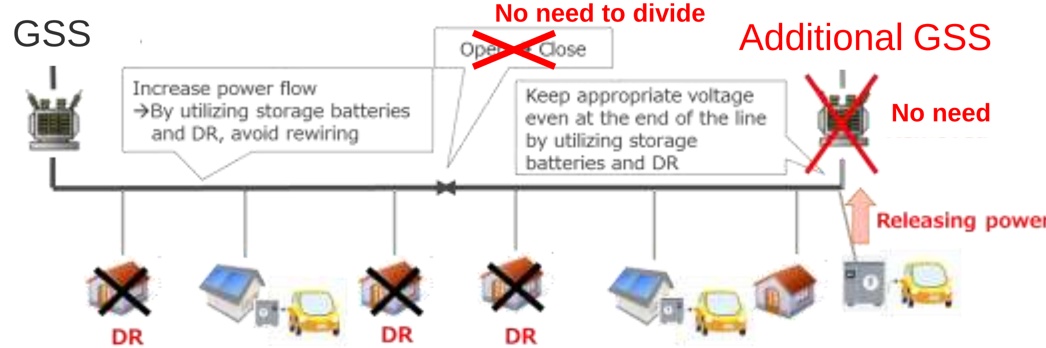



## Achieve rational network formation

**Optimizing the system formation**

- Reduce the number of SVR
- Save additional GSS, etc.

Strategic rationalizing that captures a supply side and a demand side as one




Peak demand can be controlled and reduced by DR.

[Source: modified from Game change to Utility 3.0 in energy industry in 2050]



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# 1st Seminar on System and Policy in Power Sector on Tariff Methodology

Ceylon Electricity Board
JICA Expert Team

August, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Outline of Electricity Tariff Establishment

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- Electricity tariff is specified in detail in Tariff Methodology (Nov., 2015) regarding the composition and its calculation method.
- Tariff Review, Adjustment, Approval of subsidies from The Treasury, etc. are complemented by Gazzete (July, 2016).
- The Tariff Period is 5 years and is currently the 2nd Tariff Period that started in 2016.

**TARIFF METHODOLOGY**

**Public Utilities Commission of Sri Lanka**

**November 2015**

Tariff Methodology

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The Gazette of the Democratic Socialist Republic of Sri Lanka
EXTRAORDINARY

අංක 1978/21 - 2016 අගෝස්තු මස 02 වැනි අඟහරුවාදා - 2016.08.02
No. 1978/21 - TUESDAY, AUGUST 02, 2016

(Published by Authority)

**PART I : SECTION (I) — GENERAL**

**Government Notifications**

L.D.B. 3/2009

SRI LANKA ELECTRICITY ACT, No. 20 OF 2009

RULES made by the Public Utilities Commission of Sri Lanka under Section 53 of the Sri Lanka Electricity Act, No. 20 of 2009, read with Section 30(3) of the aforesaid Act.

Chairman,
Public Utilities Commission of Sri Lanka.

Colombo,
29th July 2016.

Gazette



Source: Tariff Methodology, Gazette

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# Tariff Components

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## BST (Bulk Supply Tariff)

- Bulk Supply & Operation Business (Non Wired) Allowed Revenue
- Transmission (Wire Business) Allowed revenue
- Payments to Generation (CEB, IPP, SPP)

Loss factor at voltage level

→ **Bulk Supply Pass Through Tariff**

Distribution Tariff (Dis. Allowed revenue)

Retail Service Tariff (Commercial cycle cost)

→ **Retail Supply Tariff (End User Tariff)**



Source: Tariff Methodology

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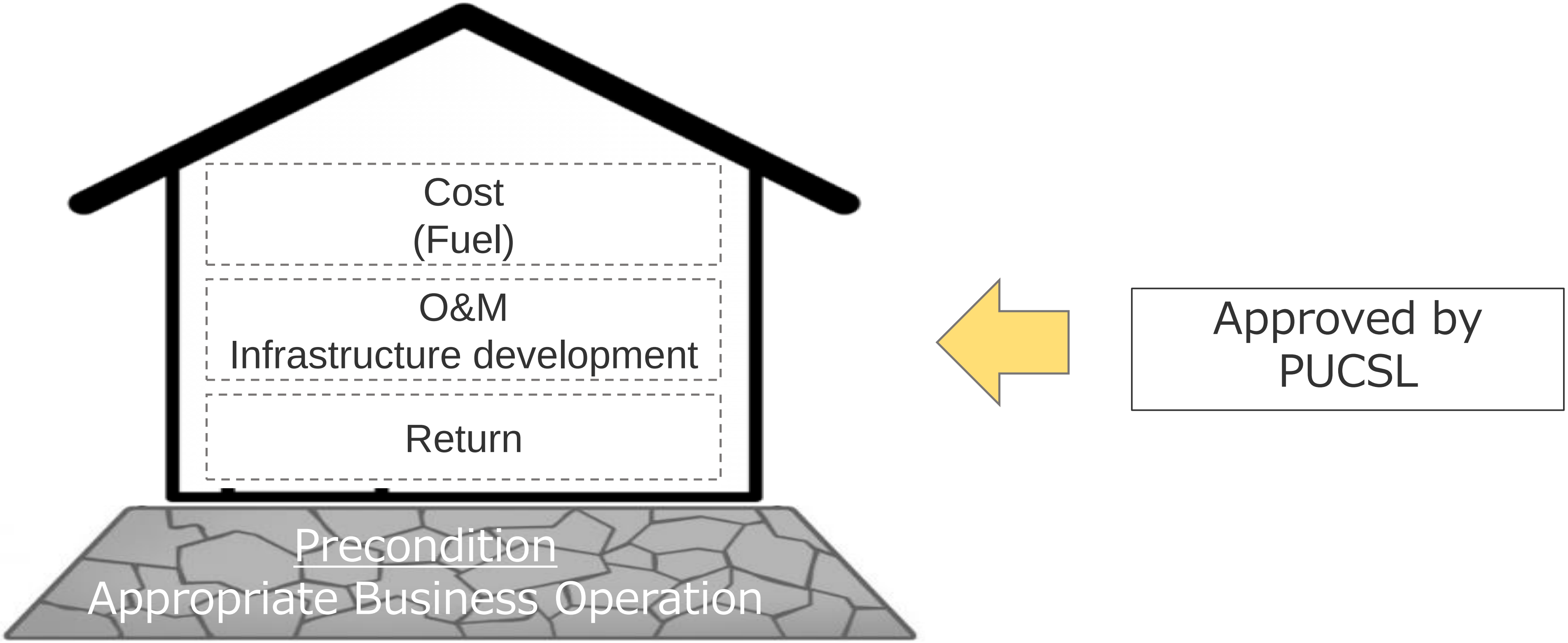
# Calculation of Electricity Tariff

- The cost and appropriate profit for each proper business segment (power generation, transmission, distribution, retail) are examined by PUCSL, and each Tariff element is decided individually after approval.
- Technical losses in the Transmission System will be allowed to be the passed-through to Bulk Supply Tariffs.




Fully distributed cost method



Source: Tariff Methodology

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# Introduction of Uniform National Tariff (UNT)

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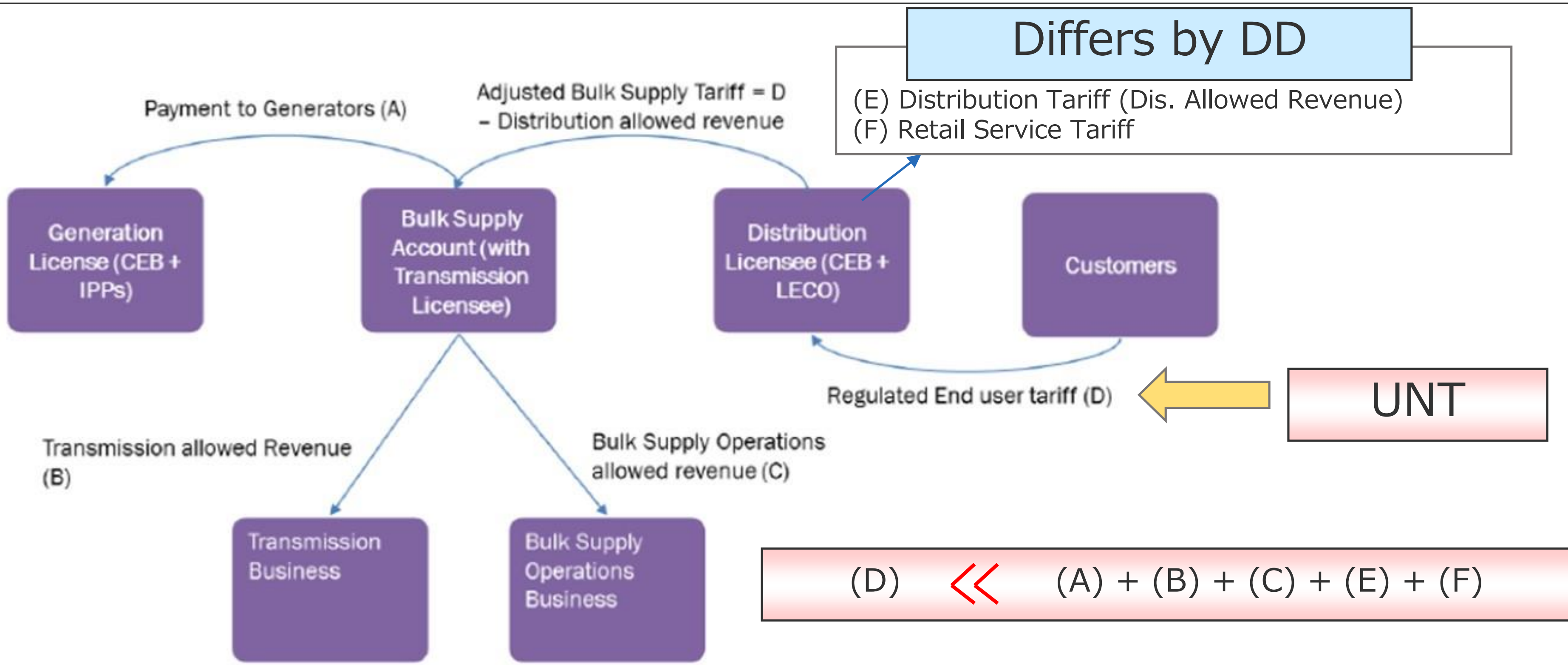
- UNT was introduced to "End user tariff" in 2016, and End user tariff has become uniform nationwide. It will continue until the completion of the Second period, and is expected to continue thereafter.
- There is a big gap between End User Tariff and the total of the electricity supply cost.
- Since the density of consumers varies from area to area, the cost of operating a distribution business varies greatly by areas






Source: CEB, Tariff Methodology

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# Subsidy

- Bulk supply pass through tariff rate, Distribution tariff and Retail service tariff rate have not been prepared since UNT was installed
- The difference between the Approved Revenues for each Licensees and the revenues generated by UNT is compensated as subsidies by GOSL
- Subsidies have been calculated every year and submitted to PUCSL

| No. | Year | Month/s | Subsidy Amount (MLKR) | Revenue | Ratio |
|---|---|---|---|---|---|
| 1 | 2016 | Jan-Dec | 58,368.13 | 206,892.00 | 28% |
| 2 | 2017 | Jan-Dec | 80,875.66 | 218,450.00 | 37% |
| 3 | 2018 | Jan-Dec | 43,149.07 | 229,557.00 | 19% |
| 4 | 2019 | Jan-Dec | 101,916.42 | 242,950.00 | 42% |
| 5 | 2020 | Jan- May | 20,466.36 | N.A | |
| | Accumulated Total | Jan 2016 – May 2020 | 304,775.64 | | |

**Subsidies account for large portion compared to Revenue**



Source: CEB, Tariff Methodology

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# Subsidies Scheme and Its Record

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- ➢ Subsidies are provided by Treasury after being approved
- ✓ Section 30 (4) of the "Sri Lanka Electricity Act"
- ✓ Clauses 18 & 19 of "General Policy Guidelines"
- ✓ Projection and approval procedure of subsidies are descried in Gazette

## Electricity Act

(4) Notwithstanding any other provision of this Act, the Commission may—

(*a*) upon being satisfied of the adequacy of funds being provided by the Treasury to bear the cost of any subsidy approved by the Government to subsidize consumers ; and

(*b*) considering any cross subsidy recoverable from such categories of consumers as determined by the Commission,

set tariffs and charges to be levied by the licensee, which reflect such subsidies.

## General Policy Guidelines

18. The lifeline tariff to domestic consumers will be limited to Samurdi Beneficiaries and to a monthly household consumption of 30kWh. The related subsidy component estimated as 50% of the cost of supply will be fully financed through Government grants.

19. Notwithstanding above, licensees will be compensated adequately for all reasonable costs, if they are compelled to sell electricity to any category of consumers at subsidized prices, on directives by the GOSL.

| Year | Grants received from GoSL (LKR Mn.) |
|---|---|
| 2016 | - |
| 2017 | (46.80) by ADB |
| 2018 | - |
| 2019 | - |
| 2020 up to date | 48,000.00 |
| Total | 48,000.0 |

- GOSL provided LKR 48 billion by offsetting CEB's fuel expense due to CPC in 2020.
- Likewise, consulting cost of wind-solar hybrid project amounting to LKR 0.0468 billion (46.8 million) was provided by ADB in 2017 not by Government.


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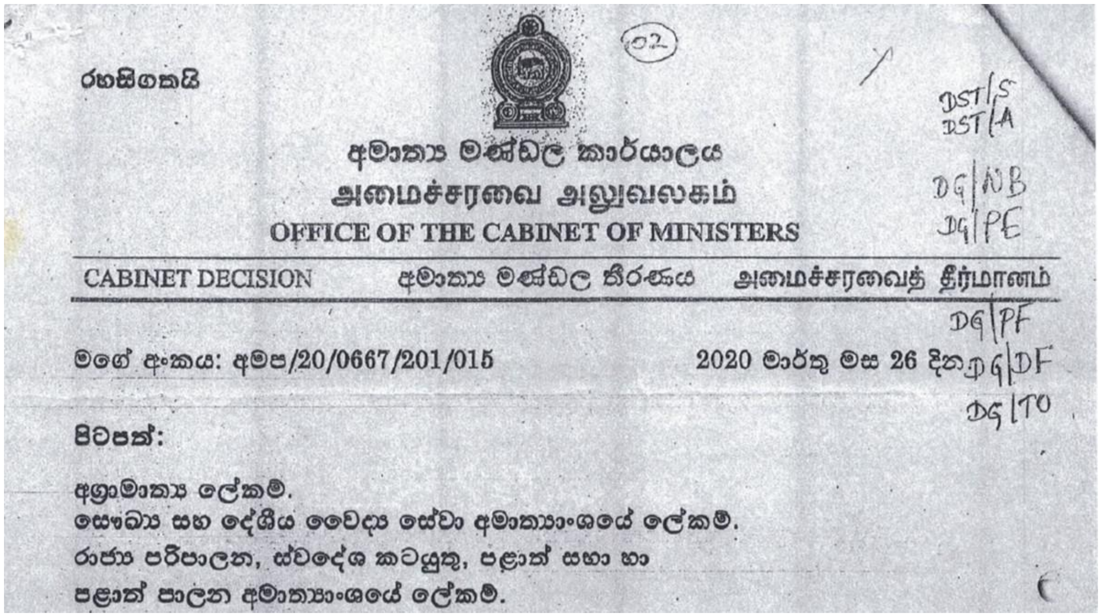
# Subsidy Record from GOSL

- LKR 48 billion in 2020.



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அமைச்சரவை அலுவலகம்

OFFICE OF THE CABINET OF MINISTERS

CABINET DECISION අමාත්‍ය මණ්ඩල තීරණය அமைச்சரவைத் தீர்மானம்

මගේ අංකය: අමප/20/0667/201/015 2020 මාර්තු මස 26 දින

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Source: CEB

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# Tariff Block

- There are many number of tariff blocks in Residential and religious categories
- There is cross subsidy and its degree is too big.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Unit Charge | | | | Fixed Charge |
| **DOMESTIC** | | | | | | | | | |
| **Consumption 0 - 60 kWh per month** | | | | | | | | | |
| Block 1 | - | 0 - 30 | units | @ | Rs 2.50 | per unit | + | | Rs 30.00 |
| Block 2 | - | 31 - 60 | units | @ | Rs 4.85 | per unit | + | | Rs 60.00 |
| **Consumption above 60 kWh per month** | | | | | | | | | |
| Block 1 | - | 0 - 60 | units | @ | Rs 7.85 | per unit | + | | N/A |
| Block 2 | - | 61 - 90 | units | @ | Rs 10.00 | per unit | + | | Rs 90.00 |
| Block 3 | - | 91 - 120 | units | @ | Rs 27.75 | per unit | + | | Rs 480.00 |
| Block 4 | - | 121 - 180 | units | @ | Rs 32.00 | per unit | + | | Rs 480.00 |
| Block 5 | - | Above 180 | units | @ | Rs 45.00 | per unit | + | | Rs 540.00 |

Almost 20 times bigger

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RELIGIOUS & CHARITABLE INSTITUTIONS** | | | | | | | | |
| Block 1 | - | 0 - 30 | units | @ | Rs 1.90 | per unit | + | Rs 30.00 |
| Block 2 | - | 31 - 90 | units | @ | Rs 2.80 | per unit | + | Rs 60.00 |
| Block 3 | - | 91 - 120 | units | @ | Rs 6.75 | per unit | + | Rs 180.00 |
| Block 4 | - | 121 - 180 | units | @ | Rs 7.50 | per unit | + | Rs 180.00 |
| Block 5 | - | Above 180 | units | @ | Rs 9.40 | per unit | + | Rs 240.00 |

Tariff Sheet (Lightning), Chubu

| Category | | Unit | Unit Charge* (tax incl.) |
|---|---|---|---|
| Basic Charge | Contract for 10 A Current | Per Month | 286.00yen |
| | Contract for 15 A Current | | 429.00yen |
| | Contract for 20 A Current | | 572.00yen |
| | Contract for 30 A Current | | 858.00yen |
| Electricity Usage Charges | First 120 kWh | Per 1 kWh | 21.04yen |
| | Over 120 kWh up to 300 kWh | | 25.51yen |
| | Over 300 kWh | | 28.46yen |
| | Minimum Monthly Charge | Per Contract Per Month | 258.24yen |

*Does not include fuel consumption adjustment unit cost.

Source: CEB, Chubu


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# Other Countries' Condition of Cross Subsidy

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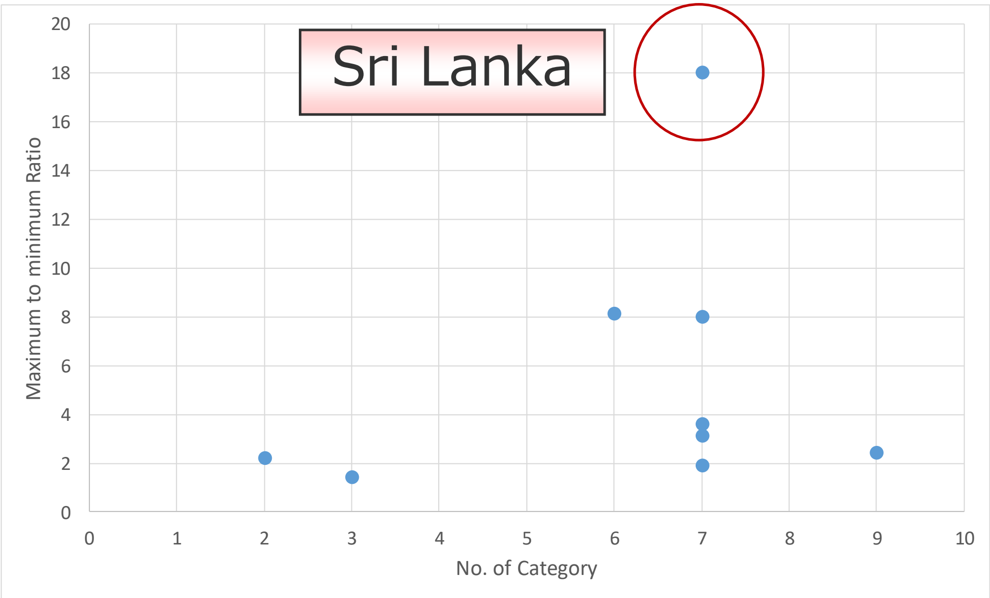
- Sri Lanka has a slightly higher number of electricity tariff categories than other similar countries and has strong tendency of Cross Subsidy.

| Country | No. of Blocks | Maximum to minimum Ratio |
|---|---|---|
| Indonesia | 6 | 8.1 |
| Thailand (PEA) | 7 | 1.9 |
| Bangladesh | 7 | 3.1 |
| Nepal | 9 | 2.4 (30 Ampere Case) |
| Myanmar | 7 | 3.6 |
| Mongol | 2 | 2.2 to Vulnerable Group |
| Jordon | 7 | 8.0 |
| Japan (Chubu) | 3 | 1.4 |
| Sri Lanka | 7 | 18.0 |





Source: HP information of each countries' electric power utilities
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# Summary

- Tariff was originally designed as "The fully distributed cost method" that can recover all the costs incurred, but since the introduction of UNT in 2016, it has become impossible to recover them.
- The portion that cannot be recovered is supposed to be provided by GoSL as Subsidy.
- Subsidy was granted only once in 2020, and the purpose of it was "Offsetting CEB's fuel expense" which was different from the original one and inadequate. It is necessary to review from the viewpoint of autonomous electric power business continuity.
- Cross subsidy for vulnerable groups tends to be stronger than similar countries.



Source: JICA

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# 1st Seminar on System and Policy in Power Sector on CEB Financial Analysis

Ceylon Electricity Board
JICA Expert Team

August, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# 1. Recent Financial Status of CEB (discussions in 2020)

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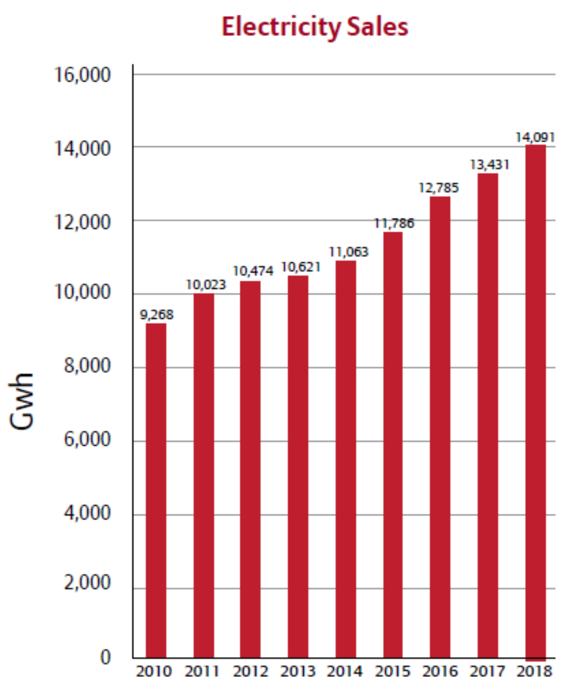
## Operational Performance

- CEB's electricity energy sales has increased consistently as demand grows over years
- However, CEB has continuously recorded gross deficit recently
- Also, finance cost (interest payments) has hiked quickly resulting in large net loss (- 12.6% of sales and – 3.3% ROA in 2018)




(LKR million)

| | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| Summary Income Statement | | | | | |
| Revenue | 202,645 | 188,684 | 206,811 | 218,450 | 229,571 |
| Cost of Sales | (213,646) | (168,781) | (222,097) | (260,273) | (250,891) |
| Gross Profit/ (Loss) | (11,001) | 19,903 | (15,286) | (41,823) | (21,320) |
| Other Income & Gain | 5,871 | 8,292 | 10,323 | 8,143 | 9,450 |
| Administrative Expenses | (3,146) | (4,087) | (4,965) | (5,110) | (5,425) |
| Finance Income | 304 | 434 | 1,048 | 1,194 | 1,466 |
| Finance Cost | (7,030) | (5,134) | (4,311) | (8,415) | (13,036) |
| Profit/ (Loss) before Income Tax | (15,002) | 19,408 | (13,191) | (46,011) | (28,865) |
| Operational Performance | | | | | |
| Average selling price per unit (LKR/kWh) | 18.50 | 16.00 | 16.18 | 16.26 | 16.29 |
| Average cost per unit at selling point (LKR/kWh) | 20.00 | 15.07 | 18.08 | 20.34 | 19.12 |
| Gross profit margin | -5.4% | 10.5% | -7.4% | -19.1% | -9.3% |
| Net Cash Flow from Operations (LKR million) * | - | 21,353 | 18,441 | 22,051 | (17,273) |
| New Bank Loans (LKR million) * | - | 319 | 6,049 | 2,582 | 62,169 |

* Indicators from financial analysis in CEB Corporate Plan 2019-2023



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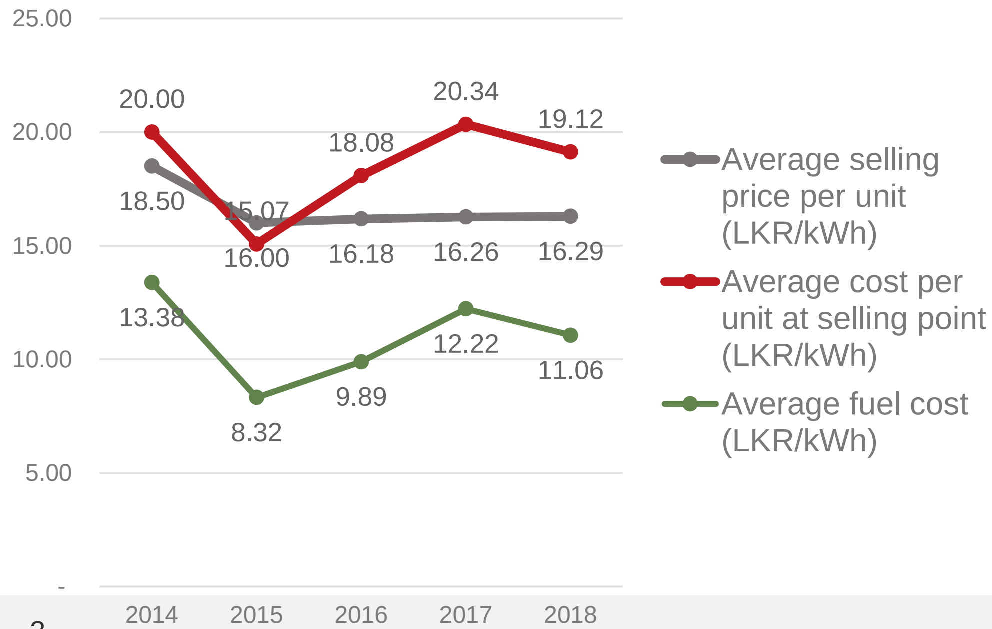
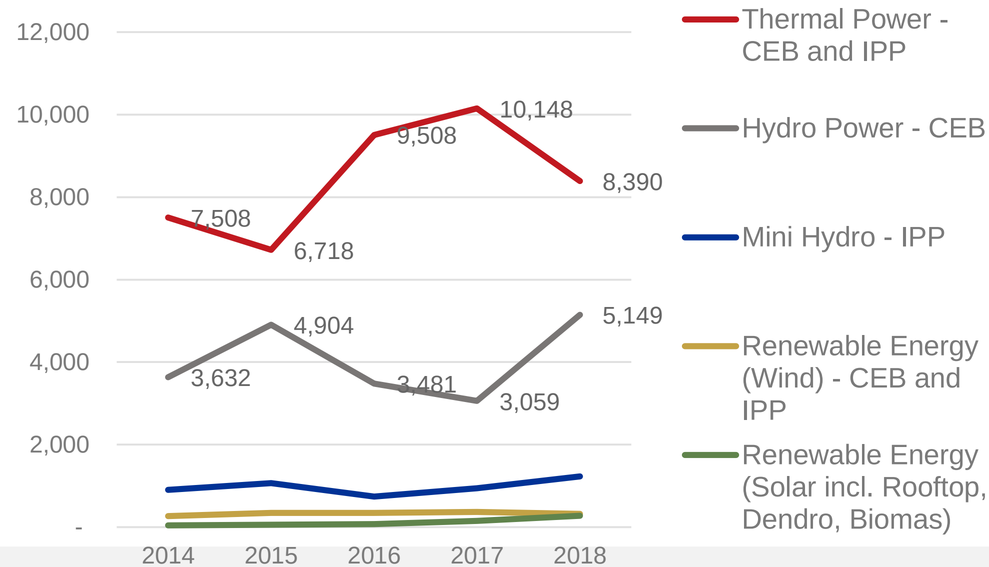
# Average electricity selling price vs. average cost

- The main cause of CEB's operational deficit is that the recent selling price does not reflect the generation and distribution cost.
- Average selling price stuck around LKR 16.20/kWh as average cost fluctuates around LKR 18 – 20/kWh. Fuel cost change directly affects the average cost as the thermal power accounts for around 60% of total generation.
- The situation was worsened during the period with dry hydrology conditions as CEB had to depend on high cost thermal power generation instead of hydro power.

## Average selling price and cost




## Energy Generation by Source (GWh)



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# Average electricity revenue by customer category

- CEB's average electricity revenue is steady over recent years because electricity tariff has not been revised since 2014.
- As compared to the total average, domestic, industrial and religious customers enjoy lower tariff level by cross-subsidizing from other customer categories.

| *Avg. Price LKR/kWh* | 2016 | 2017 | 2018 |
|---|---|---|---|
| Domestic | 13.42 | 13.48 | 13.60 |
| Non-domestic | | | |
| Religious | 7.15 | 7.21 | 7.28 |
| General Purpose | 23.90 | 23.74 | 23.78 |
| Hotel | 17.74 | 17.73 | 17.62 |
| Industrial | 14.63 | 14.77 | 14.72 |
| Government | 18.34 | 18.26 | 18.23 |
| Bulk Supply to LECO | 15.77 | 15.79 | 15.53 |
| Total | 16.18 | 16.26 | 16.29 |


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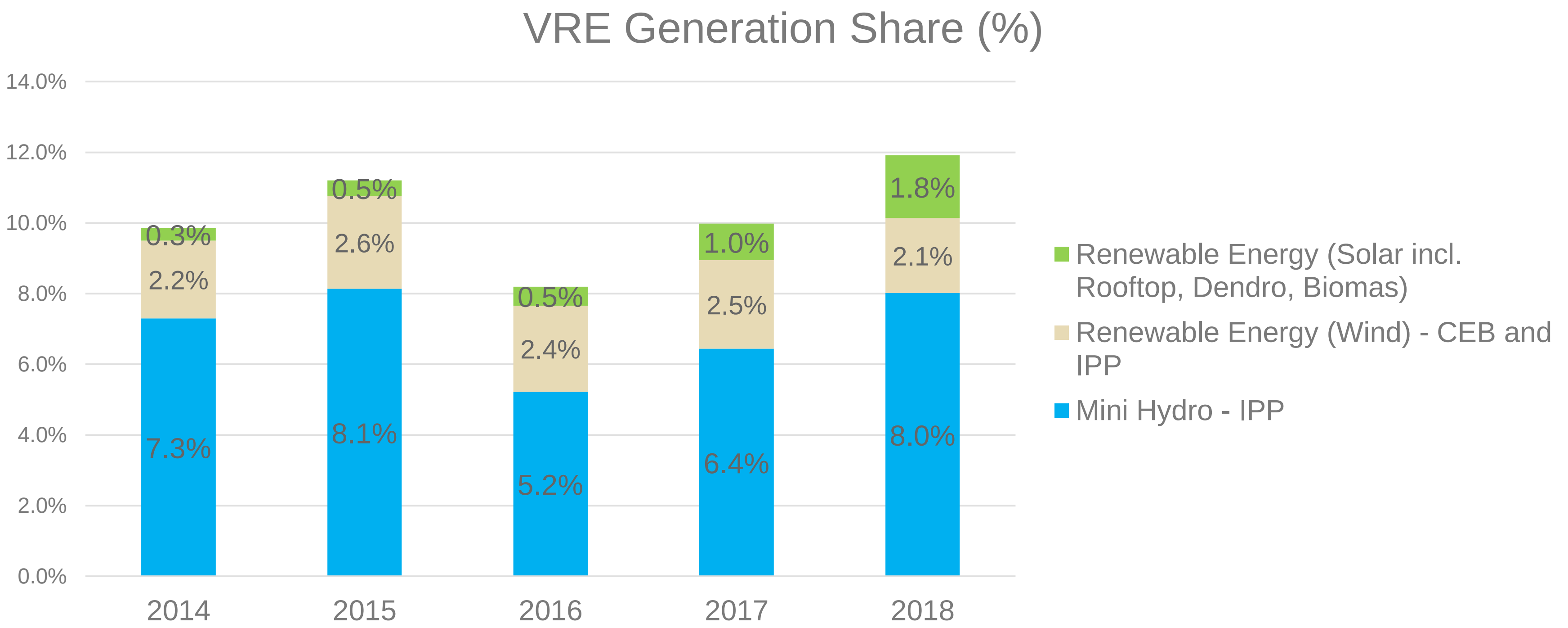
# NCRE generation trend

- Non-conventional Renewable Energy's share has grown gradually over years.
- Especially, solar, dendro and biomas generation share has increased from 0.3% in 2014 to 1.8% in 2018.
- In the face of increasing VRE generation, further financial burden is anticipated for CEB's operation:
  - Investment in transmission and distribution facilities for stable power system
  - Payments for VRE generation cost





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# Financial Position

- Current ratio indicates CEB had ability to meet its short-term obligations from 2014 to 2016 but it was gradually deteriorated from 2017.
- Assets have consistently increased as CEB invested in its power system and generation facilities.
- Funding structure increasingly relies on debt financing as indicated by the debt to assets ratio. (0.48 in 2014 to 0.73 in 2018)
- The debt service coverage ratio (DSCR) was greater than 1.0 in 2015 – 2016 indicating the core operation was able to generate sufficient cash flow to meet the debt service (interest payments and principal repayments). However, the ratio has dropped since 2017 indicating CEB's financial viability has been deteriorated.

(LKR million)

| | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| Summary Balance Sheet | | | | | |
| Assets | 764,035 | 776,852 | 804,354 | 831,990 | 870,920 |
| Property, Plant & Equipment | 681,471 | 694,415 | 704,695 | 724,065 | 747,049 |
| Liabilities | 369,204 | 347,225 | 390,991 | 464,798 | 533,276 |
| Interest Bearing Loans and Borrowings | 202,821 | 198,344 | 201,752 | 214,564 | 281,262 |
| Equity | 394,831 | 429,627 | 413,363 | 367,192 | 337,644 |
| Contributed Capital | 289,038 | 302,228 | 302,695 | 302,695 | 302,695 |
| Reserves | 27,434 | 28,463 | 30,283 | 32,783 | 34,830 |
| Retained Earnings | 78,359 | 98,936 | 80,385 | 31,714 | 119 |
| Total Equity & Liabilities | 764,035 | 776,852 | 804,354 | 831,990 | 870,920 |
| Financial Indicators | | | | | |
| Current Ratio | 0.87 | 1.16 | 0.89 | 0.62 | 0.73 |
| Debt to Assets | 0.48 | 0.45 | 0.49 | 0.56 | 0.61 |
| Debt Service Coverage Ratio (DSCR) * | - | 2.94 | 1.04 | (0.80) | 0.29 |

* Indicators from financial analysis in CEB Corporate Plan 2019-2023


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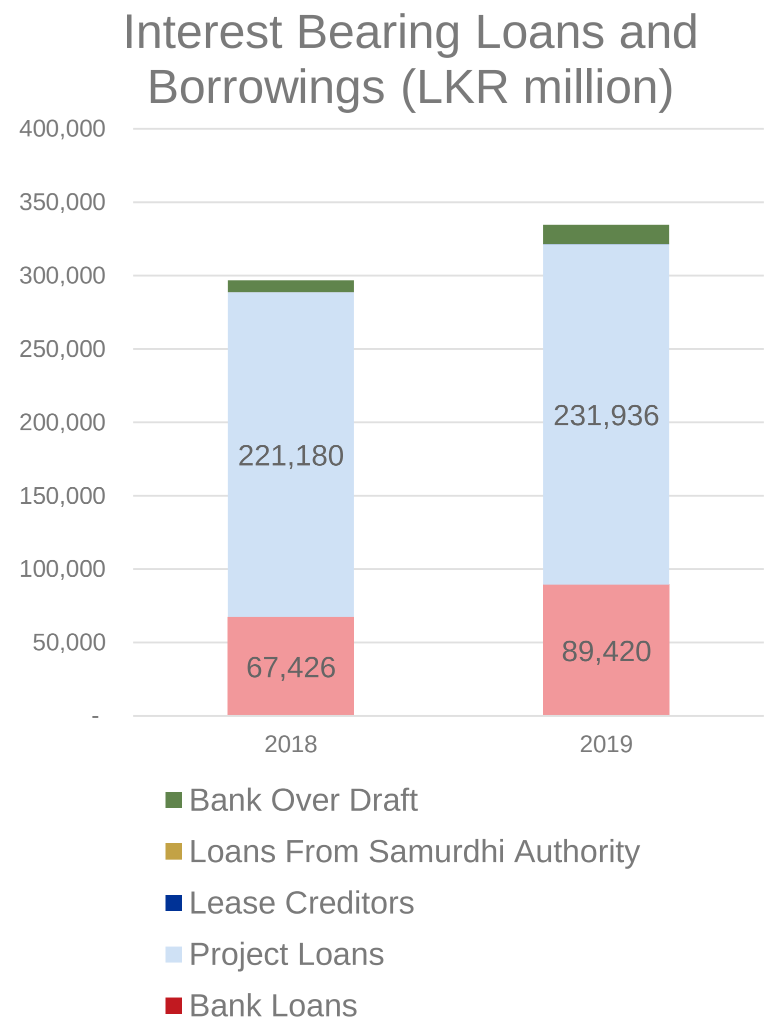
# Debt Structure and Government Capital Injection

- Most borrowings of CEB are project loans provided by bilateral and multilateral financial institutions such as ADB, JICA, AFD, etc.; 91% of which (LKR 210 billion) are subsidiary loans through GOSL treasury.
- Subsidiary loan interest rates are as high as 6% - 10% p.a. (Subsidiary loan conditions for JICA loans are not determined)
- In 2019 LKR 16.9 billion debt to treasury was transferred to equity.





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# 2. Preliminary Financial Projection (2021- 2030)

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## General Assumptions

- Inflation rate 4.0% p.a.
- Average electricity sales Rs. 16.65/kWh (2021 tariff level)
- Direct generation cost (based on 2021 budget)

| | |
|---|---|
| CEB Thermal - Oil | Rs.18.88/kWh |
| CEB Thermal – Coal | Rs.6.93/kWh |
| CEB New LNG Thermal | Rs.16.22/kWh |
| IPP | Rs.25.24/kWh |
| NCRE | Rs.17.27/kWh (Annual decrease of 3%) |

- Indirect O&M Cost Rs.5.18/kWh (based on 2021 budget)
- Year-on-year depreciation increase 4%
- Annual capital expenditure for existing facilities Rs. 35,000 mn


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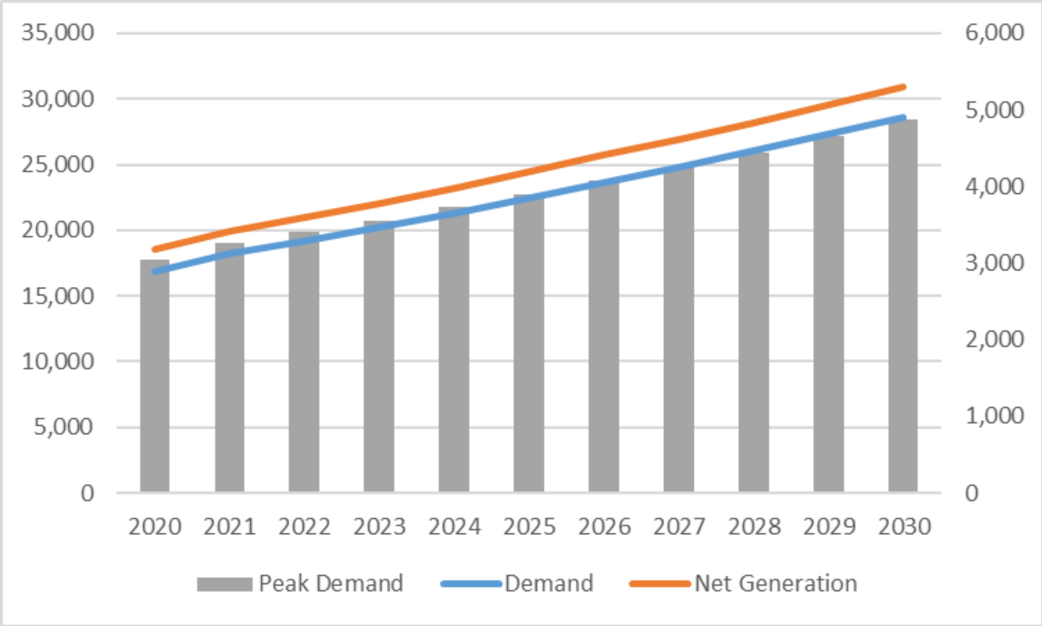
## Demand and Generation (LTGEP)

- **LTGEP 2020 – 2039** projects steady increase in demand and generation based on the previous economic assumptions.

- Currently the updating to **LTGEP 2022 – 2041** is underway.

- Once the draft LTGEP 2022 – 2041 is provided to JICA Project Team, the latest demand and generation forecast will be incorporated in the projection.



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# Preliminary results

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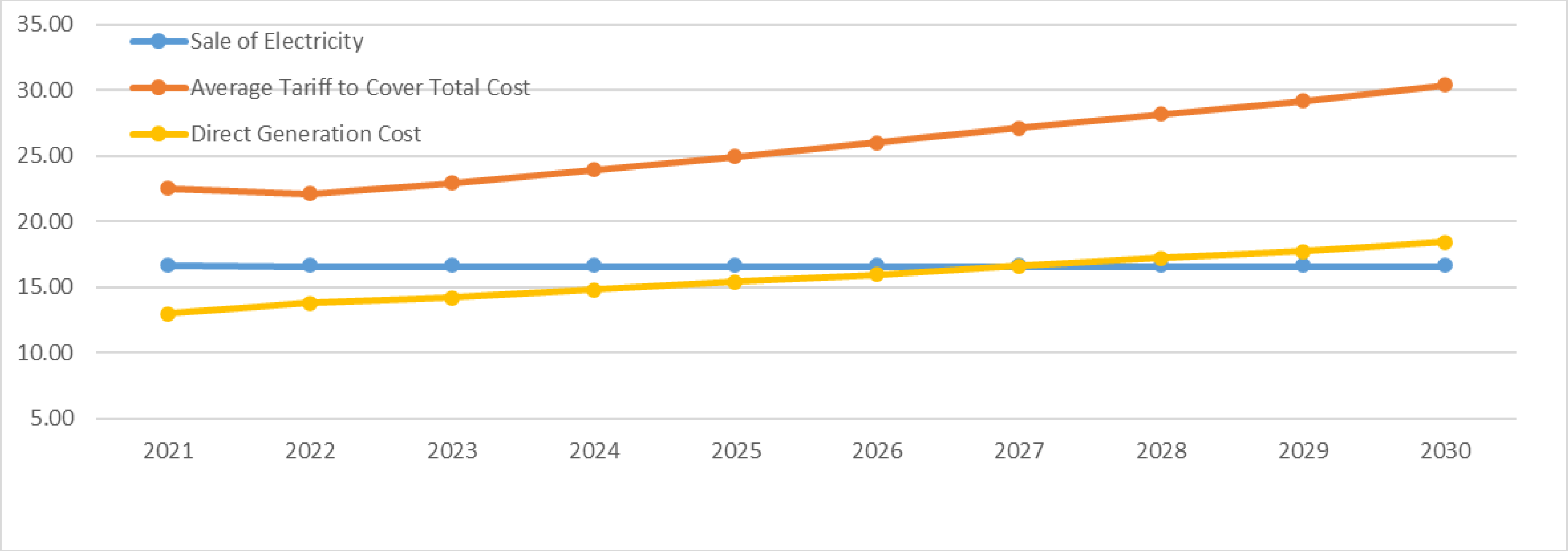
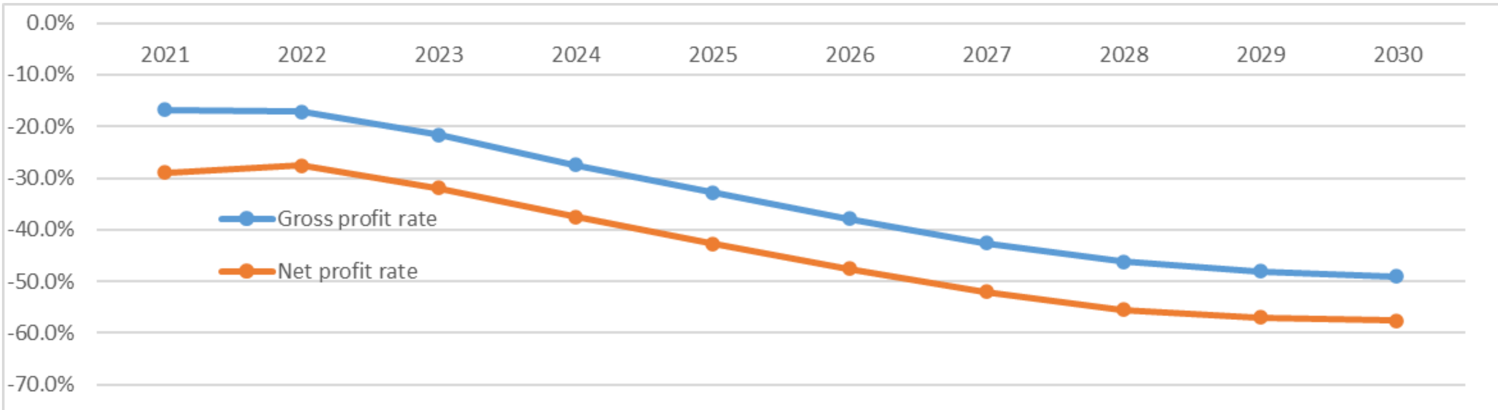
EI

- Assuming the average electricity tariff at 2021 level (Rs.16.65/kWh), energy cost cannot cover the total cost.

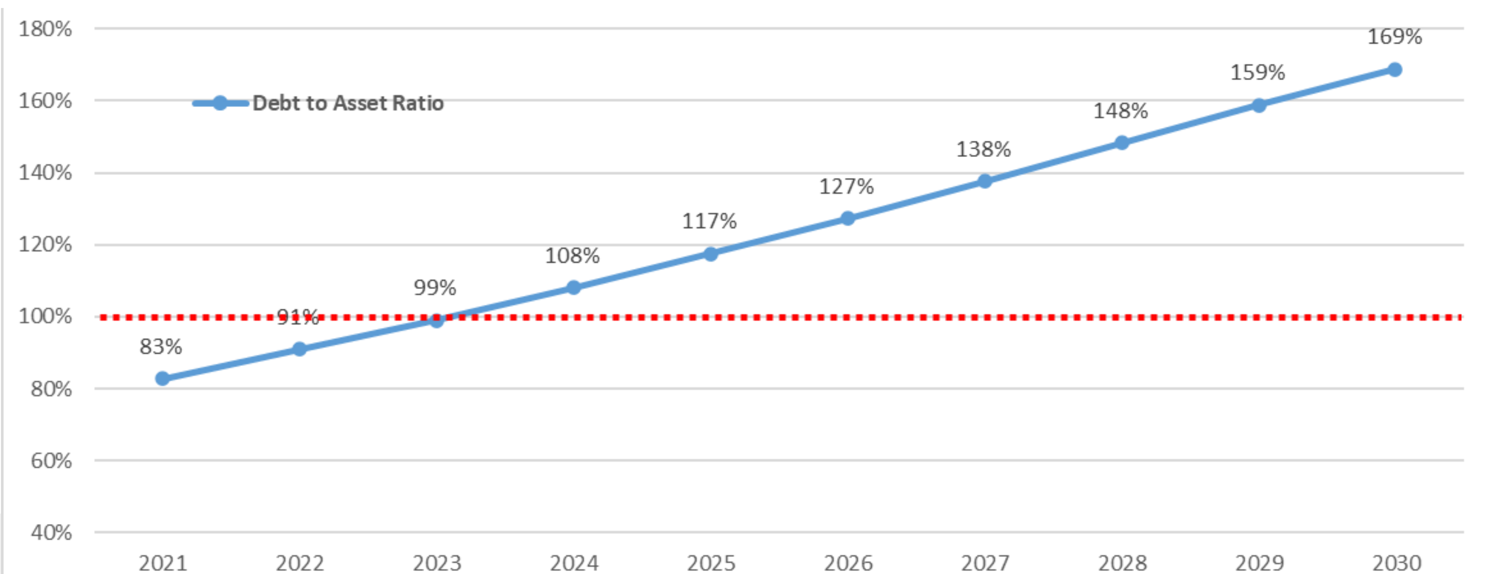
| | | | Budget 2021 | Forecast 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Electricity Demand and Dispatch** | | | | | | | | | | | | |
| Energy Sales | GWh | | 15,796 | 19,187 | 20,233 | 21,337 | 22,501 | 23,667 | 24,819 | 26,025 | 27,279 | 28,573 |
| Generation | GWh | | 17,507 | 20,960 | 22,064 | 23,230 | 24,458 | 25,697 | 26,919 | 28,196 | 29,523 | 30,890 |
| **Cost per Energy Sales** | | | **18.75** | **19.70** | **20.29** | **21.16** | **22.00** | **22.83** | **23.73** | **24.60** | **25.40** | **26.43** |
| Direct Generation Cost | | | 13.01 | 13.81 | 14.17 | 14.82 | 15.41 | 15.98 | 16.62 | 17.21 | 17.72 | 18.45 |
| Indirect OPEX | | | 5.75 | 5.89 | 6.11 | 6.35 | 6.59 | 6.85 | 7.11 | 7.39 | 7.68 | 7.98 |
| **Sale of Electricity per Energy Sales** | | Rs.16.65/kWh | **16.65** | **16.65** | **16.65** | **16.65** | **16.65** | **16.65** | **16.65** | **16.65** | **16.65** | **16.65** |
| **Average Tariff to Cover Total Cost** | | | **22.50** | **22.13** | **22.90** | **23.95** | **24.97** | **26.00** | **27.11** | **28.18** | **29.17** | **30.38** |



- Due to the operational deficit, profitability of CEB will be consistently negative…




- Resulting in negative net worth around mid-2020s unless the government provides debt-equity swap.





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## Further analysis

- Incorporating the draft LTGEP 2022 – 2041 data

- Projection based on newly proposed regulatory setup (review of FIT tariff, increased tariff level, etc.)


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# 1st Seminar on System and Policy in Power Sector on Simultaneous Achievement of Sound Financial Status of CEB and Promotion of VRE Installation

Ceylon Electricity Board
JICA Expert Team

August, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Contents




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# 01 Current CEB FIT Scheme


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# Metering Scheme of FIT Tariff

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- **There are three (3) Metering Systems as below for Roof-Top PV system.**
- **Customers who installs roof-top PV system can select the one of Metering System among three systems.**

## i) Net Metering

| Period | Notes |
|---|---|
| 20 years | ✓ This system started in 2010. Initially, started as 10 years contract scheme.<br>✓ No financial compensation for the excess energy exported by the consumer.<br>✓ All exports will be set-off against the consumer's own consumption.<br>✓ This scheme is open for all Renewable Energy forms including PV. |

- The installed capacity shall not exceed the Contract Demand for household. (A few customers have one MW contract)
- Electricity bill is prepared for the difference between the import & the export registers.
- If the export is more than the import, the Consumers receive an export credit, and it is carried over to next month to offset the consumption.
- Such Credits may be carried-over to subsequent months, as long as there is no legal change

No review has been made on this basic scheme since 2010
Only Contract Period was changed in 2016 from 10 years to 20 years.


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# Metering Scheme of FIT Tariff cont'd

## ii) Net Accounting

| Period | Notes |
|---|---|
| First 7 years | ✓ LKR 22.00/unit for export energy from the customer |
| 8th year to 20th year | ✓ LKR 15.50/unit for export energy from the customer |

- This scheme is limited only for roof-top PV
- The Contract Period is 20 years
- The installed capacity shall not exceed the Contract Demand for household. (A few customers have one MW contract).
- The energy will be measured by one energy meter. The meter measures difference of import/export energy.

No review has been made on this scheme since 2016

In "Net Metering" & "Net Accounting" scheme, power generation and consumption are offset, which means high electricity tariff payment is avoided and leads to the loss of CEB finance.


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# Metering Scheme of FIT Tariff cont'd

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## iii) Net Plus

| Period | Notes |
|---|---|
| First 7 years | ✓ LKR 22.00/unit for export energy from the customer |
| 8th year to 20th year | ✓ LKR 15.50/unit for export energy from the customer |

- This scheme is limited only for roof-top PV.
- The Contract Period is 20 years
- The installed capacity shall not exceed the Contract Demand for household. (A few customers have one MW contract).
- Total energy of electricity from the roof-top PV will be metered through a dedicated export energy meter for which the customer will be paid.
- The energy import will be measured through a separate import energy meter.

No review has been made on this scheme since 2016

"Net Plus" is fare scheme for both customers and CEB, since all generation power and consumed power is counted separately.

# 02 CEB Financial Status


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# CEB Financial Status surrounding the Electric Power Business

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- FIT Tariff is included in the CEB power generation cost.
- Average Electricity Tariff is significantly lower than Average Cost, and a deficit is piled up in the electric power business, which is the main business of CEB.

| | | Actual 2019 Rs.Mn. | Revised Budget 2020 | Budget 2021 Rs.Mn. |
|---|---|---|---|---|
| **Average Tariff** | **Rs./kWh** | **16.62** | **16.40** | **16.65** |
| Average Direct Generation Cost | Rs./kWh | 14.95 | 14.14 | 13.00 |
| Average Indirect OPEX Cost (with Dep) | Rs./kWh | 8.35 | 7.72 | 9.51 |
| **Average Cost** | **Rs./kWh** | **23.29** | **21.86** | **22.51** |
| Other Income | Rs./kWh | 0.82 | 0.87 | 0.81 |
| **Net Profit/Loss per unit** | **Rs./kWh** | **(5.84)** | **(4.58)** | **(5.05)** |

Source: CEB

- The operating balance is in the red and the business situation is unhealthy
- Electricity Tariff has not increased since 2014.
- Spare parts for O&M are purchased by USD on the other hand electricity tariff is collected in LKRs. LKR is getting weaker than USD because of high infraction in Sri Lanka. This also gives the negative impact to CEB financial status.



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# Budgeted Cash Flow Statement 2021

- A large ordinary loss is expected in 2021
- Business continuity is difficult without Subsidy

| Description | Budget 2021 Rs.Mn. |
|---|---|
| Cash Received from Electricity Debtors | 257,772 |
| Debenture Issue | 20,000 |
| Other Income | 12,862 |
| **Total Receipts** | **290,634** |
| Payment for IPP | 100,000 |
| Payment for Coal | 50,000 |
| Payment for CPC | 41,000 |
| Payment for NCRE | 50,000 |
| **Direct Generation Cost** | **241,000** |
| Payment for Indirect O & M Cost | **116,875** |
| **Total Operation Expenses** | **357,875** |
| **Net Cash Inflow / (Outflow) from Operations** | **(67,241)** |
| **Less : Capital Investments of CEB own funds** | **35,000** |
| **Capital Repayment of Loans** | **30,280** |
| **Total Cash Inflow / (Outflow)** | **(132,521)** |
| Opening Cash Balances | (11,478) |
| **Net Deficit** | **(143,999)** |
| **Funds to be Obtained to Finance the Budget Deficit** | **150,000** |
| **Closing Cash Balance as at 31st Dec** | **6,001** |

Reduction of power generation costs, which occupy a large weight in Cost, is required for the business improvement

Source: CEB



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# Brief Summary of the CEB Financial Analysis

## Review of Recent Financial Status of CEB

- ✓ Despite steady growth in electricity demand, CEB consistently records operational deficit mainly due to the electricity tariff kept low (Rs. 16.2 – 16.6/kWh) since 2014.
- ✓ CEB's operation is not able to finance its debt service for the project loans borrowed from the government

## Financial Projection of CEB (to be discussed in policy and systems seminar)

### Projection under Existing Policies

- Scenario under current tariff level and VRE regulatory setup — We are here
- Results show current financial challenges of CEB: CEB will have negative net worth in around 5 years in future

### Projection under Proposed Policies

- Scenario under proposed improvement of VRE policies and regulations
- e.g. revision of FIT tariff, Fuel Cost Adjustment, overall electricity tariff level, etc.


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# 03 Business Environmental Change surrounding VRE


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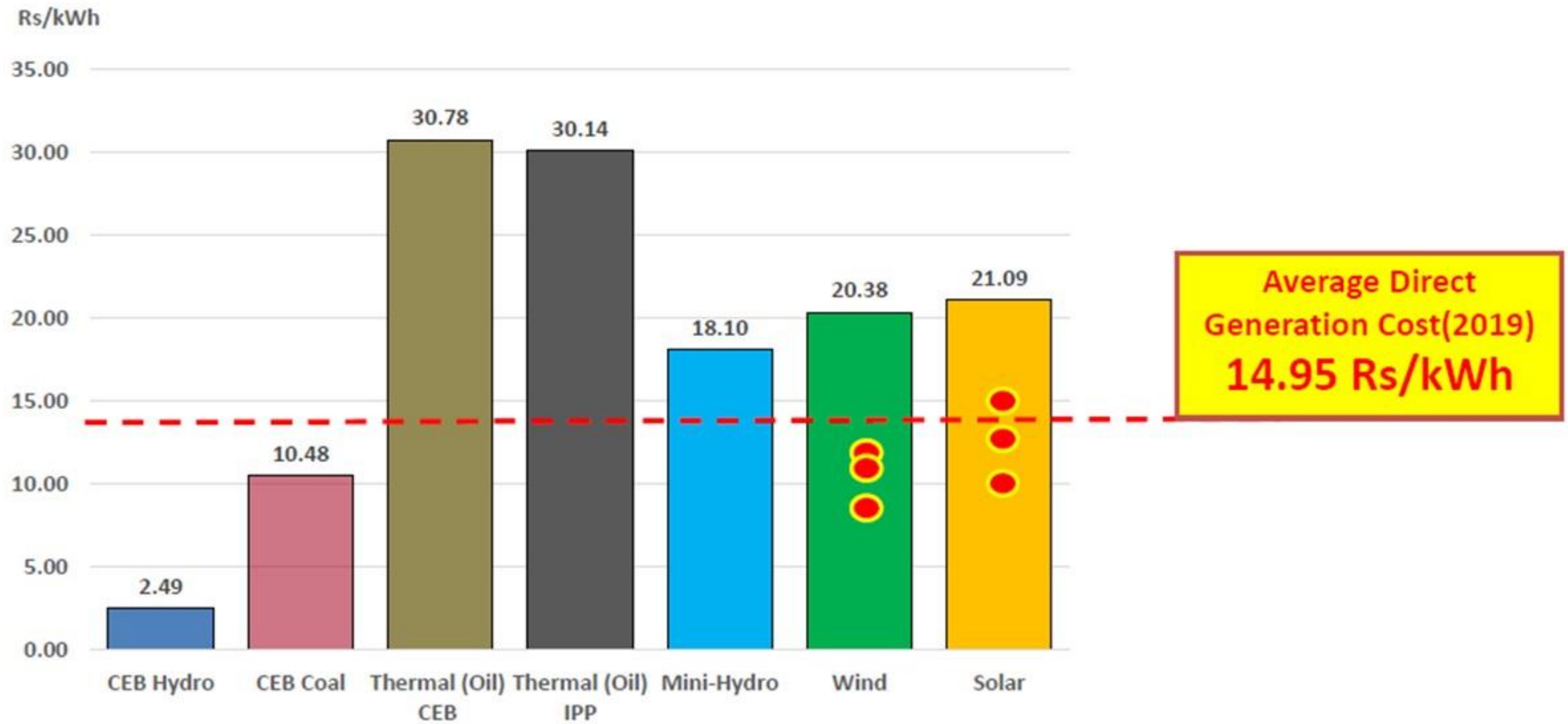
# Average Unit Cost of Generation (2019)

- VRE's Average Generation Cost are more economical than IPP-based oil thermal power generation, but they are about twice as big as coal-fired power, which is the leading conventional power source.
- Recent VRE projects are becoming more economical and some are below the Average Generation Cost (2019)






Source: CEB

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# Trend Across the Globe

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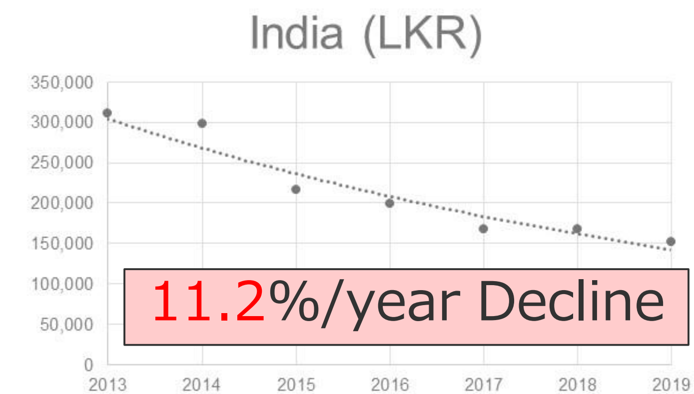
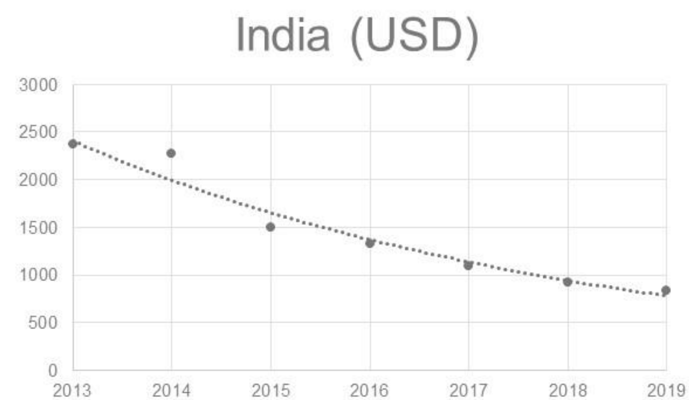
- Significant price declines across the world
- Price decline in neighboring India on [PV Installation Cost for Residential] are:
  Average rate of decline 11.2% / year in 6 years on LKR denominated
  (Average rate of decline 15.9% / year in 6 years on USD denominated)

| Sector | Market | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 USD/kW | | | | | | | | | |
| Residential | Australia | 7 715 | 6 126 | 4 301 | 3 670 | 3 424 | 2 198 | 1 988 | 1 738 | 1 557 | 1 380 |
| | Brazil | | | | 3 947 | 3 657 | 3 458 | 2 664 | 2 126 | 1 604 | 1 350 |
| | China | | | 2 823 | 2 432 | 2 330 | 1 672 | 1 591 | 1 436 | 1 079 | 840 |
| | France | | 9 797 | 6 950 | 5 773 | 4 231 | 2 359 | 2 174 | 1 967 | 1 771 | 1 600 |
| | Germany | 4 277 | 3 634 | 2 712 | 2 414 | 2 229 | 1 750 | 1 704 | 1 645 | 1 746 | 1 646 |
| | India | | | | 2 374 | 2 276 | 1 501 | 1 326 | 1 093 | 916 | 840 |
| | Italy | 6 949 | 6 106 | 4 031 | 3 660 | 2 438 | 1 983 | 1 803 | 1 676 | 1 527 | 1 460 |
| | Japan | 7 314 | 7 228 | 6 237 | 4 601 | 3 771 | 3 313 | 2 927 | 2 685 | 2 361 | 2 250 |
| | Malaysia | | | | 2 871 | 2 861 | 2 423 | 2 227 | 1 792 | 1 466 | 1 191 |
| | Republic of Korea | | | | 3 036 | 3 056 | 2 166 | 2 079 | 1 707 | 1 527 | 1 440 |
| | South Africa | | | | 4 140 | 3 684 | 3 109 | 2 916 | 2 602 | 2 231 | 1 843 |
| | Spain | | | | 2 871 | 2 438 | 1 758 | 1 633 | 1 509 | 1 445 | 1 410 |
| | Switzerland | | | | 3 864 | 3 440 | 3 216 | 3 022 | 2 716 | 2 421 | 2 173 |
| | Thailand | | | | 4 019 | 3 121 | 2 798 | 2 726 | 2 362 | 1 944 | 1 388 |
| | United Kingdom | | | | 3 300 | 3 475 | 3 007 | 2 668 | 2 692 | 2 597 | 2 566 |
| | California (US) | 7 756 | 7 325 | 6 323 | 5 475 | 5 155 | 5 231 | 5 053 | 4 529 | 4 294 | 4 096 |
| | Other US states | 7 705 | 7 049 | 5 697 | 4 921 | 4 954 | 4 925 | 4 280 | 3 844 | 3 702 | 3 652 |




15.9%/year Decline


Source: Renewable Power Generation Costs in 2019, IRENA
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# Present Cost and Past Trend (LKR denominated)



- Value of 2020 shows the current market price
- Values of 2015-2019 are assumed ones using the Indian trend based on the current market price

| Solar PV Capacity | Average Installation Cost (LKR/kW) | | | | | |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Up to 5kW | (325,000) | (289,000) | (257,000) | (228,000) | (203,000) | 180,000* |
| 5kW to 10kW (middle income class) | (307,000) | (273,000) | (243,000) | (215,000) | (191,000) | 170,000* |
| 10kW to 1MW | (199,000) | (177,000) | (157,000) | (139,000) | (124,000) | 110,000* |
| More than 1MW | (172,000) | (153,000) | (136,000) | (120,000) | (107,000) | 95,000* |

| Solar PV Capacity | Levelized Cost of Electricity** (LKR/kWh) | | | | | |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Up to 5kW | (25.48) | (22.63) | (20.10) | (17.86) | (15.86) | 14.09 |
| 5kW to 10kW (middle income class) | (24.07) | (21.38) | (18.99) | (16.87) | (14.98) | 13.31 |
| 10kW to 1MW | (15.57) | (13.83) | (12.28) | (10.91) | (9.69) | 8.61 |
| More than 1MW | (13.45) | (11.95) | (10.61) | (9.43) | (8.38) | 7.44 |

Conditions;
Operation period: 20 years
Capacity factor: 17.0%
O&M cost: 0.9% of installation cost
Deterioration rate: 0.7%
Discount rate: 8%

* Source: KHMSolar and latest PV projects (1MW, 100kW, 400kW)
** It should be assumed by sum of installation and O&M cost.

**Significant reduction in power generation costs**

# Trend of FIT Tariff and Installation Volume in Japan

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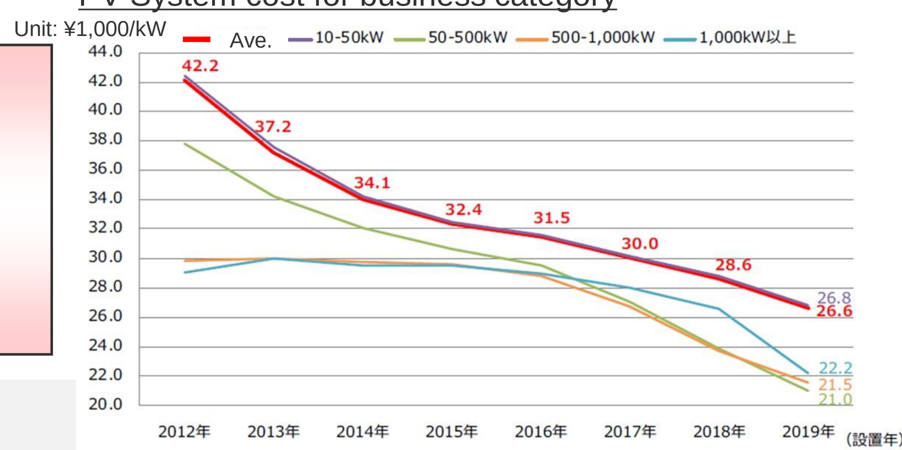
- The FIT Tariff is reviewed every year. The volume of introduction has been reduced as it fell.
- It is necessary to lower the FIT Tariff from the viewpoint of appropriate business compensation as PV panel cost declines.

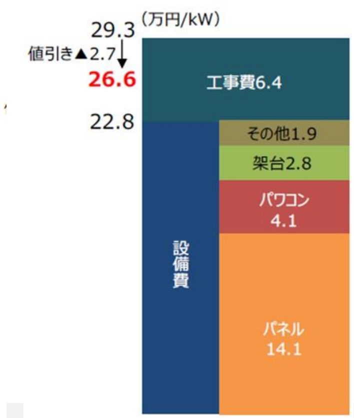
| Type of PV | Before | After FIT scheme was introduced | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ～June, 2012 | FY2012 July～ | FY2013 | FY2014 | FY2015 | FY2016 | FY2017 | FY2018 | Total volume under FIT |
| PV, Household | 4.70GW | 0.97GW | 1.31GW | 0.82GW | 0.85GW | 0.79GW | 0.66GW | 0.42GW | 5.83GW |
| =>10kW | | ¥42/kWh | ¥38/kWh | ¥37/kWh | ¥33/kWh | ¥31/kWh | ¥28/kWh | ¥26/kWh | |
| PV, Business | 0.90GW | 0.70GW | 5.74GW | 8.57GW | 8.31GW | 5.44GW | 4.77GW | 3.70GW | 37.22GW |
| <10kW | | ¥40/kWh | ¥36/kWh | ¥32/kWh | ¥29-27/kWh | ¥24/kWh | ¥21/kWh | ¥18/kWh | |

Detailed info. is shown in P.6 to 9

The FIT Tariff has not been reviewed in Sri Lanka for a long time, which possibly means that the business reward is unreasonably high.
→It should be reviewed

PV System cost for business category






Source: Agency for Natural Resource and Energy

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# Stage of VRE Promotion Scheme

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- As the cost of VRE power generation declines, the system shall be gradually amended.
- Complete transition to Competitive Bidding is achieved when it has the same level of competitiveness as conventional generation (Grid Parity)

PV generation cost would be going to decline.

| Current | FIT tariff review in accordance with PV generation price | FIP tariff is decided as the sum of "Market Price" and "subsidy". Whole sale market is necessary. | Fully competitive stage |
|---|---|---|---|
| FIT | FIT price declining | Feed In Premium | Competitive Bidding |

We are here
"FIT tariff Revision" and "FIT Applied Range Review" would be effective


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# Competitive Bidding & FIT Tariff Revision Range

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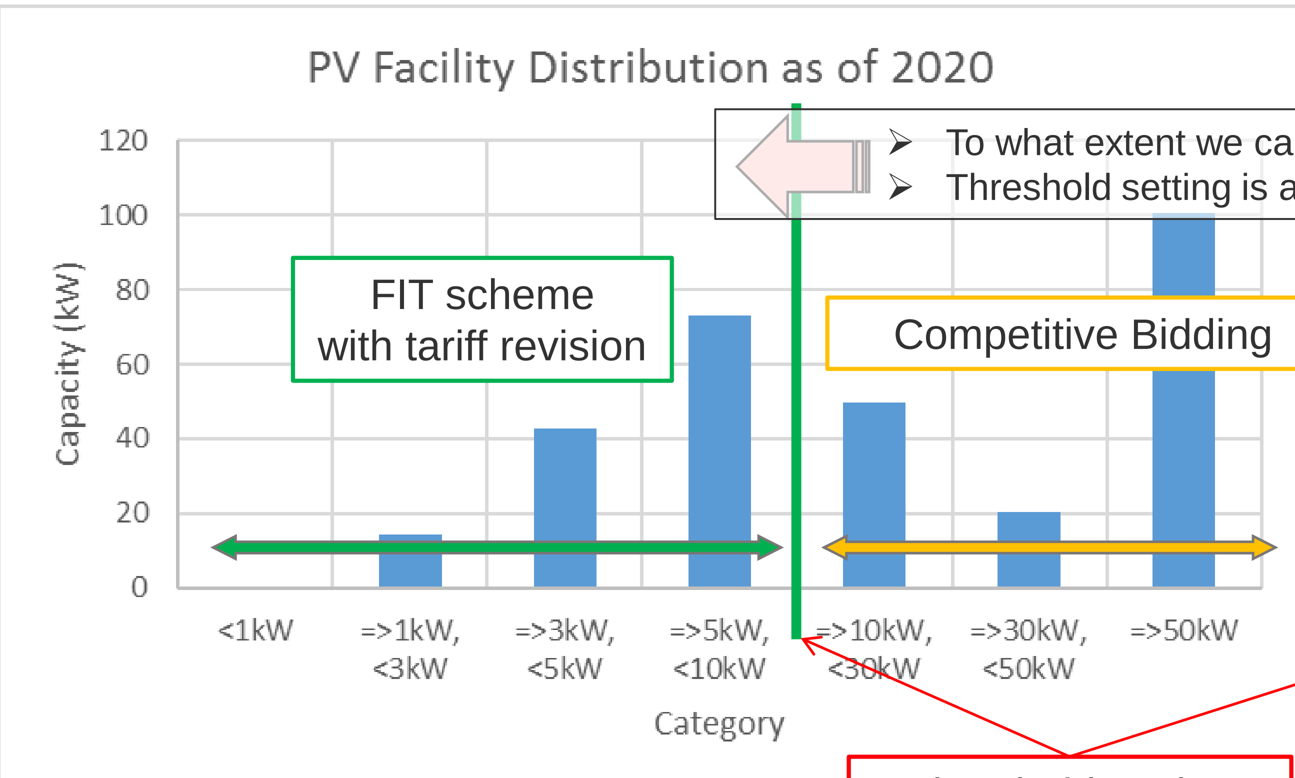
- FIT Tariff has not been revised since 2016.
- FIT Tariff can be revised
  →Since the VRE installation cost has been decreasing, business profitability can be secured even if FIT Tariff is lowered.
- Regarding the Ground mounted PV and large type of roof top PV, some projects have emerged that are as profitable as conventional power supplies (Coal fired).
  → It is possible to expand the range of Competitive Bidding




- To what extent we can shift the threshold
- Threshold setting is an issue considering business sustainability

| Solar PV Capacity | Levelized Cost of Electricity (LKR/kW) 2020 |
|---|---|
| Up to 5kW | 14.22 |
| 5kW to 10kW (middle income class) | 13.43 |
| 10kW to 1MW | 8.61 |
| More than 1MW | 7.44 |

Big difference

Threshold setting

Cost Competitive!

Source: CEB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# 04 Tariff Review Study
# Case Study of High Installation Cost (Considering the present market price)


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# Premises for Examination of Roof Top Solar PV Business Profitability

- ➢ We consider how much FIT Tariff can be lowered with keeping the profitability of roof top solar PV business based on several scenarios

## Premises

| | |
|---|---|
| Operation period | 20 years |
| Equity return to be expected | 17 %※ |
| Debt / Equity ratio | Debt 70 / Equity 30 |
| Unit cost for installation | 180,000 LKR/kW |
| O&M cost per year<br>(including inverter replacement) | 1,620 LKR/kW/year<br>(0.9% of unit cost for installation) |
| Capacity factor | 17.0 % |
| Deterioration rate per year | 0.7 %/year |
| Ratio of selling electricity to power generation | 100 % |

※: Existing Ground mounted PV project's expected EIRR, WTEI


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# Scenarios for Examination of Roof Top Solar PV Business Profitability

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- Interest rate is based on rate of Central Bank of Sri Lanka (CBSL), and Roof-top Solar Power Generation Project funded by ADB

## Scenarios and options

<table>
<tr><th colspan="2" rowspan="2">Indicator</th><th colspan="2">Scenario 1</th><th colspan="2">Scenario 2</th><th rowspan="2">Scenario 3</th><th rowspan="2">Scenario 4</th></tr>
<tr><th>Scenario 1-1</th><th>Scenario 1-2</th><th>Scenario 2-1</th><th>Scenario 2-2</th></tr>
<tr><td colspan="2">Debt / Equity ratio</td><td colspan="2">70/30</td><td colspan="2">70/30</td><td>70/30</td><td>70/30</td></tr>
<tr><td colspan="2">Interest rate</td><td colspan="2">8%<br>(CBSL 6% + margin 2%)</td><td colspan="2">4% 1- 10 year (ADB project)<br>8% 11 - 20 year</td><td>8%</td><td>8%</td></tr>
<tr><td colspan="2">Debt repayment period</td><td>7 years</td><td>10 years</td><td>7 years</td><td>10 years</td><td>20 years</td><td>20 years</td></tr>
<tr><td rowspan="2">FIT Tariff</td><td>1st - 7th year</td><td colspan="4">Items to be examined</td><td>12.6** LKR/kWh</td><td>14.95*** LKR/kWh</td></tr>
<tr><td>8th - 20th year</td><td>15.5* LKR/kWh</td><td>15.5* LKR/kWh</td><td>15.5* LKR/kWh</td><td>15.5* LKR/kWh</td><td>12.6** LKR/kWh</td><td>14.95*** LKR/kWh</td></tr>
<tr><td colspan="2">Project IRR</td><td colspan="6" rowspan="2">Items to be examined</td></tr>
<tr><td colspan="2">Equity IRR</td></tr>
</table>

* Current price ** CEB coal thermal power plant 10.48 x 1.2 = 12.6 *** Average direct generation cost (2019)



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# Examination of Roof Top Solar PV Business Profitability Scenario 1-1 and 1-2

- If the debt repayment period is shorter, EIRR is lower.
- If the debt repayment period is longer, FIT Tariff is lower and EIRR can be kept in high level (= advantage for both CEB and customer).

→ **Scenario 1-2 would be preferable for CEB and customer**

| Indicator | | Scenario 1 | | | | | |
|---|---|---|---|---|---|---|---|
| | | Scenario 1-1 | | | Scenario 1-2 | | |
| Debt / Equity ratio | | 70/30 | | | 70/30 | | |
| Interest rate | | 8% | | | 8% | | |
| Debt repayment period | | 7 years | | | 10 years | | |
| FIT Tariff | 1st - 7th year | 19.9 LKR/kWh | 21.2 LKR/kWh | 22.0 LKR/kWh | 19.0 LKR/kWh | 19.9 LKR/kWh | 21.2 LKR/kWh |
| | 8th - 20th year | 15.5 LKR/kWh | | | 15.5 LKR/kWh | | |
| Project IRR | | 12.2% | 13.1% | 13.7% | 11.6% | 12.2% | 13.1% |
| Equity IRR | | 15.2% | 17.0% | 18.2% | 15.5% | 17.0% | 19.4% |


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# Examination of Roof Top Solar PV Business Profitability Scenario 2-1 and 2-2

- If the debt repayment period is shorter, EIRR is lower.
- If the debt repayment period is longer, FIT Tariff is lower and EIRR can be kept in high level (= advantage for both CEB and customer). Scenario 2 with low interest rate (4%) can reduce FIT Tariff compared with Scenario 1 (interest rate 8%)

Scenario 2-2 would be preferable for CEB and customer

| Indicator | | Scenario 2 | | | | | |
|---|---|---|---|---|---|---|---|
| | | Scenario 2-1 | | | Scenario 2-2 | | |
| Debt / Equity ratio | | 70/30 | | | 70/30 | | |
| Interest rate | | 4% 1- 10 year<br>8% 11 - 20 year | | | 4% 1- 10 year<br>8% 11 - 20 year | | |
| Debt repayment period | | 7 years | | | 10 years | | |
| FIT Tariff | 1st - 7th year | 17.3 LKR/kWh | 19.0 LKR/kWh | 20.0 LKR/kWh | 16.5 LKR/kWh | 17.3 LKR/kWh | 19.0 LKR/kWh |
| | 8th - 20th year | 15.5 LKR/kWh | | | 15.5 LKR/kWh | | |
| Project IRR | | 10.6% | 11.6% | 12.3% | 10.1% | 10.6% | 11.6% |
| Equity IRR | | 14.7% | 17.0% | 18.5% | 15.8% | 17.1% | 20.1% |


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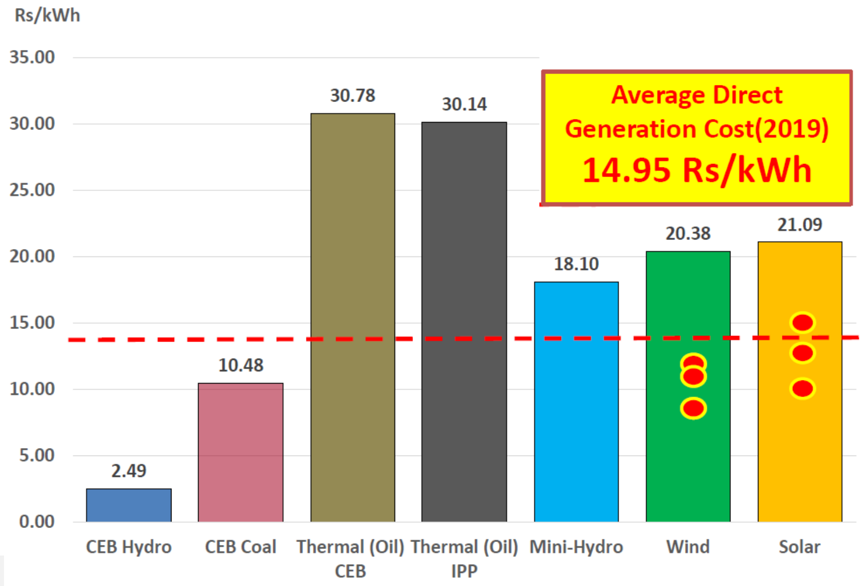
# Examination of Roof Top Solar PV Business Profitability Scenario 3 and Scenario 4

- As for FIT Tariff in scenario 3, 10.48 LKR/kWh is ideal because unit generation cost of latest coal thermal power plan is 10.48 LKR/kWh. However, since it would be difficult to realize the roof top solar PV generation cost of 10.48LKR/kWh, we assume 12.6 LKR/kWh considering margin of 1.2 times (10.48 x 1.2 = 12.6).
- In scenario 3 and 4, debt repayment period is 20 years and FIT Tariff is low so that CEB can purchase electricity without financial problems. These scenarios are preferable for CEB and construction companies. On the other hand, advantage for customers has to be considered.
- In case of scenario 3 and 4, EIRR is 1.4% and 11.1% less than 17% (equity return to be expected), respectively. These scenarios are not preferable for customer.

| Indicator | | Scenario 3 | Scenario 4 |
|---|---|---|---|
| Debt / Equity ratio | | 70/30 | 70/30 |
| Interest rate | | 8% | 8% |
| Debt repayment period | | 20 years | 20 years |
| FIT Tariff | 1st - 7th year | 12.6 LKR/kWh | 14.95 LKR/kWh |
| | 8th - 20th year | 12.6 LKR/kWh | 14.95 LKR/kWh |
| Project IRR | | 6.4% | 8.9% |
| Equity IRR | | 1.4% | 11.1% |





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# Conclusion

- When interest rate is 8% (CBSL 6% + margin 2%) and debt repayment period is 10 years, FIT Tariff can be reduced but the impact is small.
  - 1st - 7th year: 22.0 LKR/kWh → 19.9 LKR/kWh
  - 8th - 20th year: 15.5 LKR/kWh → 15.5 LKR/kWh
- High EIRR (17.0%) can be secured. Therefore, the revised FIT Tariff will be preferable for PV panel suppliers, construction companies and business owners.
- When interest rate on ADB scheme is applied, FIT Tariff can be further reduced and high EIRR can be secured at the same time.
  - 1st - 7th year: 22.0 LKR/kWh → 17.3 LKR/kWh
  - 8th - 20th year: 15.5 LKR/kWh → 15.5 LKR/kWh


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# 05 Influence to VRE installation Volume


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# Past Trend of VRE Installation Volume (Energy Base)

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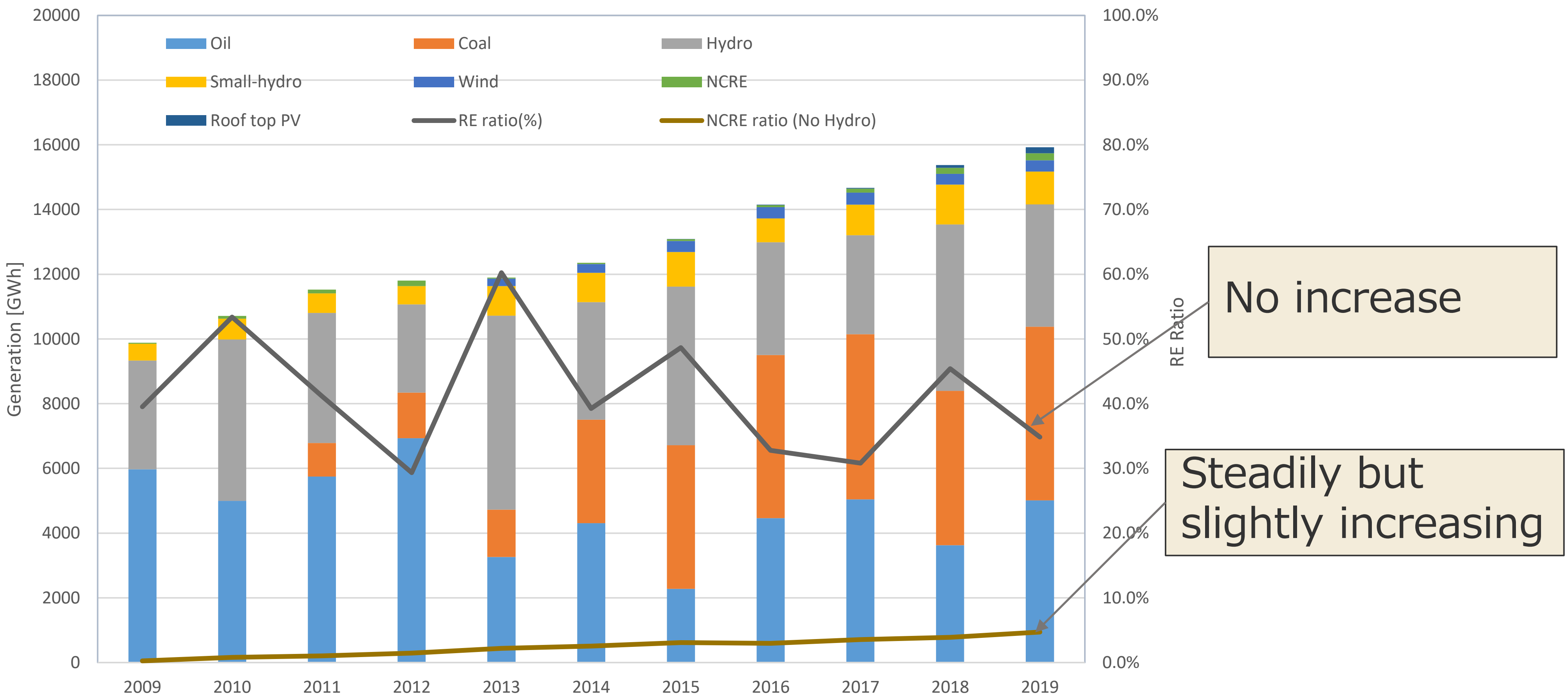
- Although the ratio of VRE (NCRE) has been slightly increasing, one of RE Levels off.
- The launch of Coal fired generation gives some influence to it.






Source: Statistical Digest, CEB

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# RE Share Forecast in 2030

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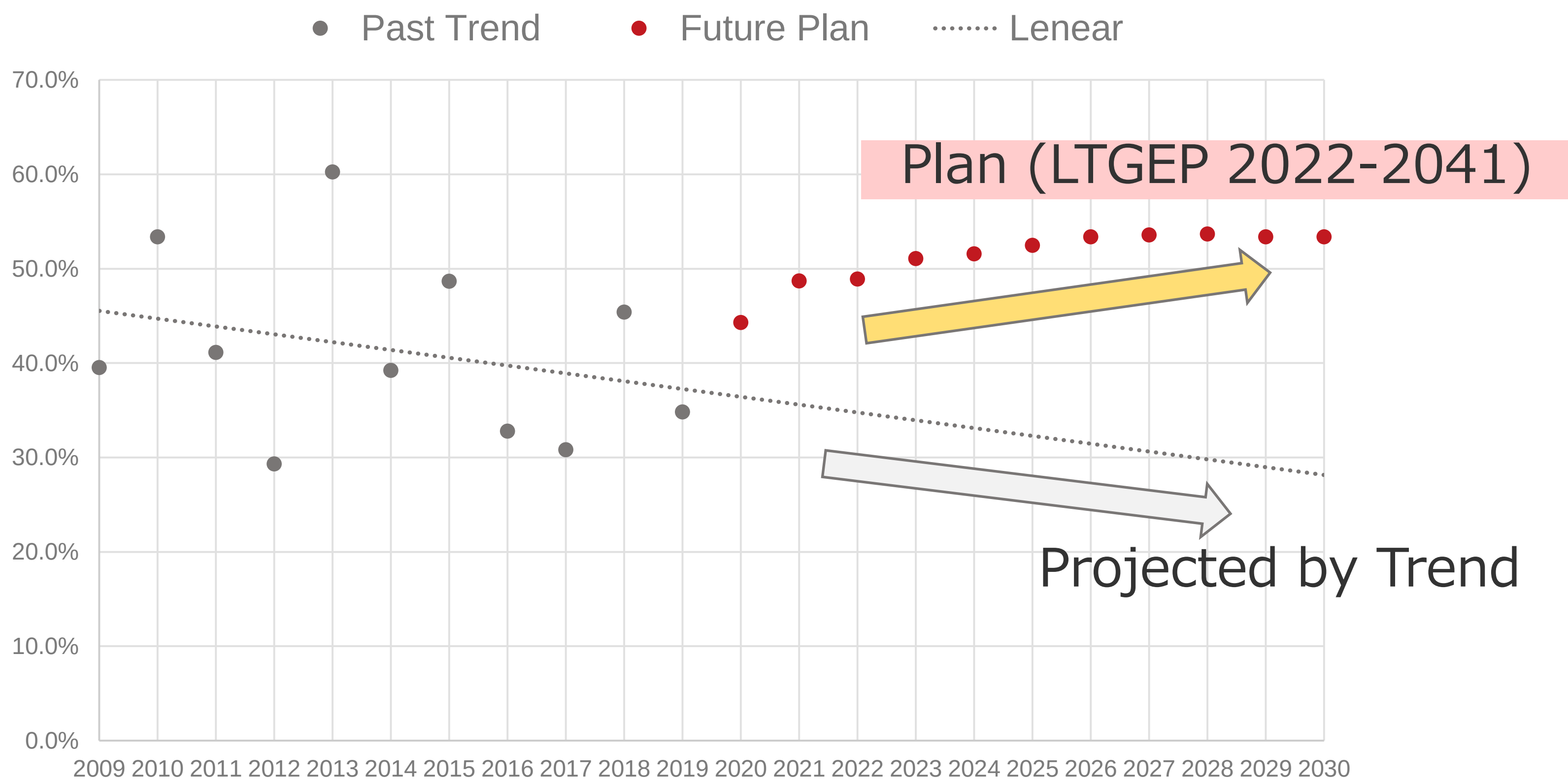
- If anything, the ratio of RE power generation is gradually decreasing. One reason is that the big coal power plant (Puttalam) started operation. If this trend continues, it will decrease further to 30% in 2030.
- According to the Draft LTGEP (2022-2041), VRE installation will be accelerated and ration of RE will be secured over 50% in 2030.




**Installation promotion of VRE is key element to meet the National Policy Plan "RE power generation ratio of 50% by 2030".**



Source: Statistical Digest, LTGEP 2022-2041(Draft)

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# National Energy Policy

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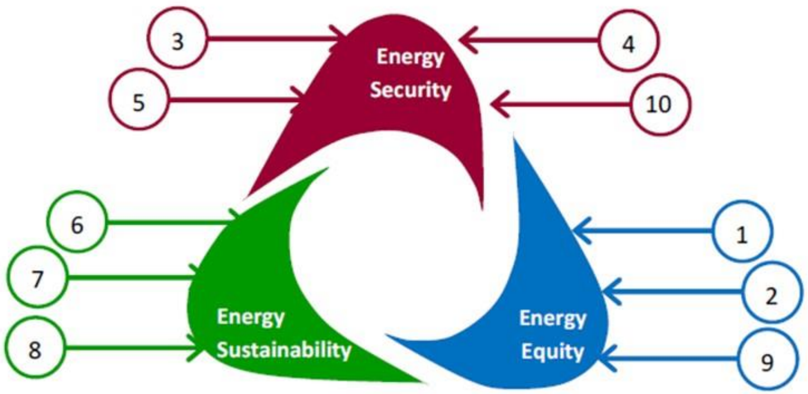
- To reduce the dependence of Sri Lanka on fossil fuels to below 50% of the primary energy supply and to reduce the specific energy use across all end-uses by 20% of 2015 level, by 2030.
- To achieve carbon neutrality and complete transition of all the energy value chains by 2050.




**Primary energy shall come from non-fossil fuels by 2030**

Source: National Energy Policy and Strategies of Sri Lanka as of Aug. 9, 2019

| No. | Items |
|---|---|
| 1 | Assuring Energy Security<br>✓ Natural bas would be the next fossil fuel option |
| 2 | Providing Access to Energy Services<br>✓ Smart grid, Smart metering, automatic power system management |
| 3 | Providing Energy Services at the Optimum Cost to the National Economy |
| 4 | Improving Energy Efficiency and Conservation<br>✓ Demand side management |
| 5 | Enhancing Self Reliance<br>✓ Further appropriate TOU tariff introduction<br>✓ Sizable fund operated by SEA |
| 6 | Caring for the Environment |
| 7 | Enhancing the Share of Renewable Energy<br>✓ Competitive scheme enhancement for RE<br>✓ Network development for RE based generation<br>✓ Research to overcome to overcome the intermittent sources (VRE)<br>✓ Effective forecasting technologies introduction<br>✓ Encouragement of Energy storage solutions<br>✓ Introduction of financing scheme both public and private |
| 8 | Strengthening Good Governance in the Energy Sector |
| 9 | Securing Land for Future Energy Infrastructure |
| 10 | Providing Opportunities for Innovation and Entrepreneurship |

# Impact on development of PV by introducing “FIT Tariff Review” and “Expansion of Competitive Bidding Applied Range”

① FIT Tariff Review
→Lowering FIT Tariff will make intention for development of PV down

②Expansion of Competitive Bidding Applied Range
→Changing from FIT to Competitive Bidding scheme will lead the contract price cheaper than FIT Tariff.

**However, we can maintain developing PV in Sri Lanka after review of FIT scheme**

- ✓ Nationwide understandings on importance of RE development
- ✓ Frequent Publicity programs by the Government for development of PV.
- ✓ Nationwide understandings that Sri Lanka is no natural resource country and energy security is important.
- ✓ Awareness campaign by Government for development of PV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# Simultaneous Attainment of “Sound Financial Status of CEB” and “Promotion of VRE Installation”

① The revision of FIT Tariff and applied range expansion will definitely affect the VRE Introduction Volume in the future. Are there any good countermeasures against it?

－Options (Tentative ideas)－

**Not permanent but a temporary** measure to reduce the impact of the FIT Tariff review

A) To launch VRE promotion fund by GOSL and support business owners by suppling xx LKR per kW

(Effect) IRR will change for the better, which improves business feasibility and gives business owners incentive to promote

B) GOSL or a public third party will subsidize XX LKR per 1kWh of power generation.

(Effect) Same the above.

The fund operates with taxes or widely and uniformly collected from electricity users

It is important not to stop increasing trend of VRE so that national target can be maintained.



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# 05 Periodical Revision of FIT Tariff


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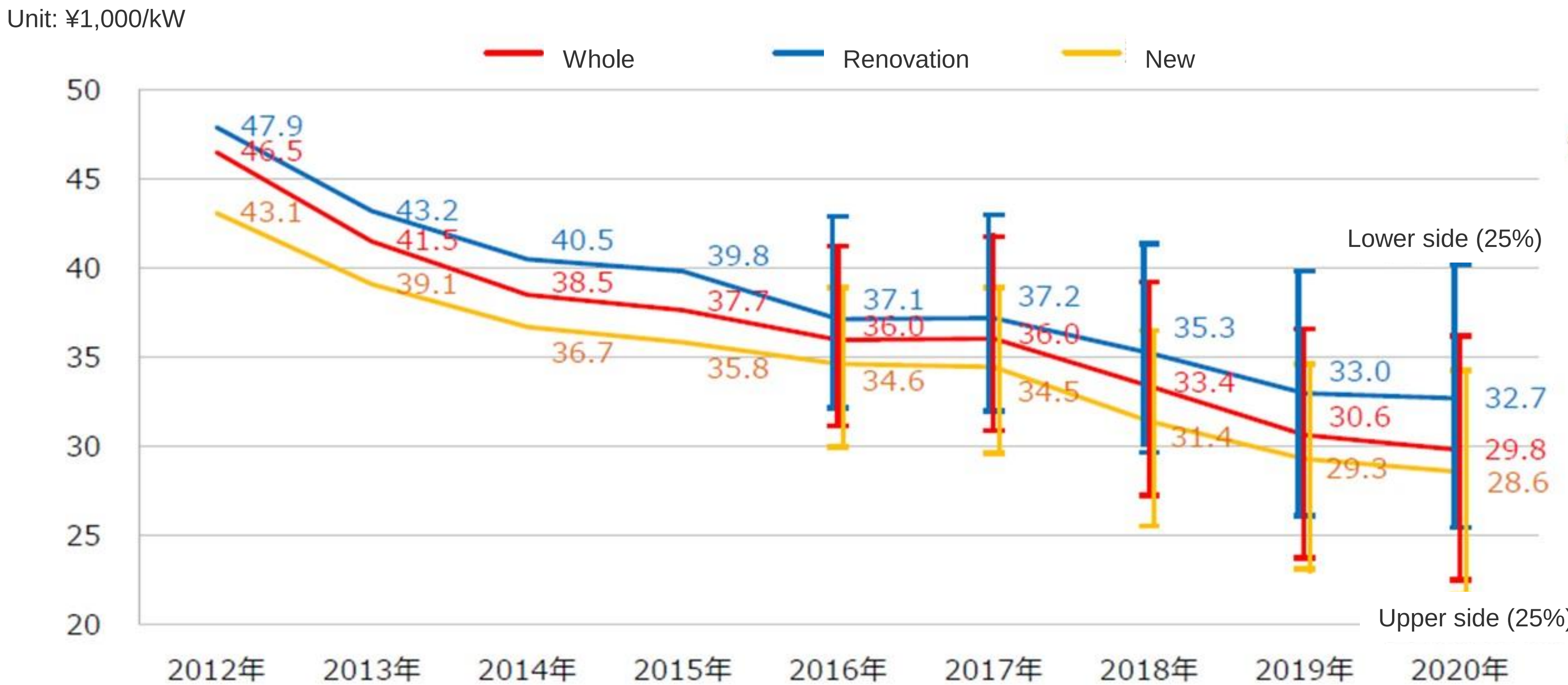
# Review of FIT Tariff linked to the PV System Price change

In the Roof Top PV business, system costs have a great impact on business feasibility for PV generation owners. And cost is dropping sharply therefore periodical review is important.

## Trend of average cost of Roof Top PV system in Japan




**Automatic revision scheme would be one option to be able to refer the down ward trend of system costs and eliminate the workload of tariff revision argument**

 Source: Natural Resource and Energy

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# Review of FIT Tariff linked to The PV System Price change (Cont'd)



In Japan, the system price assumption for the 2022 installation is evaluated based on the last two-year price decline level. The median of projects in 2020 is in the top 36-37% of 2018. From this, we propose 259,000 yen / kW in 2022.

| | PV System Cost for Household | | |
|---|---|---|---|
| % | Installed in 2020 | Installed in 2019 | Installed in 2018 |
| 5% | 16.25 | 18.25 | 20.25 |
| 10% | 17.58 | 20.29 | 23.33 |
| 15% | 19.19 | 21.78 | 24.90 |
| 20% | 21.04 | 22.85 | 25.73 |
| 25% | 22.52 | 23.75 | 27.25 |
| 30% | 23.87 | 24.79 | 28.81 |
| 35% | 25.19 | 26.09 | 29.80 |
| 36% | 25.50 | 26.33 | 30.05 |
| 37% | 25.87 | 26.62 | 30.34 |
| 38% | 26.17 | 26.91 | 30.56 |
| 39% | 26.51 | 27.[illegible] | 30.83 |
| 40% | 26.86 | 27.54 | 31.11 |
| 45% | 28.49 | 28.88 | 32.35 |
| 50% | 30.08 | 30.31 | 33.52 |

Price decline for two years

<One prospective solution>
FIT tariff shall be annually reviewed in line with the past PV system price change

 Source: Natural Resource and Energy

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# 07 Value-addition to Conventional Thermal Power Generation


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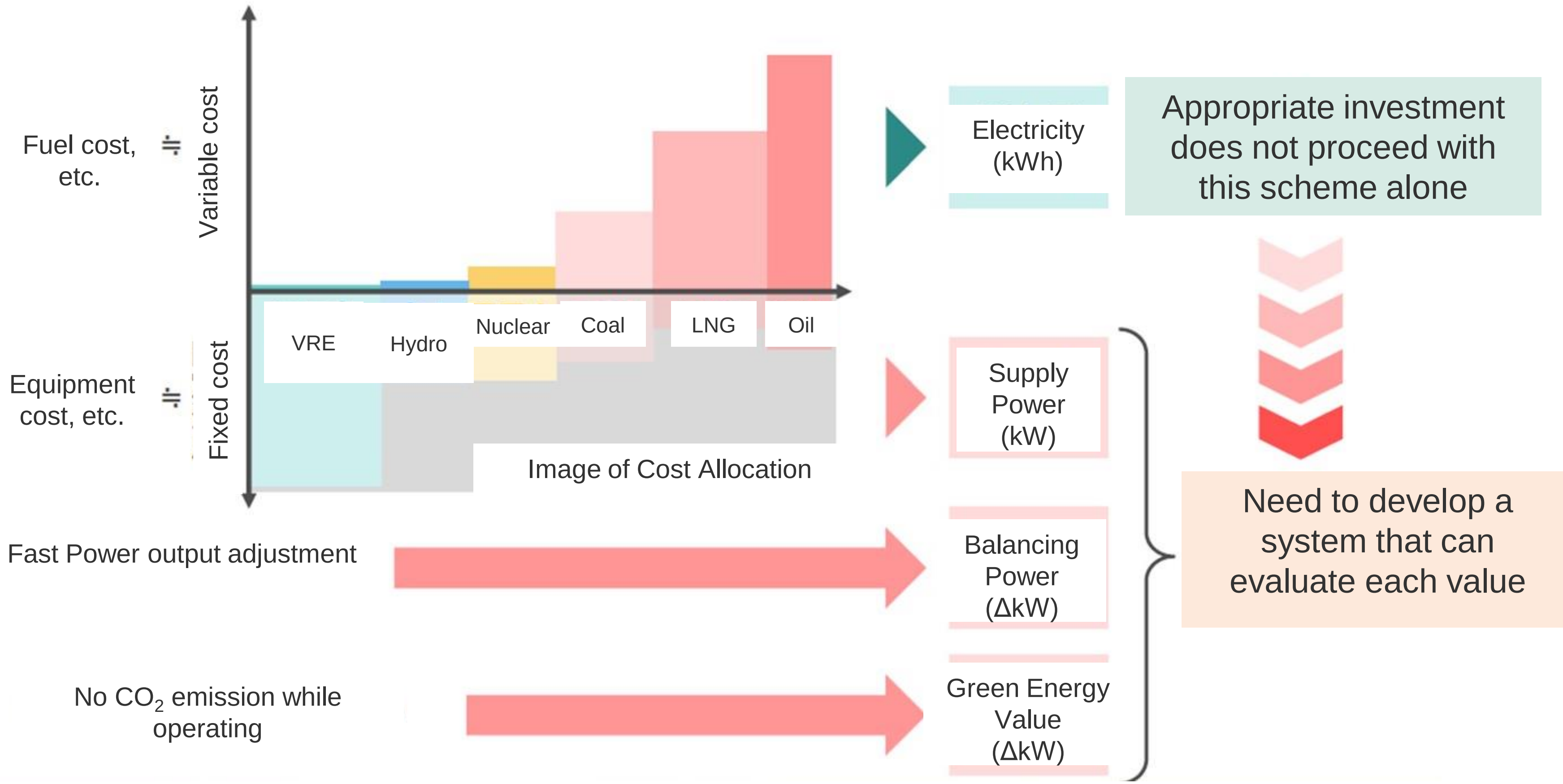
# Various Value in Generation

- Electricity (kWh) is not the only value provided by power generation facilities.
- In order to invite investment on power generation, it is necessary to establish a system to evaluate the value rather than electricity (kWh)



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# Value traded in each Market

| Type of Value by power sources | Traded Value | Markets | Procurers |
|---|---|---|---|
| Electricity 【kWh Value】 | Generated Energy | ➢ Wholesale electricity market (1 hour before, spot, future)<br>➢ Baseload trading market | Retailers |
| Supply Power 【kW Value】 | Ability to supply power (Value of existence) | Capacity Market | Retailers<br>General electric utilities (TSOs)<br>※Actually, it is procured by OCCTO※1 that is the market manager, but the cost is borne by the above |
| Balancing Power 【ΔkW＋kWh Value】 | Balancing Ability in short term | ・Public offering（at present)<br>→Balancing Market (After 2021) | General electric utilities (TSOs) |
| Others 【Green Energy Value, etc.】 | Environmental value associated with electricity generated by non-fossil power sources | Green energy trading market | Retailers |

※1: OCCTO (The Organization for Cross-regional Coordination of Transmission Operators), Please see Page 41



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# Background of Capacity Market Introduction

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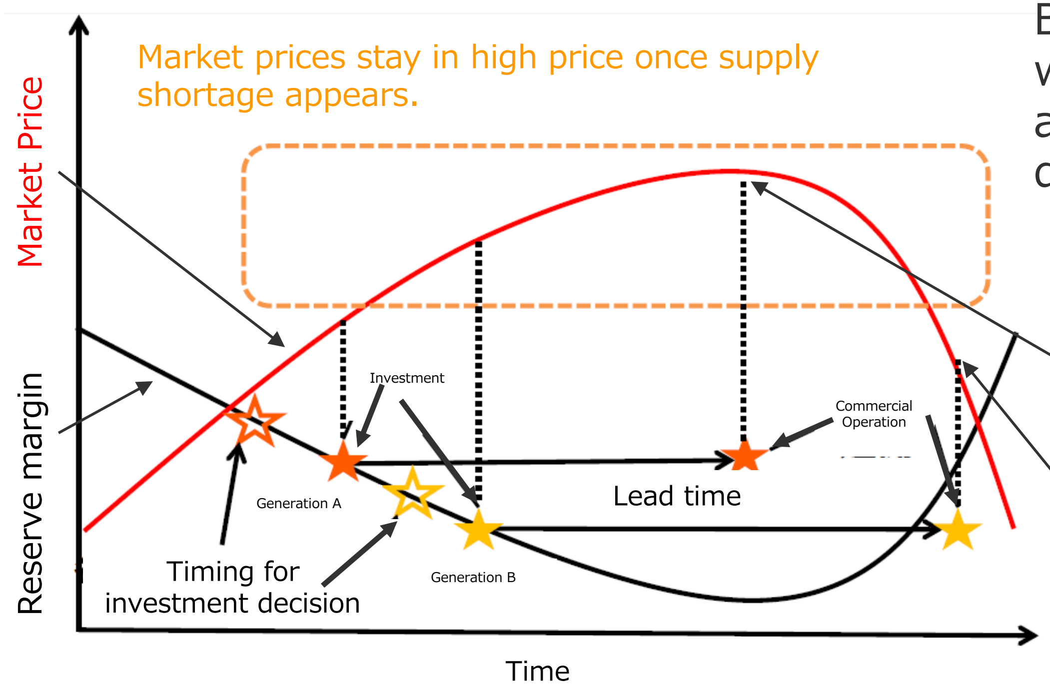
- Power generation investment decisions are difficult due to two reasons, firstly, the expansion of transactions in the wholesale electricity market and secondary the decline in market prices. Full deregulation of retail market and the expansion of renewable energy caused them.
- There is a risk that power generation investment is not carried out at the right time, and it might cause a short-term supply shortage. As a result, supply and demand may be tight and electricity prices may remain high.




Business owners cannot predict wholesale market price precisely, and the timing of investment deviates from the optimal time.

Market prices will drop sharply therefore investment cost can not be recovered

Market prices has already dropped therefore investment cost can not be recovered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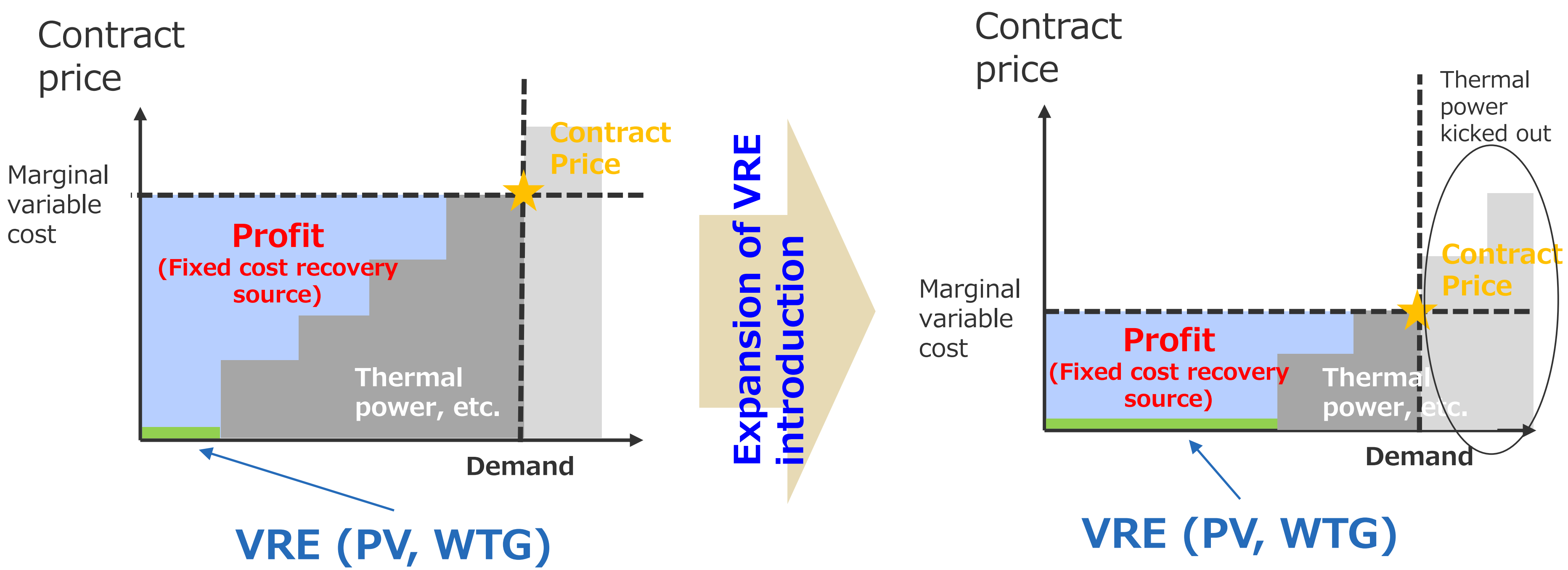
# Background of Capacity Market Introduction cont'd

- As renewable power sources with zero variable cost expand, power sources with high variable cost such as thermal power will be kicked out of the market.
- In addition, it is not possible to recover fixed costs sufficiently because the contract price decreases




Incentive for the investment is getting smaller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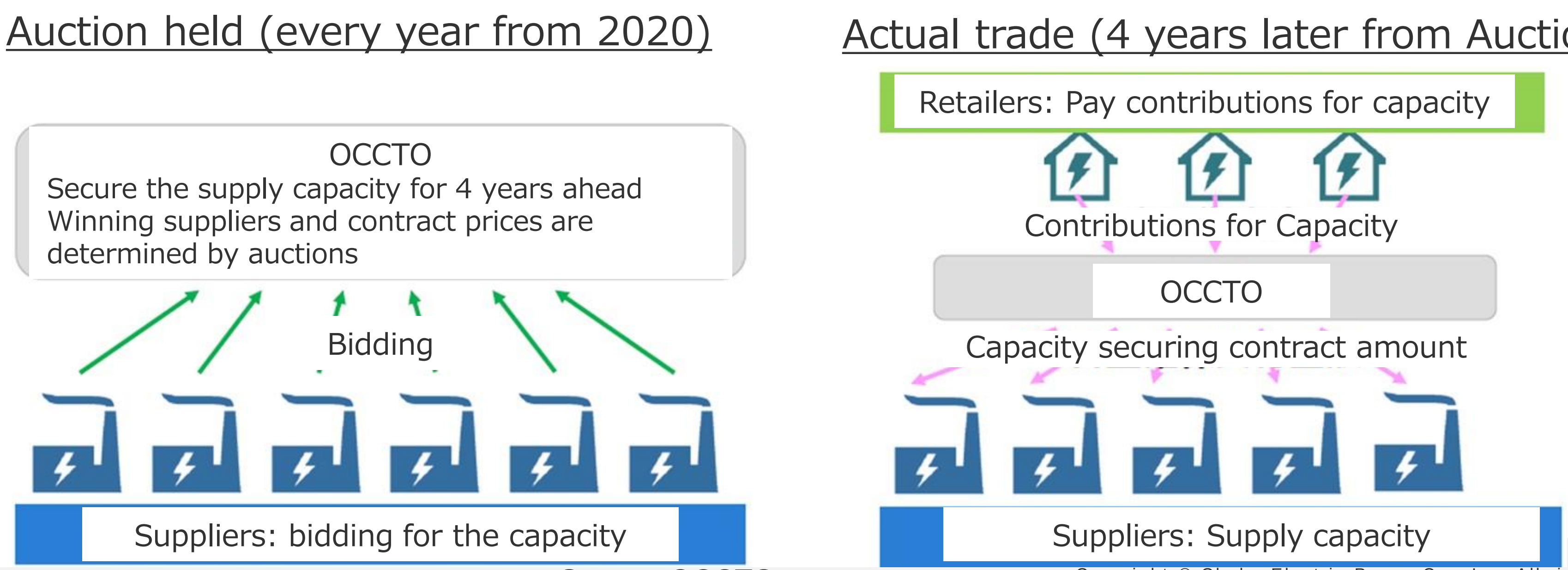
# Outline of Capacity Market

- OCCTO secures the necessary supply capacity in a nationwide in the capacity market four years before the actual trade.
  - OCCTO: Holds an auction and decides the winning supplier and contract price
    During the actual trade period, contributions for capacity securement are collected from all retail power companies, and the capacity securing contract amount is paid to the power generation companies (winning suppliers).
  - Power generation companies: Provide supply capacity if you make a successful bidding at the auction
  - Retail power companies: Pay contributions for capacity to OCCTO




Source: OCCTO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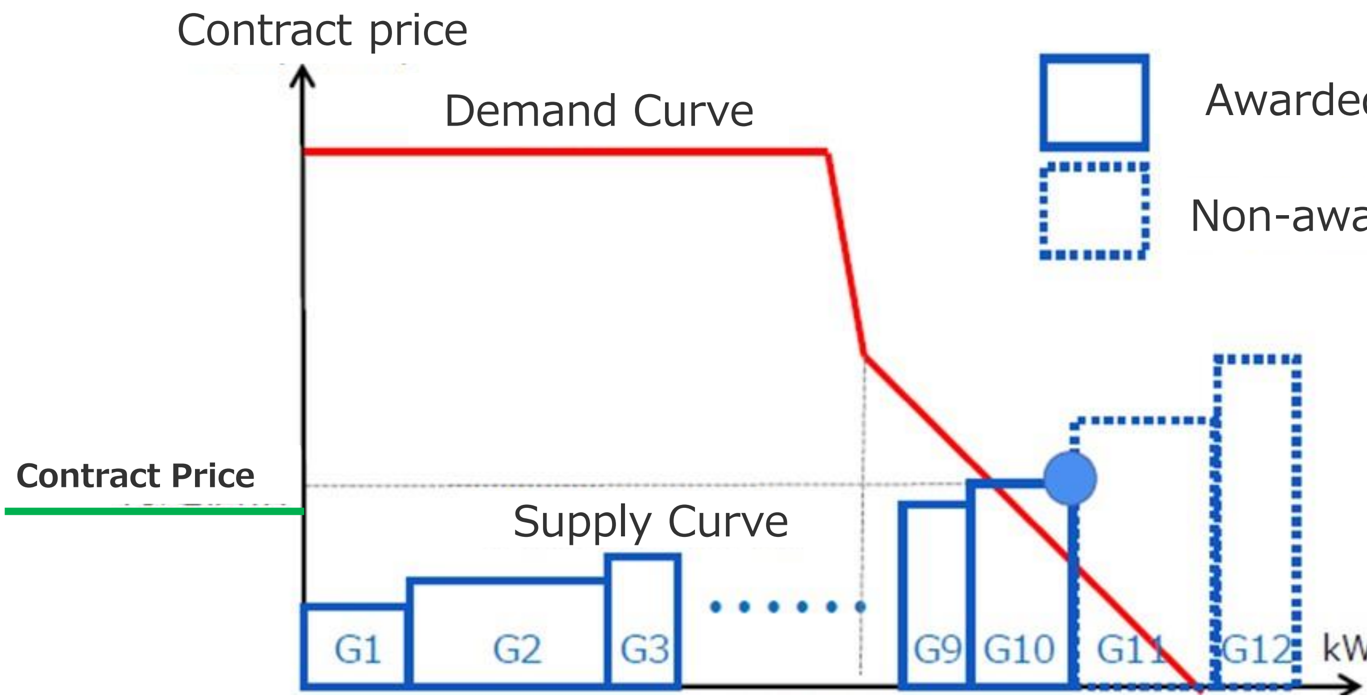
# Contract Price (Auction Style)

- Single price auction method. Buyer: OCCTO, Seller: Power generation companies
- The contract price is set at the intersection of the supply curve and the demand curve when bidding prices are arranged in ascending order.
- Suppliers of which bidding price below contract price can supply power




Source: OCCTO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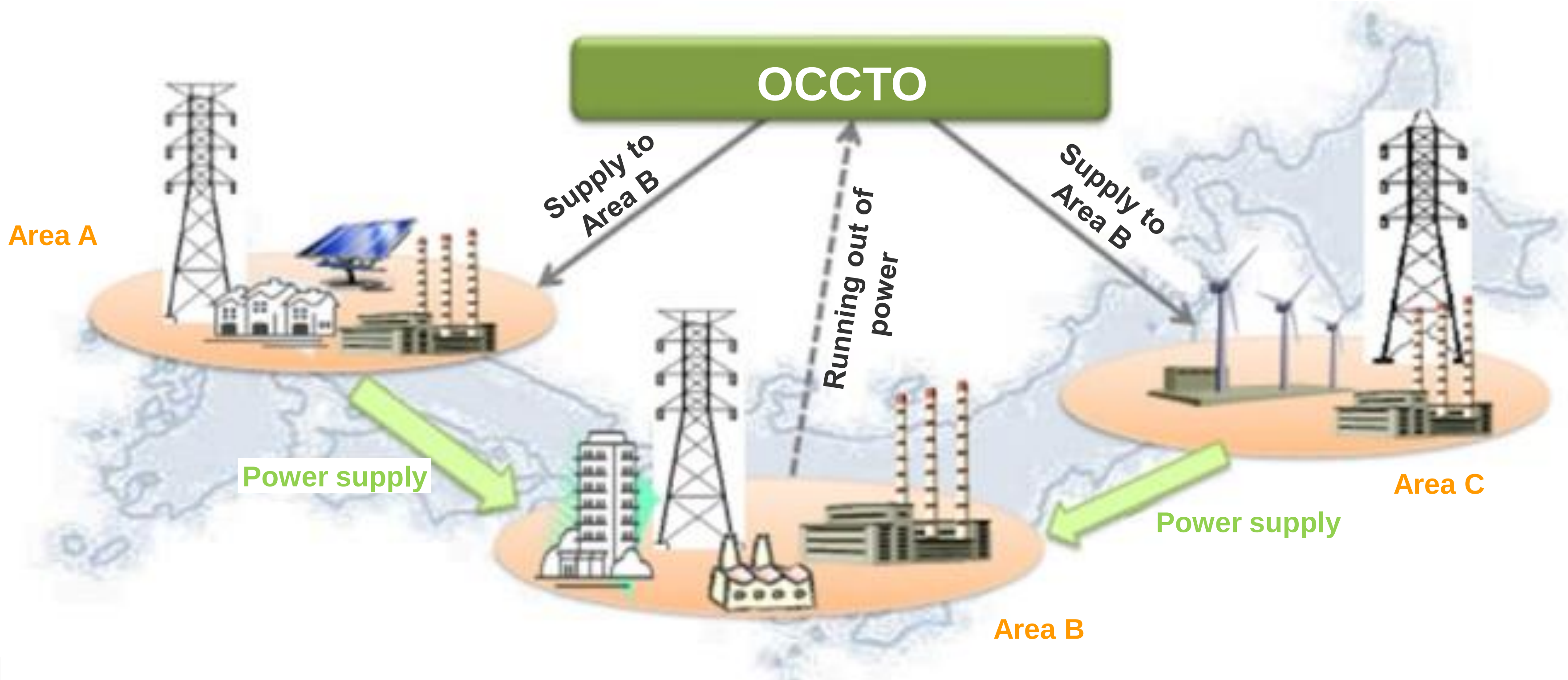
# Roll of OCCTO

(OCCTO: The Organization for Cross-regional Coordination of Transmission Operators)

- Efficiently manages demand & supply balancing beyond supply areas.
- Monitors demand-supply balance in both ordinary and emergency situation
- Aggregates supply-demand plans & grid plans, and examines whether interconnection reinforcement is necessary or not.





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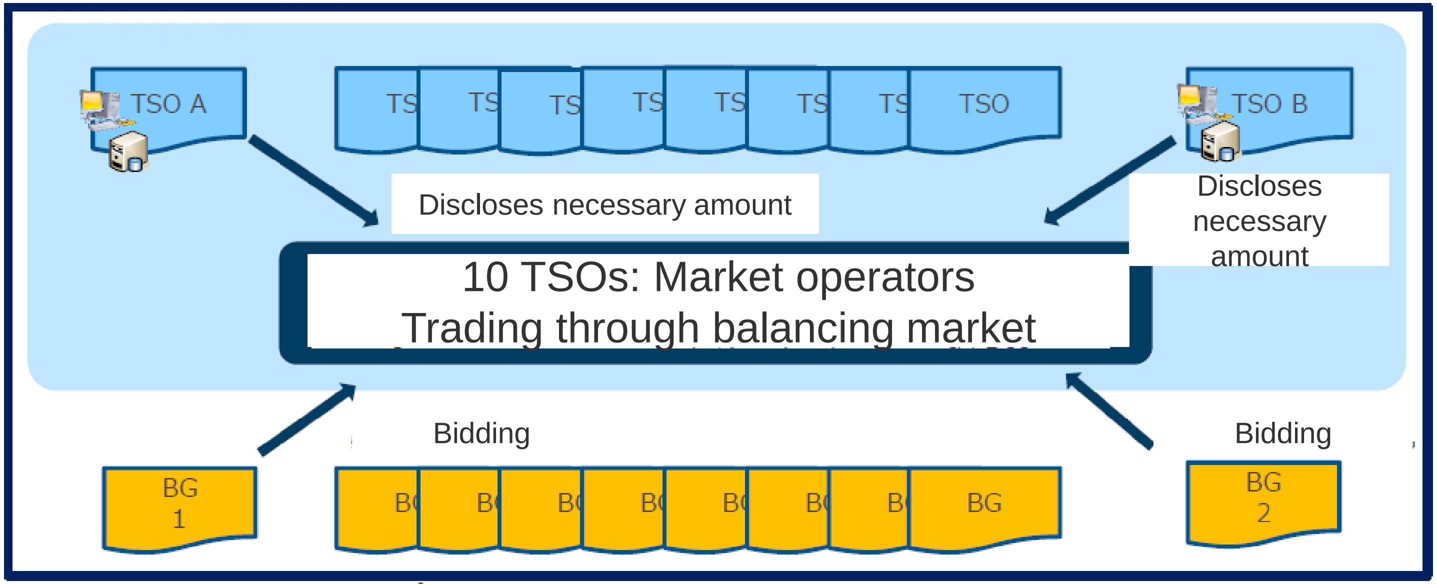
# Outline of the Balancing Market

- Balancing market will be established in order to procure and operate balancing power nationally beyond area, more efficiently with more transparency and fairness.
- Buyers of balancing power are general electric utilities (TSOs), and sellers are power generation and retailers.
- Market operators are 10 TSOs




BG: Balancing Group※

※When there is a difference between the planned and actual demand, there is an obligation to pay a penalty cost called an "imbalance fee." By forming a group, balancing can be achieved more easily for the entire group, which reduces risk.

| TSO | | Balancing power suppliers |
|---|---|---|
| 10 TSOs | Each TSO | BG |
| Market Operator | Buyer | Seller |

Source: Agency for Natural Resources and Energy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# What is Balancing Power

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- Since electricity has the characteristic of immediate consumption of generated power, TSOs instantly match the supply (power generation) with the demand (consumption) that changes from moment to moment.
- Power generators, retailers, and TSOs share roles to match the supply and the demand. Each role is below:
  - Power generation companies and the retailers match the plan with the actual result every 30 minutes under this balancing scheme.
  - TSOs find the differences, first one is error between the plans provided by the power generation companies and the actuals provided by the retailers, which remain after GC, second one is error of the generation forecast from VRE, third one is fluctuation of demand and supply that occurs within less than 30 minutes. Next TSOs consider everything the above and eventually matches the demand and the supply instantaneously utilizing balancing power.

Balancing power is the supply power used by TSOs to match the difference between the supply and the demand that cannot be grasped in advance, which has an important role in maintaining the frequency and ensuring a stable supply.



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# Balancing Power used for what? (Ref., Detailed Explanation)

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Balancing power needs to address the following four events

1. Prediction Error of Demand

Retailers prepare a demand plan by predicting demand, but it is not possible to formulate a plan that exactly matches the actual demand, so there is a difference between the forecast and the actual result after the GC. This is called "prediction error of demand".

2. Prediction Error of VRE

Difference between predicted generation of VRE and the actual

3. Fluctuation (Error) in short range

Actual demand is constantly changing, and the output of VRE is also changing momentarily. Even if the predicted value and the actual value match in terms of the 30-minute average value, error between them occurs in terms of time shorter than 30 minutes. This is called "Fluctuation (Error) in short range"

4. Generation Drop

Power supply stops due to unexpected trouble.

Source: OCCTO


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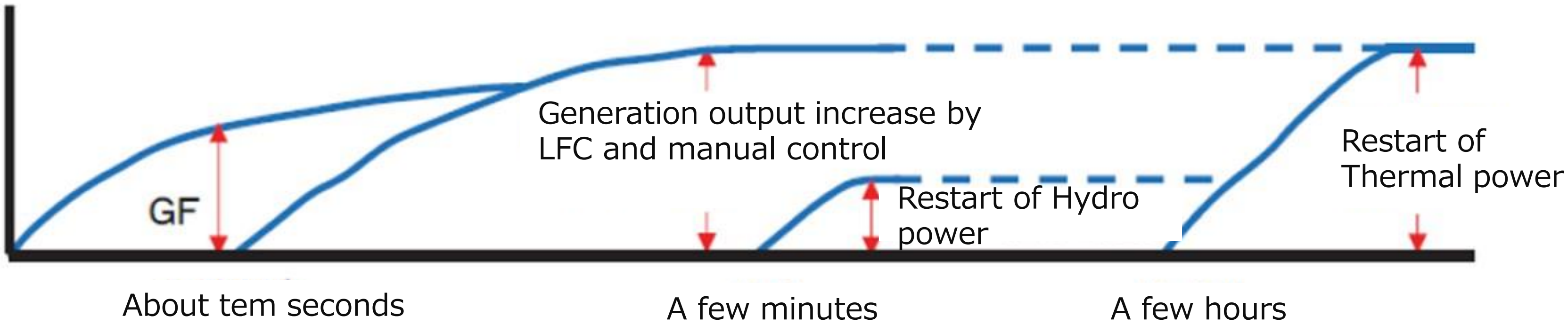
# Product Design for Balancing Market

From the viewpoint of utilizing various power source types as balancing power, they are classified into primary, secondary or tertiary according to the reaction speed, service offer period, etc.




1. Primary balancing power

   Is instantly used to suppress frequency fluctuations, such as GF function, emergency power pool control function by DC equipment, function to control demand instantaneously

2. Secondary balancing power

   Is incorporated and utilized in the LFC function

3. Tertiary balancing power

   Is utilized in response to orders from TSOs, other than the above.



Source: Agency for Natural Resources and Energy

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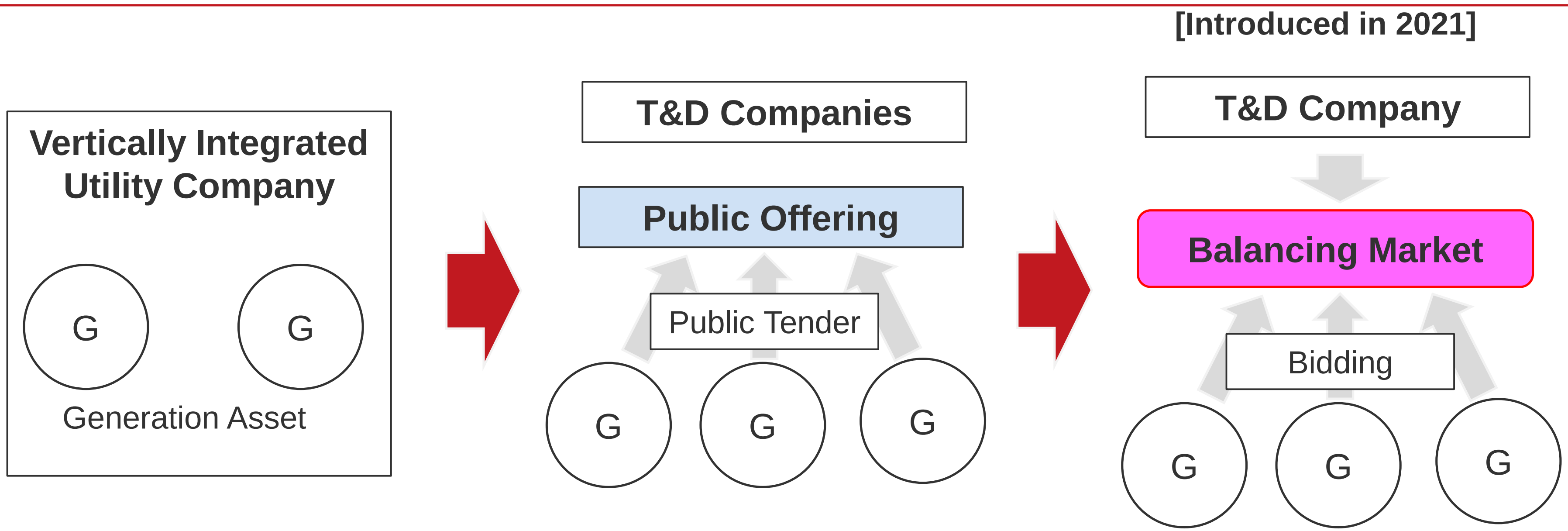
# Balancing Control Mechanism by T&D Sector (Transition)

- T&D Companies (TSOs) control frequency and supply-demand balance in their each area on the basis of license. When procuring the balancing control power, both transparency and efficiency are important factors.
- In this viewpoint, TSOs began to operate power system using balancing control power procured by "public offering" in April 2017.
- In the future, "balancing market" will be introduced in 2021. Through this market, we expect that procuring balancing control power will be more efficient.




Vertically Integrated Utility has its own Generation Asset, and its own balancing control power.

Through Public Offering, T&D companies procure its balancing control power.

Through Balancing Market, unbundled T&D Companies procure its balancing control power.

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# 08 Summary


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# Summary

- As the introduction of VRE progresses, price competitiveness will increase, so it is common and desirable to review the FIT Tariff.
- As the introduction of FIT progresses, the Scheme that supports the introduction will also change in general.
- No matter how it is VRE, when they have the same price competitiveness as conventional power sources, they should shift to competitive bidding.

  FIT → FIT Tariff Declining → FIP → Competitive Bidding
- Government-led awareness-raising activities are important so as not to slow down the introduction of VRE
- FIT Tariff can continuously operate soundly in parallel with CEB's electric power business by dividing FIT Tariff account from the account of electric power business (Shown in the different presentation).


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# Present Electricity Tariff and Issues

KVSM Kudaligama, Chief Engineer (Tariff)

Ceylon Electricity Board

17th August 2021

# Present Tariff

| (for each 30 - day billing period) | EXISTING TARIFF | | |
|---|---|---|---|
| | DOMESTIC | NON DOM. CATEGORIES | ToU for DOMESTIC |
| EFFECTIVE FROM | 16-09-2014 | 15-11-2014 | 02-05-2017 |
| DOMESTIC | Energy Charge (Rs/kWh) | | Fixed Charge (Rs/Month) |
| | | | |
| Block 1 - 0 - 30 | 2.50 | | 30 |
| Block 2 - 31 - 60 | 4.85 | | 60 |
| | | | |
| Block 1 - 0 - 60 | 7.85 | | N/A |
| Block 2 - 61 - 90 | 10.00 | | 90 |
| Block 3 - 91 - 120 | 27.75 | | 480 |
| Block 4 - 121 - 180 | 32.00 | | 480 |
| Block 5 - Above 180 | 45.00 | | 540 |
| | | | |
| Day (05.30 - 18.30 hrs) | 25.00 | | 540 |
| Peak (18.30 - 22.30 hrs) | 54.00 | | |
| Off Pk (22.30-05.30 hrs) | 13.00 | | |
| Religious | | | |
| Block 1 - 0 - 30 | 1.90 | | 30 |
| Block 2 - 31 - 90 | 2.80 | | 60 |
| Block 3 - 91 - 120 | 6.75 | | 180 |
| Block 4 - 121 - 180 | 7.50 | | 180 |
| Block 5 - Above 180 | 9.40 | | 240 |

## OTHER CUSTOMER CATEGORIES

| | | | General Purpose | | Industrial | | Hotel | Govt. |
|---|---|---|---|---|---|---|---|---|
| | | | GP 1-1 | GP 1-2 | IP 1-1 | IP 1-2 | | |
| Rate 1 Supply at 400/230V Contract demand <= 42 kVA | | | For ≤ 300 kWh/mon. | For > 300 kWh/mon. | For ≤ 300 kWh/mon. | For > 300 kWh/mon. | | |
| | Energy Charge (Rs/kWh) | | 18.30 | 22.85 | 10.80 | 12.20 | 21.50 | 14.65 |
| | Fixed Charge (Rs/Month) | | 240 | 240 | 600 | 600 | 600 | 600 |
| Rate 2 Supply at 400/230V Contract demand > 42 kVA | Energy Charge (Rs/kWh) | Day | 21.80 | | 11.00 | | 14.65 | |
| | | Peak | 26.60 | | 20.50 | | 23.50 | 14.55 |
| | | Off Peak | 15.40 | | 6.85 | | 9.80 | |
| | Demand Charge (Rs/kVA) | | 1100 | | 1100 | | 1100 | 1100 |
| | Fixed Charge (Rs/Month) | | 3000 | | 3000 | | 3000 | 3000 |
| Rate 3 Supply at 11 kV & above | Energy Charge (Rs/kWh) | Day | 20.70 | | 10.25 | | 13.70 | 14.35 |
| | | Peak | 25.50 | | 23.50 | | 22.50 | |
| | | Off Peak | 14.35 | | 5.90 | | 8.80 | |
| | Demand Charge (Rs/kVA) | | 1000 | | 1000 | | 1000 | 1000 |
| | Fixed Charge (Rs/Month) | | 3000 | | 3000 | | 3000 | 3000 |

## Street Lighting

| | |
|---|---|
| Energy Charge (Rs/kWh) | 17 |

## Electric Vehicle Charging Rates at CEB Charging Stations

| Time of Use (ToU) | DC Fast Charging (Rs/kWh) | Level 2 AC Charging (Rs/kWh) |
|---|---|---|
| Day | 50 | 30 |
| Peak | 70 | 55 |
| Off Peak | 30 | 20 |

# Issues

- **End-use customer tariffs at present are not cost-reflective**, whereas the Act requires the tariffs to be cost-reflective.
- Section 30(2)(a) of SLEA No. 20 of 2009
  - Electricity tariffs **be set by the relevant licensee.**
  - In accordance with **a cost reflective methodology approved by PUCSL**.
  - Licensees are **permitted to recover all reasonable costs**.

# Issues Contd..

- **Absence of Regular Tariff revisions.**
- Last tariff revision was done in 2013.
- However, a 25% reduction was given to the customer after successful implementation of 3 x 300 MW Coal power plant at Norochcholei.
- According to some CEB studies, to recover the full cost of CEB tariff should be increased as follows.
  - Fixed Charge/Demand Charge – 40%
  - Energy Charge – 7.25 Rs./kWh
- Abrupt tariff variations for consumers should be avoided. Hence regular revisions are necessary.

# Financial Status of CEB

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Electricity Sales (GWh) | 10,621 | 11,063 | 11,786 | 12,785 | 13,431 | 14,091 | 14,611 | 14,287 |
| Avg. Selling Pr. (Rs./kWh) | 18.28 | 18.32 | 16.01 | 16.18 | 16.26 | 16.29 | 16.63 | 16.72 |
| Total Cost @ selling Point (Rs./kWh) | 16.95 | 20.15 | 15.11 | 18.12 | 20.85 | 19.22 | 24.12 | 21.20 |

Source: Statistical Digests, CEB

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Profit/ (Deficit) MLKR | 26,270 | (30,512) | 2,025 | (58,368) | (80,876) | (43,149) | (101,916) | (45,931) |

Source : Bulk Supply Transaction Accounts

# Major payable balances as at May 31, 2021

| No. | Items | Amount (MLKR) |
|---|---|---|
| 1 | Independent power producers - Thermal Oil | 39,731 |
| 2 | NCRE | 10,321 |
| 3 | Ceylon Petroleum Corporation (with delay interest) | 78,140 |
| 4 | Term Loans to finance Working Capital | 119,582 |
| 5 | Senior Unsecured Listed Redeemable Rated Debentures | 20,000 |
| 6 | Project Loans (excludes Treasury Sub Loans serviced by Govt.) | 49,259 |
| | Total | 317,032 |

# Revenue Requirement of CEB Licensees for 2021

| Item | Total estimated cost per annum (MLKR) | Estimation Basis |
|---|---|---|
| Generation Capacity Cost | 64,345.86 | BST Jan-June 2021 submission |
| Generation Energy Cost | 193,182.35 | -do- |
| Allowed Revenue TL | 34,861.00 | Draft Tariff Filing 2021-2025 |
| Allowed Revenues | | |
| DL1 | 26,929.00 | -do- |
| DL2 | 22,774.00 | -do- |
| DL3 | 14,559.00 | -do- |
| DL4 | 10,561.00 | -do- |
| Total | 367,212.21 | |
| | | |
| Expected sales (GWh) | 14,816 | |
| The avg. cost @ point of supply (Rs./kWh) | 24.79 | |

# Issues Contd..

- Certain classes of customers are subsidized as a government policy, while others pay a surcharge to finance the cross subsidy.
- Example for December 2020 Data with 2% Covid recovery.

| Tariff Category | Avg. Bill per customer (Rs/month) | Avg unit price (Rs/kWh) | Profit/(subsidy) per (Rs/kWh) |
|---|---|---|---|
| **Domestic** | | | |
| 0-30 | 61.0 | 4.92 | (11.75) |
| 31-60 | 260.7 | 4.66 | (12.01) |
| 61-90 | 851.22 | 9.60 | (7.11) |

Customers subsidized

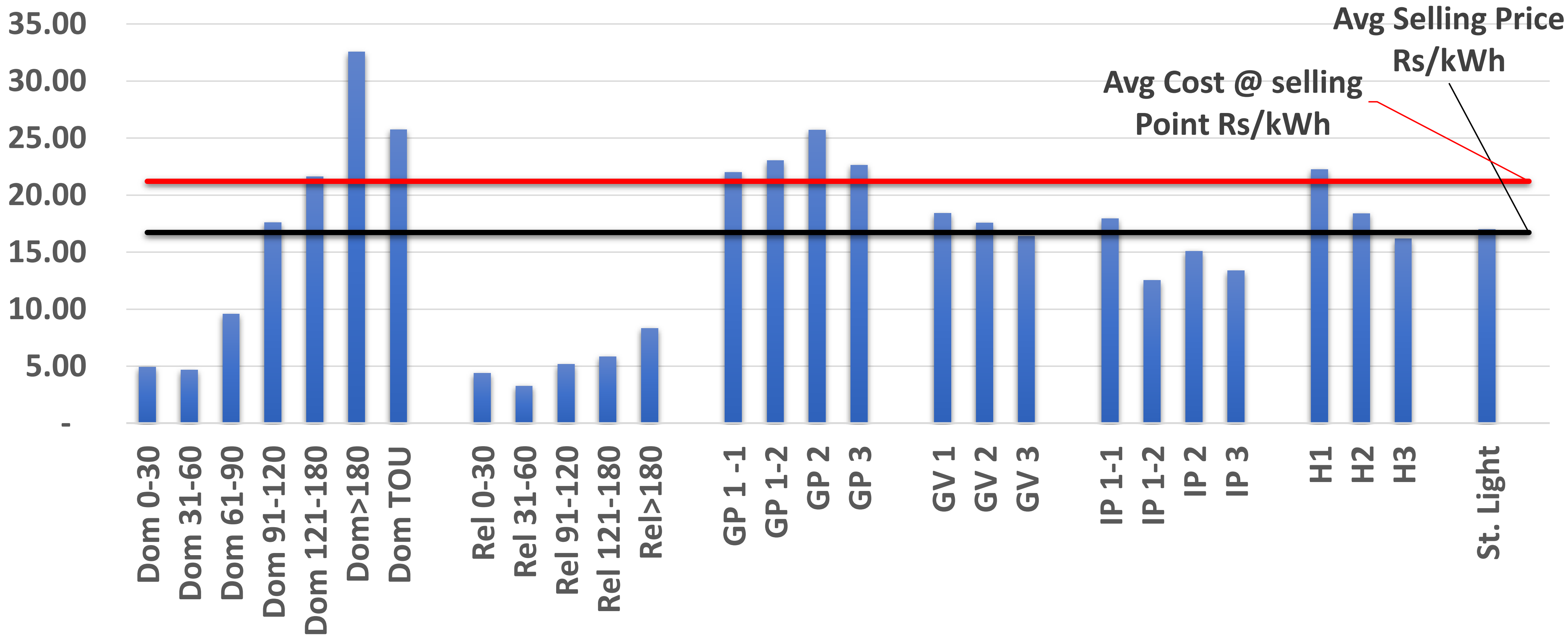
# Issues Contd..

| Tariff Category | Avg. Bill per customer (Rs/month) | Avg unit price Rs/kWh | Profit/(subsidy) per Rs/kWh |
|---|---|---|---|
| **Domestic** | | | |
| 91-120 | 2,159.76 | 17.6 | 0.93 |
| 121-180 | 3,662.47 | 21.6 | 4.96 |
| >181 | 10,546.58 | 32.5 | 15.87 |

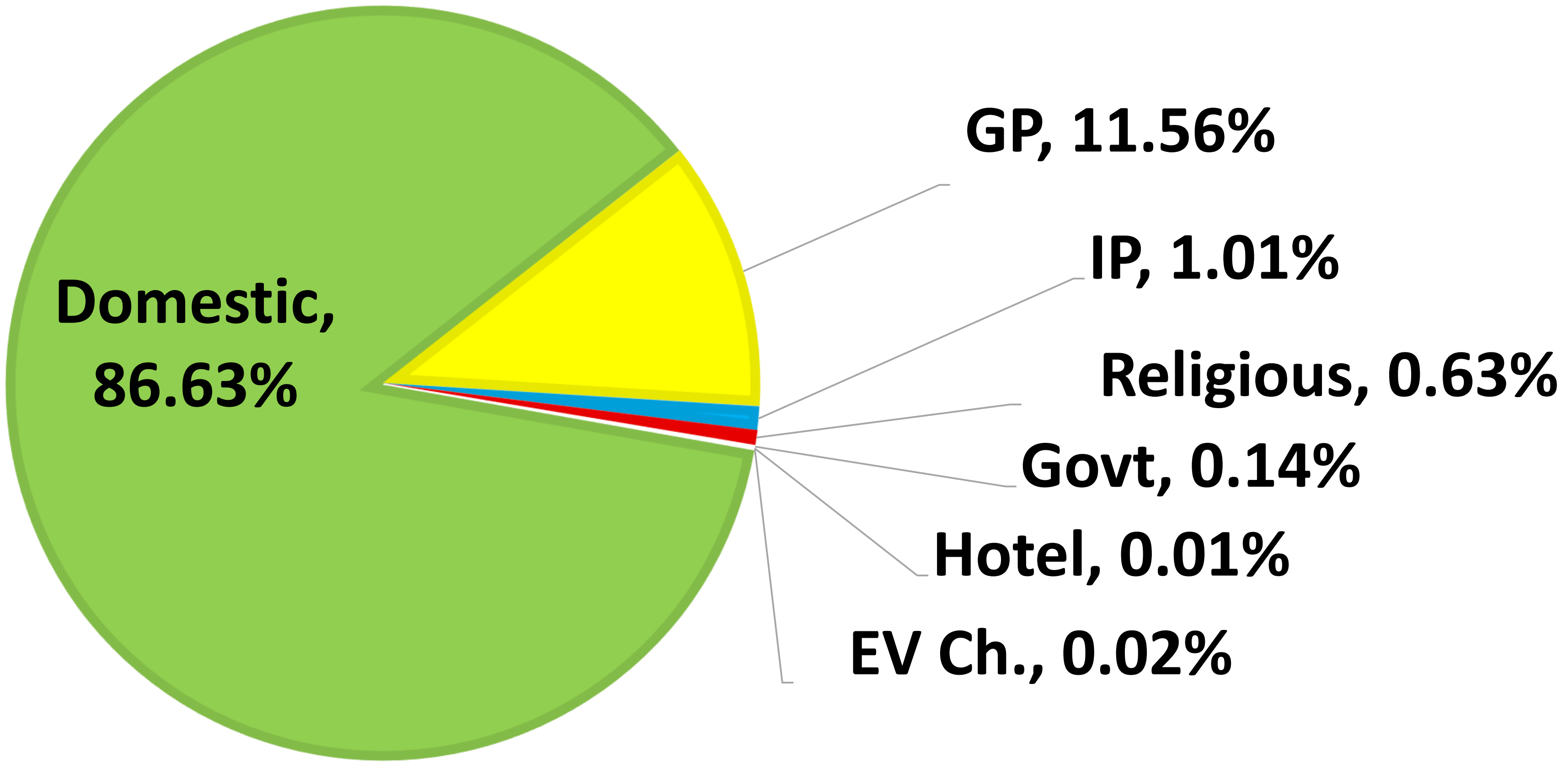
Customers Financing the Cross subsidy

- Subsidy mismatches exists between Categories.
- The removal of cross subsidies requires rebalancing the tariffs.

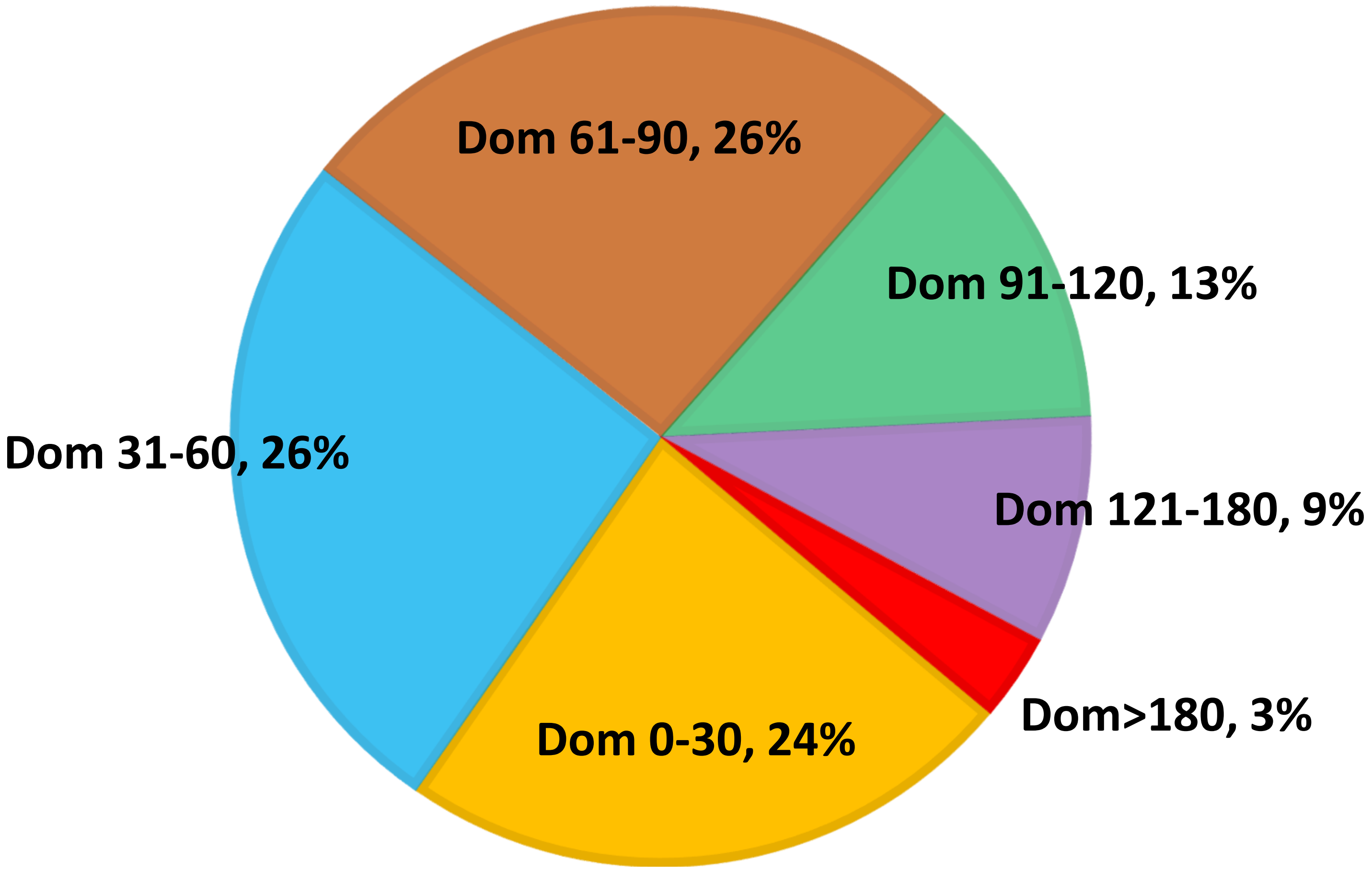
# Cross Subsidy



# Electricity Customer Base as at 2020



# Domestic Customer Distribution as at 2020



# Issues Contd..

- Life-line rates can be a solution.
- A household with basic requirements would use 30 kWh/month.
- Government to directly subsidise such customers through an appropriate mechanism such as “Samurdhi Scheme”.
- Then the subsidy would flow external to the electricity tariffs.

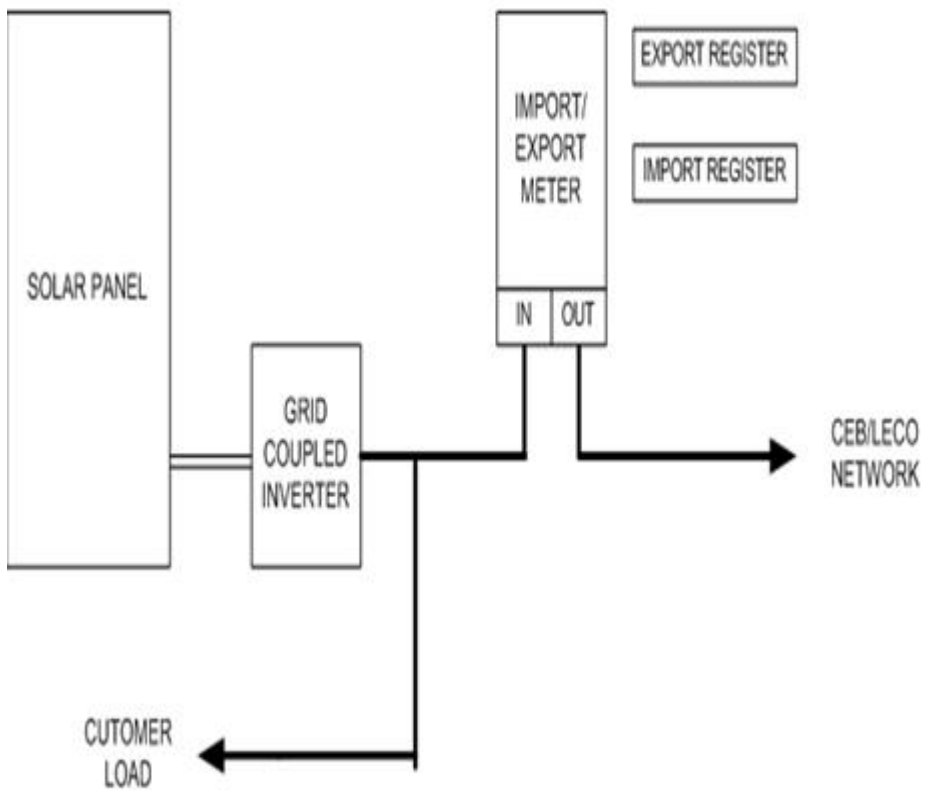
# Issues Contd..

- Too many Tariff blocks and too many Tariff Categories.
- To achieve cost reflectivity it is necessary to reduce Tariff Blocks and unify consumer categories as much as possible.
  - Ex. Industrial, General and Hotel Purpose categories can be unified.
- Electricity tariffs are defined by means of customer categories rather than voltage level at which each customer is served (cost of supply depends on voltage).
- Setting the price of electricity in accordance with the purpose of electricity use, has caused many difficulties for DLs to determine the category to which each customer Belongs.
- Customers have complained to PUCSL of unfair classifications by DLs.
- Similarly, the block tariffs applied to household customers have burdened the DLs with the task of defining the boundaries of a household.

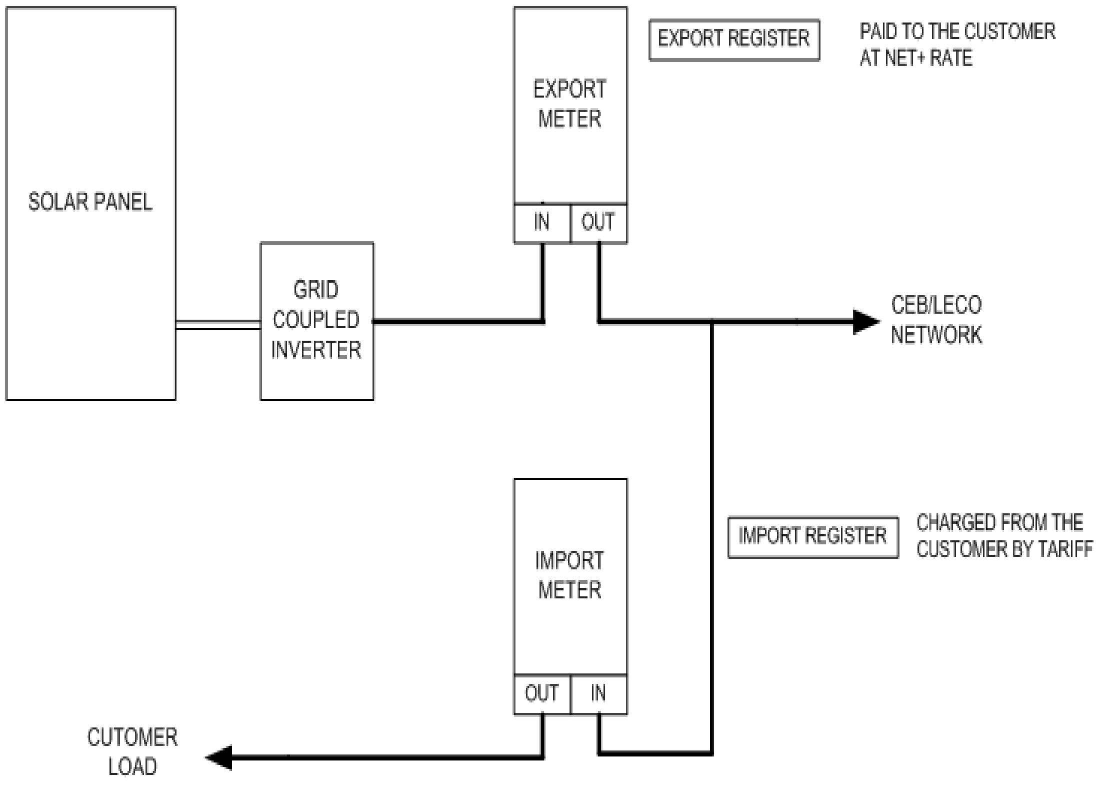
# Issues Contd..

## Electricity Tariffs Vs Rooftop Solar Schemes

### Net metering/Net Accounting



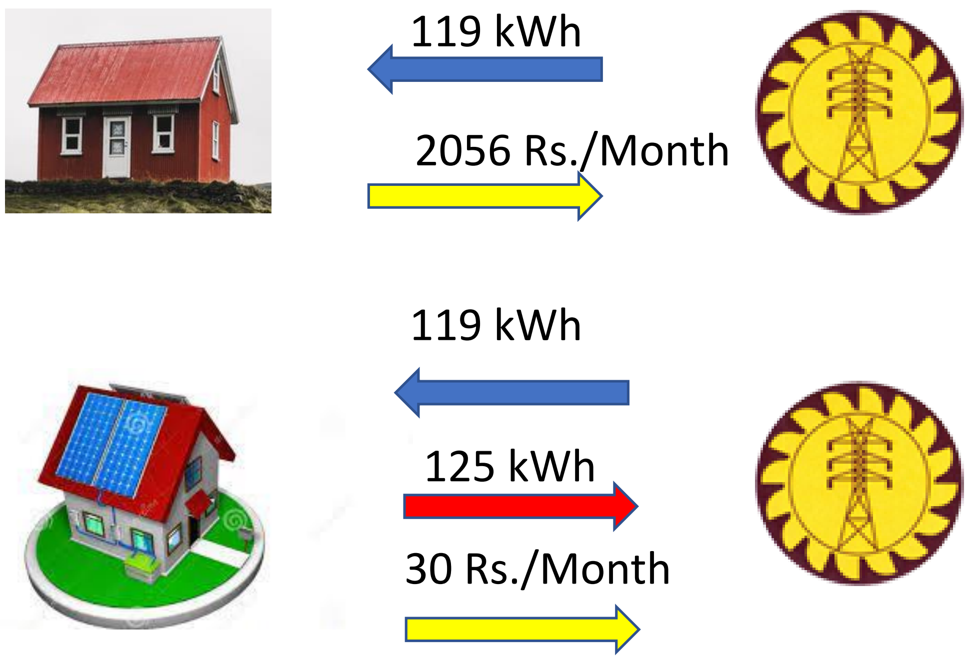

### Net Plus Schemes




SCHEME III

# Impact – 1 kWp rooftop Solar System

**Net Metering**

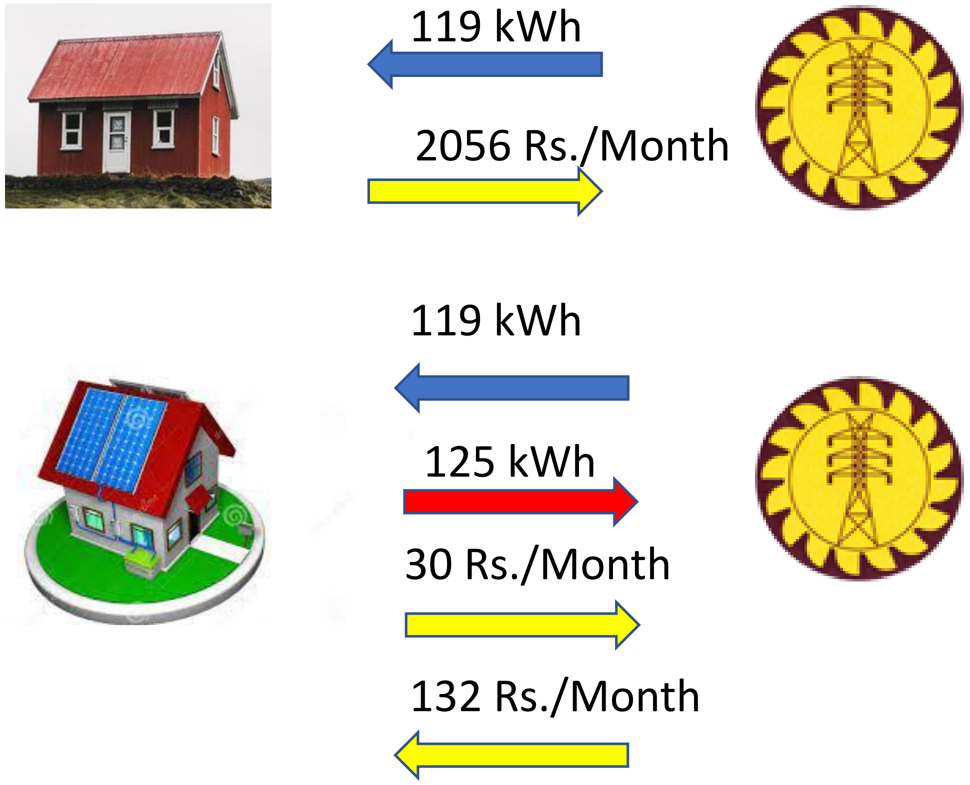



- Earnings from exported electricity - none (LKR 0)
  - Excess of 6 kWh carried forward for next bill & could bank for 10 yrs
  - After 10 yrs, utility keeps the unutilised ‘banked energy’
- Total profit 2,026 Rs./Month (i.e. 2056-30)
- Simple payback* period 6.2+ years

*assuming LKR150,000 cost per $kW_p$ installed capacity

# Impact - 1kWp system

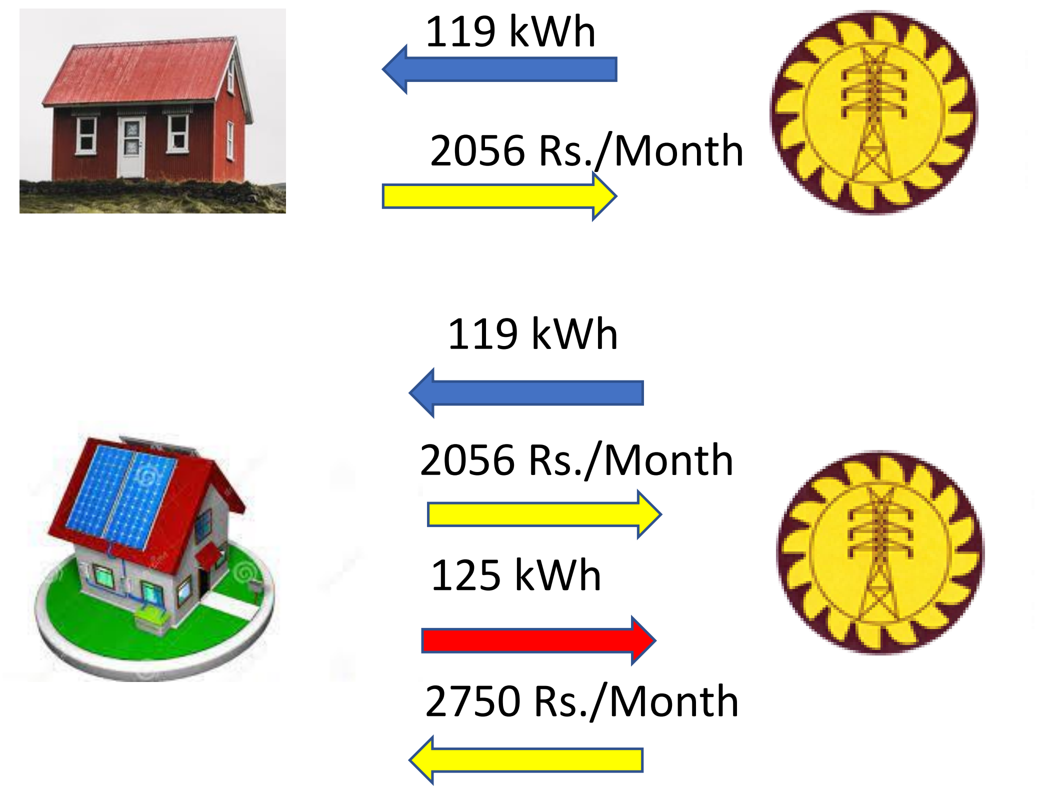
**Net Accounting**




- Earnings from exported electricity 6 kWh = 132 Rs./Month
- Total profit = 2,158 Rs./Month (2056-30+132)
- Simple payback period 5.7+ years

# Impact - 1kWp system

**Net Plus**




- Total profit = 2,750 Rs./Month (i.e. 125 x 22).
- Simple payback period 4.5+ years.
- IP1-1 Customer with roof top solar.
  - - Purchased from CEB @ 10.80 Rs./kWh.
  - - Sell to CEB @ 22 Rs./kWh

# Roof Top Solar Schemes

- Due to high Export Tariff a niche market is created.
- Most high end users may find it a worthy investment.
- Cross subsidy structure is distorted.
- Tariff revision with out revising Roof top solar export tariff may encourage affluent customers to put up solar.

# 1st Seminar on System and Policy in Power Sector on Independence of FIT Scheme from Electricity Tariff

Ceylon Electricity Board
JICA Expert Team

August, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# 01 Current CEB FIT Scheme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# Flow of Collected Electricity Tariff

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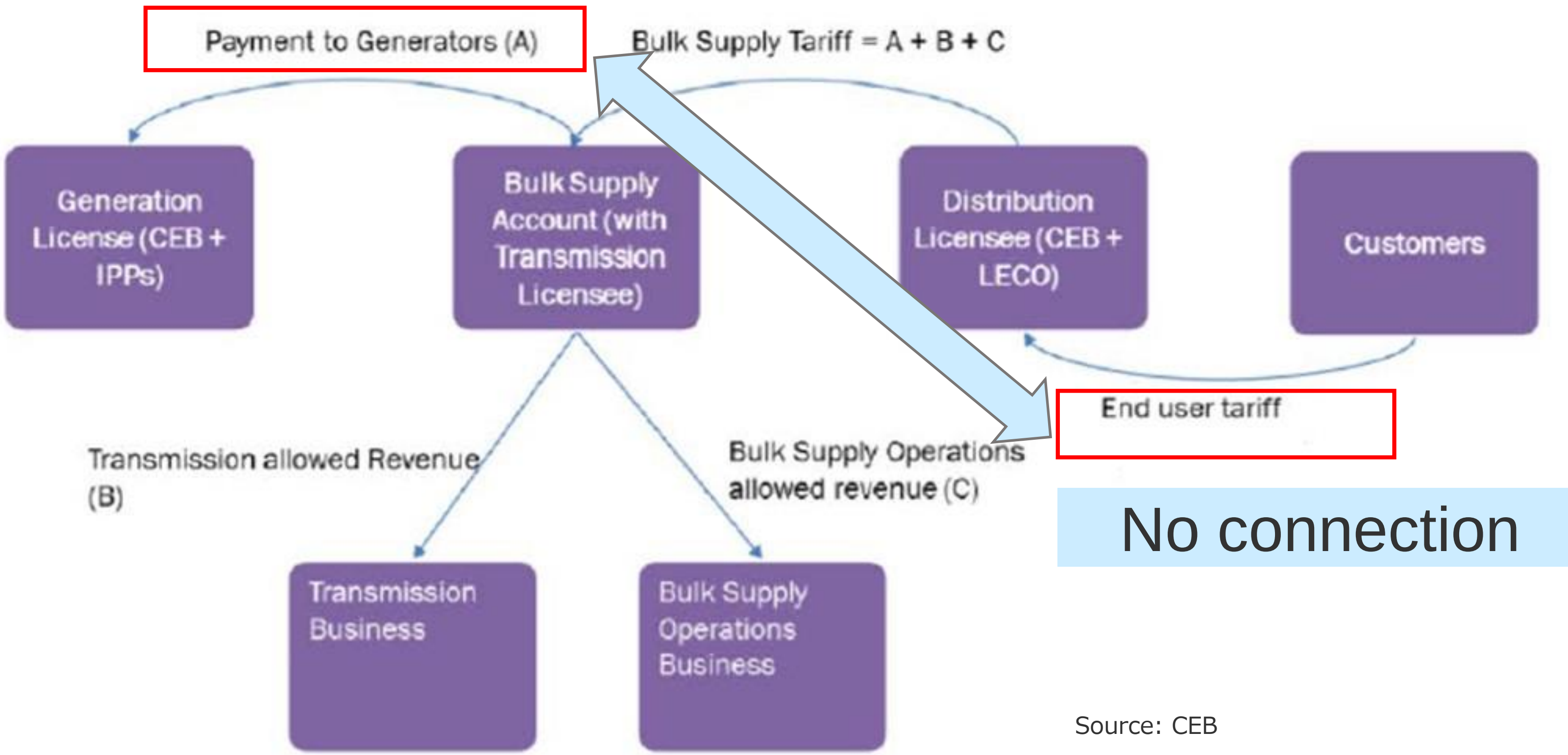
- Revenue collected from End users and Cost (FIT Tariff) paid to power generation companies are not linked.
- Bulk supply path through tariff, which was previously recognized as Pass through tariff, has been unable to pass on costs to End users since the introduction of UNT (Uniform National Tariff).

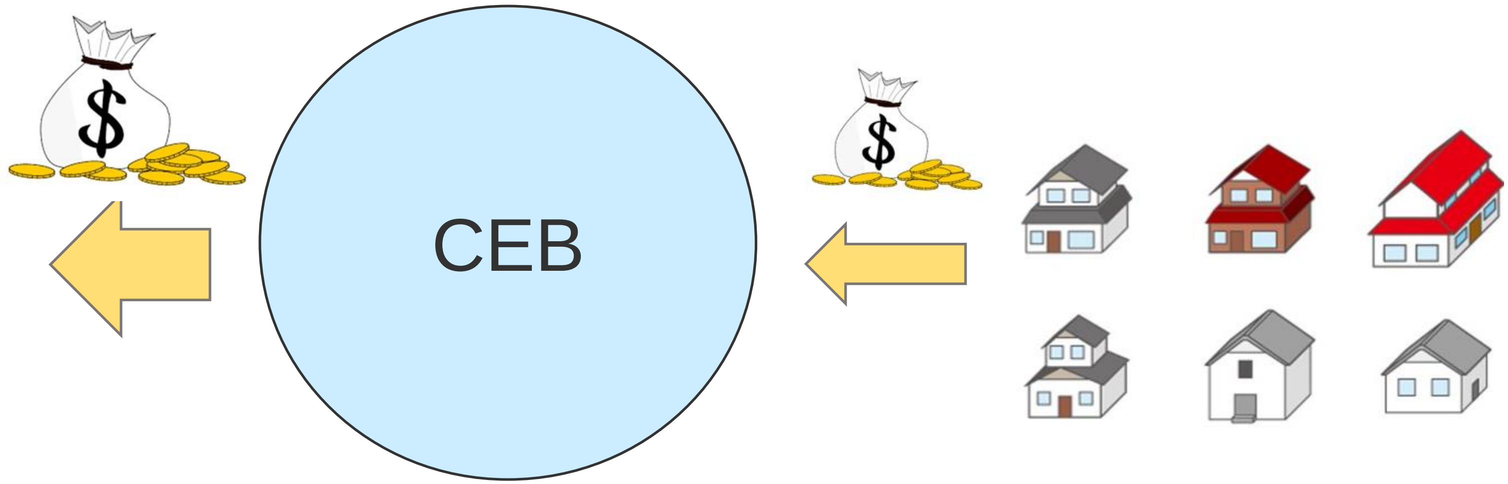



Source: CEB

**The CEB stands between the customers and the generating companies, acting as role to absorb the difference between revenue and cost.**

# Problems of CEB Financial Status

Since FIT Tariff is higher than Average Electricity Tariff, CEB cannot operate a sound electric power supply business.




Financial Deficit

General measures in terms of business perspective

Keeping the balance between Cost and Revenue for CEB
- To raise Electricity Tariff
- To lower FIT Tariff

Another approach

Independence of FIT scheme from Electricity Tariff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# 02 Independence of FIT scheme (Case in Japan)


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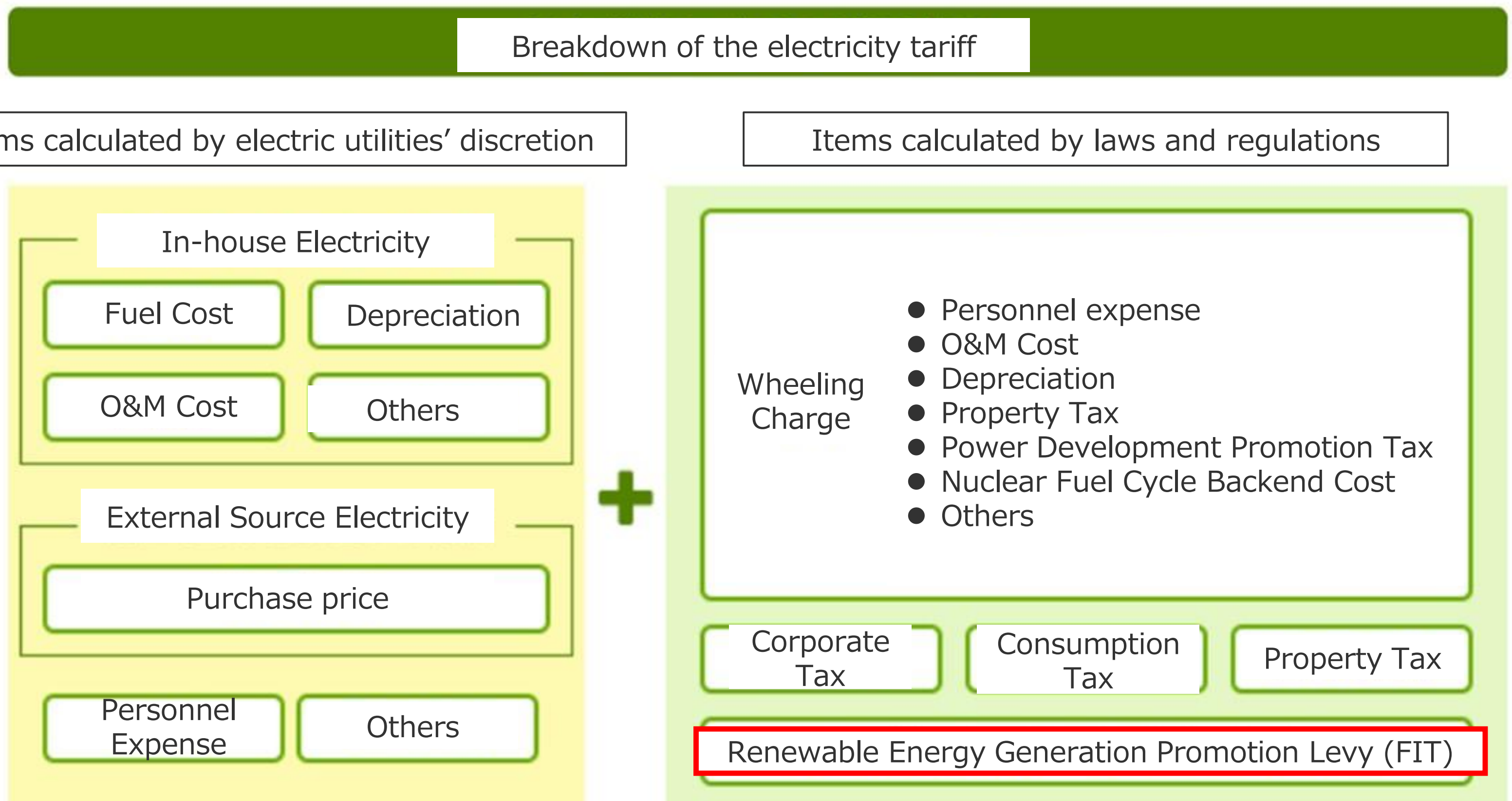
# Collection together with Electricity Tariff

- Electricity tariff consists of the items calculated by electric utilities' discretion and the items calculated by laws and regulations.
- FIT is a national scheme not electric utilities to achieve the renewable energy introduction target, which is National Goal. It is calculated separately from the main elements of electricity tariff.




Source: Agency for Natural Resources and Energy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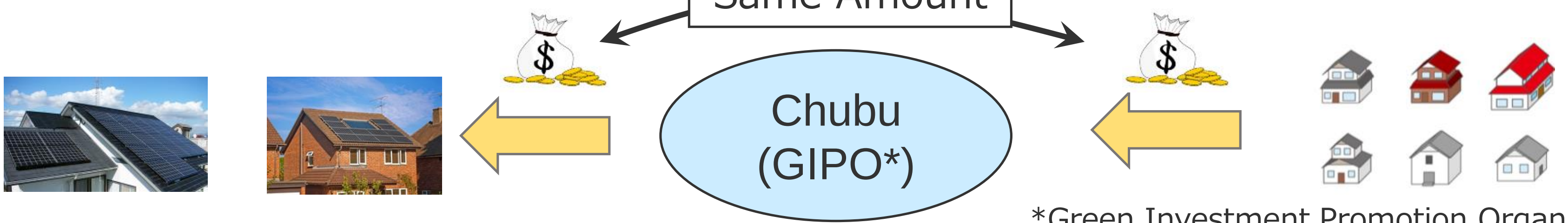
# Drawing Line between FIT Tariff and Electricity Tariff

FIT Tariff paid to power generation companies is collected from End Users as FIT Surcharge separately from electricity charges.




*Green Investment Promotion Organization

## Bill Sheet (Case in Chubu)


Electricity Tariff

FCA

FIT Surcharge

1. ご契約名義
2. お客さま番号
3. ご契約内容
4. 当月のご使用期間
5. ご使用量
6. 当月指示数
7. 前月指示数
8. 前年同月の使用実績
9. 翌月の検針日など
10. 当月分のご請求予定額
11. 振替予定日
12. 基本料金
13. 電力量料金
14. 口座振替初回引落割引額
15. FIT Surcharge
16. 燃料調整単価
17. 再エネ発電促進賦課金単価
18. 太陽光発電促進付加金単価
19. 電気料金領収証
20. お問い合わせ先

**FIT surcharge is collected separately from Electricity Tariff**



Source: Chubu HP

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# FIT Surcharge Calculation

- The Generation cost from renewable energy will be borne by the all end users as a FIT Surcharge (renewable energy power generation promotion levy) according to the amount of electricity used, at a uniform unit price nationwide.
- Since the introduction speed of renewable energy varies from region to region, an organization (cost burden adjustment organization) will be set up to adjust the burden, and the FIT Surcharge collected by each electric power company by a uniform unit price nationwide. Once the coordinating organization (GIPO) collects it, they deliver a grant to each electric utility according to the FIT Tariff they pay to generation companies.

$$\text{Unit price of FIT} = \frac{\text{Total expected grants for the year}}{\text{Estimated amount of electricity supplied to consumers in the same year}}$$

**Scheme in which all customers in Japan participate**



Source: Agency for Natural Resource and Energy

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# FIT Surcharge Price Setting and its Management

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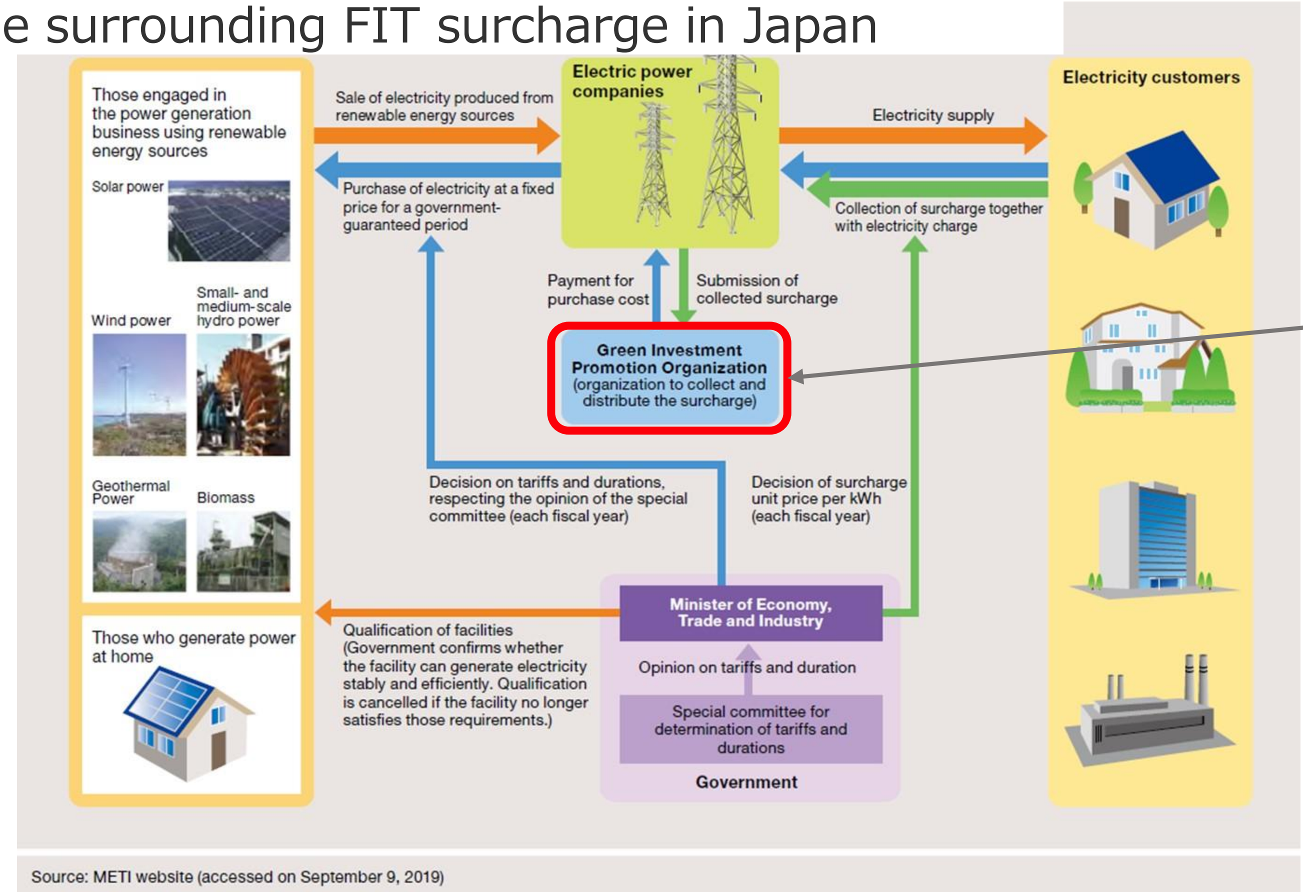
- The electric power companies collect the FIT surcharge, but the third-party "Green Investment Promotion Organization" manages it.
- How about creating the scheme that CEB collects FIT Tariff from customers and pass through it to VRE operators as it is?

Scheme surrounding FIT surcharge in Japan




Centralized management of FIT Surcharge



Source: Agency for Natural Resource and Energy

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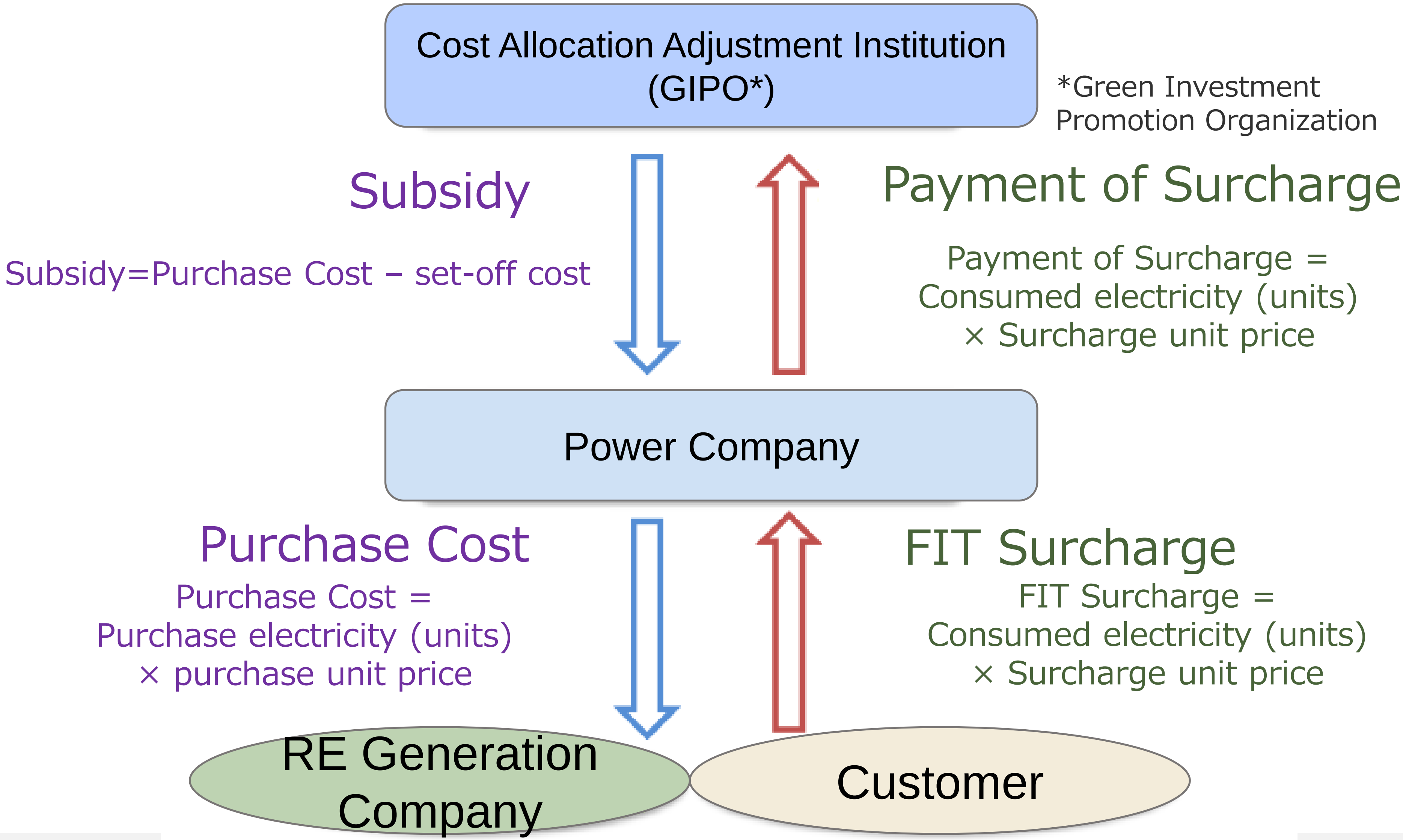
# FIT Surcharge Price Setting and its Management




Source: Agency for Natural Resource and Energy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# Changes in FIT Surcharge unit price paid by Consumers

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- In order to prevent the burden on the public from increasing significantly even if the FIT amount increases, the FIT Tariff of power generation companies has been lowered to suppress the increase in the FIT surcharge paid by consumers.
- To minimize the burden is necessary while the RE ratio is achieved

| FY | Unit Price of FIT (Consumers) | Burden for general family |
|---|---|---|
| 2012 | Yen 0.22/kWh | Yen 66/month |
| 2013 | Yen 0.35/kWh | Yen 105/month |
| 2014 | Yen 0.75/kWh | Yen 225/month |
| 2015 | Yen 1.58/kWh | Yen 474/month |
| 2016 | Yen 2.25/kWh | Yen 675/month |
| 2017 | Yen 2.64/kWh | Yen 792/month |
| 2018 | Yen 2.90/kWh | Yen 870/month |
| 2019 | Yen 2.95/kWh | Yen 885/month |
| 2020 | Yen 2.98/kWh | Yen 894/month |

Will be lowered in the future

Reducing the burden on the public in parallel with preventing the introduction of VRE from slowing down.

Source: Agency for Natural Resource and Energy


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# Achievement of National Energy Plan with Surfacing the Levy

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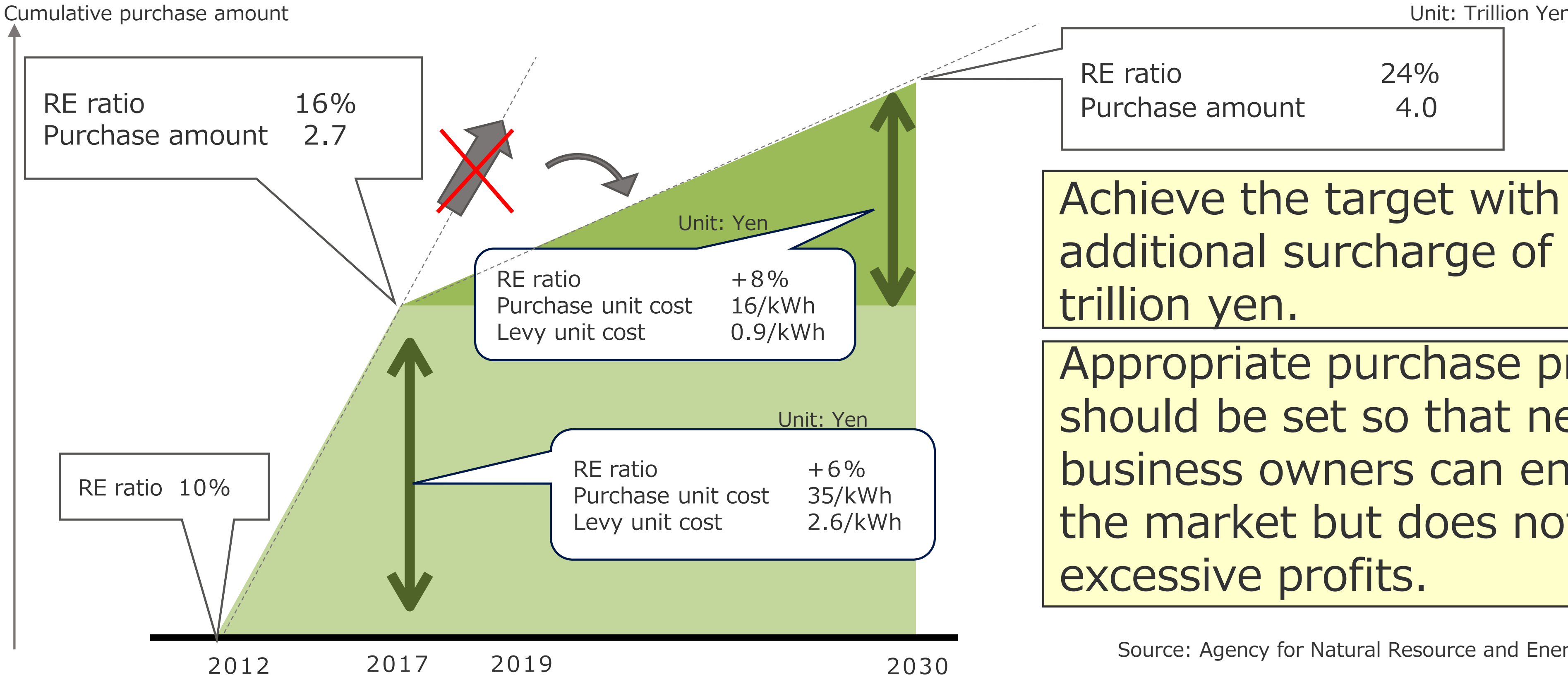
- 2.7 trillion yen levy was required to achieve a RE ratio of 10% to 16% (mostly VRE).
- Further increase of 8% is necessary to achieve 22-24% of RE ratio by 2030
- To minimize the burden is necessary while the RE ratio is achieved




Achieve the target with additional surcharge of 1.3 trillion yen.

Appropriate purchase price should be set so that new business owners can enter the market but does not get excessive profits.

Source: Agency for Natural Resource and Energy

It is important to reduce the burden on the public and promote the introduction of renewable energy (maintaining the VRE business environment).


rved.

# Issues of FIT Surcharge system and Government action

Issues of FIT Surcharge system in Japan

i) Customers burden to pay FIT surcharge has become heavy in line with increasing purchase electricity amount owing  to big development of Renewable Energy.

ii) Some developers do not start construction PV plant even they got approval of construction of the plant. They have right to sell PV generated electricity in high price in 20 years after start operation. This situation has a possibility of taking high burden of FIT surcharge to customers.

↓

FIT regulation had amended in 2016. Suitability and feasibility of the approved project have become to check under the regulation for approving responsible developer and reducing unconstructed plant.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# Separately FIT Tariff Collection from Electricity Tariff

- Expected merits for Separately Tariff Collection from Electricity Tariff in Sri Lanka

✓ Development of renewable energy will make the energy self-sufficiency rate improving.

✓ The energy self-sufficiency rate improvement will lead to a decrease in dependence on fossil fuels, and from the viewpoint of suppressing fluctuations in electricity prices due to turbulence in fuel prices, there are advantages for all users of electricity.

✓ The energy self-sufficiency situation in Sri Lanka is similar to Japan. Therefore, Sri Lanka can expect receiving the same advantages as Japan.

✓ The Separation FIT Tariff collection clarifies the electricity tariff and the cost of renewable energy development, and makes it easy to gain public understanding.

↓

How about creating the scheme that CEB collects FIT Tariff from customers and pass through it to VRE operators as it is?


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jica

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Electric Power

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# 1st Seminar on System and Policy in Power Sector on Renewable Energy introduction promotion system in Asian countries

Ceylon Electricity Board
JICA Expert Team

August, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# 01 Basic Information

# Basic information of each country

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| | Sri Lanka | India | Indonesia | Thailand | Philippines | Vietnam | Malaysia | Taiwan |
|---|---|---|---|---|---|---|---|---|
| Population [million] | 21.0 (2018) | 1,339.2 (2018) | 264.0 (2017) | 69.0 (2017) | 101.0 (2015) | 95.5 (2017) | 31.6 (2017) | 23.5 (2016) |
| GDP[billion US$] | 87.2 (2017) | 2,263.5 (2016) | 932.2 (2016) | 406.8 (2016) | 304.3 (2016) | 202.6 (2016) | 296.4 (2016) | 529.9 (2016) |
| GNI/Capita [US$] | 3,840 (2017) | 1,680 (2016) | 3,400 (2016) | 5,640 (2016) | 2,947 (2016) | 2,050 (2016) | 9,850 (2016) | 23,284 (2016) |
| Electrification Rate [%] | 99.6 (2018) | 99.9 (2019) | 91.2 (2016) | 99.9 (2016) | 88 (2016) | 99.1 (2016) | 99.9 (2016) | 100 (2016) |
| Peak Demand[MW] | 2,669 (2019) | 156,934 (2016) | 32,200 (2016) | | 13,790 (2017) | 30,857 (2017) | 21,740 (2016) | 35,860 (2016) |
| Energy Sales [GWh] | 13,431 (2017) | 1,135,33 4(2016) | 216,004 (2016) | 181,085 (2016) | 77,800 (2017) | 159,790 (2016) | 158,672 (2016) | 212,532 (2016) |
| Generation Cap.[MW] | 4,087 (2017) | 344,002 (2017) | 50,630 (2016) | 40,605 (2015) | 22,728 (2017) | 48,573 (2018) | 32,870 (2016) | 49,910 (2016) |
| RE Ratio*[%] Energy base | 34.8 (2019) | 17.0 (2016) | 8.2 (2016) | 11.2 (2017) | 6.6 (2016) | 42.3 (2018) | 1.8 (2016) | 5.5 (2016) |

*Include hydro


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# 02 VRE promotion in India



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# (India) Target of Renewable Energy Development

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Renewable energy introduction target of Indian government

- ✓ 40% of the installed capacity of generation will be non-fossil fuel power sources by 2030
- ✓ 36.5%, 175GW of renewable energy will be introduced by 2022.

Renewable energy introduction target by 2022 and past record [MW]

| | Solar Large scale | Solar Rooftop | Wind | Biomass | Small-hydro | total |
|---|---|---|---|---|---|---|
| Target | 60,000 | 40,000 | 60,000 | 10,000 | 5,000 | 175,000 |
| Past record* | 21,119 | 1,934 | 34,193 | 9,909 | 4,493 | 71,588 |
| Progression rate | 35% | 5% | 57% | 99% | 90% | 41% |

*as of the end of May 2018

Source: MNRE website


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# (India) Past trend of RE development system

2009
FIT
-Solar, Wind, small-hydro, biomass

2010
RPO(Renewable Portfolio Obligation)
(for large customers)
-Solar, Wind, small-hydro, biomass

2014
Solar park
-Solar(over 50kW)

# (India)　RE Introduction Promotion System (Feed in Tariff)

FIT: Feed in Tariff

- ✓ FIT started in 2009
- ✓ Tariff are set by both Central Electricity Regulatory Commission(CERC) and state jurisdiction


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# (India) RE Introduction Promotion System (RPO)

## RPO: Renewable Purchase Obligation

- ✓ RPO started in 2010
- ✓ Obligation to procure a certain percentage of renewable energy for large consumers and consumers with private power generation facilities
- ✓ If the amount required for procurement is not met, purchasing a Renewable Energy Certificate(REC)
- ✓ At the beginning of this system, the target value was set to 3%
- ✓ From 2016, amount of renewable purchase obligation was divided into solar and non-solar, and was raised to a total of 21%

Renewable Purchase Obligation(RPO) [%]

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Solar | 2.75 | 4.75 | 6.75 | 7.25 | 8.75 | 10.50 |
| RE other than solar | 8.75 | 9.50 | 10.25 | 10.25 | 10.25 | 10.50 |
| Total | 11.50 | 14.25 | 17.00 | 17.50 | 19.00 | 21.00 |

Source: MOP


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# (India) RE Introduction Promotion System (Solar Park)

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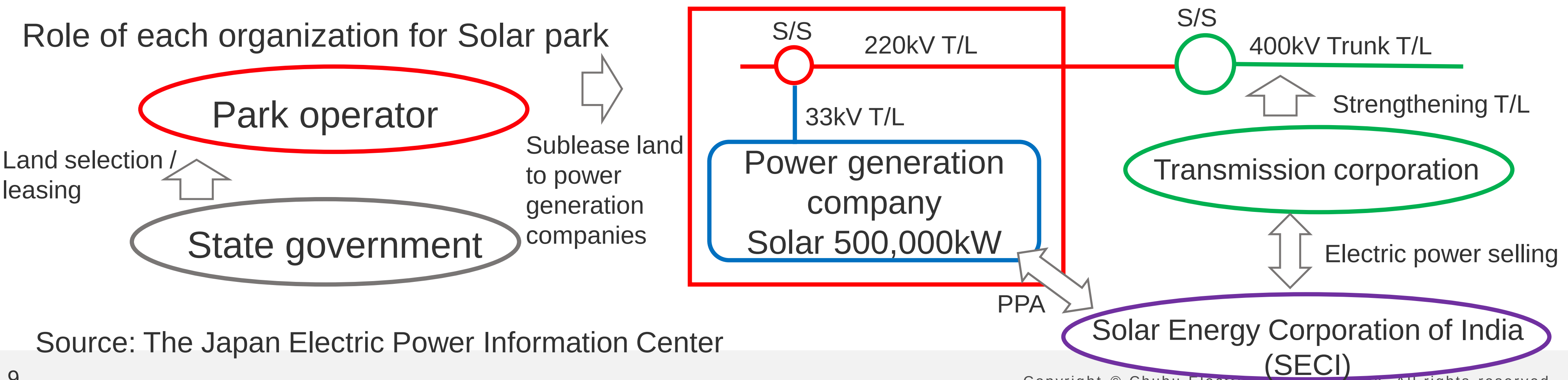
Solar park

- ✓ Solar park started in 2014, for solar generation of 500MW and more
- ✓ The state government provides land for the park
- ✓ The park operator maintains the land and the transmission lines for the park
- ✓ Subsidy for the park operator: Park maintenance cost 2.5million Rupees/1park, grid connection cost 2million Rupees/1,000kW or 30% of project cost(which ever cheaper)
- ✓ Power generation companies are selected by competitive bidding and conclude PPA with Solar energy corporation of India(SECI)
- ✓ Power generation companies are free for land acquisition. In addition, there is an advantage that the transmission line is constructed by the park operator.

Role of each organization for Solar park




Source: The Japan Electric Power Information Center



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# 03 VRE promotion in Indonesia


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# （Indonesia） Target of Renewable Energy Development

◆Energy Policy

National Energy Policy （KEN） (2014)

✓ Target of RE energy ratio in primary energy : 23% by 2025, 31% by 2050

◆Plan

- Comprehensive Energy Plan （RUEN） (2017)

✓ 75% of target in 2025 (i.e. RE ratio 23%) was allocated to power sector.

- Comprehensive Power Development Plan （RUKN） (2019)

Target of RE development amount at 2025 in KEN and results at 2018

| | Power Sector allocation: 69.2 million ton oil equivalent | | |
|---|---|---|---|
| | Target at 2025 | Results at 2018 (Ratio to the Target [%]) | |
| Geothermal | 7,200 MW | 1,950 MW | (27.1%) |
| Hydropower | 17,900 MW | 5,890 MW | (32.9%) |
| Small Hydropower | 3,000 MW | 310 MW | (10.3%) |
| Biomass Energy | 5,500 MW | 1,860 MW | (33.8%) |
| Solar Power | 6.5 MW | 0.15 MWp | (2.3%) |
| Wind Power | 1.8 MW | 0.15 MW | (8.2%) |
| Others (Tidal Power etc.) | 3,100 MW | - | |

Source: The Japan Electric Power Information Center


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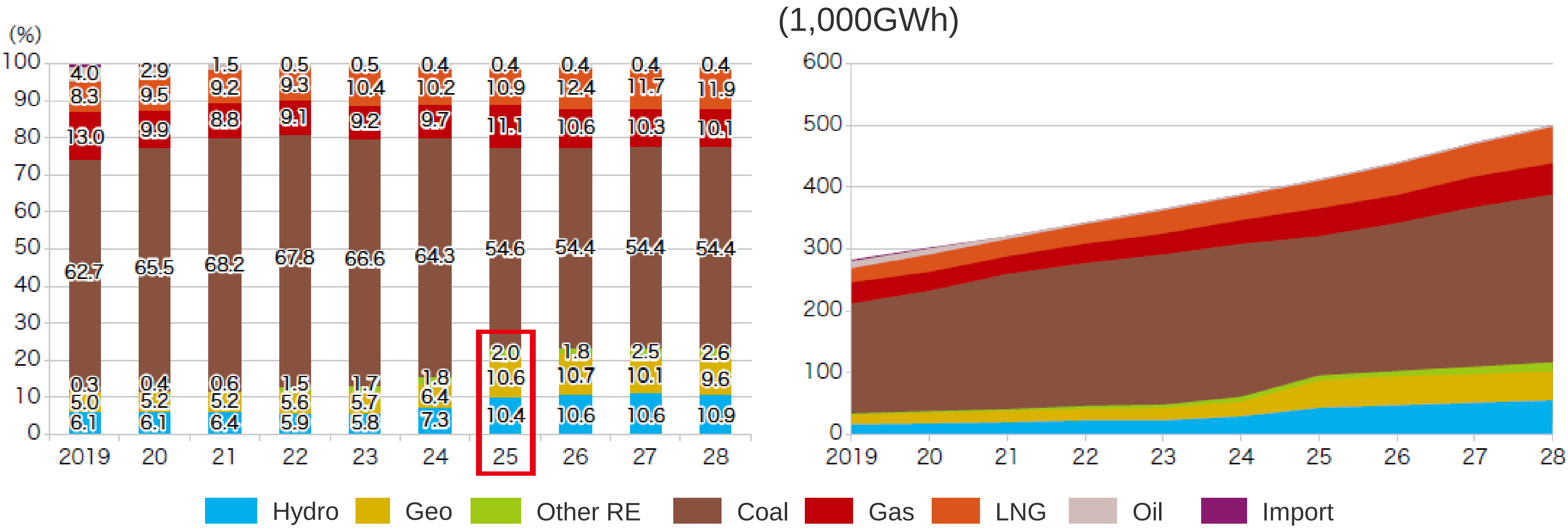
# (Indonesia) Target of Renewable Energy Development

CHUBU Electric Power
NIPPON KOEI

## Power generation forecast from 2019 to 2028 in Power Supply Plan in PLN (RUPTL)




Left: Shares in Power Generation (%), Right: Expected future trend of Power Generation (GWh)

Source: The Japan Electric Power Information Center



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# (Indonesia) Past trend of RE development system

## Renewable Energy Plant below 10MW

**2006**
Purchasing all RE power
-PLN has obligation for purchasing

**2016**
PV FIT system

**2017**
Purchasing all RE power by generation cost when the cost is lower than Average Power Generation Cost by State (BPP)

**2017**
BOOT(Built-Own- Operation - Transfer) scheme shall be applied

**2020**
BOOT was switched to BOO (no transferred)

* In Indonesia, only PLN is an Off-taker.

# (Indonesia) RE Introduction Promotion System (Feed in Tariff)

CHUBU Electric Power
NIPPON KOEI

◆Past trend of FIT (1)

✓ 2016: FIT system for PV

-FIT price of PV in each area was different in this scheme

e.g. Jakarta:14.5 US cent/kWh, Bali:16.0 US cent/kWh

✓ 2017: Direct Selection Scheme (bidding included)

-Direct Selection Scheme was introduced.

This scheme designated Average Power Generation Cost by State (BPP) as the standard generation cost.

Under this scheme;

i) In case, RE Generation Cost is lower than the BPP

>PLN purchase RE power for generation cost

ii) In case, RE (PV, Wind, Biomass, etc.) Generation Cost is higher than the BPP

>PLN purchase RE power for maximum 85% of generation cost


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# (Indonesia) RE Introduction Promotion System (Feed in Tariff)

CHUBU Electric Power
NIPPON KOEI

◆Past trend of FIT (2)

(2017: Continued from previous page)

-RE plant shall be applied BOOT (Built-Own-Operation-Transfer) scheme. Plant is transferred after 20 years since COD.

⇩

-Under this scheme, incentive for development of RE did not rise, because

i) Purchasing price by PLN was low, and

ii) The profit of PV plant owner was only PV power sold income.

✓ 2020: Direct Selection Scheme was replaced with Direct Appoint Scheme

-It became possible to nominate a specific business operator by PLN without bidding.

-BOOT was switched to BOO (Built-Own-Operation) for RE plant below 10MW


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# 04 VRE promotion in Thailand


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# （Thailand） Target of Renewable Energy Development

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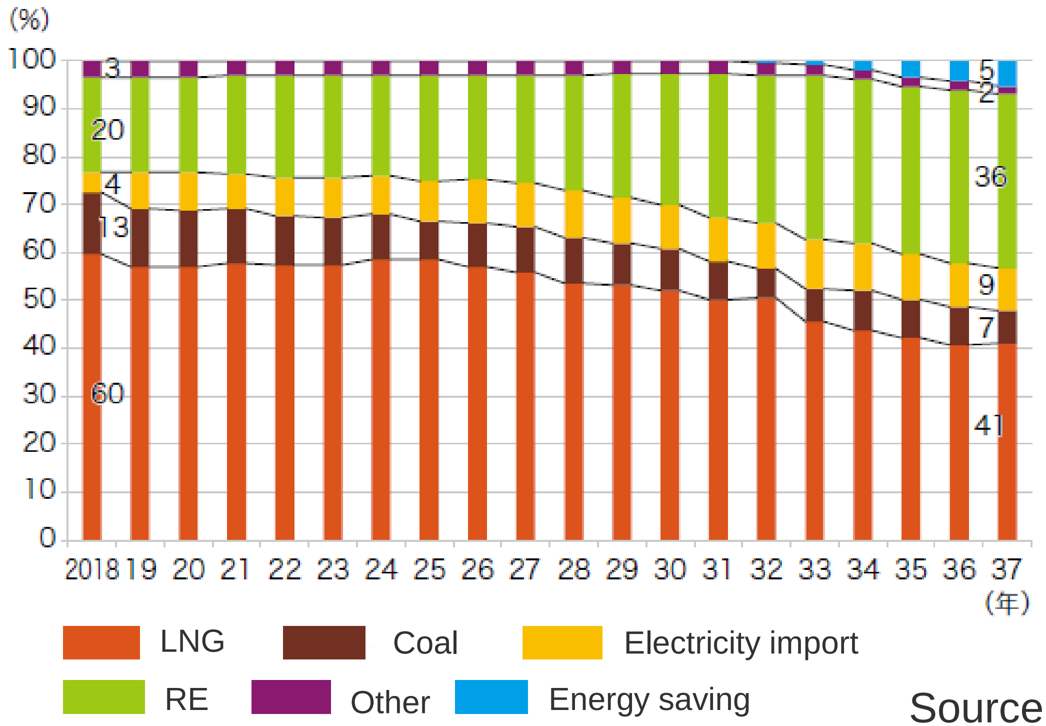
NIPPON KOEI

A power development plan for 2018-2037 is formulated by Power Development Plan(PDP) 2018
The ratio of renewable energy is planned to increase from 20% in PDP 2015 to 36%

Composition ratio of each power generation in PDP 2018




Source: PDP2018



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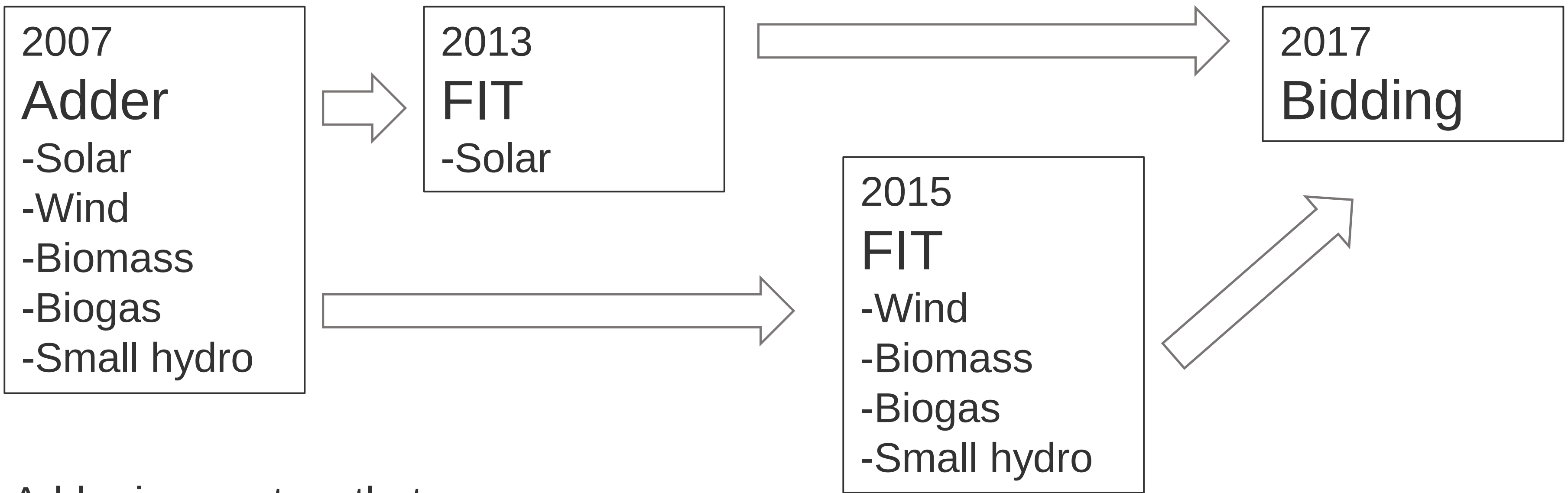
# (Thailand) Past trend of RE development system

Introduction promotion system have changed from Adder to FIT, Bidding




Adder is a system that adds a certain amount to the wholesale fee

# (Thailand) RE Introduction Promotion System ( Adder)

- ✓ "Adder" program since 2007
- "Adder" system adds some rate of Bahts (Thailand currency unit) per kWh to the base tariff, depending on the type of technology.
- Special Adder rate are added for the introduction instead of diesel and introduction to the three southern provinces.
- Due to a sharp increase application for solar, the adder rate was reduced, from 8.0 to 6.5Baht/kWh, and new application was postponed in 2010

Adder rate by RE type

| Type of RE | Installed cap. | Adder rate [Baht/kWh] | Special adder for diesel replacement [Baht/kWh] | Special adder for three southern provinces [Baht/kWh] | Years supported |
|---|---|---|---|---|---|
| Wind | ≦50kW | 4.5 | 1.5 | 1.5 | 10 |
| | ＞50kW | 3.5 | 1.5 | 1.5 | 10 |
| Small hydro | 50kW - 200kW | 0.8 | 1.0 | 1.0 | 7 |
| | ≦50kW | 1.5 | 1.0 | 1.0 | 7 |
| Solar | | 8.0→6.5 | 1.5 | 1.5 | 10 |

Source: The Japan Electric Power Information Center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# (Thailand) RE Introduction Promotion System (FIT for Rooftop PV)

- ✓ Rooftop PV FIT program since 2013
- Thailand's first FIT program was introduced for rooftop PV
- Three types were classified by capacity for residential and commercial use, and the supported period ware 25 years
- ERC(Energy Regulatory Commission) of Thailand have introduced the FIT program in consideration of the increased burden due to the increased application of Adder and the lowering of equipment prices due to technological progress.

FIT rate for roof top solar

| Classification | Installed cap. | FIT rate [Baht/kWh] | Supported duration year | Target value |
|---|---|---|---|---|
| Residential | 0 - 10kW | 6.96 | 25 | 100MW |
| Small commercial | 10 – 250kW | 6.55 | 25 | 100MW |
| Medium/Large commercial | 250 – 1,000kW | 6.16 | 25 | |


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# (Thailand) RE Introduction Promotion System (FIT)

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- ✓ FIT for RE (Excluded Solar power) since 2015
- Renewable technologies other than rooftop solar were switched from Adder program to FIT by ERC(Energy Regulatory Commission)
- FIT rates are categorized by renewable technologies and the supported period are 10 or 20 years.

FIT rate by RE type

| Type | FIT rate [Baht/kWh] | Supported duration year |
|---|---|---|
| Waste < 1MW | 6.34 | 20 |
| Waste >1-3MW | 5.82 | 20 |
| Waste >3MW | 5.08 | 20 |
| Landfill waste | 5.6 | 10 |
| Biomass < 1MW | 5.34 | 20 |
| Biomass > 1-3MW | 4.82 | 20 |
| Biomass >3MW | 4.24 | 20 |
| Biogas | 3.76 | 20 |
| Biogas(Energy crop) | 3.76 | 20 |
| Hydro < 200kW | 4.9 | 20 |
| Wind | 6.06 | 20 |

Source: The Japan Electric Power Information Center


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# 05 VRE promotion in Philippines


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# (Philippines) Target of Renewable Energy Development

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- ✓ The government is accelerating renewable energy projects as one of the measures to secure electricity supply capacity and reduce carbon dioxide emissions, and the National Renewable Energy Board(NREB) take the lead in promoting the National Renewable Energy Plan.
- ✓ NREP aims to increase the amount of renewable energy generated from 5.4million kWh in 2010 to 15.3million kWh in 2030.

Target of renewable energy introduction by power source by NREP [MW]

| Power source | Installed capacity as of 2010 | Installed capacity as of 2030 |
|---|---|---|
| Geothermal | 1,966.0 | 3,461.0 |
| Hydro | 3,400.0 | 8,794.1 |
| Biomass | 39.0 | 315.7 |
| Wind | 33.0 | 2,378.0 |
| Solar | 1.0 | 385.0 |
| Marine | 0.0 | 70.5 |
| Total | 5,439.0 | 15,304.3 |

Source: NREP 2011-2030


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# (Philippines) Past trend of RE development system

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FIT was introduced, and then Net metering and RPS were added

2012
**FIT**
-Solar, Wind, Biomass, Run-of river hydro

2013
**Net metering**
(up to 100kW)
-Solar, Wind, Biomass

2018
**RPS**(Renewable Portfolio Standards)
-Solar, Wind, Biomass, Run-of river hydro

# (Philippines) RE Introduction Promotion System

CHUBU Electric Power
NIPPON KOEI

In order to promote the development of renewable energy, the renewable energy law set financial and non-financial incentives

Various incentives based on the renewable energy law

| | |
|---|---|
| Financial incentives | Income tax exemption |
| | Import duty exemption |
| | Import VAT exemption |
| | VAT exemption for buying and selling renewable energy |
| Non-financial incentives | Feed in tariff |
| | Renewable Portfolio Standard |
| | Net metering |

Source: The Japan Electric Power Information Center


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# (Philippines) RE Introduction Promotion System (FIT)

CHUBU Electric Power
NIPPON KOEI

- ✓ FIT system since 2012
- FIT rates are categorized by renewable technologies such as solar, wind, biomass, small hydro and the supported period are 20 years.
- In 2015, since the installed capacity of Solar and Wind power reached the target, the FIT tariff and target capacity had reviewed.

FIT rate by RE type and target/record value

| Type of RE | | FIT rate[P/kWh] | Introduction target | Introduction record |
|---|---|---|---|---|
| Solar (over 500kW) | Published in 2012 | 9.68 | 50MW | 109.38MW |
| | Published in 2015 | 8.69 | 450MW | 417.05MW |
| | Total | | 500MW | 526.43MW |
| Wind | Published in 2012 | 8.53 | 200MW | 249.90MW |
| | Published in 2015 | 7.40 | 200MW | 177.00MW |
| | Total | | 400MW | 426.90MW |
| Biomass | Published in 2012 | 6.63 | 250MW | 126.38MW |
| Run of river hydro | Published in 2012 | 5.90 | 250MW | 45.27MW |

Source: The Japan Electric Power Information Center



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# (Philippines) RE Introduction Promotion System (Net metering, RPS)

CHUBU Electric Power
NIPPON KOEI

✓ Net metering since 2013

- It is possible to deduct the selling price of renewable power from the electricity price of consumers.
- If the selling price exceeds the buying price, the excess can be carried over to the next month or later, and the excess accumulated at the end of the year can be refunded.
- Capacity limit of renewable power is up to 100kW.
- Solar, wind, biomass or such other renewable power system are eligible to participate in the net metering program.

✓ RPS system since 2018

- RPS (Renewable Portfolio Standards) requires electricity suppliers, such as distribution utilities and retailers, to procure more than a certain percentage of renewable energy.
- In addition to the introduction of PRS, REM (Renewable Energy Market) was established and RECs (Renewable Energy Certificate) were issued. And RECs are traded on the REM.
- The electric power supplier can allocate the purchased REC to the mandatory renewable energy amount determined by RPS.


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# 06 VRE promotion in Vietnam


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# (Vietnam) Target of Renewable Energy Development

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Power generation portfolio in 2030 was revised in PDP7 (the 7th National Power Development Plan) which was established in March, 2016.

- ✓ Assumption: economic growth rate is 7.0% per year
- ✓ VRE ratio in 2030: 21% (except for large hydropower)

| Power source | | Target at 2030 | Ratio | |
|---|---|---|---|---|
| VRE | Solar power | 12,000 MW | 9.3% | 21.0% |
| | Wind power | 6,000 MW | 4.6% | |
| | Biomass energy | 3,280 MW | 2.5% | |
| | Small hydropower | 5,915 MW | 4.6% | |
| Hydropower (including pumped storage power generation) | | 21,885 MW | 16.9% | 79.0% |
| Gas thermal power (including LNG thermal power) | | 19,036 MW | 14.7% | |
| Coal thermal power | | 55,167 MW | 42.6% | |
| Nuclear power | | 6,216 MW | 4.8% | |
| Import | | | | |
| Total | | 129,500 MW | - | |

Source: The Japan Electric Power Information Center


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# (Vietnam) Past trend of RE development system

CHUBU Electric Power
NIPPON KOEI

**Solar PV**

- **2017**
  **FIT**
- **20XX**
  **Competitive bidding** (under discussion), except for roof top solar PV and solar PV power station under construction

**Wind**

- **2011**
  **FIT**
  - Introduction of power plant was not accelerated due to low FIT tariff
- **2018**
  **FIT**
  - FIT tariff was raised. As the result, introduction of power plant was accelerated

**Biomass**

- **2014**
  **FIT**
- **2020**
  **FIT**
  - FIT tariff was raised

# (Vietnam) RE Introduction Promotion System

① FIT scheme

- Vietnam Electricity (EVN), Ministry of Industry and Trade (MOIT), Ministry of Finance (MOF) and Ministry of Justice (MOJ) review FIT tariff and propose the reviewed tariff to Prime Minister. Prime Minister has responsibility to decide FIT tariff.
- FIT tariff is applied to specific period (e.g. July 1st, 2019 - December 31st, 2021). The period is disclosed with revised FIT tariff.

  → FIT tariff is basically reviewed once per 2 - 3 years
- As of 2020, FIT tariff for wind and biomass is raised to accelerate the introduction. On the other hand, FIT tariff for solar PV is lowered due to depletion of solar PV system price.

② Duty exemption to materials during construction

③ Special interest rate for loan from Bank for Investment and Development of Vietnam

④ Reduction of corporate tax during power station operation

| VRE | | FIT tariff [cent / kWh] | Compared with previous FIT tariff |
|---|---|---|---|
| Solar PV | Ground mounted | 7.09 | Down |
| | Roof top | 8.38 | Down |
| Wind | Onshore | 8.50 | Up |
| | Offshore | 9.80 | Up |
| Biomass | | 8.47 | Up |

Source: The Japan Electric Power Information Center


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# 07 VRE promotion in Malaysia


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# (Malaysia) Target of Renewable Energy Development

A target value for renewable energy power sources is set for each year, and the target is to raise it to 3.14million kW by 2020 and 7.09million kW by 2030

Target value of renewable energy introduction [MW]

| Year | Biogas Biomass | Small-hydro | Solar (Under 1MW) | Solar (Over 1MW) | total |
|---|---|---|---|---|---|
| 2020 | 1,400 | 490 | 190 | 1,060 | 3,140 |
| 2030 | 2,128 | 490 | 1,370 | 3,100 | 7,088 |

Source: Ministry of Energy, Green Technology &Water


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# (Malaysia) Past trend of RE development system

FIT was introduced, and then Net metering and Bidding were added

2011
**FIT &REF** (Renewable Energy Fund)
-Solar, Wind, Biomass, Biogas ,Small hydro

REF is fund to reduce the burden of FIT

2016
**Net metering**
(up to 12kW for Domestic or residential)
(up to 1MW for Commercial & industrial)
-Rooftop solar

2016
**Bidding**
-Large scale solar
(over 1MW)

# (Malaysia) RE Introduction Promotion System (FIT＆REF)



- ✓ FIT and REF system since 2011
- REF (Renewable Energy Fund) was established at the same time as FIT to reduce the burden of FIT.

How to collect funds for REF
- REF's financial resources are levied from large customers electricity bill.
- 1% of the electricity bill of customers with monthly usage of over 300kWh was allocated to REF.
- Since 2014, it has been raised to 1.6%.

- In order to control the introduction capacity, the quota was set by the type of FIT.

Quota for FIT system [MW]

| Year | Solar (Individual) | Solar (Non-individual) | Solar (Community) | Biogas | Biomass | Small hydro | Total |
|---|---|---|---|---|---|---|---|
| 2012 | 5 | 45 | 0 | 30 | 60 | 30 | 170 |
| 2013 | 11 | 45 | 0 | 30 | 60 | 30 | 166 |
| 2014 | 13 | 51 | 5 | 25 | 50 | 45 | 189 |
| 2015 | 26 | 54 | 7 | 31 | 18 | 0 | 136 |
| 2016 | 15 | 53 | 7 | 25 | 20 | 50 | 170 |
| 2017 | 15 | 24 | 7 | 15 | 30 | 100 | 191 |

Source: The Japan Electric Power Information Center


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# (Malaysia) RE Introduction Promotion System （FIT＆REF）

- ✓ FIT and REF system since 2011
- FIT rates are categorized by capacity for renewable technologies and the supported period are 16 or 21 years.

FIT rate for biogas, biomass, small hydro, geothermal (as of Jan 2020)

| Type | Installed cap. | FIT rate [Ringgit/kWh] | Supported duration year |
|---|---|---|---|
| Biogas | ≦ 5MW | 0.2210 – 0.2814 | 21 |
| Biomass | ≦ 10MW | 0.3085 | 16 |
| | 10MW – 20MW | 0.2886 | 16 |
| | 20MW – 30MW | 0.2687 | 16 |
| Small hydro | ≦ 2MW | 0.26 | 21 |
| | 2MW – 10MW | 0.25 | 21 |
| | 10MW – 30MW | 0.24 | 21 |
| Geothermal | ≦ 30MW | 0.45 | 21 |

Source: The Japan Electric Power Information Center


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# (Malaysia) RE Introduction Promotion System （FIT＆REF）

- ✓ FIT and REF system since 2011
- In solar FIT, FIT rates are categorized by capacity and individual or non-individual and the supported period is 21 years.
- Bonuses are added to the FIT rate when conditions at introduction time are met for the introduction.

FIT rate and bonus FIT rate for solar (as of Jan 2020)

| Type | Installed cap. | FIT rate [Ringgit/kWh] | Supported duration year |
|---|---|---|---|
| Solar | ≦ 4kW(Individual) | 0.5413 | 21 |
| | 4kW – 12kW(Individual) | 0.5280 | 21 |
| | ≦ 4kW(Non-individual) | 0.5413 | 21 |
| | 4kW – 24kW(Non-individual) | 0.5280 | 21 |
| | 24kW – 72kW(Non-individual) | 0.3205 | 21 |
| | 72kW – 1MW(Non-individual) | 0.3096 | 21 |
| Bonus FIT rate | use as installation in buildings or building structures | +0.1017 | 21 |
| | use as building materials | +0.0542 | 21 |
| | use of locally manufactured or assembled solar PV modules | +0.05 | 21 |
| | use of locally manufactured or assembled solar inverters | +0.05 | 21 |

Source: The Japan Electric Power Information Center


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# (Malaysia) RE Introduction Promotion System（Net metering）

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- ✓ Net metering since 2016
- Net metering was a system that subtracts the amount of renewable energy generated from the amount of electricity used by customers who have introduced rooftop solar.  Solar capacity was limited by customer type.
- Net metering was introduced, since the introduction of renewable power by FIT system did not reach the target.
- In comparison with the target (500MW) of net metering, the actual introduction was only 20MW in October 2018.
- Therefor the Malaysian government revised the rate calculation method at January 2019.

Net metering system conditions

| Item | Contents |
|---|---|
| Capacity limit | Domestic or residential :12kWp for single-phase or 72kWp for 3-phase<br>Commercial & industrial :1MWp or 75%of maximum demand (which is lower) |
| Installation types | On the rooftop of building, garage, car park or similar buildings |
| Calculation for net billing of electricity | Net billing = [Energy Consumed from DL (kWh) x Gazetted Tariff] – [Energy Exported to DL (kWh) x Displaced Cost]<br><br>From 2019<br>Net billing = [Energy Consumed from DL – Energy Exported to DL (kWh)] x [Gazetted Tariff] |

Source: The Japan Electric Power Information Center


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# (Malaysia) RE Introduction Promotion System (Bidding system)

CHUBU Electric Power
NIPPON KOEI

- ✓ Bidding system for large-scale solar since 2016
- In addition to the Net metering system, bidding system for large-scale solar, over 1MW, was introduced.
  (FIT system is applied to solar of 1MW or less)
- The four times bidding was conducted by 2020FY


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# 08 VRE promotion in Taiwan


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# (Taiwan) Target of Renewable Energy Development

CHUBU Electric Power
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Formulated a power source composition (Energy base) for 2025 in the "Power Development Plan" (jointly formulated by Bureau of Energy, Ministry of Economic Affaires (BoE) and Taiwan Power Company(TPC))

- ✓ Increased share of renewable power generation to 20%
- ✓ Increased share of natural gas-fired power to 50%
- ✓ Nearly zero nuclear power
- ✓ Reduced coal-fired share to 27%

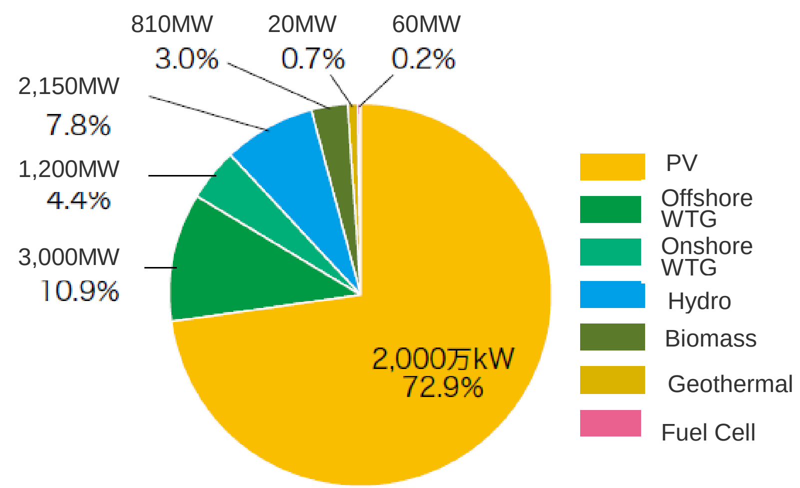
## Generation Development Plan (Energy Base)

(Unit: B TWh)

| | 2018 (Actual) | | 2020 | | 2025 | |
|---|---|---|---|---|---|---|
| RE | 12.7 | 5% | 24.9 | 9% | 61.7 | 20% |
| LNG | 94.8 | 35% | 93.2 | 33% | 158.0 | 50% |
| Coal | 126.6 | 46% | 126.3 | 45% | 85.1 | 27% |
| Nuclear | 27.7 | 10% | 29.5 | 10% | 2.9 | 1% |
| Others (PSPP, etc.) | 11.8 | 4% | 8.2 | 3% | 5.4 | 2% |
| Total | 273.6 | 100% | 282.0 | 100% | 313.2 | 100% |

Source: BoE

## Target Energy Mix (2025)




Source: BoE



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# (Taiwan) Past trend of RE development system

CHUBU Electric Power
NIPPON KOEI

FIT was introduced, and

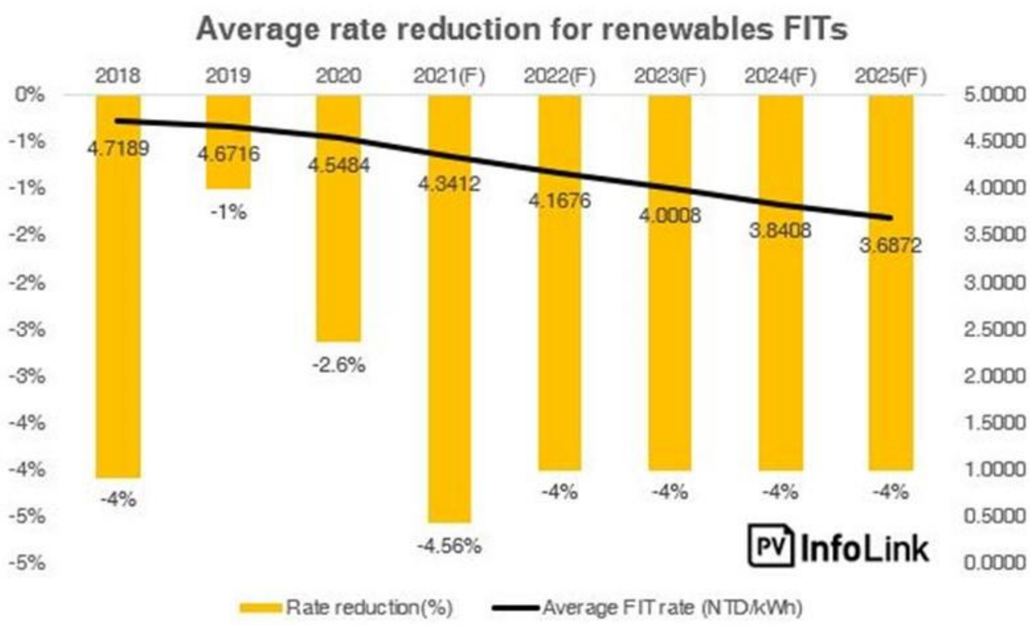
2009

FIT

-Solar, Wind, Biomass, Biogas ,Small hydro

# (Taiwan) RE Introduction Promotion System

- ✓ FIT system since 2009
- ✓ FIT tariff has been reviewed annually by the "Renewable Energy Wholesale Price Review Board" led by the Ministry of Economic Affairs.
  - PV: Reviewed twice a year
  - Other RE: Reviewed once a year
- ✓ FIT Tariff is gradually declining due to the annual review.




Source: InfoLink Newsletter (Nov. 30, 2020)

**Taiwan's FIT Rates for Solar PV in 2021**

| | Capacity Size | 1H21 (NT$/kWh) | 2H21 (NT$/kWh) |
|---|---|---|---|
| Rooftop PV Projects | 1-20kW | 5.6707 | 5.6281 |
| | 20-100kW | 4.3304 | 4.2906 |
| | 100-500kW | 3.9975 | 3.9227 |
| | >500kW | 3.9449 | 3.898 |
| Ground-Mounted PV Projects | ≥1kW | 3.7994 | 3.7236 |
| Floating PV Projects | ≥1kW | 4.1957 | 4.1204 |

**Taiwan's FIT Rates for Offshore Wind**

| | 2020 (NT$/kWh) | 2021 (NT$/kWh) |
|---|---|---|
| 20-Year Fixed Rate | 5.0946 | 4.6568 |
| Tiered Rate (1st / 2nd decade) | 5.8105 / 3.8227 | 5.3064 / 3.5206 |

* 1H21: 1ST Half of 2021, 2H21: 2nd Half of 2021

Source: Energy Trend, Trend Force Corp.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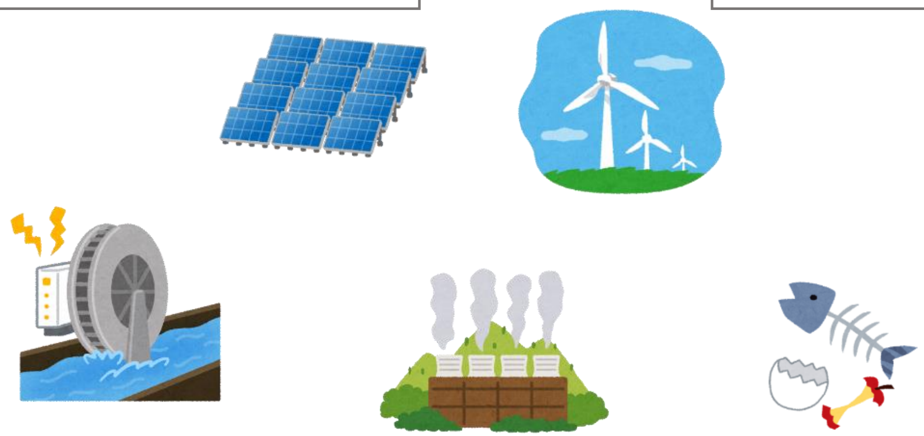
# (Taiwan) RE Introduction Promotion System (Supplementary Scheme)

- ✓ Introduced support measures such as investment promotion tax system
- ✓ Exemption from import duties on facilities or mechanical equipment for RE generation (as long as they cannot be produced in Taiwan).
- ✓ Under the Construction Ordinance, construction conditions for small-scale RE generation facilities will be relaxed.
- ✓ In the construction and renovation work of public works and public buildings, power source from RE is introduced as much as possible.

## Improved Investment Environment

Mitigation of Regulation for construction and permission getting

Investment promotion tax law (Immediate depreciation, tax deduction, etc.)




Source: JEPIC, Japan Electric Power Information Center



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இலங்கை மின்சார சபை
CEYLON ELECTRICITY BOARD

CHUBU
Electric Power

NIPPON KOEI

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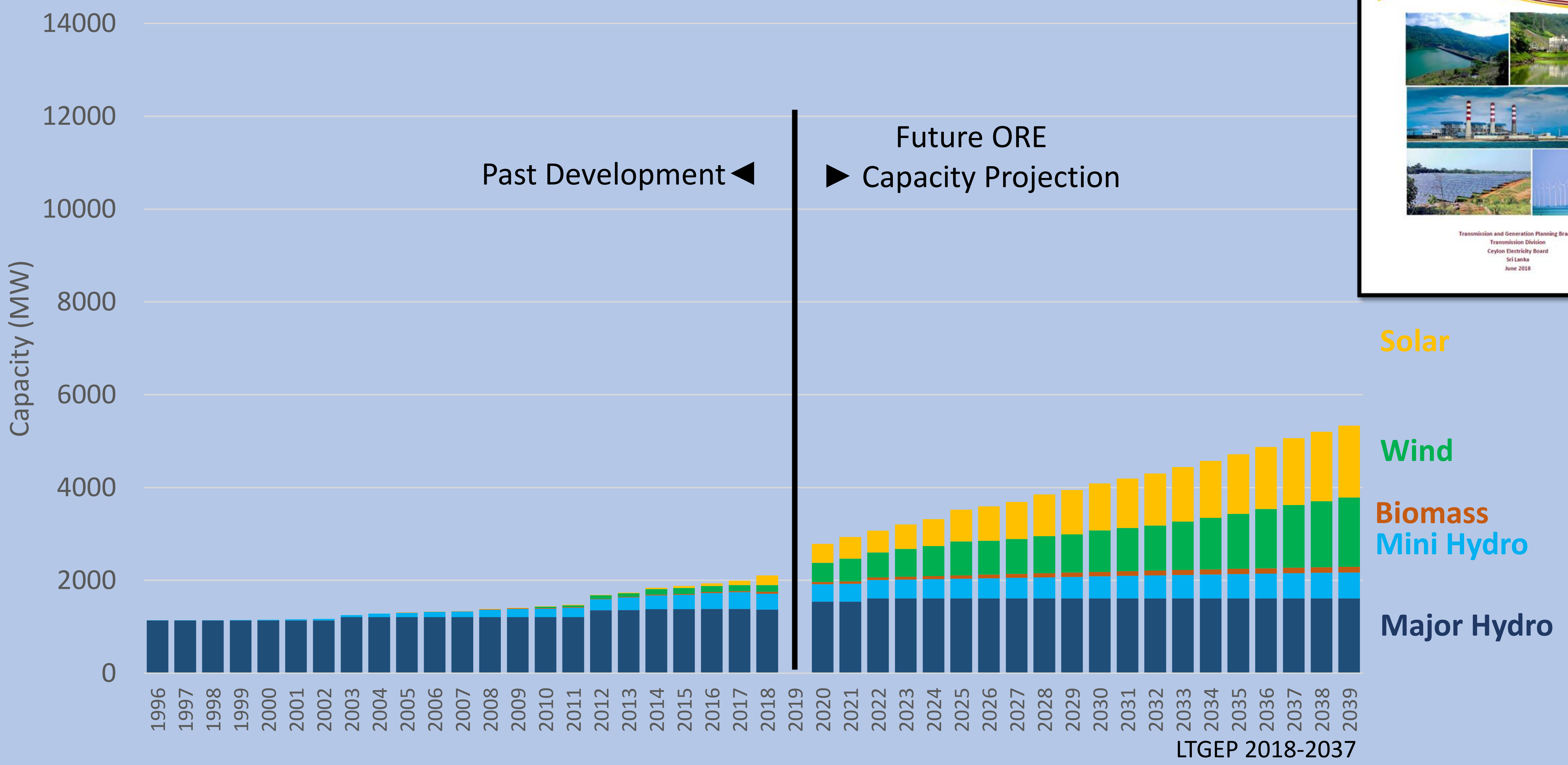
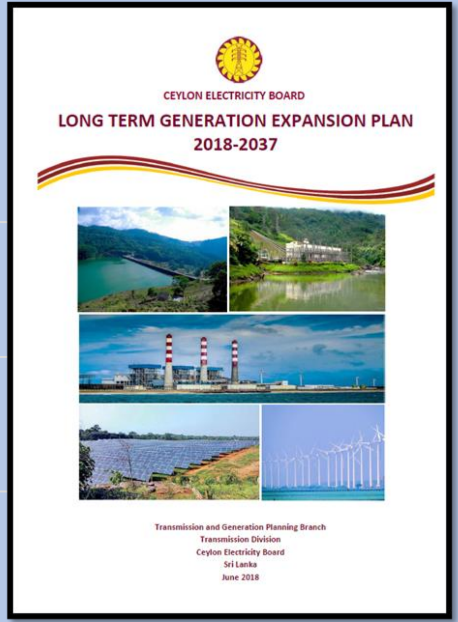
# RENEWABLE ENERGY DEVELOPMENT PLANS

**M.L. Weerasinghe**
DGM (Tr & Gen Planning)

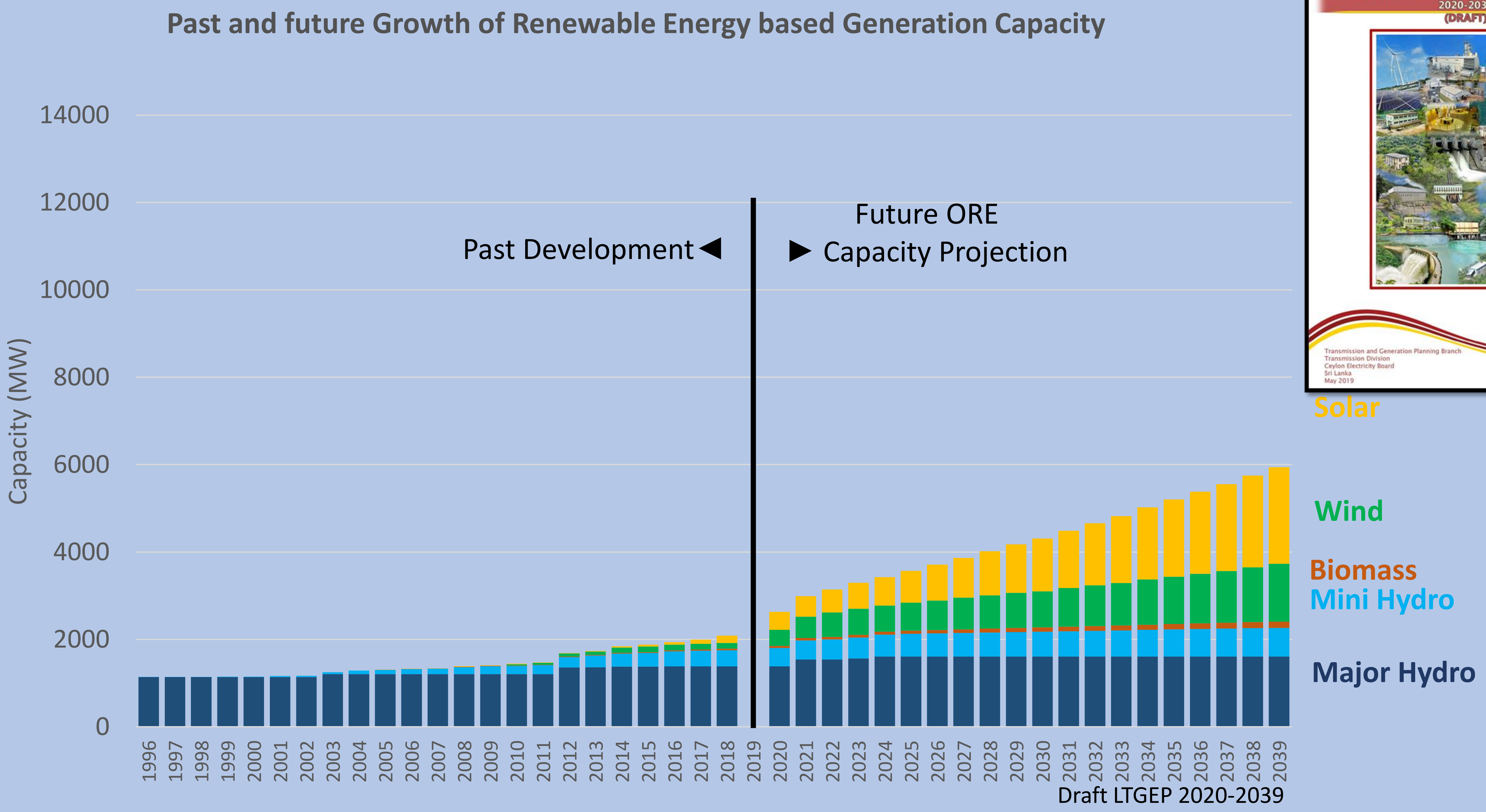
# Long Term Generation Expansion Plans

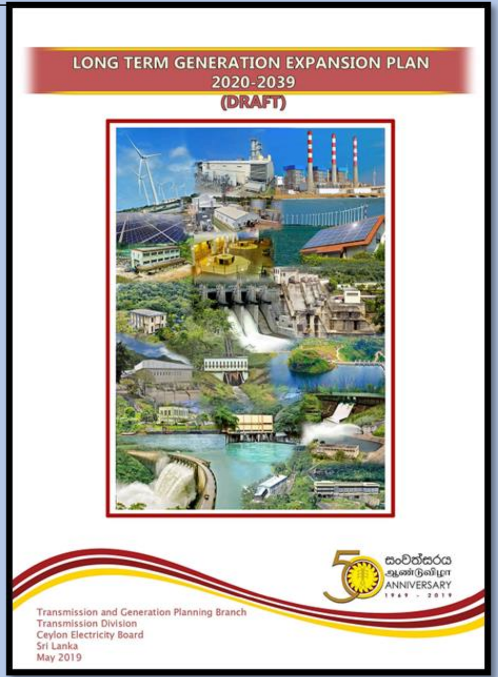
# LTGEP 2018-2039 APPROVED PLAN



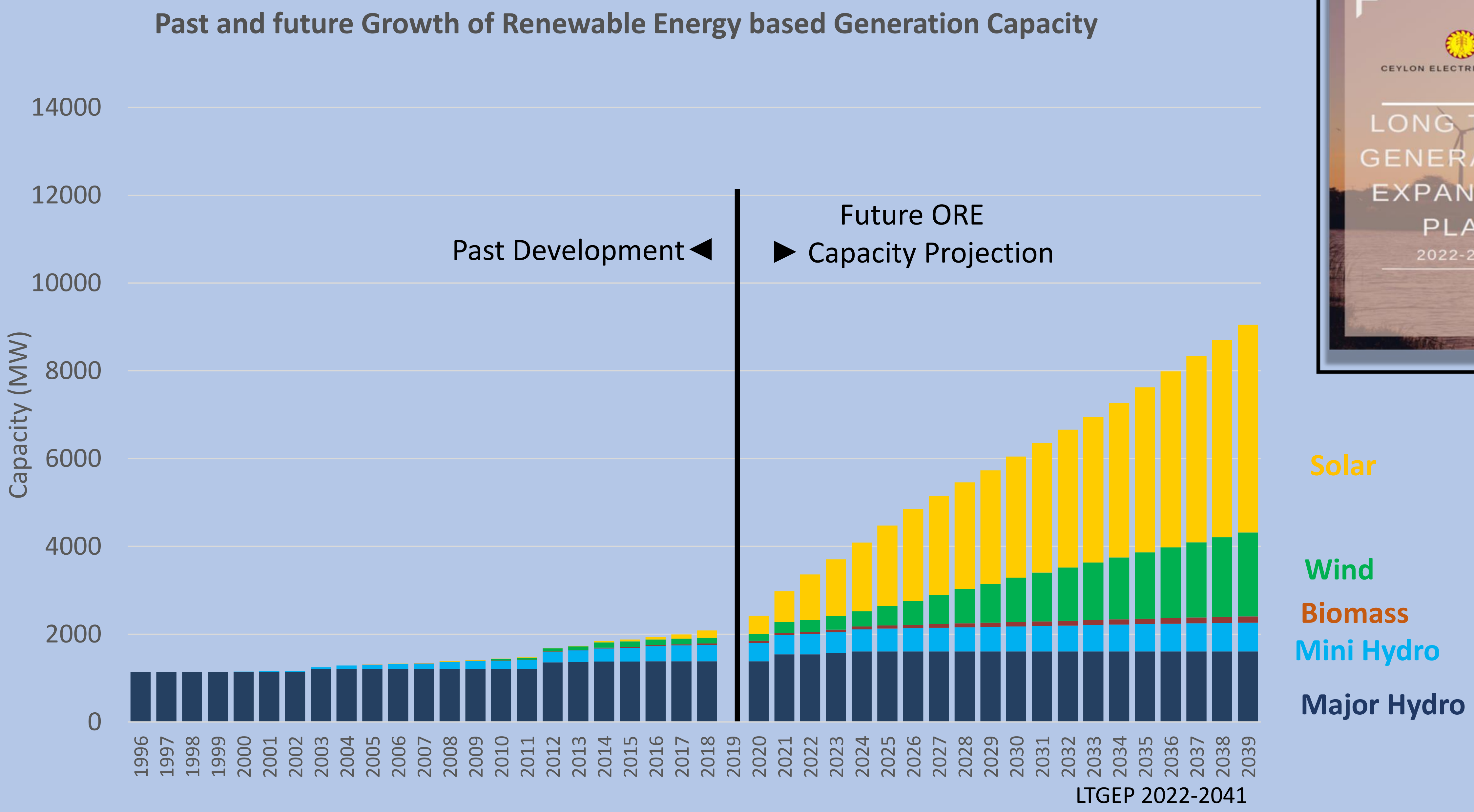



# LTGEP 2020-2039 NOT APPROVED

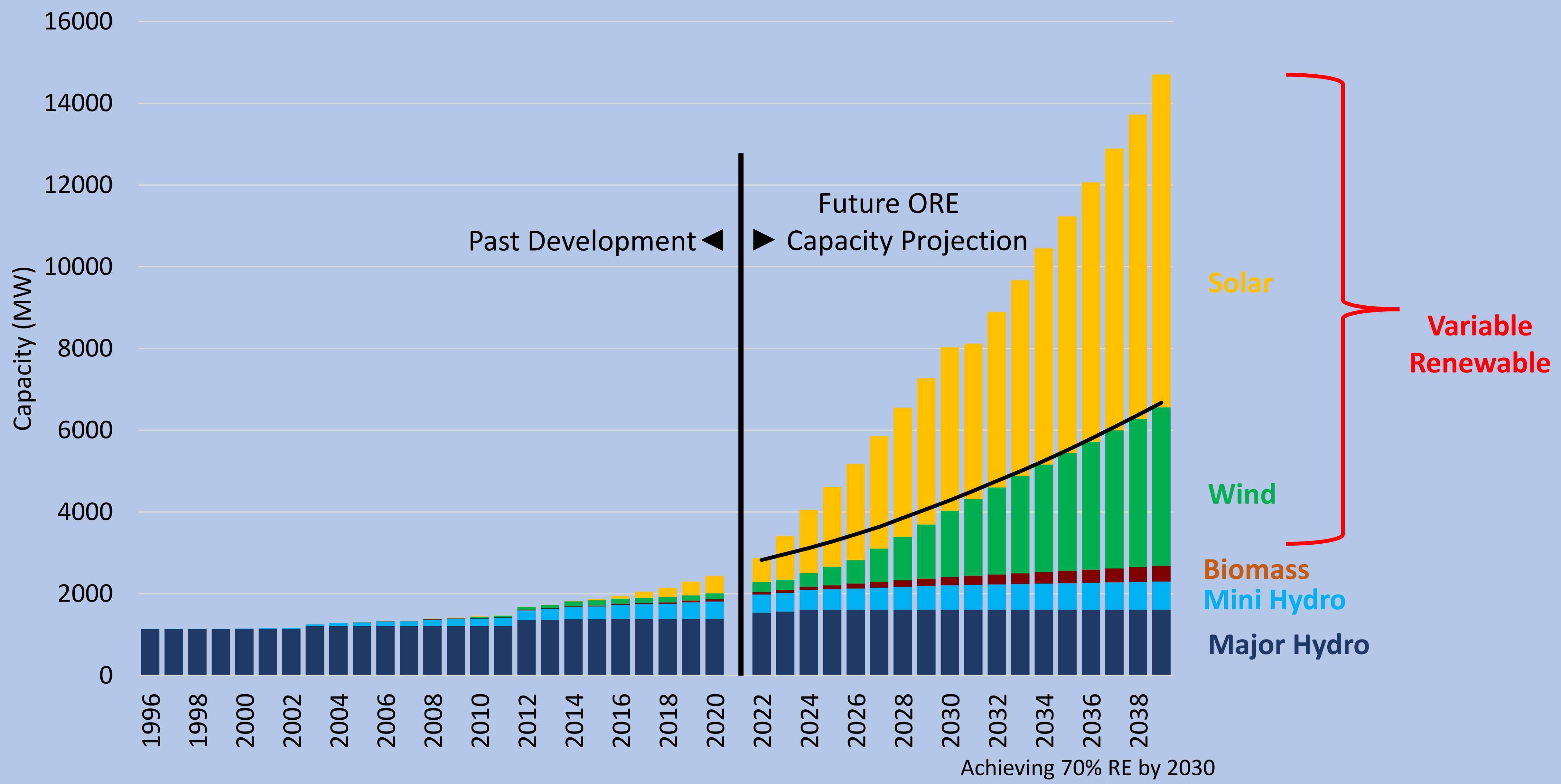


# – LTGEP 2022 – 2041 CONDITIONALLY APPROVED

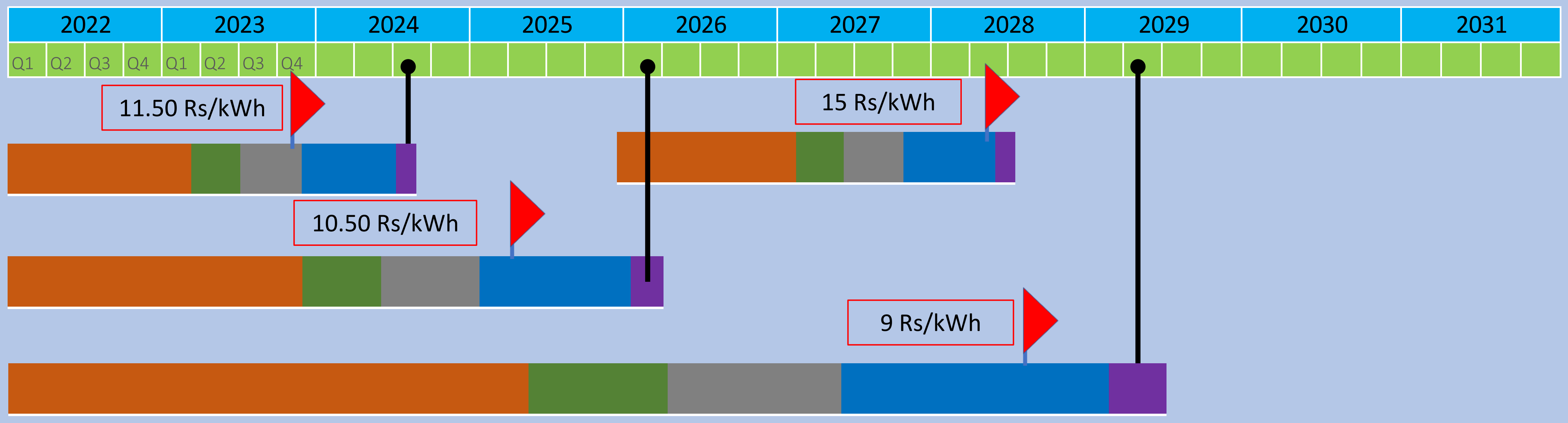



# Tentative Schedule to achieve 70% from RE by 2030 Policy



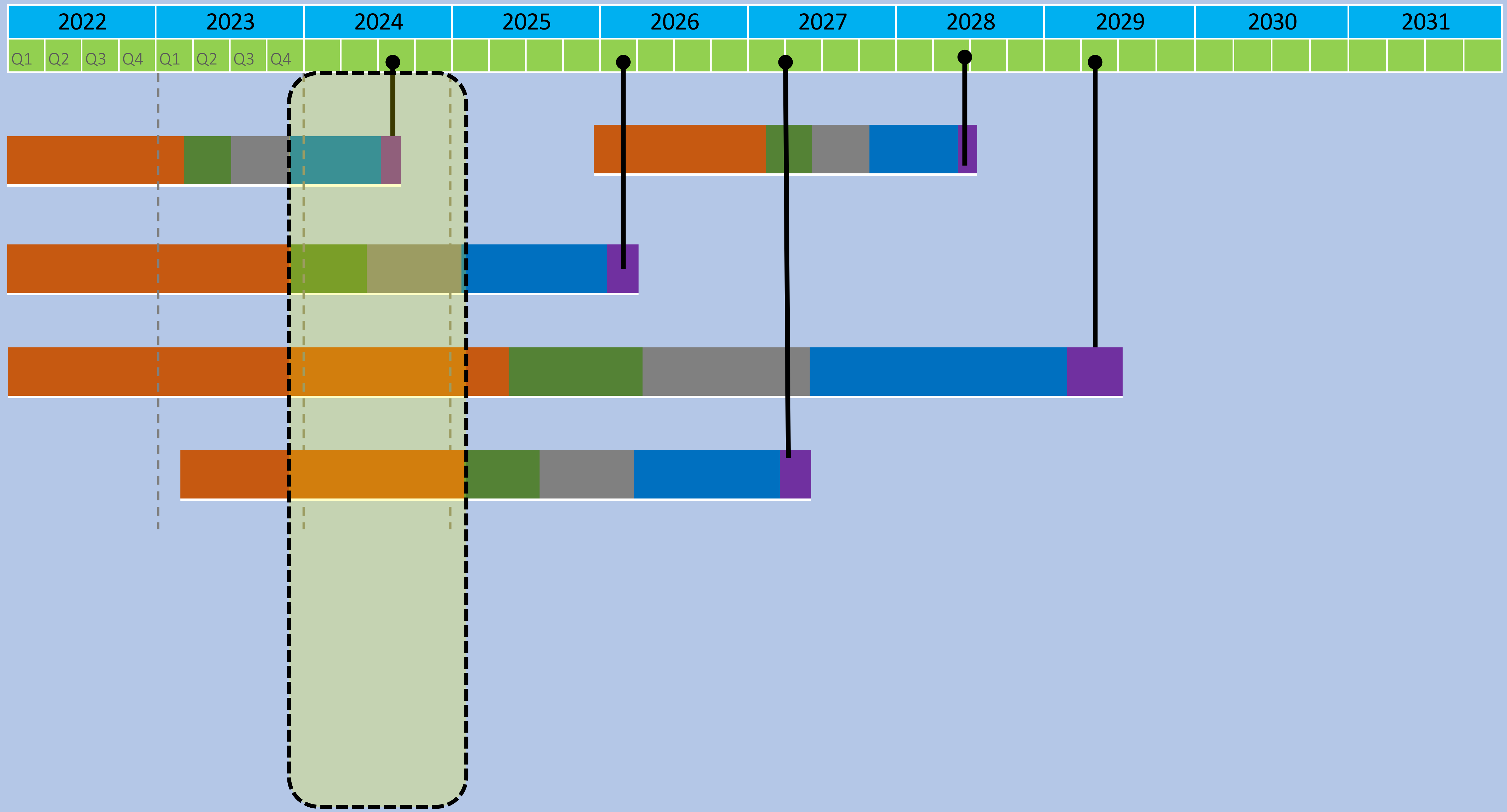
# RE Development
# Master Action Plan

# IMPLEMENTATION PLAN/ ACTION PLAN FOR MONITERING



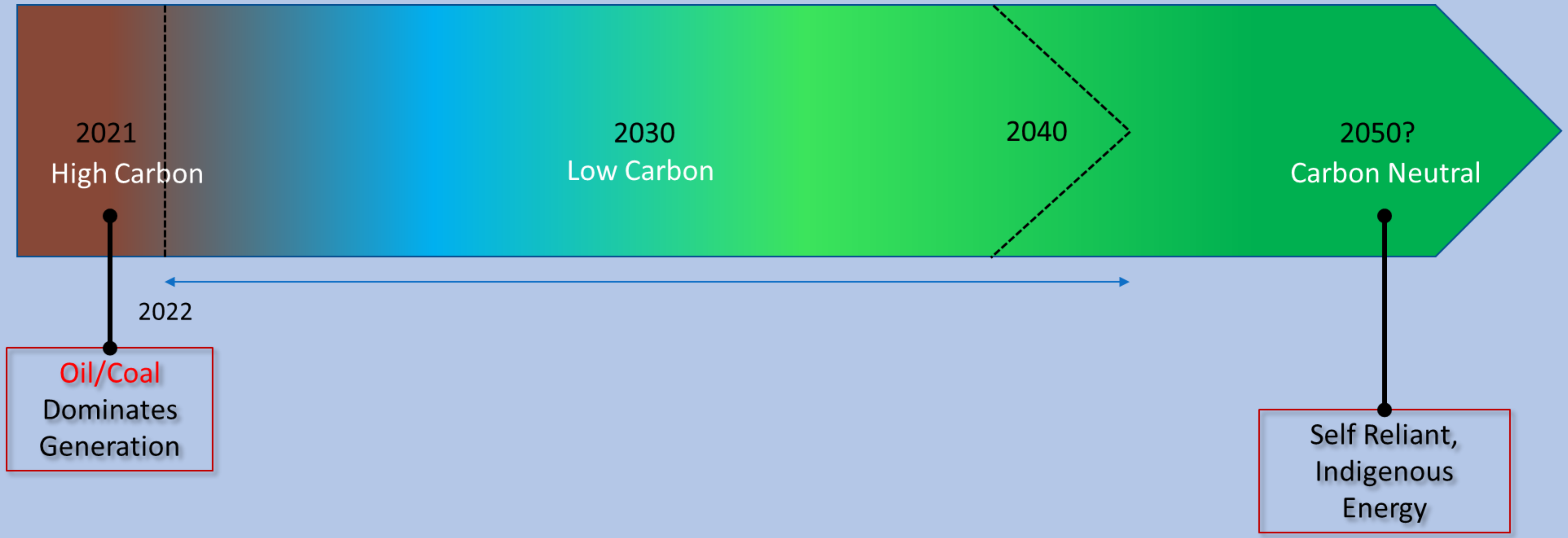

Placement of the Project considers the availability of the point of interconnection with the national grid.

# CAN BE USED EASILY FOR PROGRESS MONITORING

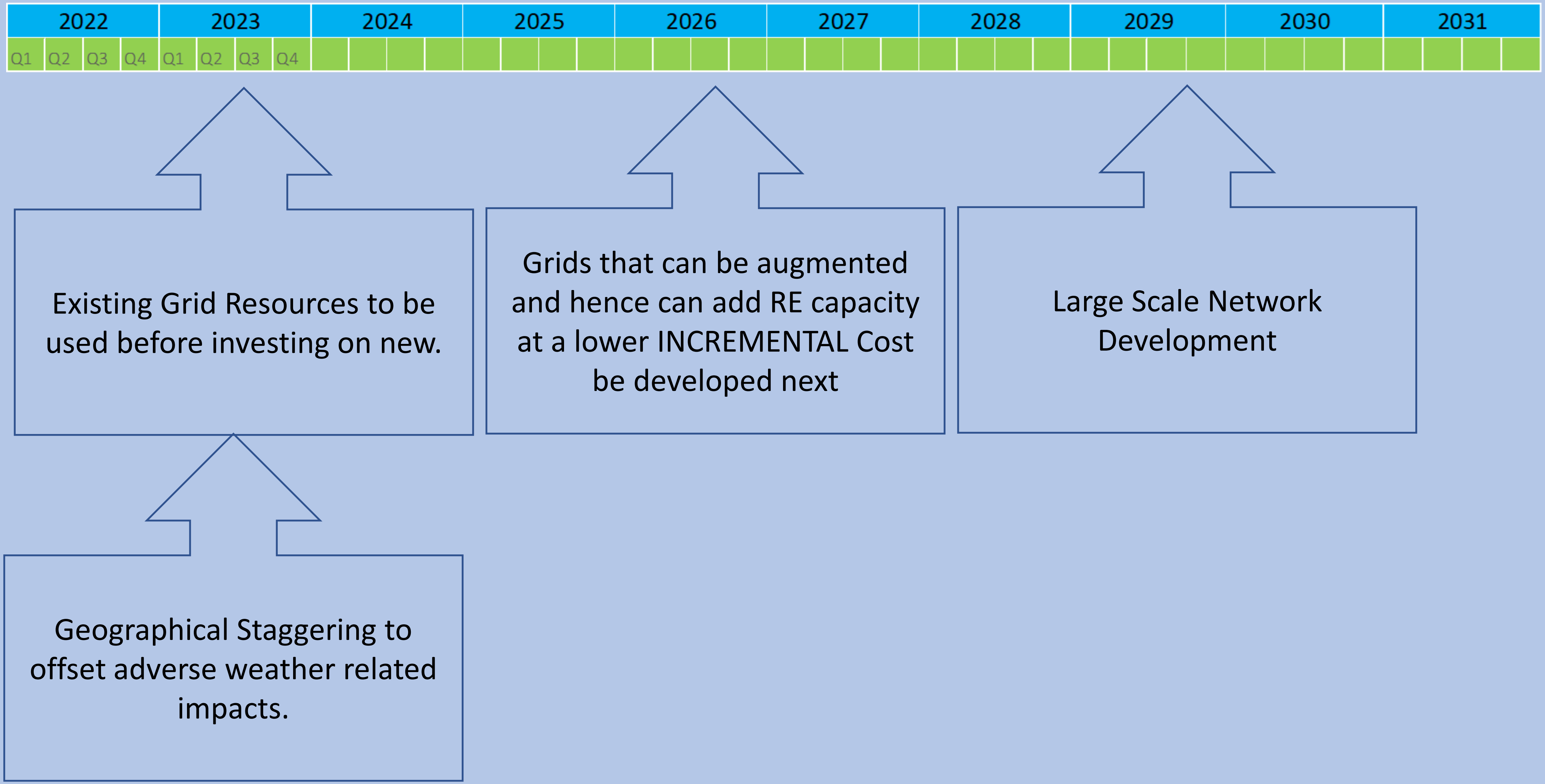


# RE Development
# Strategic Plan

# RE Transition Strategy



# RE Development Strategy



# Review of FIT tariff for Roof Top PV

Ceylon Electricity Board
JICA Expert Team

January, 2021

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Contents





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# Background


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# Background

The FIT system has been promoted the introduction of rooftop PV.

↓

The Target of developing renewable energy by the Government requires the consecutive rooftop PV introduction, and the introduction system for rooftop PV should be sustainable.

↓

| | | |
|---|---|---|
| The installation cost of solar PV is decreasing. | Installation cost is further reduced for large-scale solar PV. | FIT tariff for rooftop PV have not been reviewed since 2016. |

↓

FIT tariff for rooftop PV need to be reviewed.


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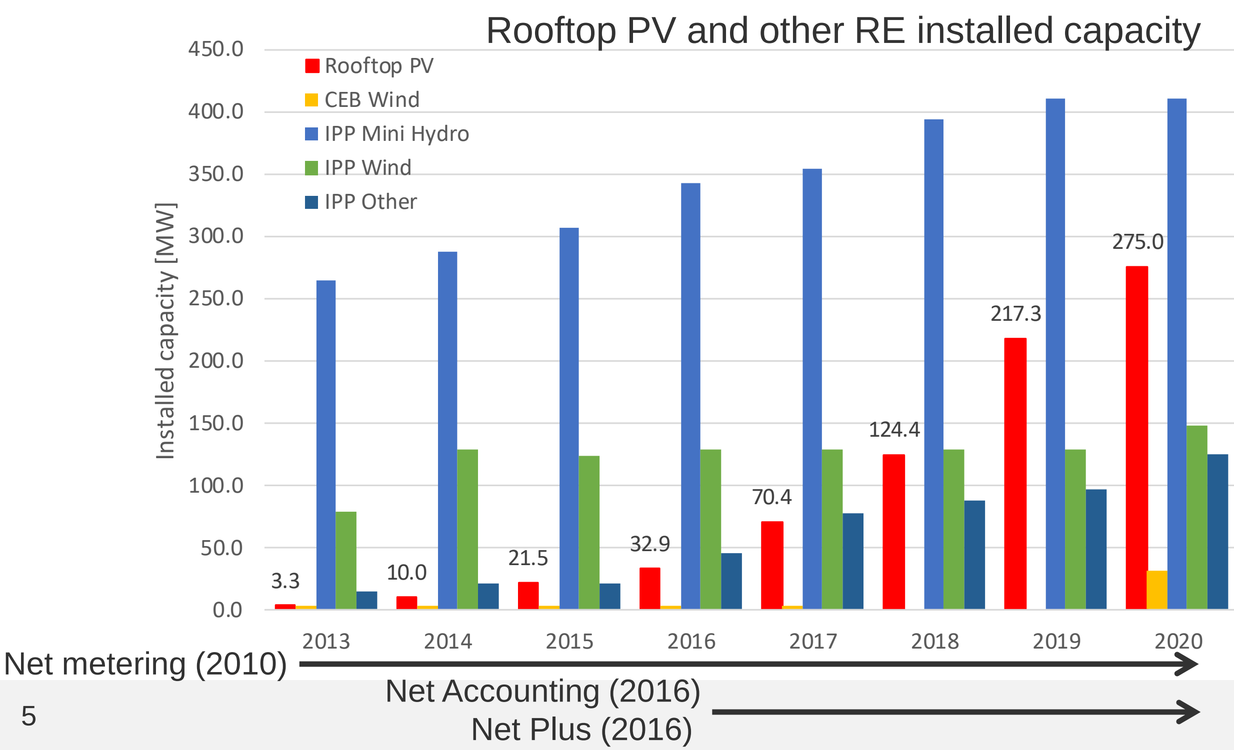
# Rooftop PV introduction status

- After the introduction of the Net Metering system in 2010, the introduction of rooftop PV has gradually progressed.
- After the introduction of Net Accounting and Net Plus for Rooftop PV in 2016, the introduction of rooftop PV has increased sharply.
  *Net Accounting: Measure power sale/purchase with 1 meter and sell surplus power at FIT tariff.
  Net Plus: Measure power sale/purchase with each meter and sell generation power at FIT tariff.




The introduction amount of rooftop PV began to increase from around 2016, and since 2019, it has grown to the amount of renewable energy introduced next to IPP small hydropower

Source: Statistical Digest 2013-2020, CEB



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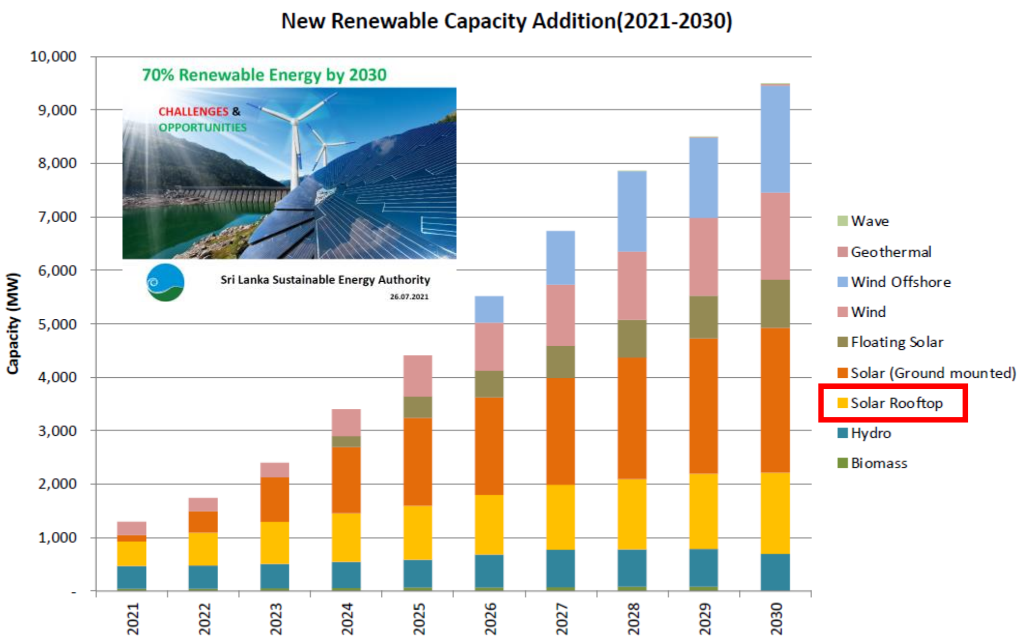
# Achievement of new government target for introduction of renewable energy

- In order to achieve the government target of introducing 70% of renewable energy in 2030, PV has set an introduction target of 4,200MW (44% of renewable energy) in 2030, which is a major factor.
- Of the PV introduction target, rooftop PV accounts for 1,500MW, 36%, which is an important position.

**A system to continuously introduce rooftop PV is needed**




❑ New Renewable Energy Capacity (MW) addition (2021-2030) Cont..

| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Biomass | 44 | 44 | 54 | 60 | 65 | 70 | 75 | 80 | 85 | 90 |
| Mini Hydro | 427 | 440 | 455 | 485 | 520 | 617 | 700 | 700 | 700 | 700 |
| Solar Rooftop | 463 | 613 | 788 | 913 | 1,013 | 1,113 | 1,213 | 1,313 | 1,413 | 1,513 |
| Solar (Ground mounted) | 118 | 395 | 838 | 1,238 | 1,643 | 1,823 | 1,998 | 2,278 | 2,528 | 2,713 |
| Floating Solar | | | | 200 | 400 | 500 | 600 | 700 | [illegible] | 900 |
| Wind | 249 | 249 | 269 | 504 | 769 | 899 | 1,149 | 1,279 | 1,454 | 1,629 |
| Wind Offshore | | | | | | 500 | 1,000 | 1,500 | 1,500 | 2,000 |
| Geothermal | | | | | | | | | 10 | 30 |
| Wave | | | | | | | | [illegible] | 5 | 10 |
| Battery Storage MWh (4hrs) | | 100 | 300 | 500 | 700 | 900 | 1,100 | 1,400 | 1,600 | 2,000 |
| **Total Capacity (MW)** | **1,300** | **1,740** | **2,403** | **3,399** | **4,409** | **5,521** | **6,735** | **7,855** | **8,495** | **9,585** |

**Solar（Rooftop ＋Ground mounted) 4,200MW**

Identified resources will be swapped with other to obtain planned capacity as per the requirement

Source: SEA presentation material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# Global trend of lowering solar PV installation cost

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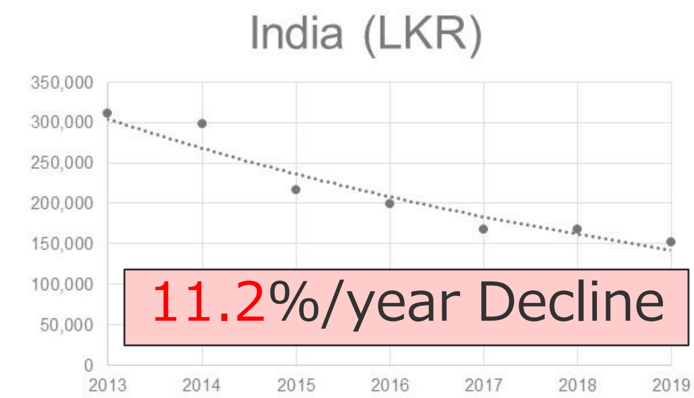
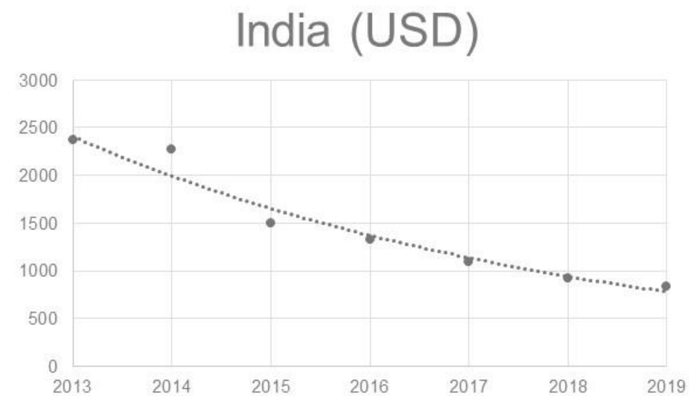
- Significant price declines is occurring across the world
- For example, price decline in neighboring India on [PV Installation Cost for Residential] are:
  Average rate of decline 11.2% / year in 6 years on LKR denominated
  (Average rate of decline 15.9% / year in 6 years on USD denominated)

| Sector | Market | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 USD/kW | | | | | | | | | |
| Residential | Australia | 7 715 | 6 126 | 4 301 | 3 670 | 3 424 | 2 198 | 1 988 | 1 738 | 1 557 | 1 380 |
| | Brazil | | | | 3 947 | 3 657 | 3 458 | 2 664 | 2 126 | 1 604 | 1 350 |
| | China | | | 2 823 | 2 432 | 2 330 | 1 672 | 1 591 | 1 436 | 1 079 | 840 |
| | France | | 9 797 | 6 950 | 5 773 | 4 231 | 2 359 | 2 174 | 1 967 | 1 771 | 1 600 |
| | Germany | 4 277 | 3 634 | 2 712 | 2 414 | 2 229 | 1 750 | 1 704 | 1 645 | 1 746 | 1 646 |
| | India | | | | 2 374 | 2 276 | 1 501 | 1 326 | 1 093 | 916 | 840 |
| | Italy | 6 949 | 6 106 | 4 031 | 3 660 | 2 438 | 1 983 | 1 803 | 1 676 | 1 527 | 1 460 |
| | Japan | 7 314 | 7 228 | 6 237 | 4 601 | 3 771 | 3 313 | 2 927 | 2 685 | 2 361 | 2 250 |
| | Malaysia | | | | 2 871 | 2 861 | 2 423 | 2 227 | 1 792 | 1 466 | 1 191 |
| | Republic of Korea | | | | 3 036 | 3 056 | 2 166 | 2 079 | 1 707 | 1 527 | 1 440 |
| | South Africa | | | | 4 140 | 3 684 | 3 109 | 2 916 | 2 602 | 2 231 | 1 843 |
| | Spain | | | | 2 871 | 2 438 | 1 758 | 1 633 | 1 509 | 1 445 | 1 410 |
| | Switzerland | | | | 3 864 | 3 440 | 3 216 | 3 022 | 2 716 | 2 421 | 2 173 |
| | Thailand | | | | 4 019 | 3 121 | 2 798 | 2 726 | 2 362 | 1 944 | 1 388 |
| | United Kingdom | | | | 3 300 | 3 475 | 3 007 | 2 668 | 2 692 | 2 597 | 2 566 |
| | California (US) | 7 756 | 7 325 | 6 323 | 5 475 | 5 155 | 5 231 | 5 053 | 4 529 | 4 294 | 4 096 |
| | Other US states | 7 705 | 7 049 | 5 697 | 4 921 | 4 954 | 4 925 | 4 280 | 3 844 | 3 702 | 3 652 |




15.9%/year Decline



Source: Renewable Power Generation Costs in 2019, IRENA

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# Lowering the installation cost of large-scale PV

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- The installation cost of rooftop PV of 1MW is about half of less than 5kW
- Since the FIT tariff of rooftop PV is the same regardless of the equipment size, it is has possibility that the business owner of a large rooftop PV gets is making an excessive profit.

| Rooftop PV Capacity | Average Installation Cost in 2020(LKR/kW) |
|---|---|
| Less than 5kW | 180,000 |
| 1MW | 85,000 |

Source: KHM Solar and Financial status and a four-year road map for financial recovery, Jan. 2021,CEB

Double installation cost difference in the same FIT system for rooftop PV

FIT tariff should be set for rooftop PV capacity category


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02

# Objective of the FIT system revision for rooftop PV


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# Objective of the FIT system revision for rooftop PV

Considering the recent decrease in the installation cost of rooftop PV, the FIT system will be reviewed for the following items to make it a sustainable rooftop PV introduction system.

- Review the FIT tariff by rooftop PV capacity category, which contributes to secure appropriate profits for business owners, and reduce the financial burden on CEB as well.


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# 03 Target of the FIT system revision


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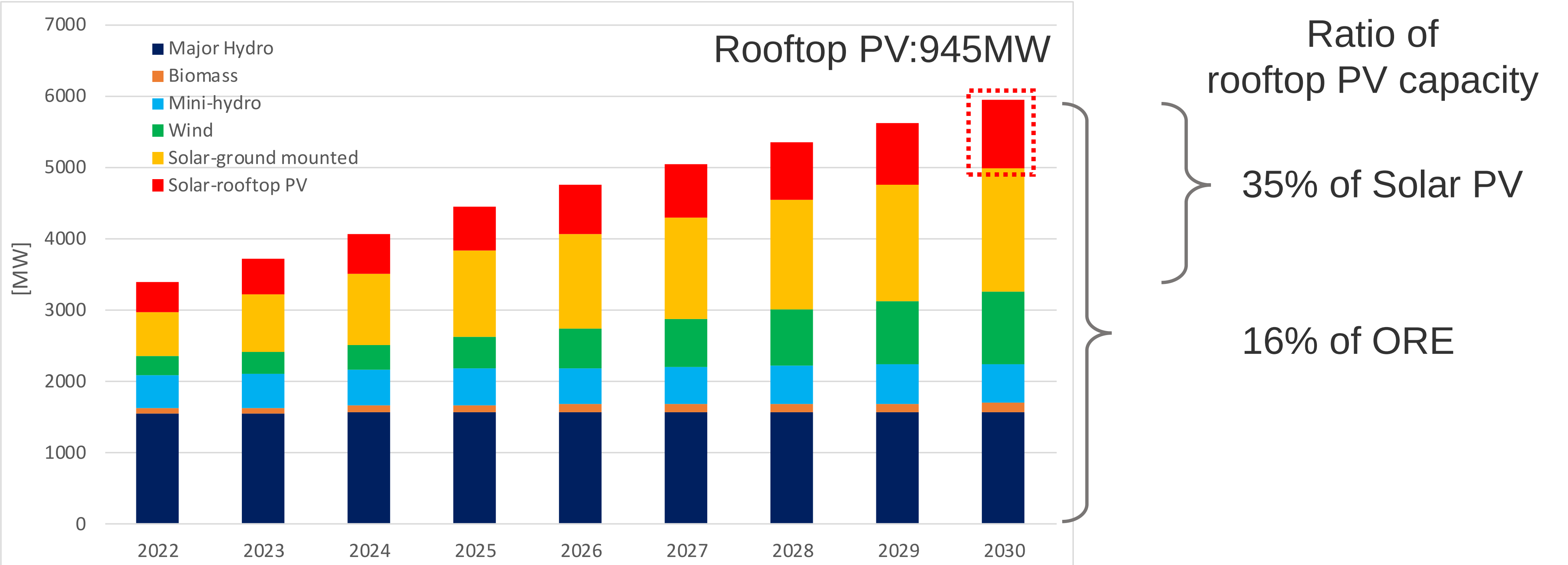
# Target of the FIT system (rooftop PV)

- PV will continue to grow. Among them, rooftop PV will greatly contribute to it.

CEB has set the introduction target of solar PV as 1,829MW in 2025 and 2,684MW in 2030 in the Long Term Generation Expansion Plan 2022-2041. As of 2020, 275MW rooftop PV has been introduced, and in this plan, the rooftop PV has a target of introducing 945MW in 2030, which accounts for 16% of ORE, and for 35% of Solar. Sustainable introduction of rooftop PV is an important item in achieving government goal.




Source: LTGEP2022-2041(Draft), CEB



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# Target of the FIT system for rooftop PV (by capacity category)

- There is a big difference in the installation cost depending on the introduction capacity.
- FIT tariff should be set for rooftop PV capacity category instead of a uniform FIT tariff.

| Capacity classification for examination | Average installation cost |
|---|---|
| 0-5kW | 180,000 LKR/kW*1 |
| 5-10kW | 170,000 LKR/kW*1 |
| 10-20kW | 125,000 LKR/kW*2 |
| 20-40kW | |
| 40-60kW | 120,000 LKR/kW*2 |
| 60-100kW | |
| 100kW-1MW | 90,000 LKR/kW*2 |
| More than 1MW | 85,000 LKR/kW*2 |

Source *1:KHM Solar, *2: Financial status and a four-year road map for financial recovery, Jan. 2021,CEB


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# 04 Flow of examination


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# Flow of examination

**Step1**

**Setting the premises for examination**

**Step2**

**Examination of FIT tariff category by rooftop PV capacity**

Calculate the generation cost for each capacity of rooftop PV and examine the capacity category of FIT tariff.

**STEP3**

**Examination of FIT tariff for each rooftop PV capacity category**

Calculate categorized FIT tariff using the weighted average of installation cost for each capacity category of rooftop PV.


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# 05 Step1 Setting the premises for examination


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# Premises of unit generation cost calculation for the FIT tariff revision for rooftop PV

- We calculate the generation cost that can secure the Equity IRR using the calculation conditions in the table such as the unit cost for installation of each capacity of rooftop PV.

| Item | Value | Remarks |
|---|---|---|
| Unit cost for installation | Depend on capacity | |
| Operation period | 20 years | FIT program period |
| Cost of Debt(Interest rate) | 10.18% for 1st year to 7th year (7.18% on Oct. 29, 2021 +3%) | Average Weighted Prime Lending Rate(AWPLR)+3% margin |
| Debt repayment period | 10 years | Repayment period set by commercial bank for FIT user |
| Equity return to be expected | 13.05 % | Latest Ten Year Bond rate (10.05% on Sep. 15, 2021) +3% margin |
| Debt / Equity ratio | Debt 70 / Equity 30 | |
| O&M cost per year | Depend on capacity (Including inverter replacement) | 0.9% of unit cost for installation, escalated 4.2%,the five year average inflation rate from 2016 to 2020, NCPI. |
| Capacity factor | 17.0 % | |
| Deterioration rate per year | 0.7 %/year | |
| Grid availability | 99 % | |


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# Unit cost for installation

- Calculate the unit generation cost using the installation cost for each capacity of rooftop PV.

| PV capacity | Average installation cost |
|---|---|
| 0-5kW | 180,000 LKR/kW |
| 5-10kW | 170,000 LKR/kW |
| 10-20kW | 125,000 LKR/kW |
| 20-40kW | 125,000 LKR/kW |
| 40-60kW | 120,000 LKR/kW |
| 60-100kW | 120,000 LKR/kW |
| 100kW-1MW | 90,000 LKR/kW |
| Over 1MW | 85,000 LKR/kW |

Source: KHM Solar and Financial status and a four-year road map for financial recovery, Jan. 2021,CEB


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# Debt condition

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## Cost of Debt

- The cost of debt is the nearest Average Weight Prime Lending Rate(AWPLR) plus 3% as a margin for interest rate fluctuations.
  AWPLR 7.18% (Oct. 29, 2021) +3%, taken as 10.18%
- Debt repayment period
  The repayment period is set to 10 years.

**Commercial Bank Lending and Deposit Rates ( Per cent per annum )**

| End Week | Average Weigted Lending Rate (AWLR) | Average Weighted Prime Lending Rate (AWPR) | | | Average Weighted Deposit Rate | | Average Weighted Fixed Deposit Rate (AWFDR) Rate (% ) |
|---|---|---|---|---|---|---|---|
| | | Weekly | Monthly | 6 months | Monthly | 6 months | |
| 2021-11-05 | | 7.62 | | | | | |
| 2021-10-29 | | 7.82 | 7.18 | 6.08 | 4.79 | 4.82 | 5.70 |
| 2021-10-22 | | 7.23 | | | | | |
| 2021-10-15 | | 6.95 | | | | | |
| 2021-10-08 | | 6.71 | | | | | |
| 2021-10-01 | | 6.42 | 6.39 | 5.82 | | | |
| 2021-09-30 | 9.37 | | | | 4.75 | 4.86 | 5.64 |
| 2021-09-24 | | 6.46 | | | | | |

Source: Data Library - Central bank of Sri Lanka
https://www.cbsl.lk/eResearch/Modules/RD/SearchPages/CMB_LendingAndDeposit.aspx


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# EIRR

## Equity IRR

- Equity IRR (Cost of Equity) is the rate of the latest 10-year government bond plus 3% as a margin for interest rate fluctuations.
- 10.05% (Sep. 15, 2021) +3%, taken as 13.05%

**Rates on Government Securities**
(Per cent per annum)

| End Week | Treasury Bill | | | Treasury Bond | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 91 days | 182 days | 364 days | 02 year | 03 year | 04 year | 05 year | 06 year | 07 year | 08 year | 09 year | 10 year | 12 year | 15 year | 20 year | 30 year |
| 2021-10-08 | 7.15 | 7.20 | 7.28 | | | | | | | | | | | | | |
| 2021-10-01 | 6.70 | 6.99 | 7.01 | | | | | | | | | | | | | |
| 2021-09-24 | 6.38 | 6.27 | 6.50 | | | | | | | | | | | | | |
| 2021-09-17 | 6.08 | | 6.12 | | | | | | | | | | | | | |
| 2021-09-15 | | | | | 8.10 | | | | | | | 10.05 | | | | |
| 2021-09-10 | 6.01 | | 6.05 | | | | | | | | | | | | | |
| 2021-09-03 | 5.92 | 5.95 | 5.96 | | | | | | | | | | | | | |
| 2021-09-01 | | | | 6.75 | | 8.55 | | | | | | | | | | |

Source: Data Library - Central bank of Sri Lanka
https://www.cbsl.lk/eResearch/Modules/RD/SearchPages/Indicators_GovernmentSecurities.aspx


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# Other item

These premises were determined by CEB's actual operation and WG discussion

Debt Equity ratio

- 70:30

O&M cost

- 0.9% of installation cost
- Inverter replacement cost included in O&M cost
- Consideration of 5 years average inflation rate(2016-2020): 4.2%

  2.9%(2016 Jan.), 4.6%(2017 Jan.), 7.6%(2018 Jan.), 1.8%(2019 Jan.), 4.1%(2020 Jan.)
  source: NCPI（National Consumer Price Index）

  http://www.statistics.gov.lk/InflationAndPrices/StaticalInformation/MonthlyNCPI/Inflation-FoodAndNonFoodGroups

Capacity Factor

- 17%

Deterioration rate per year

- 0.7%/year

Grid availability

- 99%


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05

# Step2
# Examination of FIT tariff category by rooftop PV capacity


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# Examination of FIT tariff category by rooftop PV capacity

Categorize the FIT tariff based on the generation cost.

- FIT tariffs are divided with a threshold of 10kW and 100kW.

Category 1: 0-5kW, 5-10kW; Category 2: 10-20kW, 20-40kW, 40-60kW, 60-100kW; Category 3: 100kW-1MW, Over 1MW

| Rooftop PV capacity | | 0-5kW | 5-10kW | 10-20kW | 20-40kW | 40-60kW | 60-100kW | 100kW-1MW | Over 1MW |
|---|---|---|---|---|---|---|---|---|---|
| Installation cost [LKR/kW] | | 180,000 | 170,000 | 125,000 | 125,000 | 120,000 | 120,000 | 90,000 | 85,000 |
| Generation Cost [LKR/kWh] | 1st - 7th year | 19.73 | 18.16 | 12.66 | 12.66 | 12.16 | 12.16 | 9.12 | 8.61 |
| | 8th - 20th year | 15.50 | 15.50 | 12.66 | 12.66 | 12.16 | 12.16 | 9.12 | 8.61 |
| Project IRR | | 11.55% | 11.59% | 11.67% | 11.67% | 11.68% | 11.68% | 11.68% | 11.67% |
| Equity IRR for customer | | 13.05% | 13.05% | 13.05% | 13.05% | 13.07% | 13.07% | 13.07% | 13.05% |

There is a big difference in generation cost


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# 06 Step 3 Examination of FIT tariff for each rooftop PV capacity category


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# Unit cost of installation for newly recommended FIT tariff calculation for rooftop PV

- In order to calculate the FIT tariff as three categories, the weight average installation cost of 0-10kW is 177,000 LKR/kW, 10-100kW is 124,000 LKR/kW and over 100kW is 87,000 LKR/kW.

| Category | PV capacity | Installation cost | Accumulating installation capacity | Weighted average installation cost |
|---|---|---|---|---|
| 1 | 0-5kW | 180,000 LKR/kW | 65.11 MW | 176,246 LKR/kW →177,000 LKR/kW |
| | 5-10kW | 170,000 LKR/kW | 39.13 MW | |
| 2 | 10-20kW | 125,000 LKR/kW | 59.84 MW | 123,746 LKR/kW →124,000 LKR/kW |
| | 20-40kW | 125,000 LKR/kW | 47.67 MW | |
| | 40-60kW | 120,000 LKR/kW | 17.43 MW | |
| | 60-100kW | 120,000 LKR/kW | 18.50 MW | |
| 3 | 100kW-1MW | 90,000 LKR/kW | 18.83 MW | 86,871 LKR/kW →87,000 LKR/kW |
| | Over 1MW | 85,000 LKR/kW | 31.50MW | |


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# Calculation result of Generation cost(newly recommended FIT tariff for rooftop PV)

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- As a result of calculation using the rooftop PV installation cost in 2020, then current FIT tariff of 22.00LKR/kWh(1st – 7th year) and 15.50LKR/kWh(8th – 20th year) can be reduced to 19.26 LKR/kWh for under 10kW, 12.56LKR/kWh for 10-100kW and 8.82 LKR/kWh for over 100kW while securing the appropriate profit of the business operator.
- Rooftop PV of over 100kW is set to increase the average direct generation cost by 5% in order to secure profitability by the FIT system.

| Item | | Examination result | | | Current tariff level |
|---|---|---|---|---|---|
| Rooftop PV capacity | | Category 1: Under 10kW | Category 2: 10-100kW | Category 3: Over 100kW | - |
| Installation cost [LKR/kW] | | 177,000 | 124,000 | 87,000 | - |
| FIT tariff | 1st - 7th year | 19.26 LKR/kWh | 12.56LKR/kWh | 8.82 LKR/kWh*1 ⇨ 12.17 LKR/kWh*2 | 22.00 LKR/kWh |
| | 8th - 20th year | 15.50 LKR/kWh | 12.56LKR/kWh | 8.82 LKR/kWh*1 ⇨ 12.17 LKR/kWh*2 | 15.50 LKR/kWh |

*1: Calculated FIT tariff using above installation cost

*2: 5% increase in average direct generation cost(11.59LKR/kWh)



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# 06 Recommendation


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# Recommendation

- Rooftop PV will apply the new FIT tariff(19.26 LKR(1-7 year) and15.50LKR(8-20 year) for under 10kW,  12.56 LKR for 10-100kW and 12.17LKR for over 100kW).
- The FIT tariff will be reviewed annually to reflect lower installation cost and changes in financing conditions. (supplementary explanation is on page 29)


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# Review of FIT Tariff linked to The PV System Price change

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In Japan, the system price assumption for the 2022 installation is evaluated based on the last two-year price decline level. The median of projects in 2020 is in the top 36-37% of 2018. From this, we propose 259,000 yen / kW in 2022.

| % | PV System Cost for Household | | |
|---|---|---|---|
| | Installed in 2020 | Installed in 2019 | Installed in 2018 |
| 5% | 16.25 | 18.25 | 20.25 |
| 10% | 17.58 | 20.29 | 23.33 |
| 15% | 19.19 | 21.78 | 24.90 |
| 20% | 21.04 | 22.85 | 25.73 |
| 25% | 22.52 | 23.75 | 27.25 |
| 30% | 23.87 | 24.79 | 28.81 |
| 35% | 25.19 | 26.09 | 29.80 |
| 36% | 25.50 | 26.33 | 30.05 |
| 37% | 25.87 | 26.62 | 30.34 |
| 38% | 26.17 | 26.91 | 30.56 |
| 39% | 26.51 | 27.[illegible] | 30.83 |
| 40% | 26.86 | 27.54 | 31.11 |
| 45% | 28.49 | 28.88 | 32.35 |
| 50% | 30.08 | 30.31 | 33.52 |

Price decline for two years

<One prospective solution>
FIT tariff shall be annually reviewed in line with the past PV system price change


Source: Natural Resource and Energy

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# 07 Conclusion


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# Conclusion

Outline of FIT system revision

- The rooftop PV generation cost was calculated using the rooftop PV installation cost for each capacity in 2020.
- Under 10kW rooftop PV is proposed to apply the new FIT tariff for 19.26 LKR(1-7 year) and15.50LKR(8-20 year).
- 10-100kW rooftop PV is proposed to apply the new FIT tariff for 12.56LKR.
- Over 100kW rooftop PV is proposed to apply the new FIT tariff for 12.17LKR


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# CEB Financial Projection

JICA Expert Team

January 2022

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Contents





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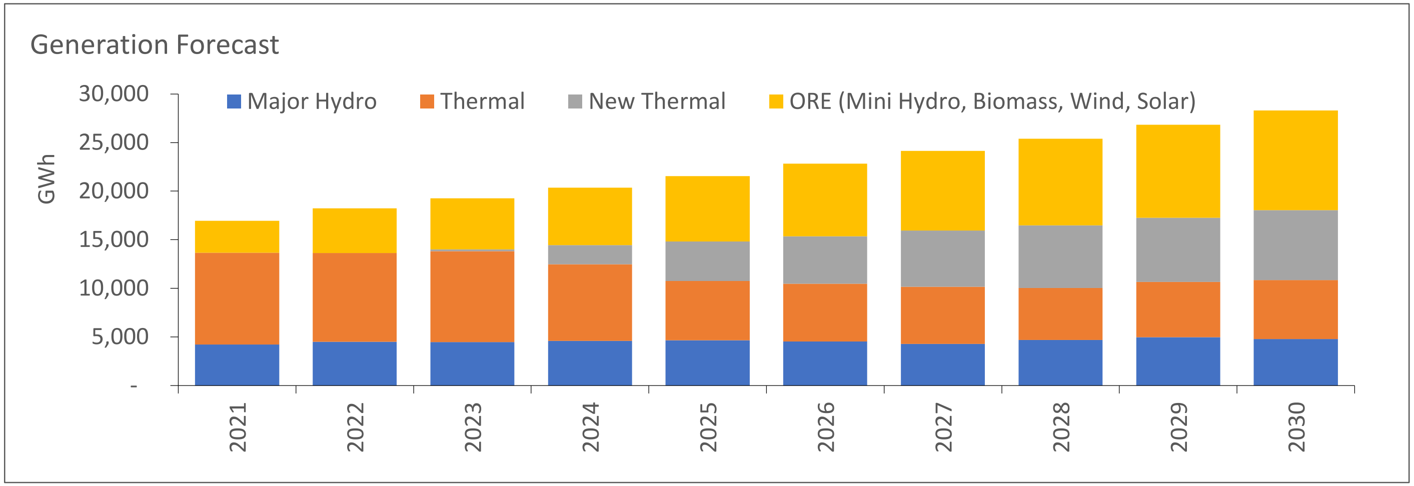
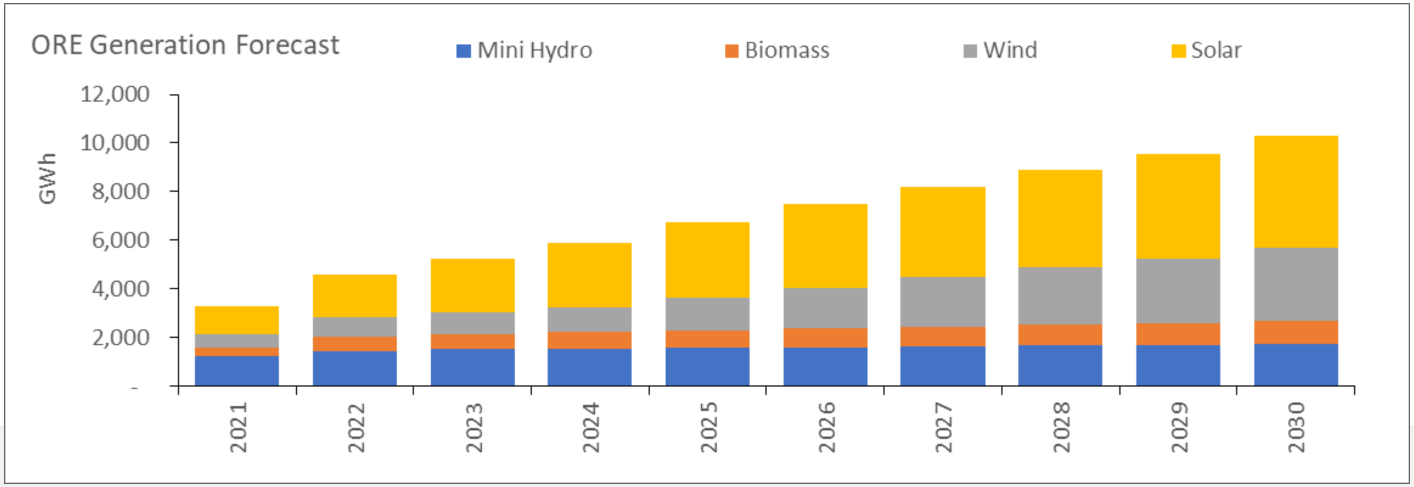
# LTGEP 2022 – 2042 at a glance

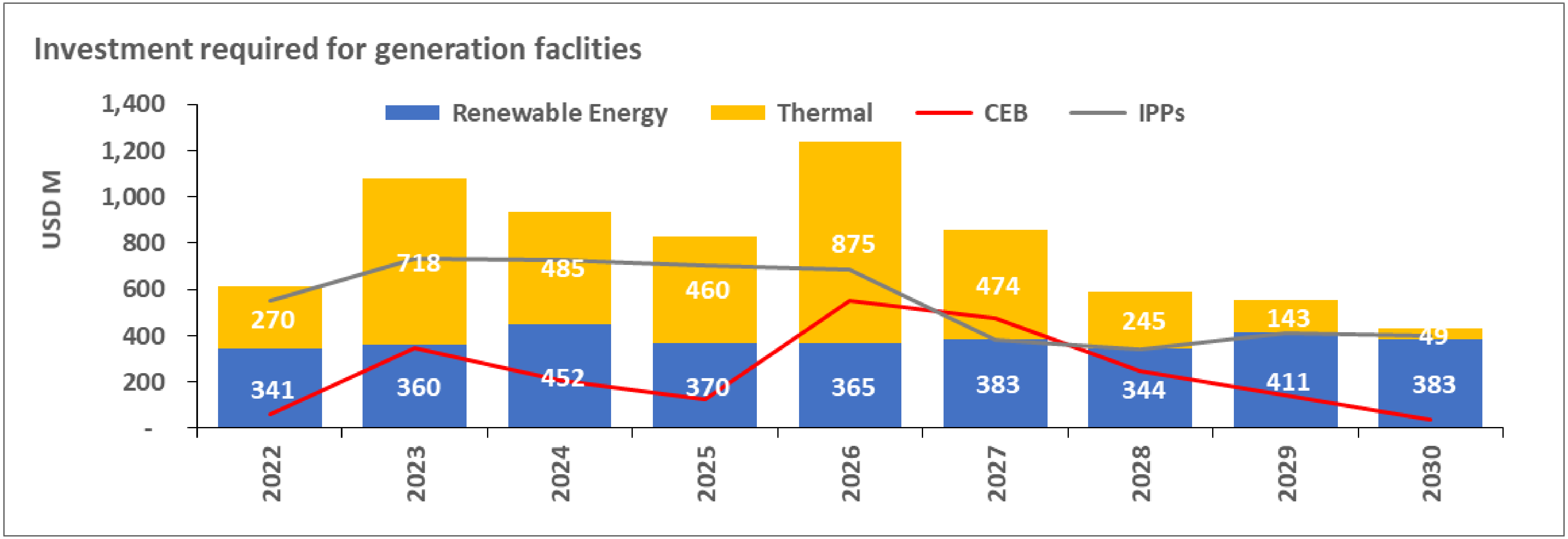
- Rapid demand growth is projected
- Generation mix will be transitioned to new efficient thermal power and renewable energy as majority sources
- Solar PV generation accounts for about half of the NCRE sources.



# Financial challenge for CEB

- Over USD 7 billion investment is anticipated in 2020s for generation facility development
- While private investment in IPPs is expected, it is also a major challenge for CEB to invest in not only generation sources but transmission and distribution network.
- According to LTGEP, large investment requirement is anticipated in mid-2020s.





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# CEB Financial Projection

- Financial projection has been prepared to assess CEB's financial status in near future in the current business environment and constraints.
- Cost reduction effect of the rooftop solar PV FIT is assessed
- Major assumptions:
  - Projection period: 2021 – 2030
  - Expressed in nominal price applying inflation rate of 5% for local currency and 1.5% for foreign currency
  - Based on LTGEP 2022 – 2041 for demand forecast, generation facility development, etc.
  - No government subsidy or equity injection is anticipated in base case
  - Current tariff level (16.72 LKR/kWh in 2020) is applied in base case
  - Foreign bank loan is assumed for financing needs for capital expenditure

    Interest rate 3.4% (6 months LIBOR + 3.0% premium)

    Repayment period 20 years
  - Short-term loans are assumed for cash balance (interest rate 7.5%)


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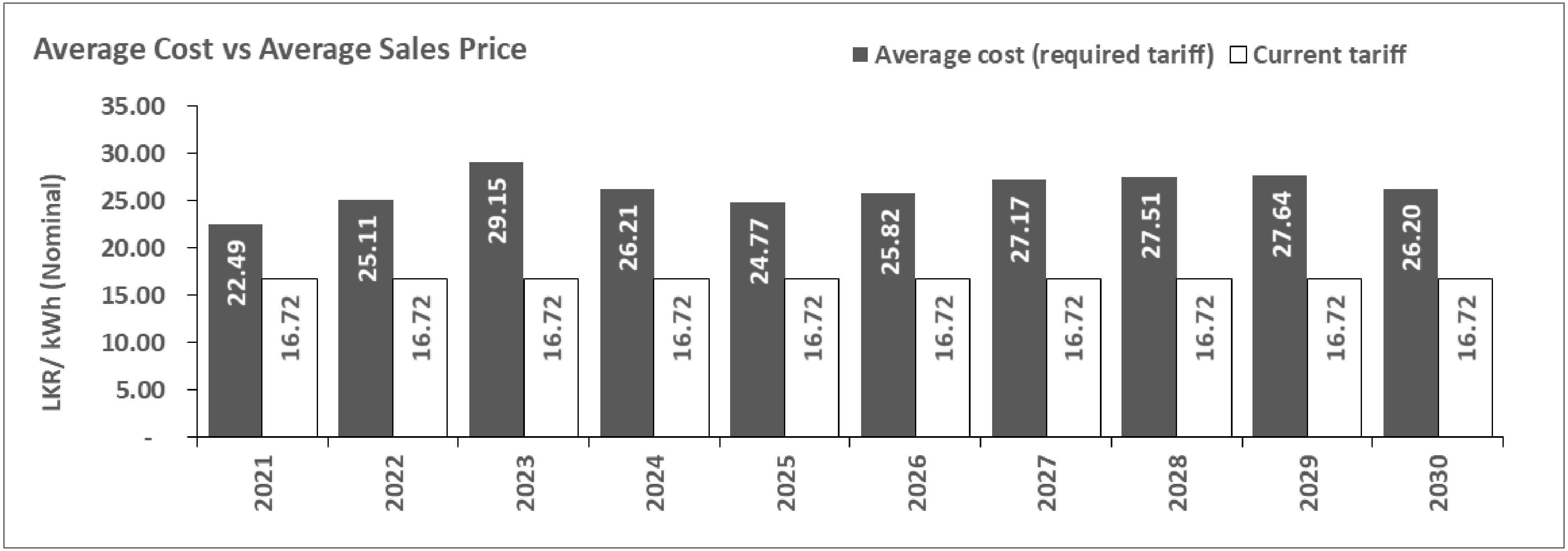
# Average cost per kWh

- As electricity tariff revision has not been made for years, wide operating deficit is anticipated for coming years.
- Cost increase around 2023 is due to generation of inefficient plants such as diesel TPPs which will be replaced by new NG-fired plants in mid-2020s.



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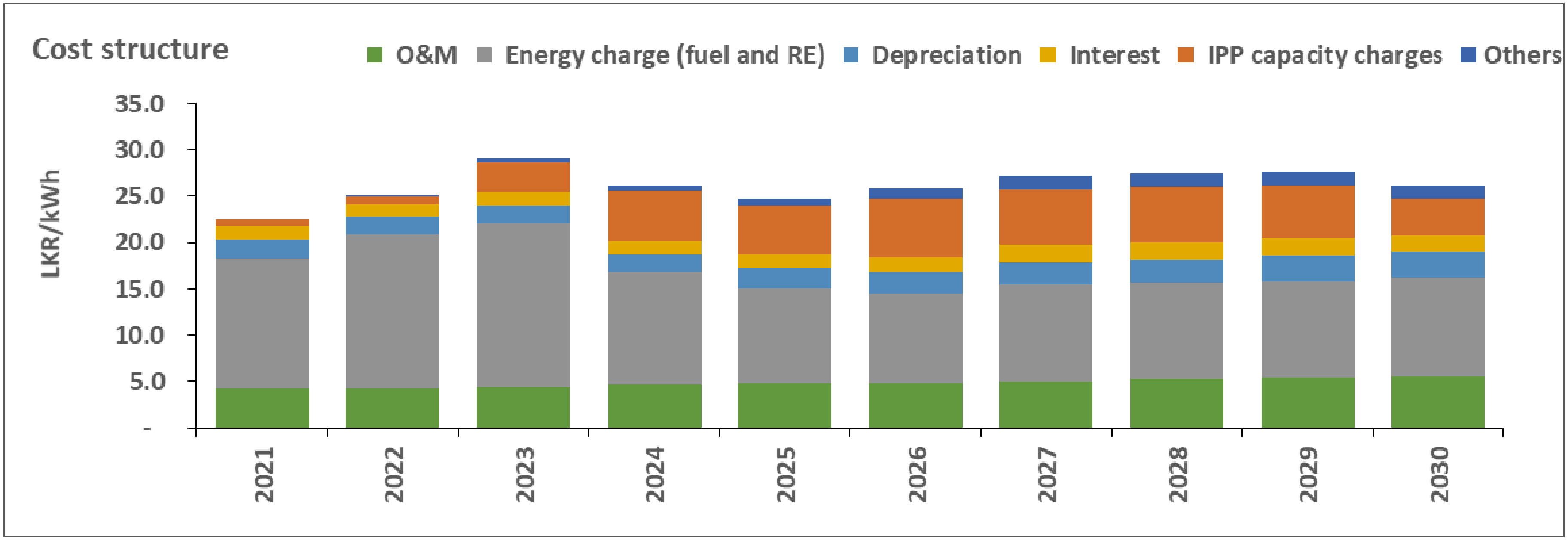
# Cost structure

- It shows energy charge (fuel cost) will decrease from 2024.
- As IPP projects are commissioned, the capacity charge payments are going to increase.





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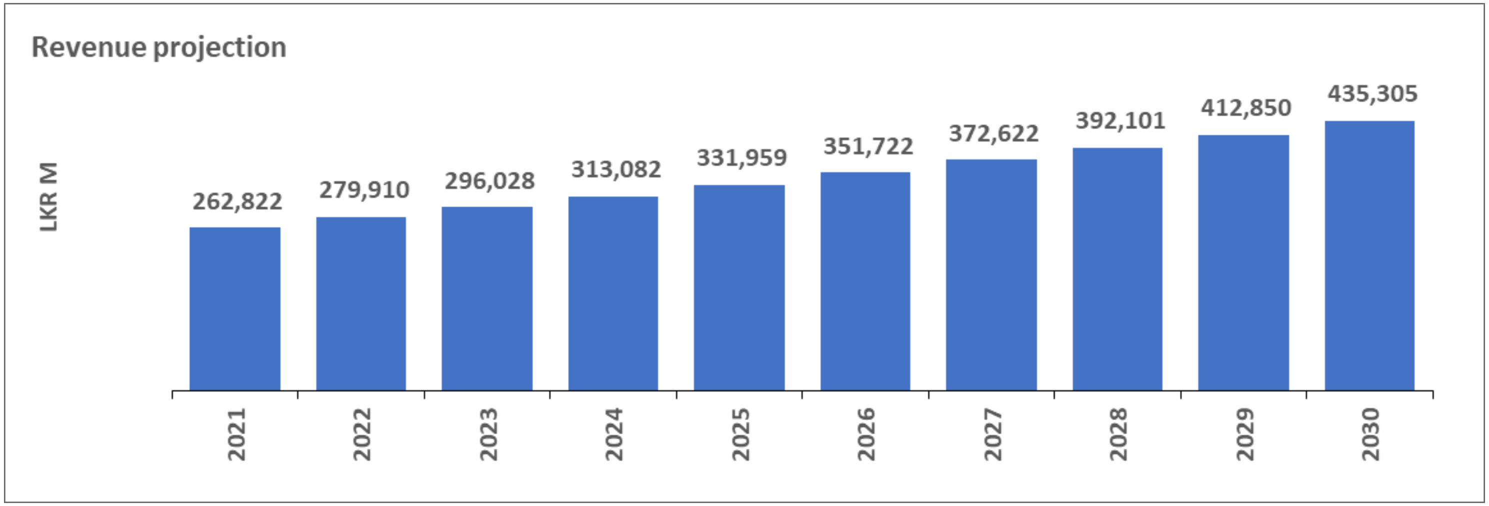
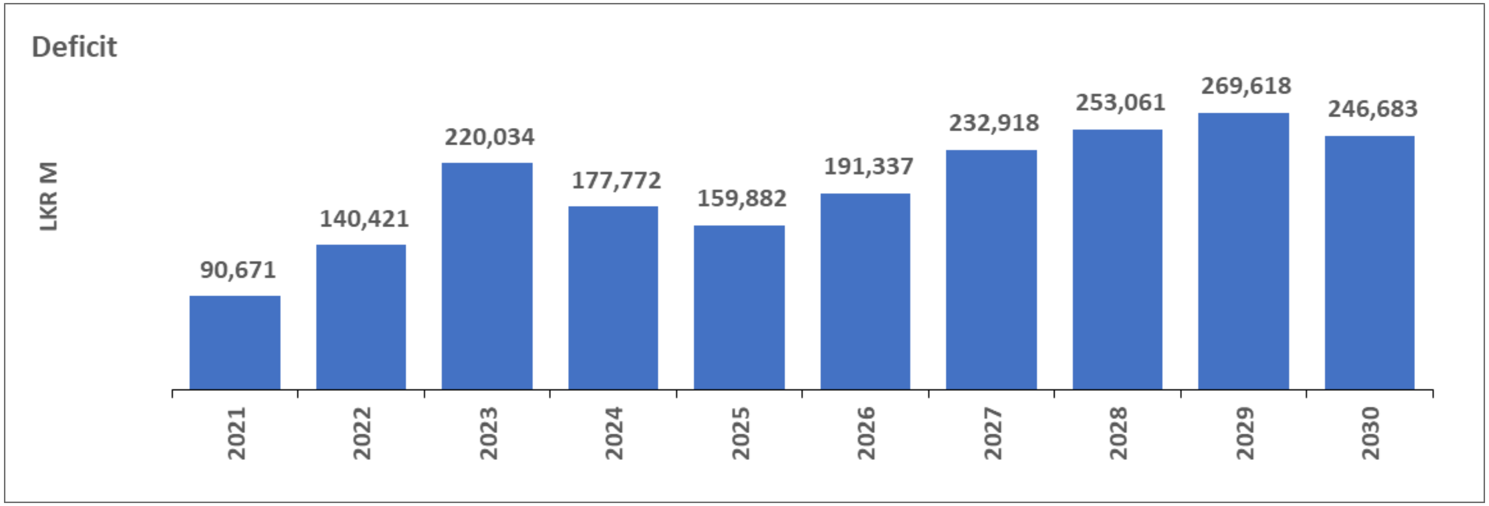
# Financial Status

➢ As a result of negative margin, despite steady revenue growth, deficits will be accumulated.



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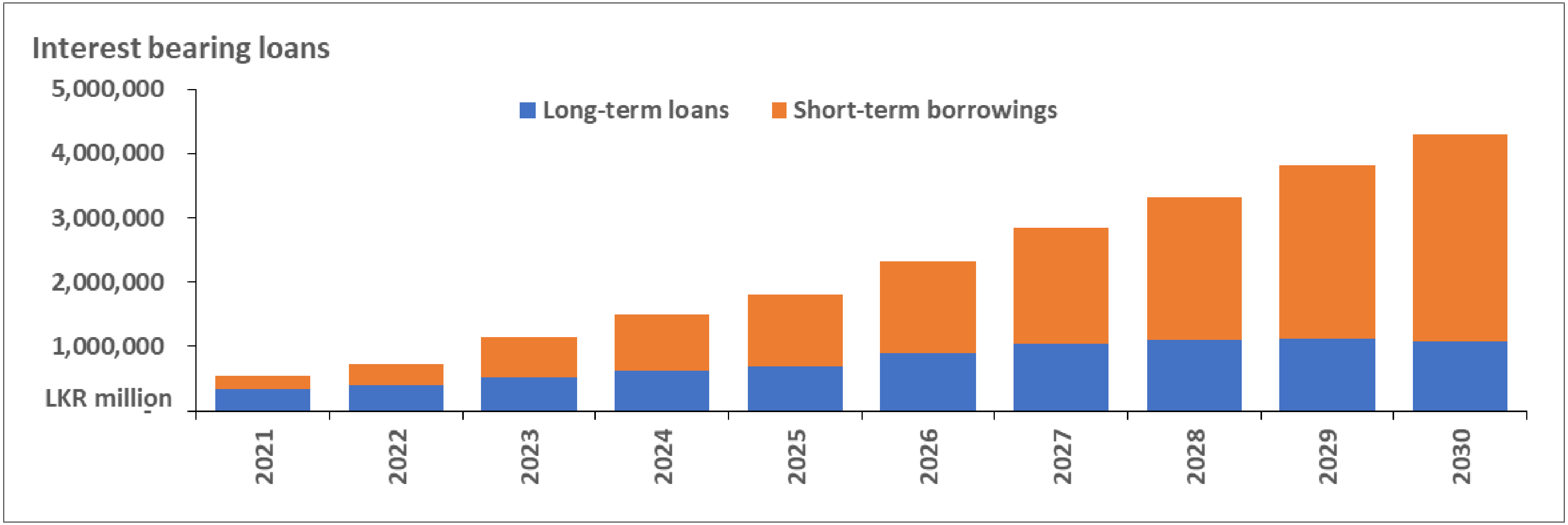
➢ To maintain its cash balance, CEB has to rely on short-term borrowings.





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# Proposed revision of Rooftop PV FIT

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Current FIT
Y1 - Y7: 22.00 LKR/kWh
Y8 – Y2: 15.50 LKR/kWh

Average 20.22 LKR/kWh

Average 17.93 LKR/kWh

**Proposed FIT**

Y1 – Y7: 19.26 LKR/kWh
Y8 – Y20: 15.50 LKR/kWh

12.56 LKR/kWh

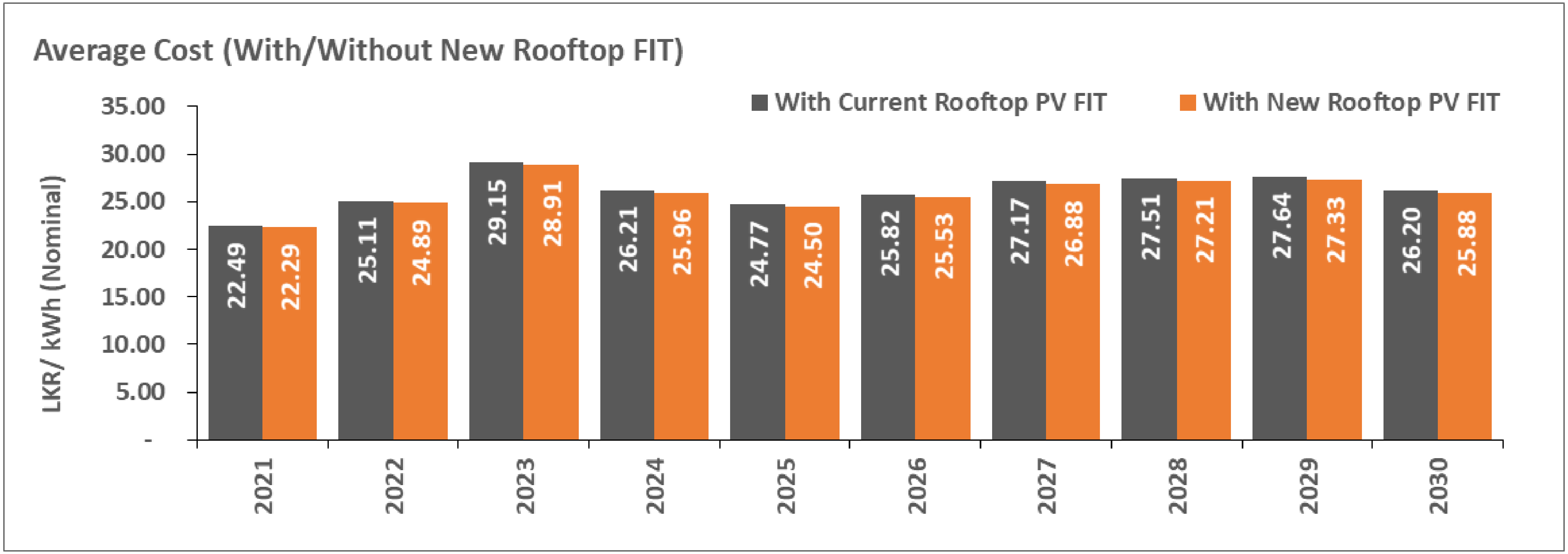
12.17 LKR/kWh

| Rooftop PV capacity | | 0-5kW | 5-10kW | 10-20kW | 20-40kW | 40-60kW | 60-100kW | 100kW-1MW | Over 1MW |
|---|---|---|---|---|---|---|---|---|---|
| Installation cost [LKR/kW] | | 180,000 | 170,000 | 125,000 | 125,000 | 120,000 | 120,000 | 90,000 | 85,000 |
| Generation Cost [LKR/kWh] | 1st - 7th year | 19.73 | 18.16 | 12.66 | 12.66 | 12.16 | 12.16 | 9.12 | 8.61 |
| | 8th - 20th year | 15.50 | 15.50 | 12.66 | 12.66 | 12.16 | 12.16 | 9.12 | 8.61 |
| Project IRR | | 11.55% | 11.59% | 11.67% | 11.67% | 11.68% | 11.68% | 11.68% | 11.67% |
| Equity IRR | | 13.05% | 13.05% | 13.05% | 13.05% | 13.07% | 13.07% | 13.07% | 13.05% |

- Impact on CEB's average cost is assessed through projection in case with "FIT revision for rooftop solar PV"
- To facilitate the calculation, an average tariff of 17.93 LKR/kWh is used for Category 1 (below 10kW) customers.

# Revision of Rooftop PV FIT

- The results show that the cost reduction effects on CEB's overall average cost is around 0.2 – 0.3 LKR/kWh.
- This is due to the small share of rooftop solar PV in total generation (10.2% in 2025).





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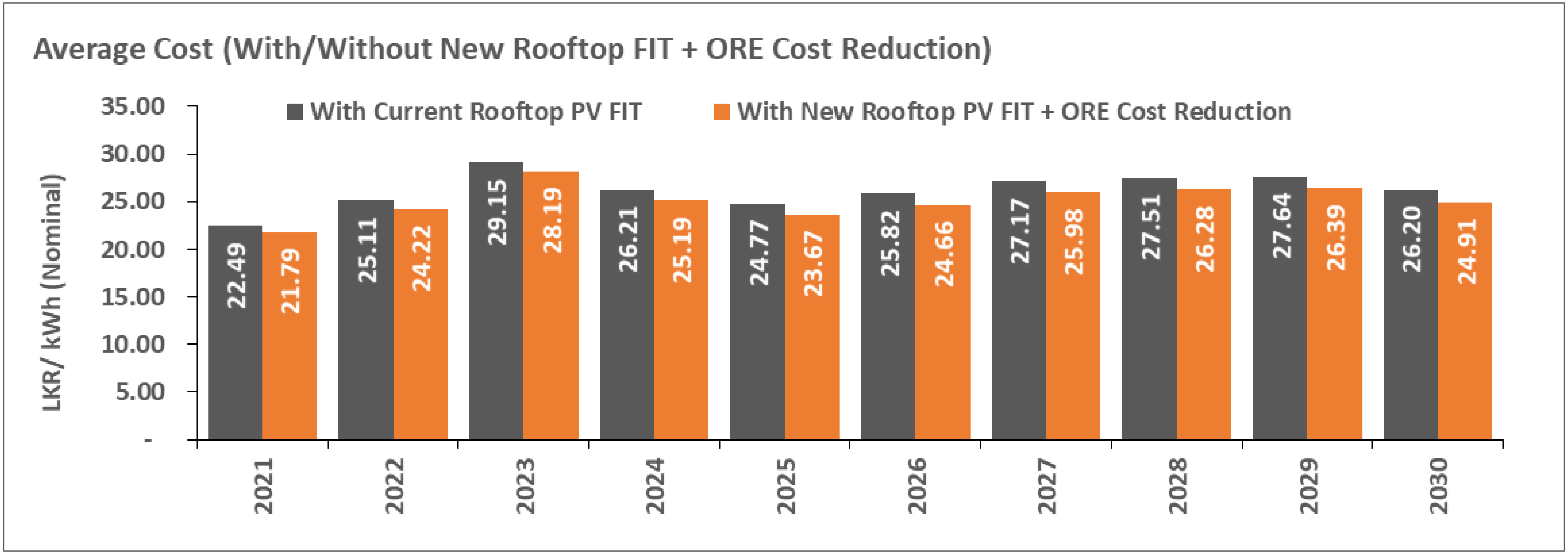
# Revision of Rooftop PV FIT and other RE cost

- The analysis was made for the case in which other renewable energy cost is also reduced to the same level (12.17 LKR/kWh).
- CEB's cost reduction is estimated at 0.7 to 1.3 LKR/kWh.





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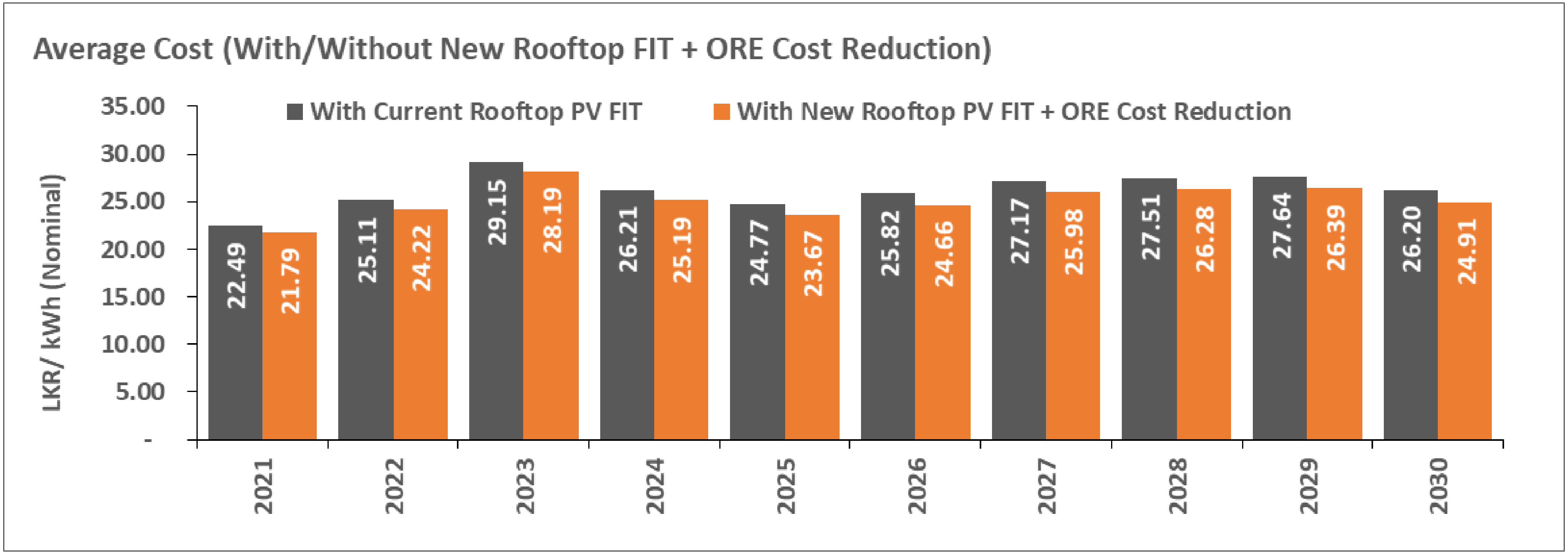



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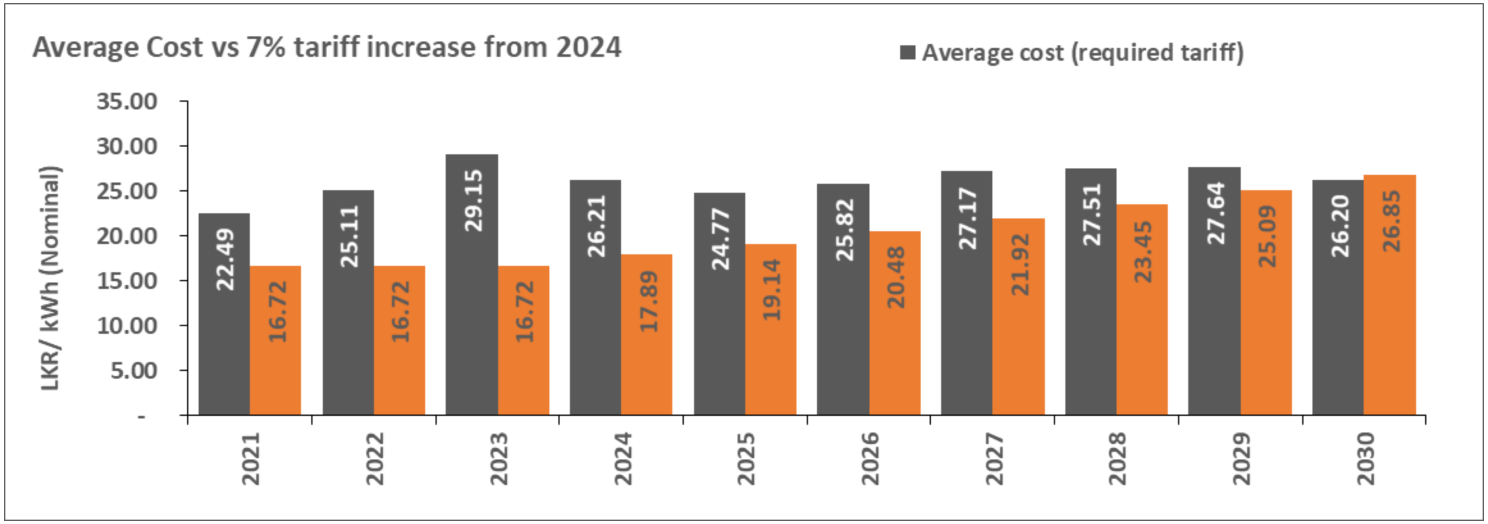
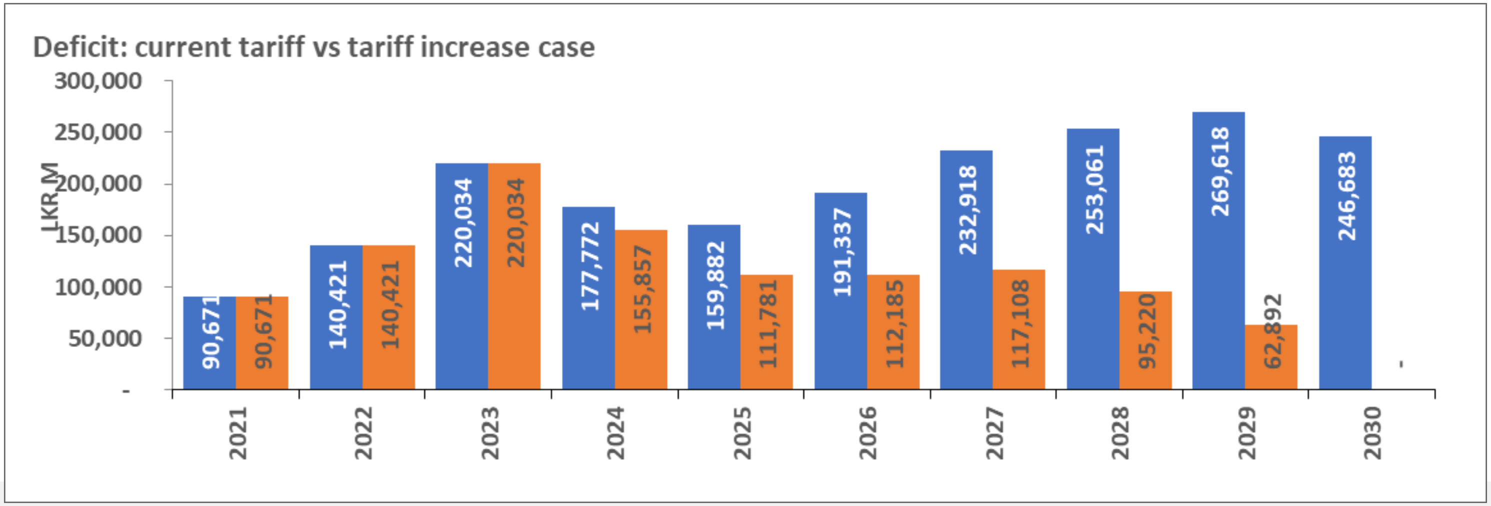
# Electricity tariff increase case

- The case with 7% electricity tariff increase from 2024 would reach the break-even point in 2030 and significantly improve CEB's financial status.





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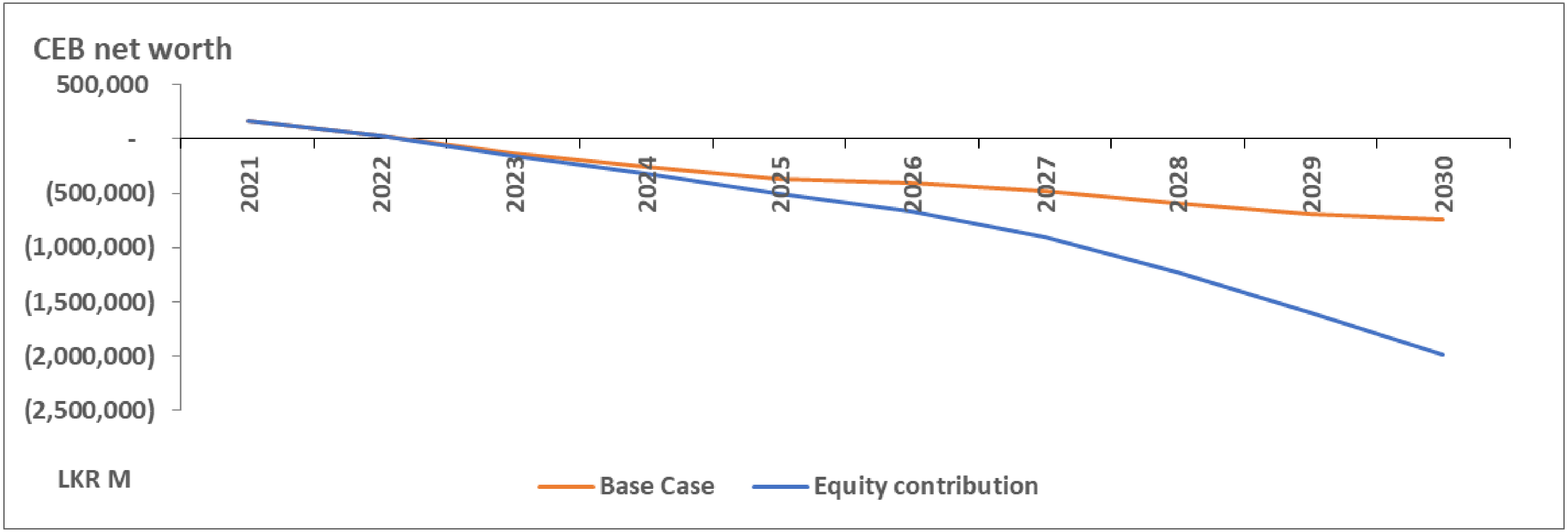
# Effect of capital contribution by GoSL

- In this case, GoSL provides 50% capital contribution to capital expenditure of CEB.
- Equity investment by GoSL would improve CEB's financial position.



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# CEB Financial Projection

- CEB's financial status continues to be very severe due to its electricity tariff level.
- Rooftop PV FIT revision may not show significant effects to overall financial status; however, it will have more impact in the long run as its generation share grows over time.
- It would be useful if a user-friendly financial projection tool is available for CEB staff for their financial planning purposes. JICA Expert Team will improve the present model and share it with CEB staff.


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# Procurement Procedures for Development of Renewable Energy

~ 2nd Seminar on System and Policy in Power Sector ~

Ceylon Electricity Board
JICA Expert Team

Jan. 20, 2022

Chubu Electric Power Co., Inc.
Nippon Koei Co., ltd.

# INDEX





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# Background

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70% of Renewable Energy by 2030

The approval process for renewable energy has not changed since 2011

The approval process has difficulties in accelerating renewable energy projects

- Complicated process
- Time-consuming process
- Comings and goings process

The approval process is needed to be revised to achieve the above target



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# 2. Grasping the Process


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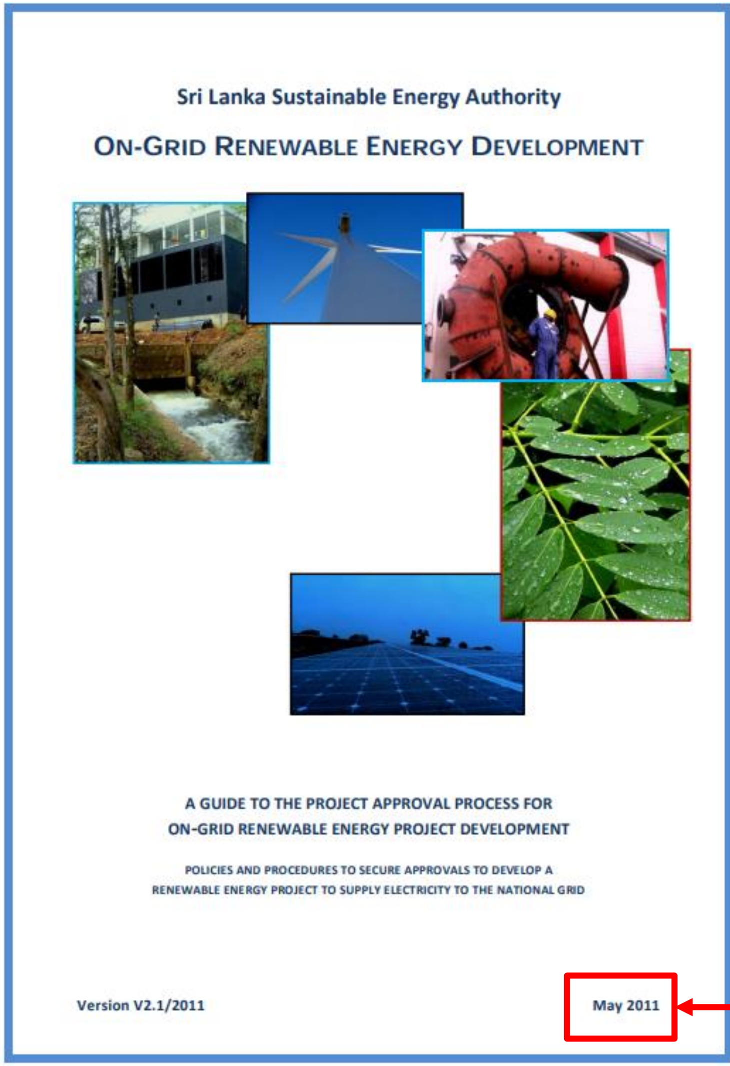
# A Guide to the Project Approval Process


Sri Lanka Sustainable Energy Authority

ON-GRID RENEWABLE ENERGY DEVELOPMENT

A GUIDE TO THE PROJECT APPROVAL PROCESS FOR
ON-GRID RENEWABLE ENERGY PROJECT DEVELOPMENT

POLICIES AND PROCEDURES TO SECURE APPROVALS TO DEVELOP A
RENEWABLE ENERGY PROJECT TO SUPPLY ELECTRICITY TO THE NATIONAL GRID

Version V2.1/2011

May 2011

No revision since it was issued in 2011

The virtuous circle of improving the procedure and a revision of the guideline is important


*Renewable Energy Development Guideline*
[http://www.energy.gov.lk/index.php/en/renewable-energy/new-renewable-energy]



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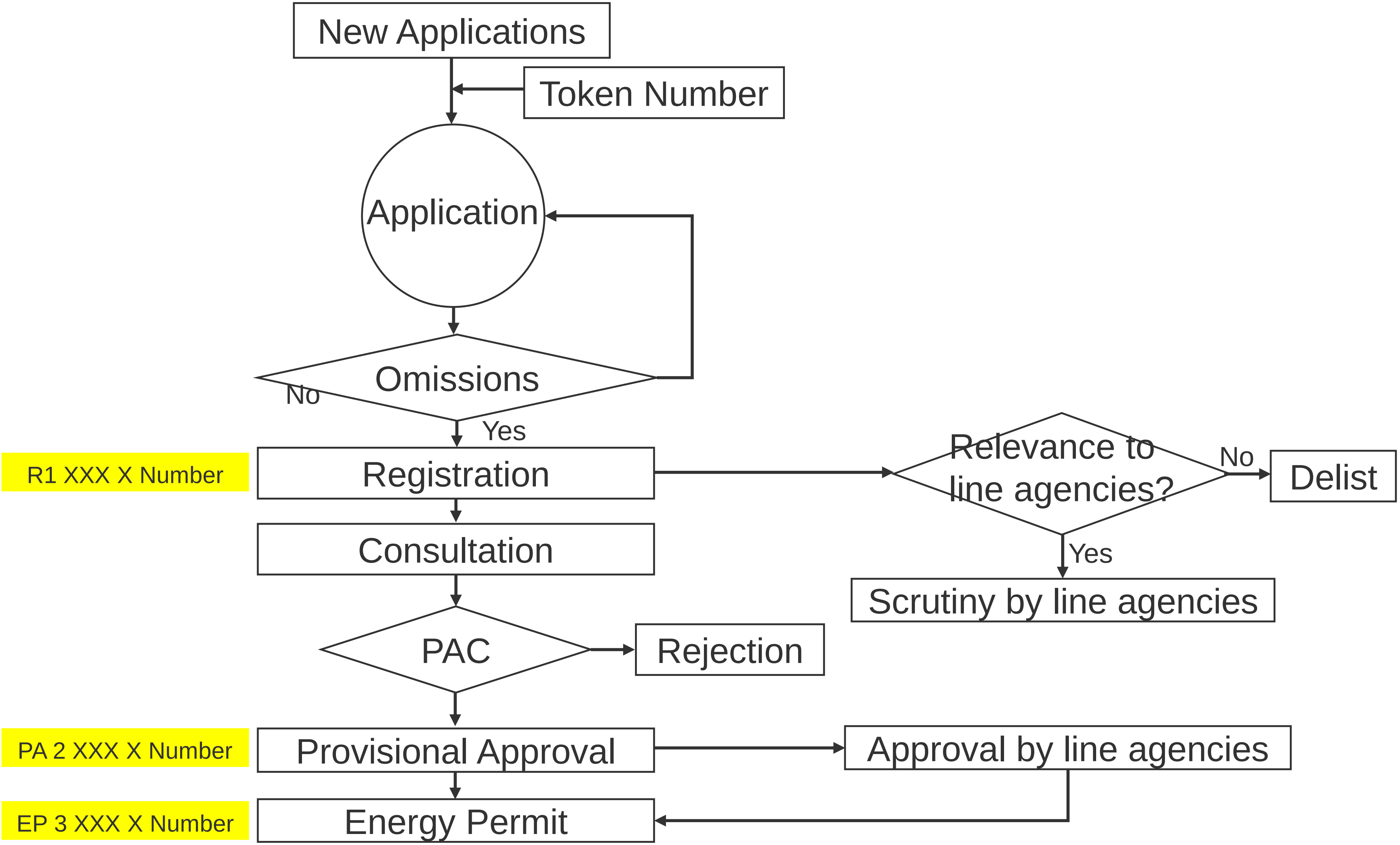
# Outline of the Process in the Guideline



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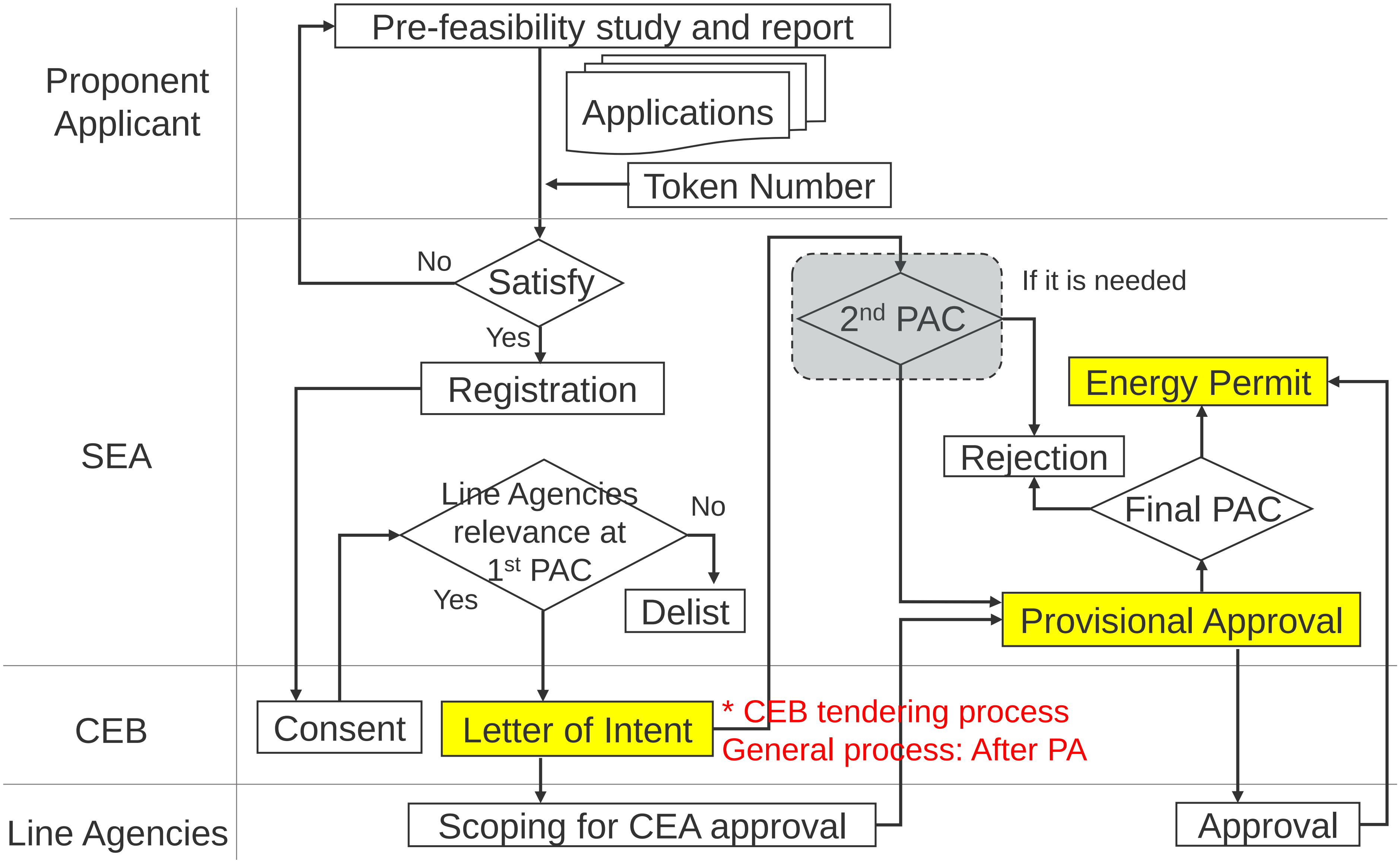
# Arrangement of the Process Flowchart





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# Duration of the Approval Process of the Projects

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As for CEB tendering process,
4 main phases to see how the approval process takes time

LOI Issued → PA Issued → EP Issued → Grid Connected

LOI: Letter of Intent, PA: Provisional Approval, EP: Energy Permit, GC: Grid Connection

Refer 60 tenders in 2017, 90 tenders in 2018

| | Number | | | |
|---|---|---|---|---|
| | LOI | PA | EP | GC |
| 1MW×60 (35 registers) [2017] | 35 | 35 | 35 | 28 |
| 1MW×90 (65 registers) [2018] | 65 | 65 | 64 | 10 |


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# Duration of the Approval Process of the Projects

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LOI Issued → PA Issued → EP Issued → Grid Connected

LOI: Letter of Intent, PA: Provisional Approval, EP: Energy Permit, GC: Grid Connection

LOI to PA → PA to EP → EP to Grid Connected

| | | Duration [Days] | | |
|---|---|---|---|---|
| | | **LOI to PA** | **PA to EP** | **EP to GC** |
| 1MW×60 (35 registers) [2017] | AVE | 198 | 136 | 559 |
| | MAX | 603 | 451 | 978 |
| | Min | 21 | 13 | 271 |
| 1MW×90 (65 registers) [2018] | AVE | 117 | 291 | 491 |
| | MAX | 342 | 719 | 551 |
| | min | 8 | 75 | 413 |

**Much time compared to Japan where the process could be 90 days**

→ **Find out what the time-consuming processes are**



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# Arrangement of the Process Flowchart

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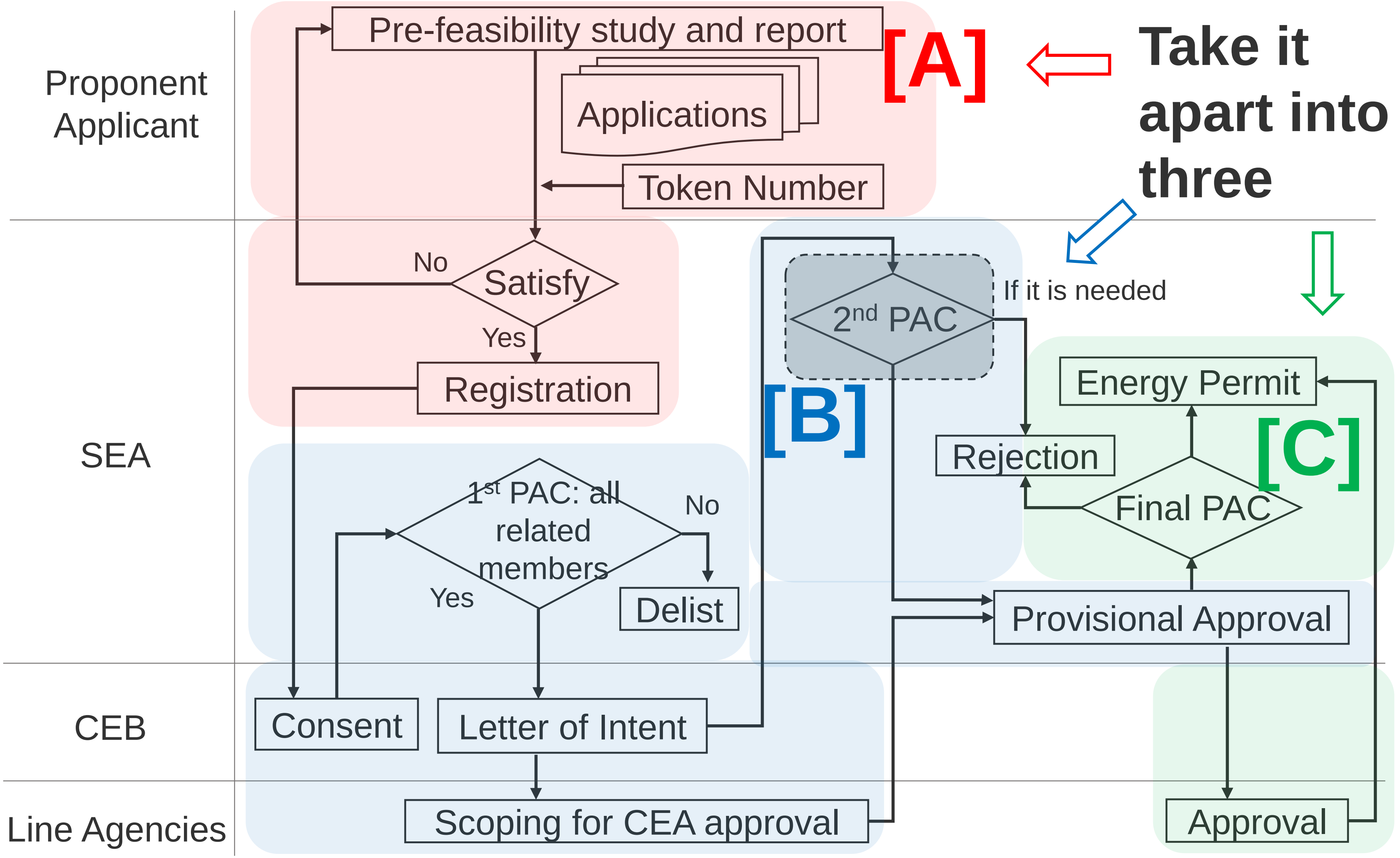
NIPPON KOEI



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# 3. Explanation of Each of the Processes


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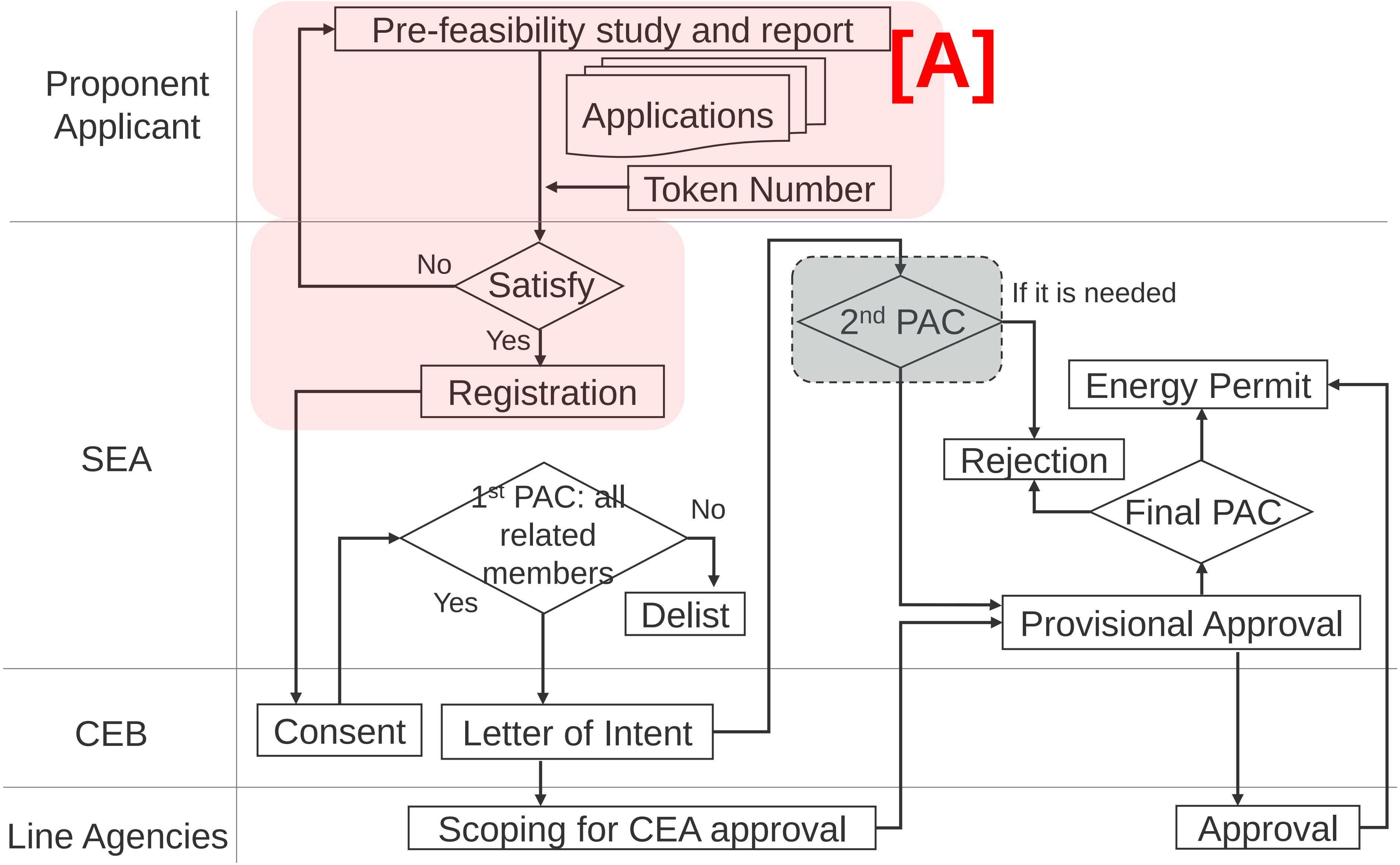
# Arrangement of the Process Flowchart



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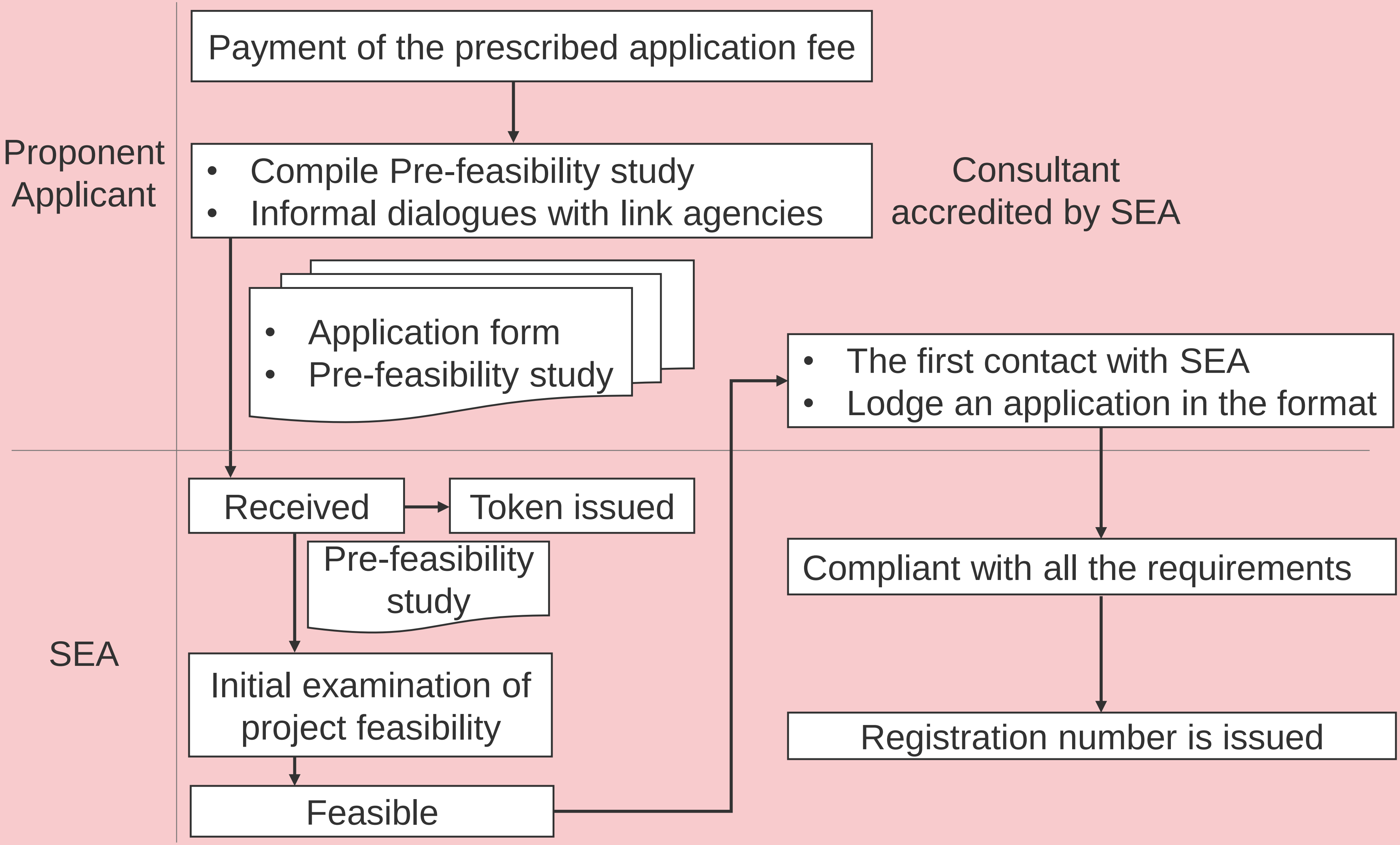
# Process Flowchart [A]



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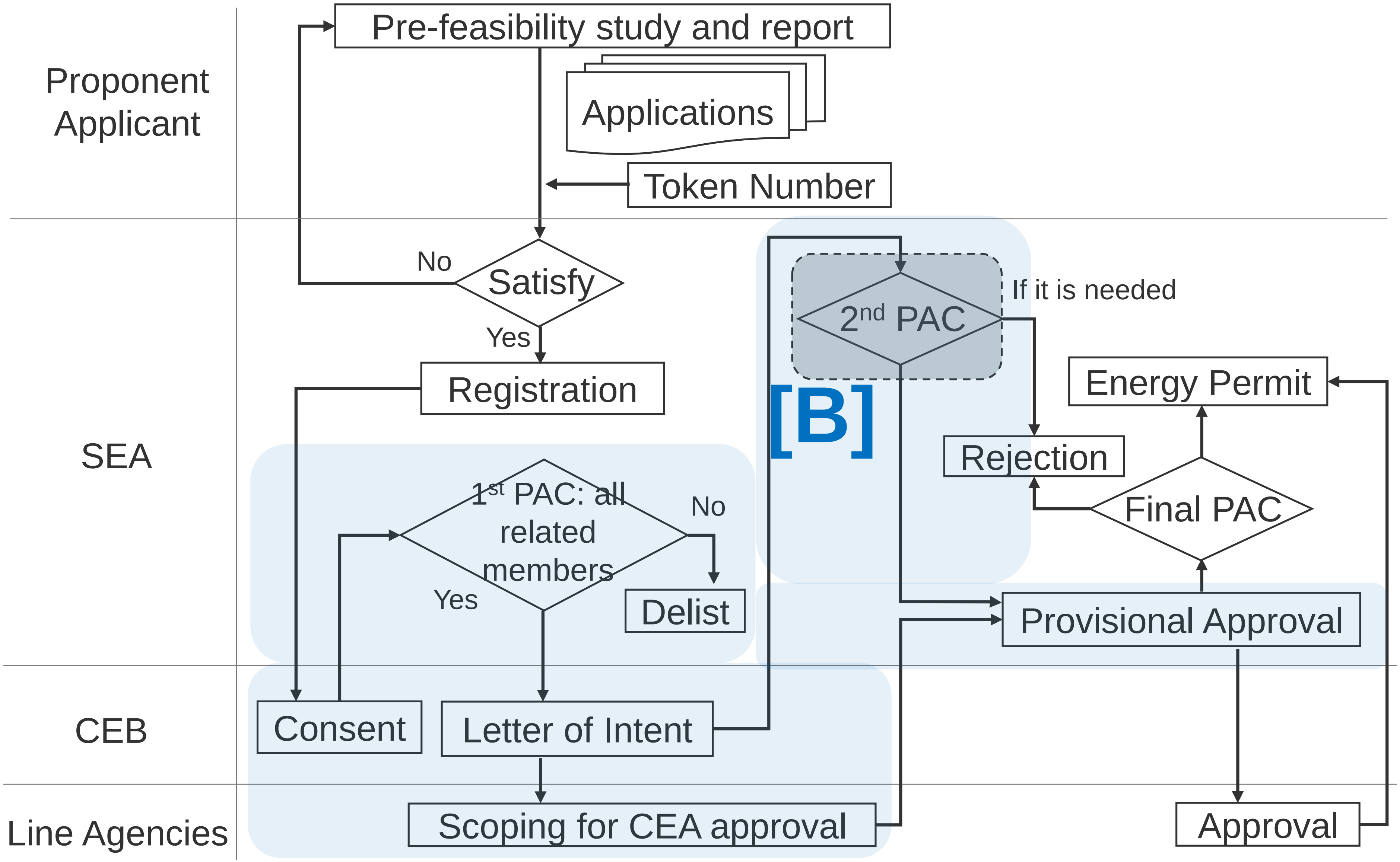
# Arrangement of the Process Flowchart





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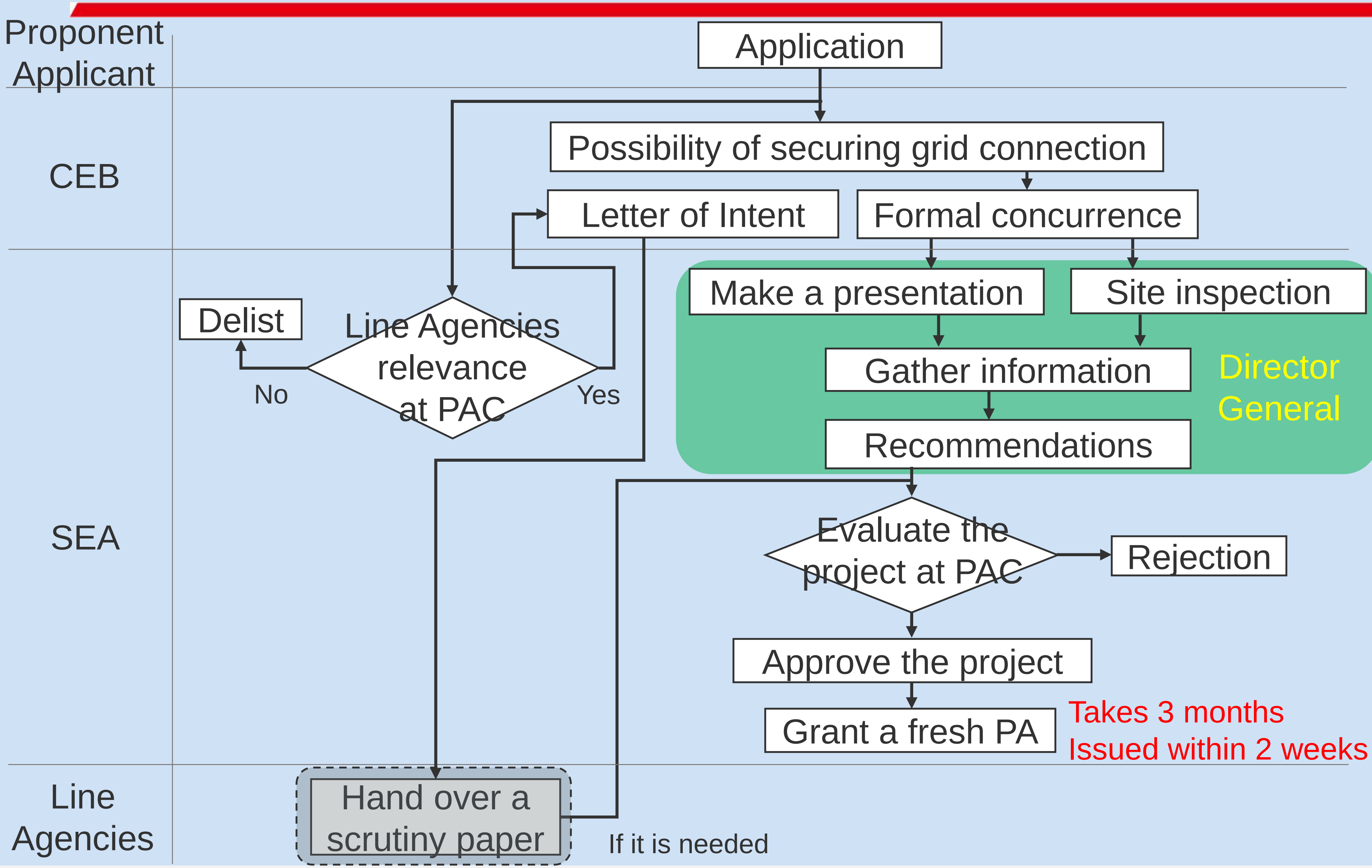
# Process Flowchart [B]





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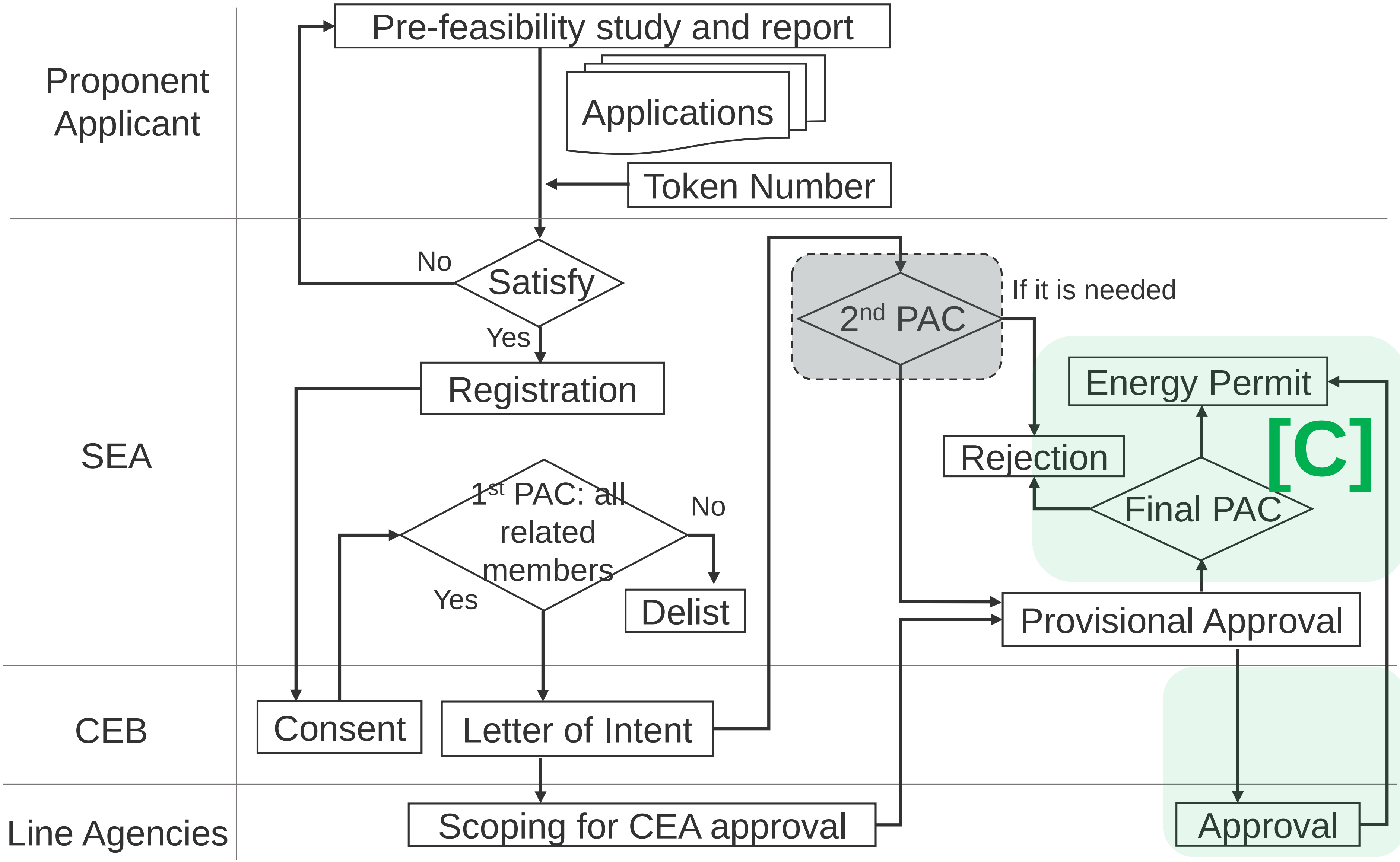
# Arrangement of the Process Flowchart



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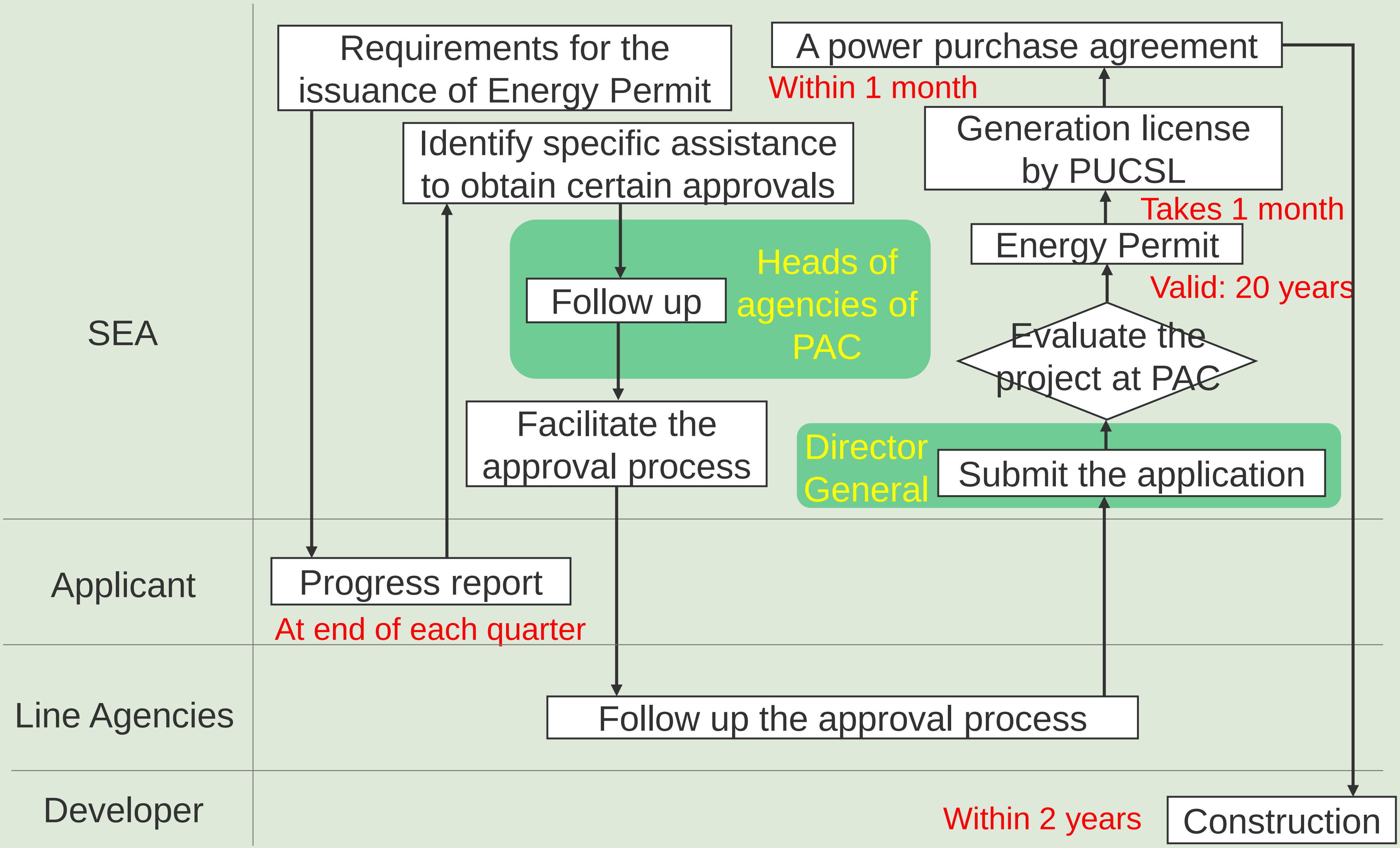
# Process Flowchart [C]



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# About Land – Process Flowchart [C]

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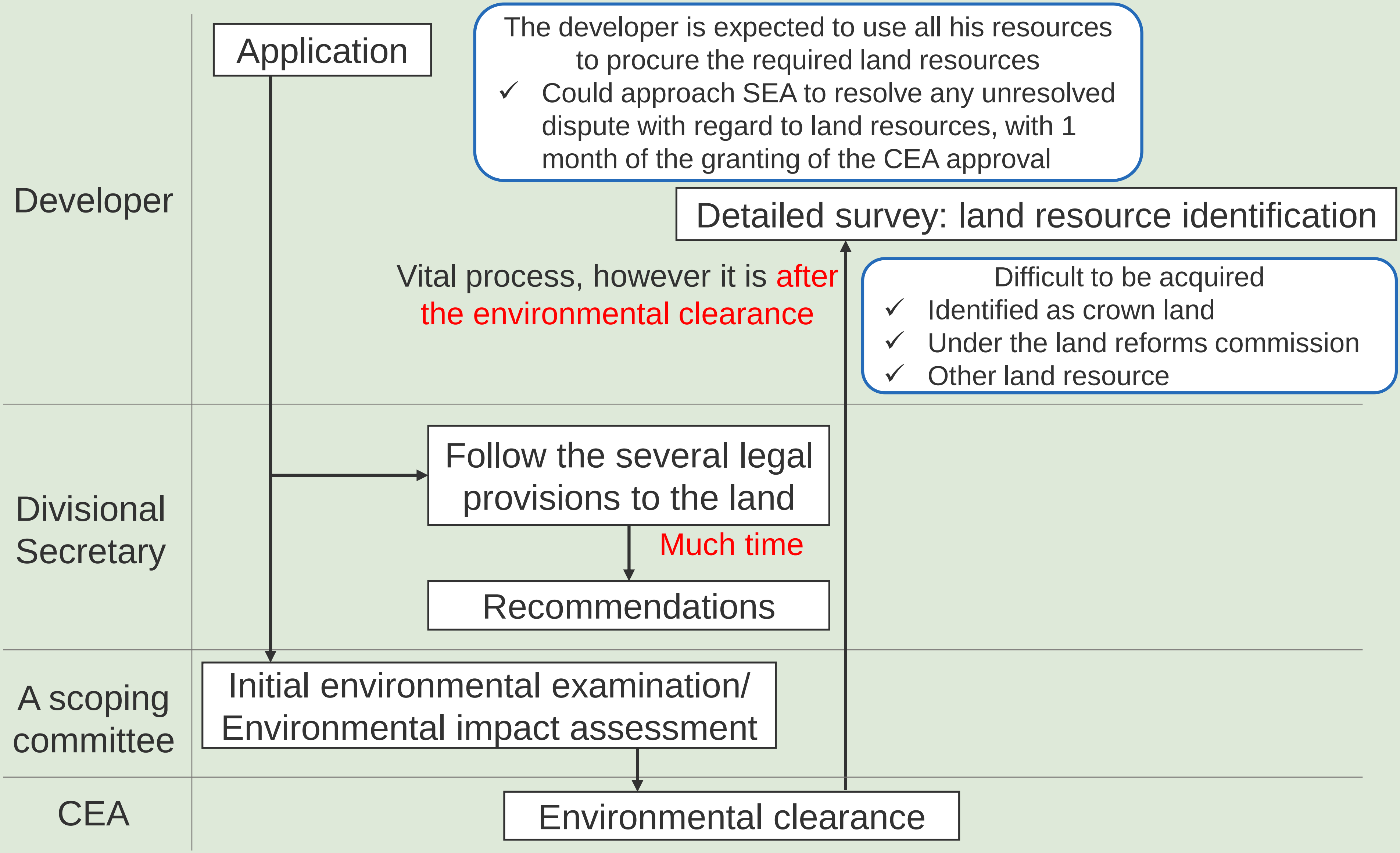




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# 4. Issues and Measures


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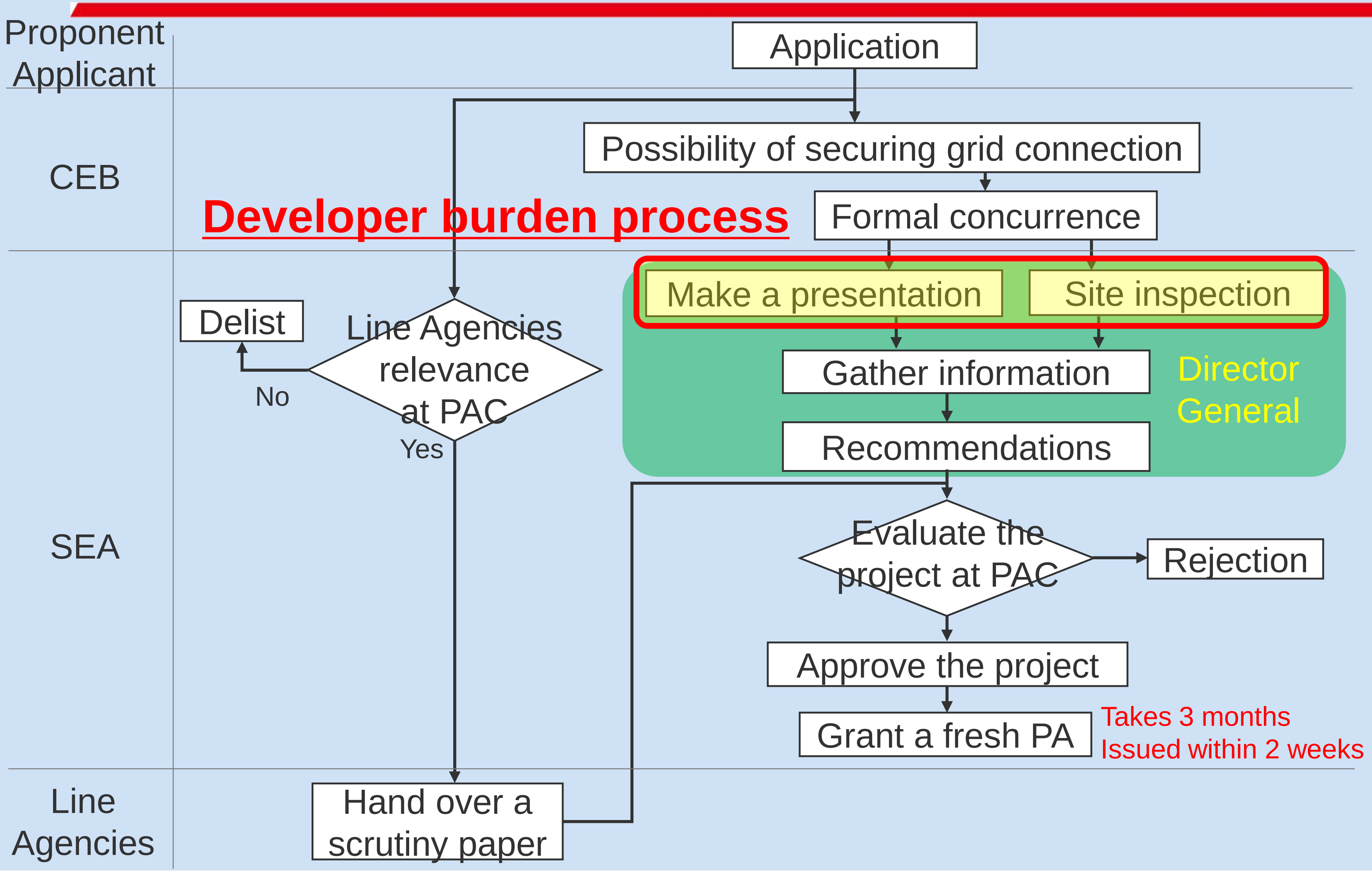
# Process Flowchart [B]



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# Process Flowchart [C]

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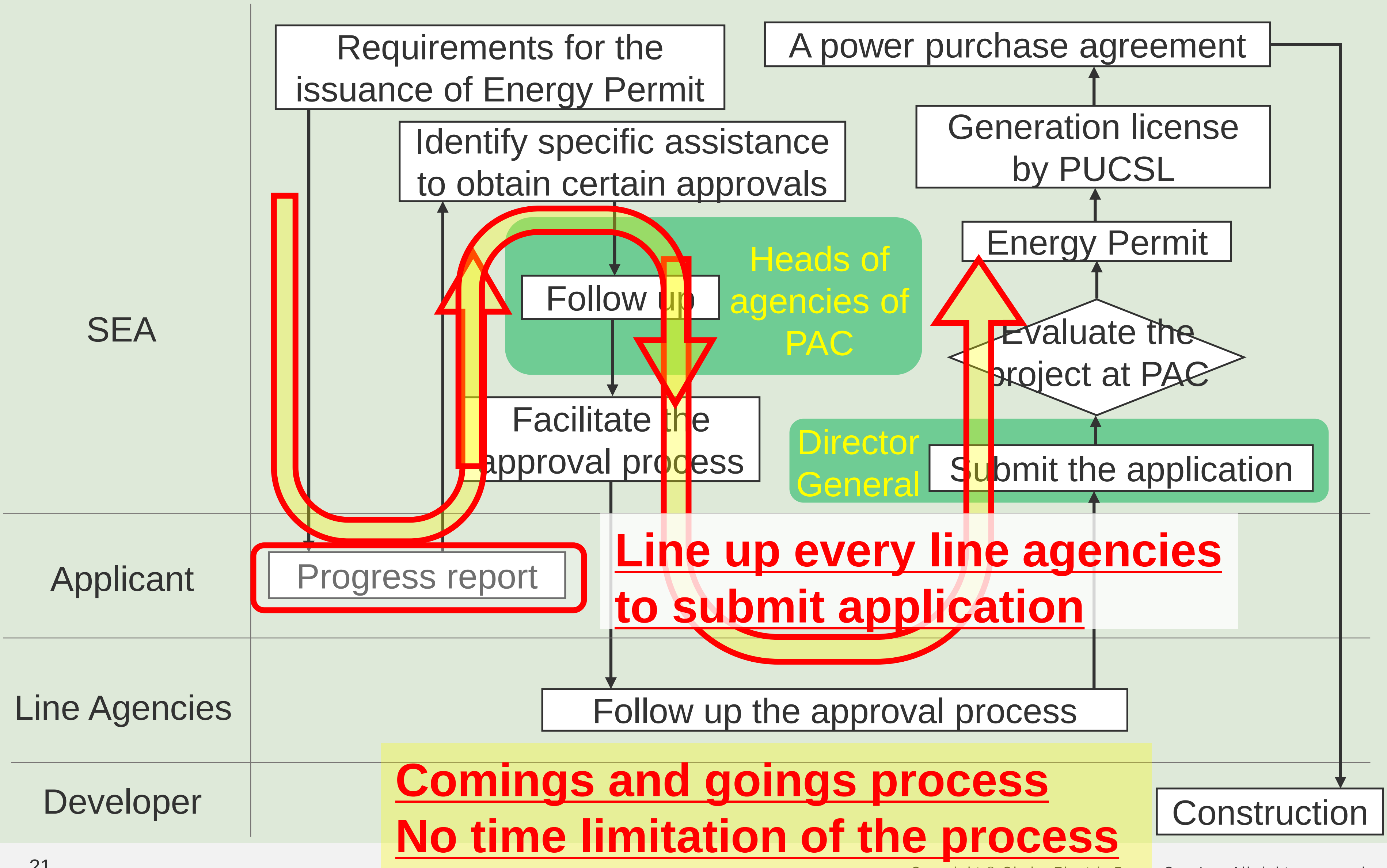




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# About Land – Process Flowchart [C]

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## Developer

Application

The developer is expected to use all his resources to procure the required land resources
- ✓ Could approach SEA to resolve any unresolved dispute with regard to land resources, with 1 month of the granting of the CEA approval

Detailed survey: land resource identification

Vital process, however it is after the environmental clearance

Difficult to be acquired
- ✓ Identified as crown land
- ✓ Under the land reforms commission
- ✓ Other land resource

## Divisional Secretary

Follow the several legal provisions to the land

Much time

Recommendations

**Important process that should be conducted earlier**

## A scoping committee

Initial environmental examination/ Environmental impact assessment

**Developer burden process**

## CEA

Environmental clearance



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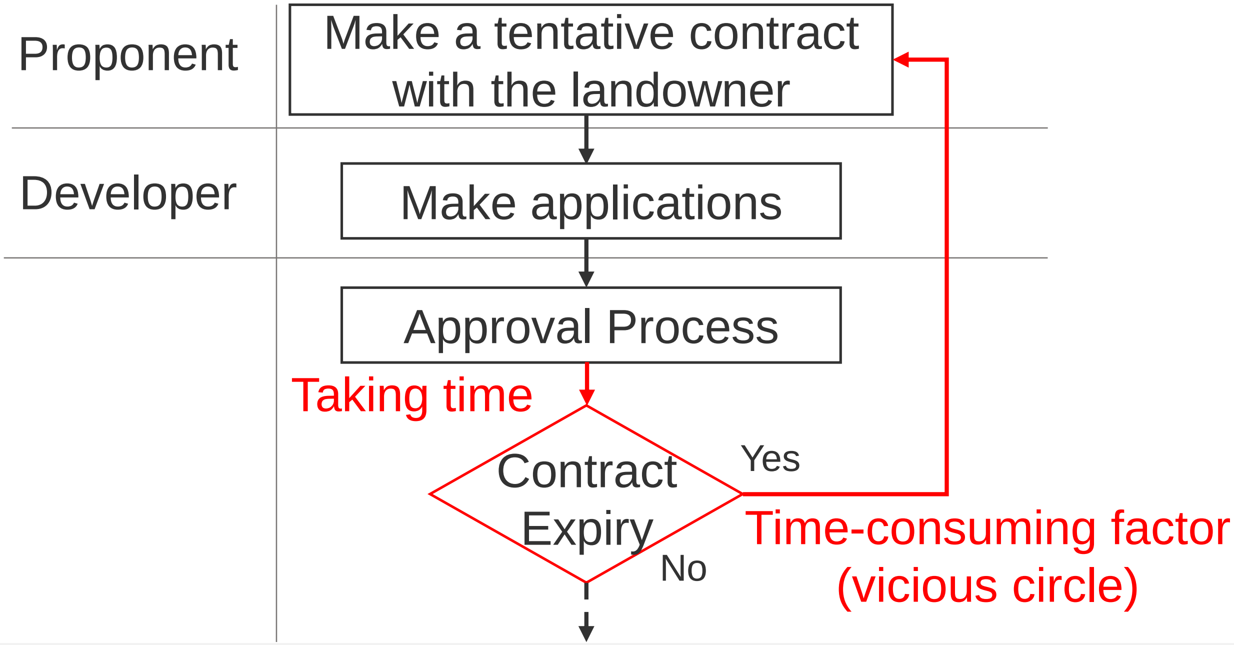
# Issues of the Land Lease / Acquisition

- A proponent tentatively make a contract with the landowner for either land lease or land acquisition
- A developer makes applications and they proceed based on condition of the tentative contract
- The approval process takes much time
- The tentative contract expires
- A proponent make a tentative contract again




- ✓ Cannot predict and estimate the duration of the approval process
  - It badly affects developers and proponents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# Issues of Forest / Wild life department

## ■ Forest / Wild life department

- After the energy permit has been issued under the condition that the project area is outside of forest and wild life area, the project area is not allowed to use because the  demarcated area has changed / the project area was close to the demarcated area, then the project will be stopped

[1.5MW hydro project of actual case]

| <2010> | <2010~2020> | <2021> |
|---|---|---|
| Energy permit issued | Construction (almost done: 90%) | Wild life area has been changed and the project stops |

➢ Although the energy permit was issued and the construction was almost done, the wild life area had been changed because of the government requirement and the project was stopped

✓ Cannot predict and estimate the change of the demarcated area

➢ It badly affects the developers



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# Point of the Issues & Possible Measures

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## Time-consuming factors

**Issues**

- Developer burden process
- Comings and goings process
- Land property
- Variable demarcated area
- No time limitation for line agency approval

**Measures**

**Process**
- Make a SEA relation
- Put an emphasis on land identification
- Eliminate the process

**System**
- Find out ways not to be affected by demarcated area

**Guideline**
- Make a guideline whole process can be seen
- Define each duration of the process


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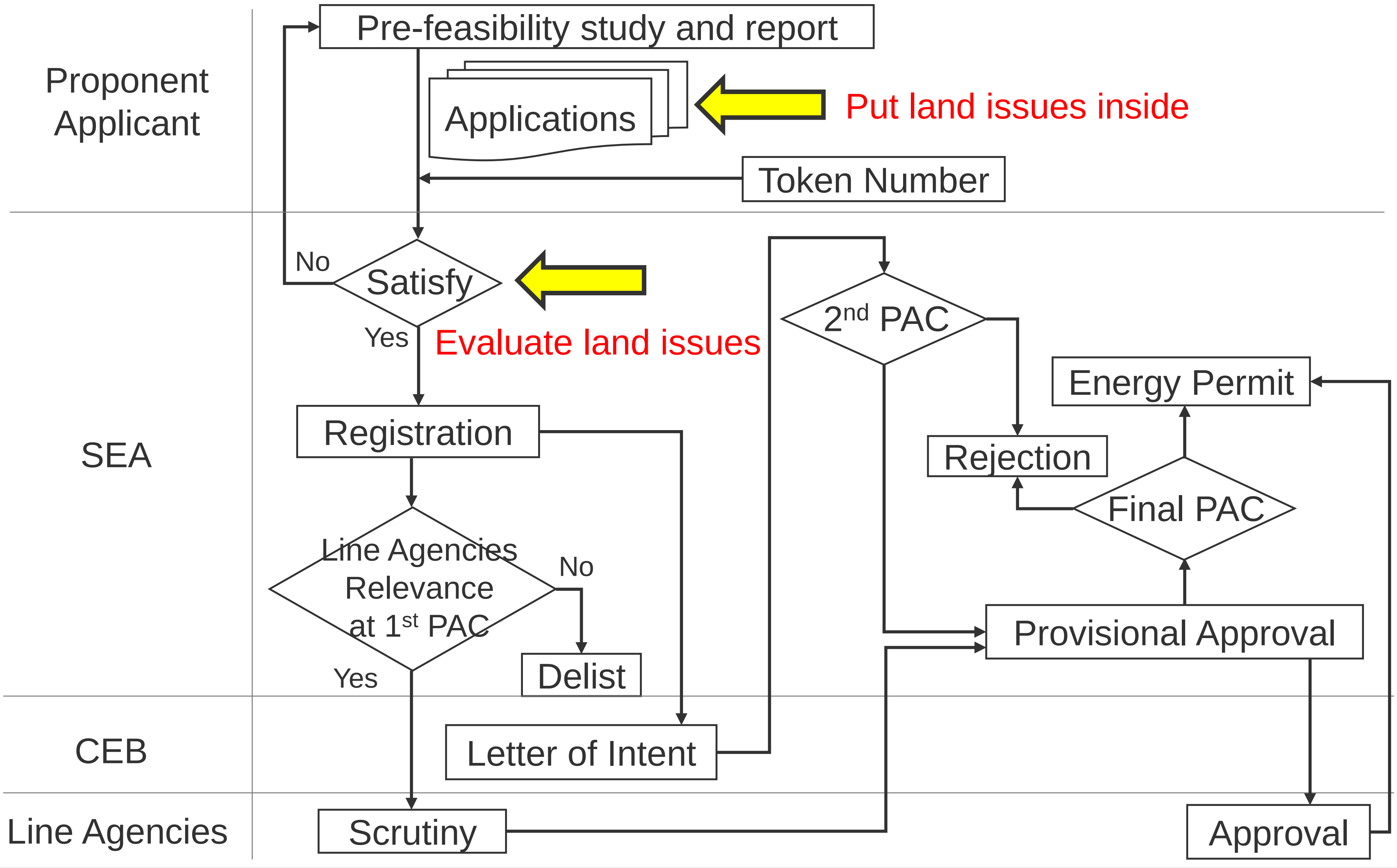
# Arrangement of the Process Flowchart



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# Process Flowchart [A]

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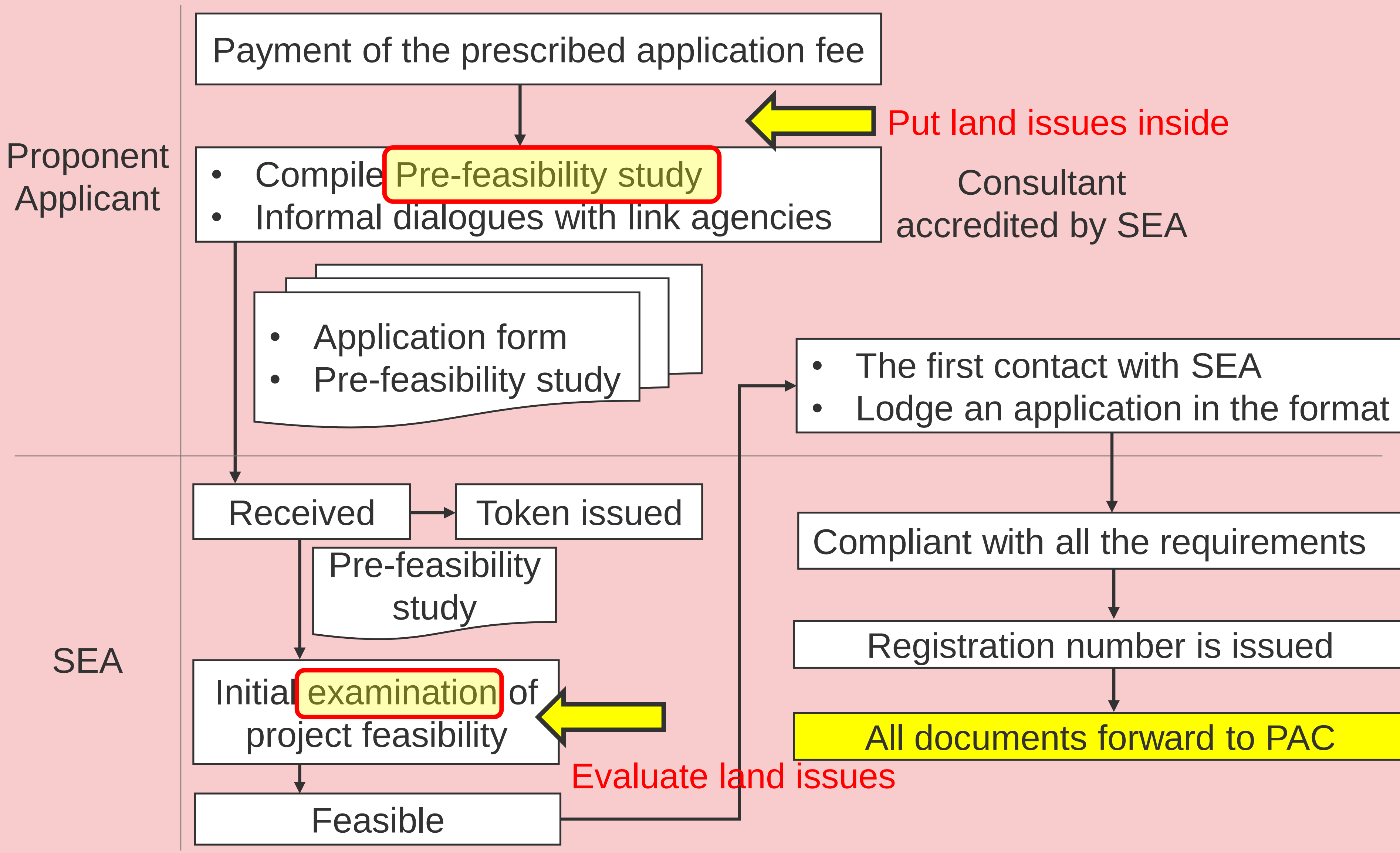




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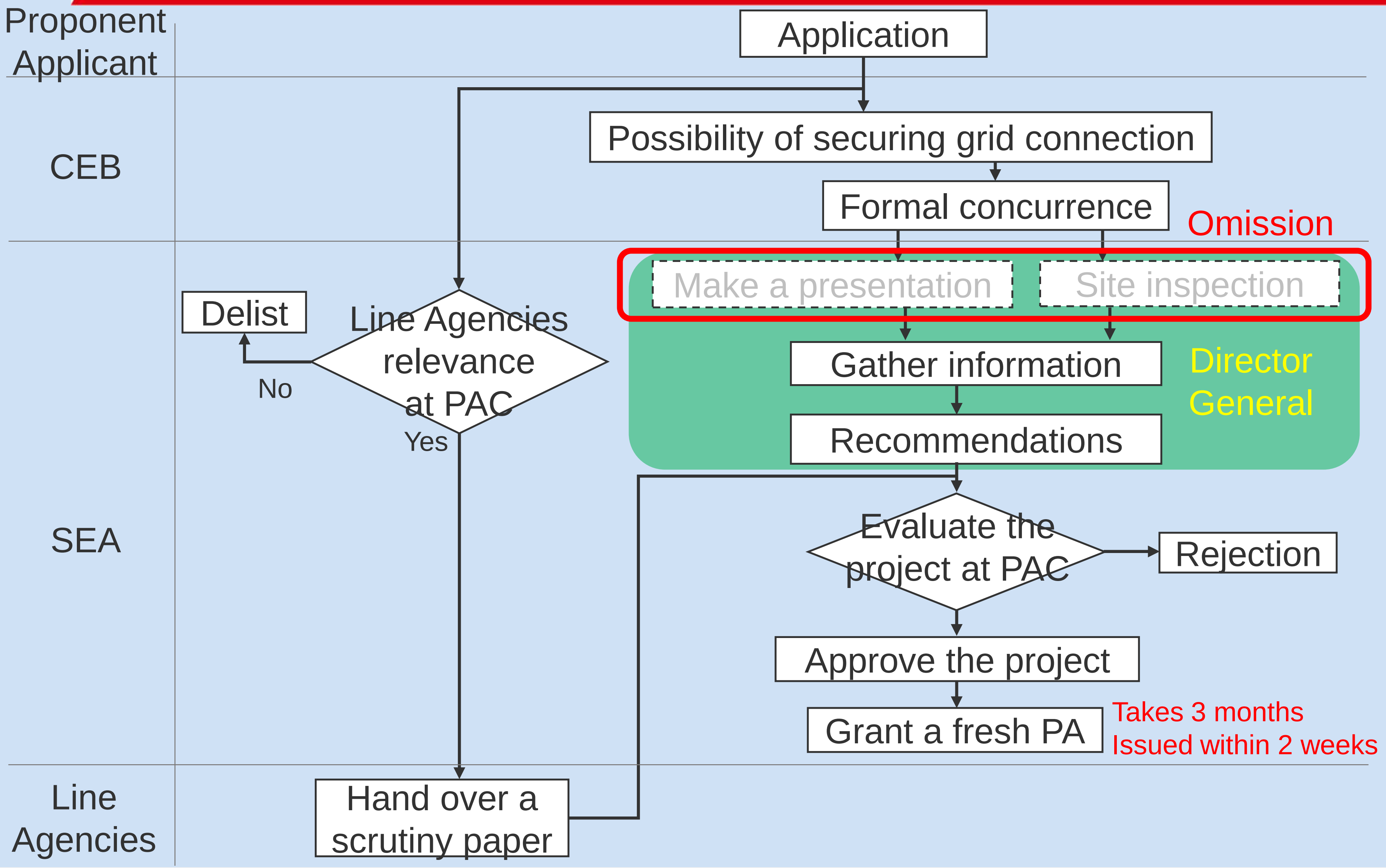
# Process Flowchart [B]



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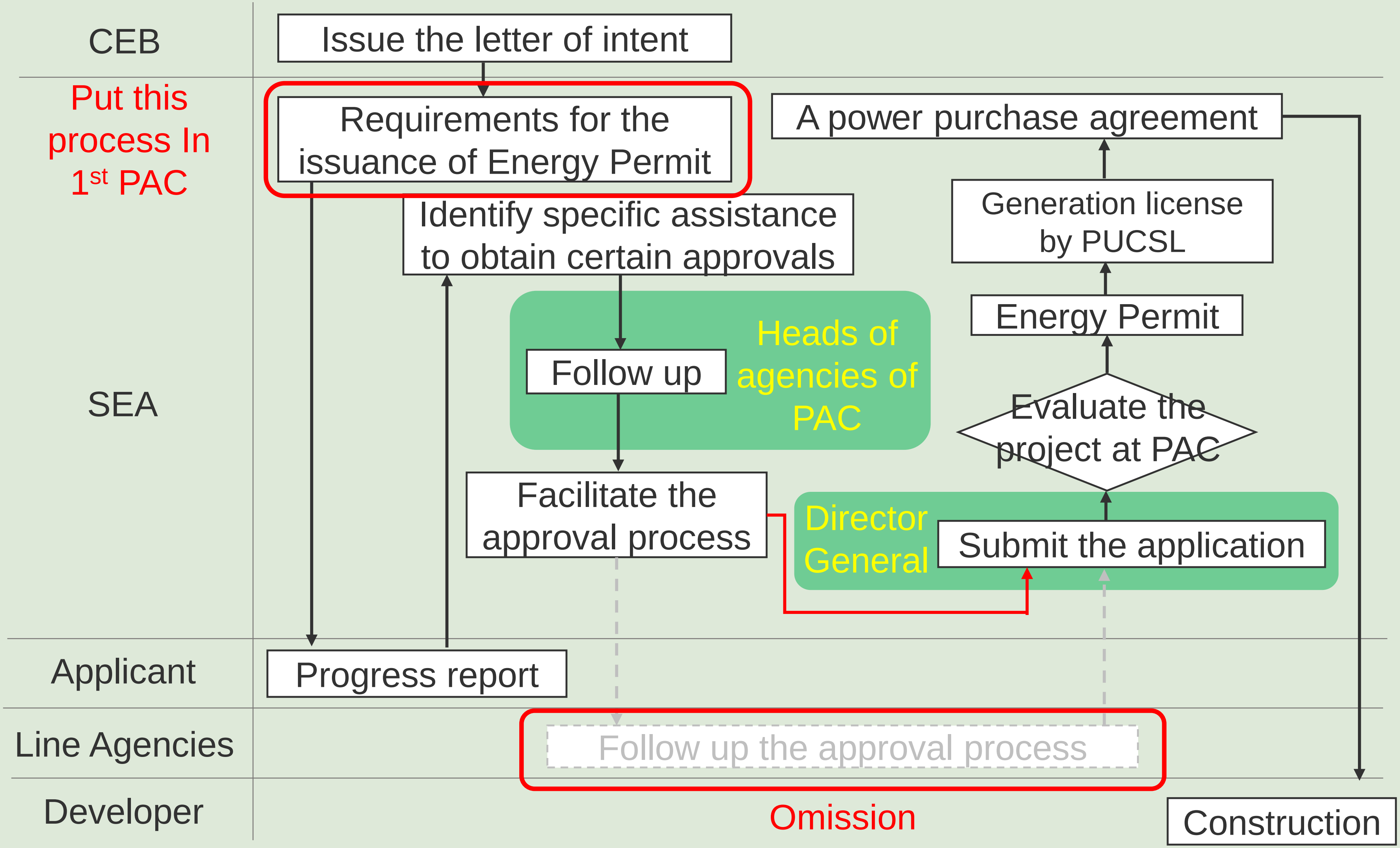
# Process Flowchart [C]



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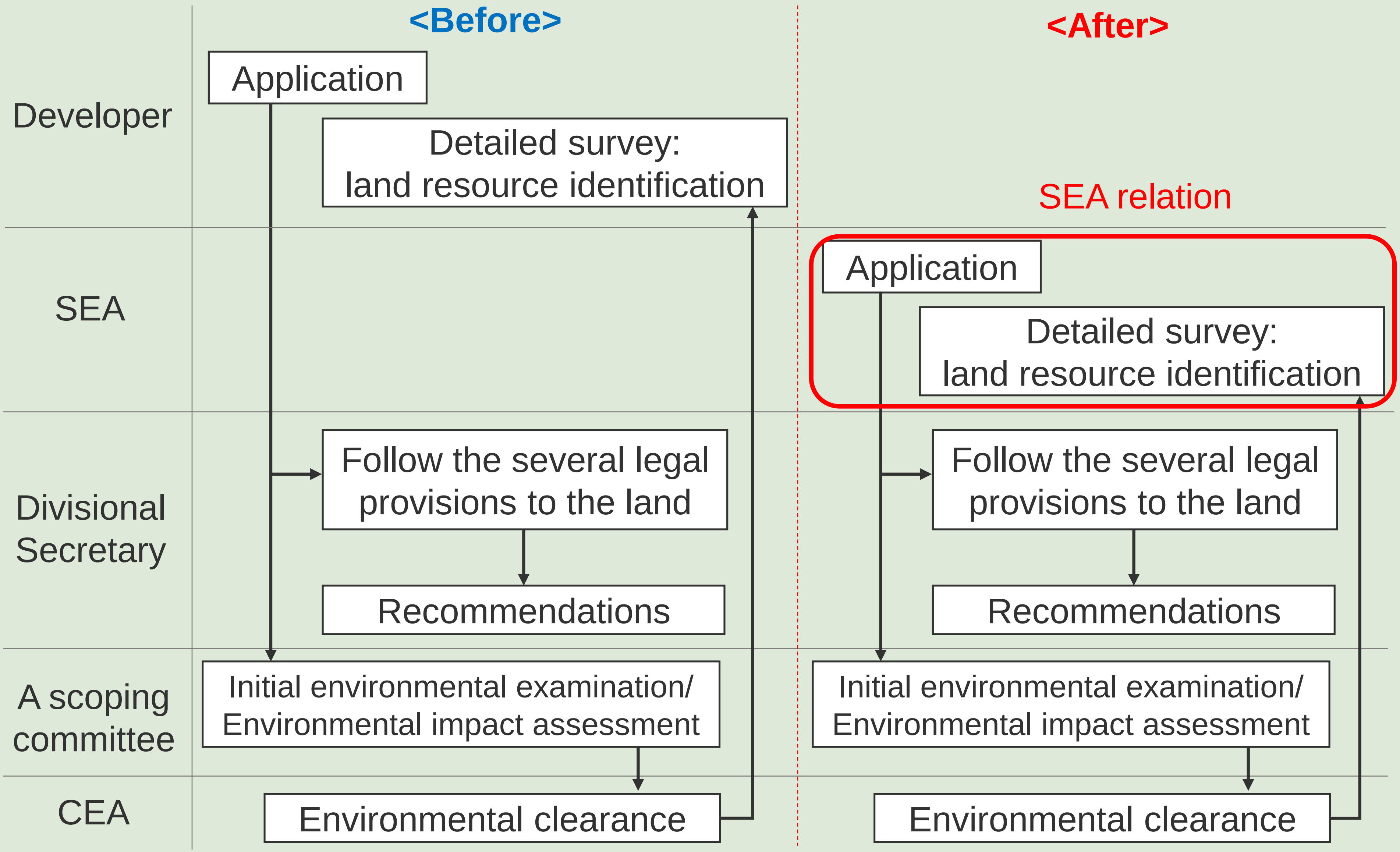
# About Land – Process Flowchart [C]



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# Summary

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## The approval process for renewable energy has not changed since 2011

The approval process has difficulties in accelerating renewable energy projects

↓

Recognize the time-consuming factors

↓

Part of them could be reduced by revising the approval process and the guideline

↓

Consider the revision of them and they will be published this year


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# Future Plan

- The new attempts will begin this year
  - New approval process
  - New guideline
  - Online system
- Evaluation will be needed
  - Find out how the new attempts will go
  - Compare new and previous in the duration and burden
  - How much time is the procedure reduced
  - Identify drawbacks
  - Consider further revision


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JICA

ශ්‍රී ලංකා සුනිත්‍ය බලශක්ති අධිකාරිය
இலங்கை நிலைபெறுதகு வலு அதிகாரசபை
Sri Lanka Sustainable Energy Authority

ලංකා විදුලිබල මණ්ඩලය
இலங்கை மின்சார சபை
CEYLON ELECTRICITY BOARD

CHUBU
Electric Power

NIPPON KOEI

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CHUBU Electric Power

NIPPON KOEI

# Wholesale Market in Japan
# JEPX(Japan Electric Power Exchange)

Ceylon Electricity Board
JICA Expert Team

Jan. 20, 2022

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# Background of JEPX Establishment

- Before the deregulation, the electric suppliers all over Japan were limited to 10 general electric power companies such as Tokyo Electric Power Company and Kansai Electric Power Company. This rule was gradually revised so that new electric power companies could enter the market and also supply electricity, and liberalization progressed.
- Under these circumstances, in 2003, Report from the Electricity Business Subcommittee of METI (Ministry of Economy, Trade and Industry) was released and JEPX established with the investment of conventional general electric power companies and new electric power companies, and started trading in 2005.
- JEPX is the only electricity trading market in Japan established in response to the trend of electricity liberalization.

Now it has been completely liberalized and all consumers are free to choose their electric power company.

Many new electric power companies do not have power generation, and it is necessary to procure power to send electricity. Therefore, JEPX was developed as an electricity market that can be accessed by all electric power companies.



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# JEPX Members

- To trade electricity with JEPX, you need to be a trading member of the Japan Electric Power Exchange.
- It is a wholesale market where only members (company) can trade in the market, and individual household cannot buy electricity directly.
- Initially, the market had 27 members, but as of January 2020, JEPX has 222 member companies. Most of the newly joined companies are new electric power companies.
- Ex. of new electric power company, many type of companies such as telecommunications, trading companies, house makers, and restaurants have entered the market.

## New comers (Mother business)

- SB Power (Telecommunications)
- Watami Energy (Restaurant)
- KDDI (Telecommunications)
- Diamond Power Cooperation (Electric Power)
- ENEOS (Energy)
- Marubeni Power Retail Corporation. (Trading company), etc.

## Conditions to become members

- To have connection and supply contract with TSO
- To meet financial requirement
  - Net assets of 10 million yen or more
  - Admission fee 100,000 yen
  - Deposit 1 million yen

1 LKR = 0.56 yen (Jan. 19, 2022)



Source: JEPX

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# Markets handled by JEPX

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JEPX deals only with actual electricity (kWh). Trading is taking place in two markets.

- One day before market (Spot Market)
- Same-day market (Pre-market)

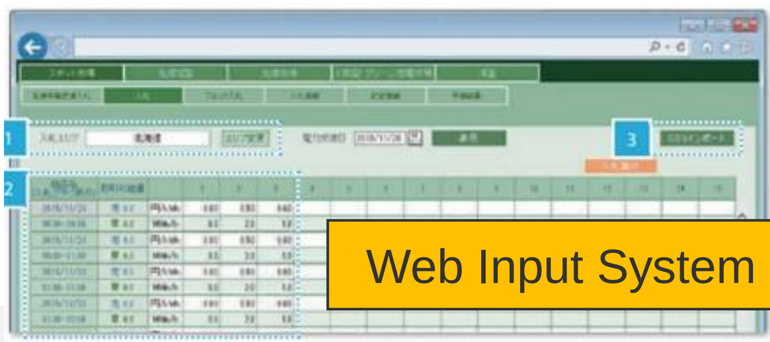
## One day before market (Spot Market)

All bids of power generation companies and retailers are put together, matched, and balanced by price and quantity.

- Divide a day into 48 individual products (0 to 30 minutes, 30 to 60 minutes every hour) and trade.
- Unit is a day, you can buy and sell only the required time slots
- The unit of transaction power is 0.1MW (30 minutes, so the amount of energy is 50kWh)
- Bid through the trading system
- Blind single price auction method*

## Same-day market (Pre-market)

- A place for adjustment after 1 day before planning.
- Used to adjust for fluctuations in demand due to unpredictable weather changes and the inability to generate due to generator failure.



Web Input System

Source: JEPX

* It is traded at the contract price regardless of the bid price. For example, even if you bid for ¥10 / kWh, if the contract price is ¥15 / kWh, it will be traded at ¥15 / kWh. Blind means that the bidding status of other participants cannot be disclosed at the time of bidding.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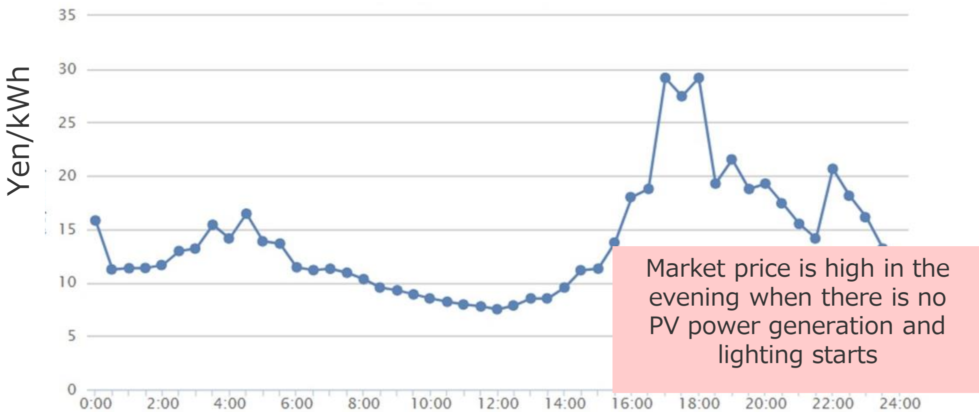
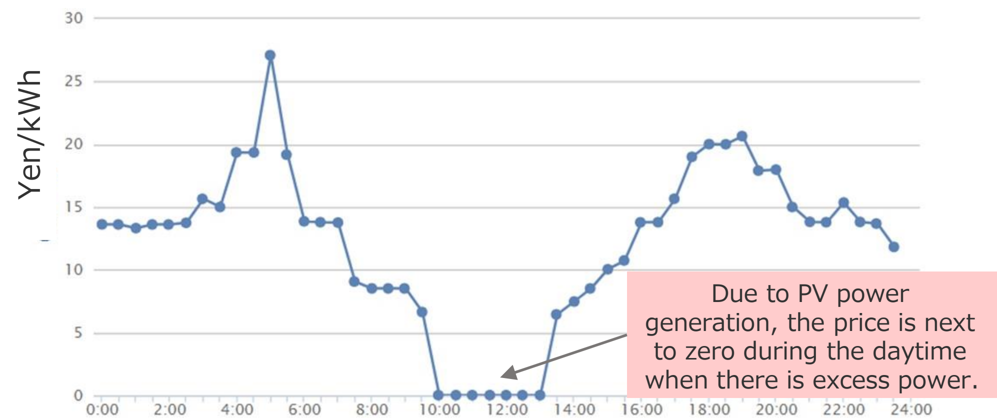
# Actual Transaction Status

- Market prices fluctuate according to the balance between supply and demand
- Prices often peak in the evening when PV power generation decreases and lighting demand rises, which means power supply is tight.




Ex. Sunny weekday (2021/11/3, Wed.)




Ex. Sunny weekend (2021/11/7, Sun.)

Source: JEPX

<Ref.> Tariff Menu B
(Typical House Case)

Source: CHUBU HP

| | | | |
|---|---|---|---|
| Electricity Usage Charges | First 120 kWh | Per 1 kWh | 21.04yen |
| | Over 120 kWh up to 300 kWh | | 25.51yen |
| | Over 300 kWh | | 28.46yen |
| Minimum Monthly Charge | | Per Contract Per Month | 258.24yen |



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# Soaring Market Price and their Causes

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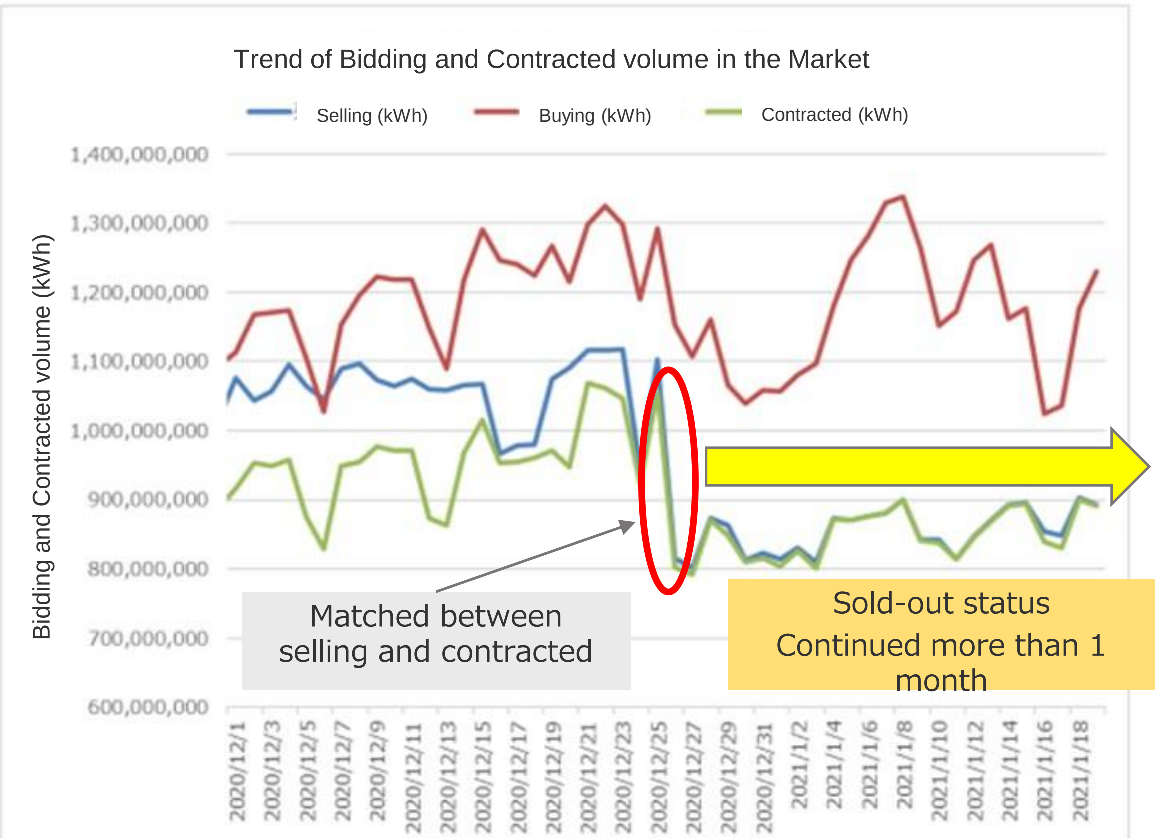
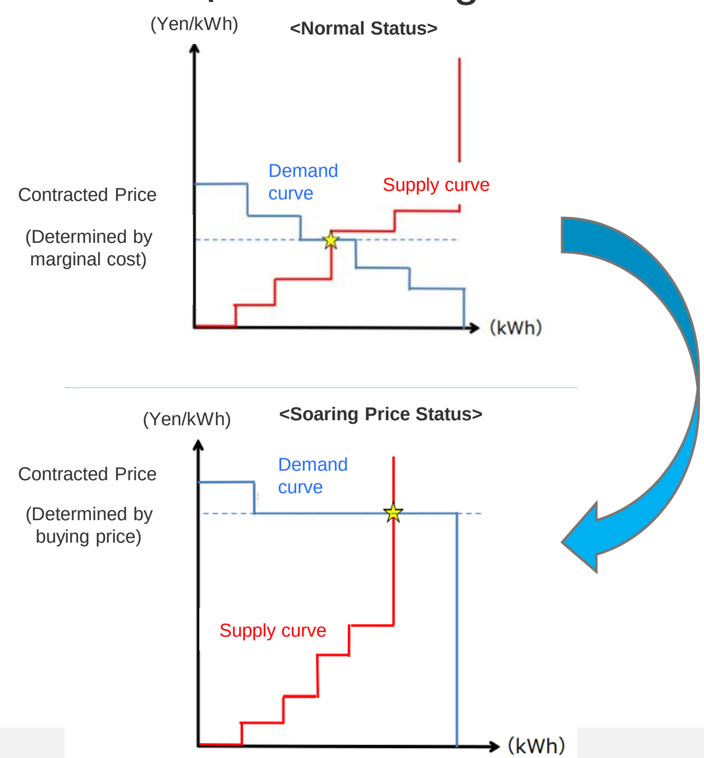
NIPPON KOEI

- Remarkable power shortage occurred due to an demand increase caused by the big cold wave during the year-end and New Year holidays, a decrease in PV power generation caused by bad weather and midwinter, and a global shortage of LNG supply.
- From around December 24th, there was a sold-out condition where the volume of sales and volume of contracts matched, and it continued for a month until January 22nd.




Demand is too much larger than supply, which induced market price soaring






Source: METI

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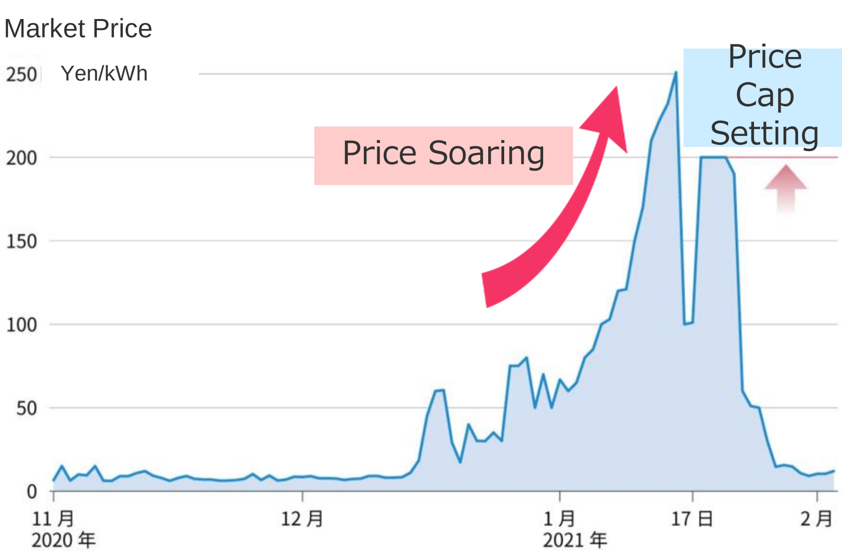
# Situation of Soaring Trading Market Price and its Problem

- The market price of JEPX began to soar from mid-December 2020, and reached the highest record of 251 yen/kWh in mid-January.
- Along with this, the electricity bill of some consumers who have contracts with new electric power companies has soared.
- METI sets price cap.




NPC can procure from the Market

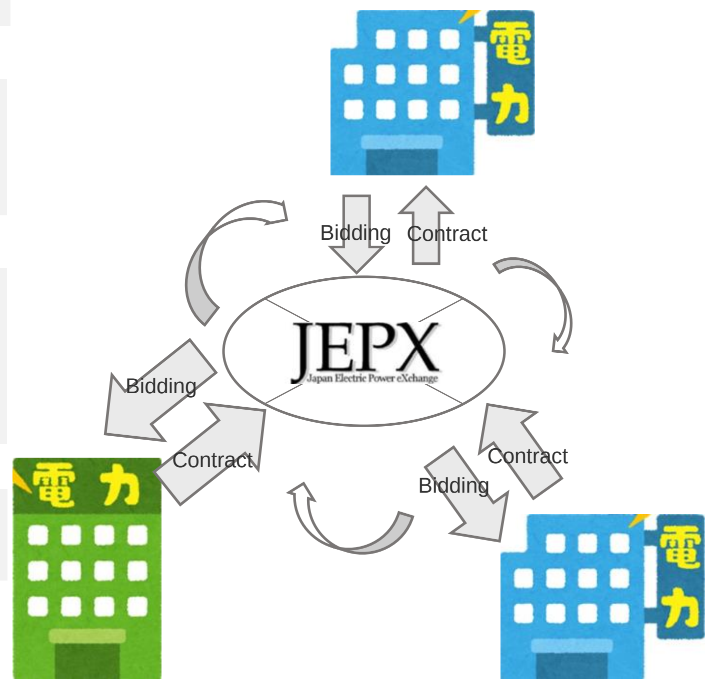
If they cannot procure, they must pay the imbalance fee (penalty)

Bid at a price higher than the market price (better than paying a penalty)
Market price < Penalty

Repeats

Contract price gets into rising spiral

Price Rising Spiral




[Source: Reuters]



[Source: METI]

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# Damage caused by Soaring Market Price

- In response to the sharp rise in market prices, new electric power companies, whose financial position had deteriorated rapidly due to Negative spread, went bankrupt.
- The cash was absorbed by JEPX (finally by the TSO as an imbalance charge) in the market procurement.
- General customers who had market-linked electricity contracts were directly affected by soaring prices.

## Family Energy (FE)

- Established in 2016 as a Japanese subsidiary of Family Energy, American electric power sales company
- Expanded business by aggressive door-to-door sales to general households and small businesses

Total debt of 800 million yen or more

When acquiring new customers, FE received the business suspension order because FE only told that the electricity price would be cheaper than that of general electric power company and did not tell the risk of price fluctuations.

## Phoenix Energy

- Established in 2017 with an investment from JPG Energy Management LLC, American electric power sales company
- Acquired new customers using network business methods, etc.

Total debt of 300 million yen or more

- The number of businesses that received the special support of installment payment of imbalance fee is 177 (as of 2021/3/25).
- There is concern about other bankruptcy of new electric power companies in the future.



Source: Energy Shift Source: Green People's Power

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# Summary

- It is necessary to design a system based on the lesson from precedent cases
- Deregulation is required before the wholesale electricity market opens
- After the deregulation, it is expected that many new players will enter the market as retailers. It is necessary to convey correct information and rules for them, who have little knowledge.
  - Retailers have a responsibility to enter the business with a thorough understanding of market risks.
  - It is desirable that the tariff scheme introduced by retailers should be open and fair.

    (General costumers can also be victims of immature market design)
- General consumers also need to understand the rules of the market before concluding a contract. (It is necessary to understand hidden risks, not just electricity tariff comparison)



Source: JEPX

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Reference case in the UK

Measures to avoid tight supply at System Peak


Source: JEPX
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# Tariff Setting to Suppress System Peak (Triad)

CHUBU Electric Power
NIPPON KOEI

## What are Triads?

The Triads are the three half-hour settlement periods of highest demand on the GB (Great Britain) electricity transmission system between November and February each year. National Grid uses the "Triads" to determine TNUoS (Transmission Network Use of System Charge) demand charges for customers with half hourly (HH) meters (smart meters).

## Who pays?

The Triads are used to calculate charges for those who are HH metered. This tends to be industrial and commercial customers. If they don't consume electricity in the three Triad periods, they don't need to pay Triads Charge for the entire financial year.

## What might signal a Triad?

National Grid does not forecast the Triads in advance - they are only known post-February after the winter period has concluded. This is designed to encourage demand customers to avoid taking energy off the system during peak times if possible, thereby reducing the need to build expensive infrastructure that all customers would need to pay for. Some suppliers and consultancies provide a Triad forecasting service to notify their customers when they believe a Triad is likely to occur.


Source: National Grid, UK
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# Tariff Setting to Suppress System Peak (Triad) cont'd

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## How are Triads calculated?

The Triads for each financial year are calculated at the end of March using system demand data for the half hourly settlement periods between November and February.

Demand charges for the year are based on the HH (Half Hourly) demand tariff* which ranges depending on which geographical demand zone customers are located in. Tariff is multiplied by average demand in kW during the three Triad half-hours.

## Example Triad Calculation (London Area)

*: Thanks to the SM, electricity consumption is metered and sent to the supplier

| | |
|---|---|
| Maximum Demand 1 | 375 kW |
| Maximum Demand 2 | 215 kW |
| Maximum Demand 3 | 558 kW |
| **Total Demand Figure:** | **1,148 kW** |
| Loss Adjustment Factor | 1.082 |
| **Adjusted Demand Figure:** | **1,242 kW** |
| HH Zonal Tariff | £51.87/kW |
| **Total Annual Triad Cost:** | **£64,429.88** |
| Number of Maximum Demand Readings | 3 |
| **Annual Triad Figure:** | **£21,476.63** |

Very Expensive

**Incentive of demand restraint at the system peak works strongly to avoid Triad.**

 Source: National Grid, UK    Source: Energy News

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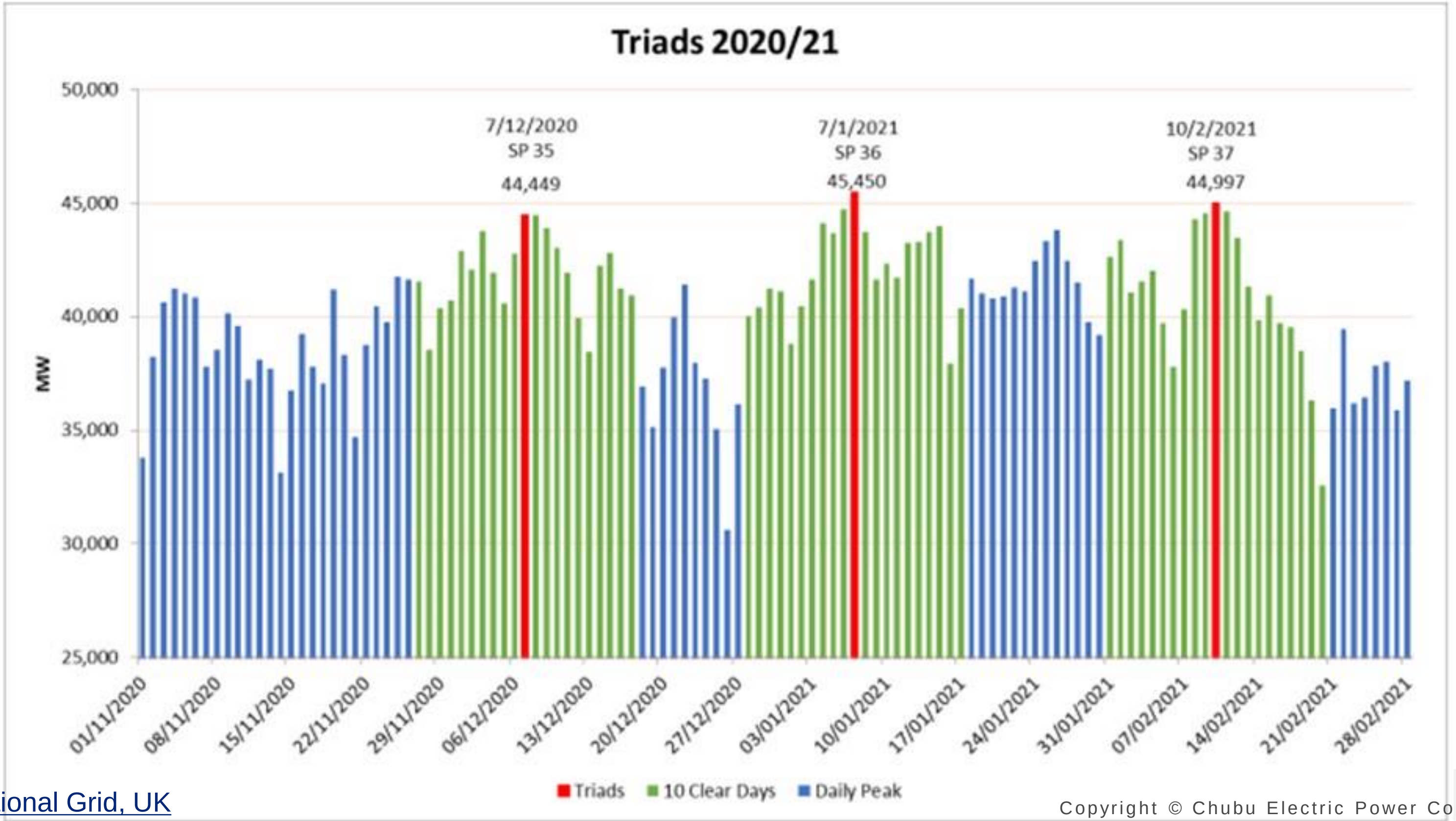
# When the Triad occurred in 2020/21

At the end of March, which is the end of the fiscal year, the grid operator National Grid will notify about when Triad occurred.

| Date | Settlement Period | Net System Demand (MW) |
|---|---|---|
| 7th December 2020 | 35 | 44,449 |
| 7th January 2021 | 36 | 45,450 |
| 10th February 2021 | 37 | 44,997 |





Source: National Grid, UK

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# Introduction of Balancing Market in UK

Ceylon Electricity Board
JICA Expert Team

January, 2022

Chubu Electric Power Co., Inc.
Nippon Koei Co., Ltd.

# 1 UK Energy Sector Overview


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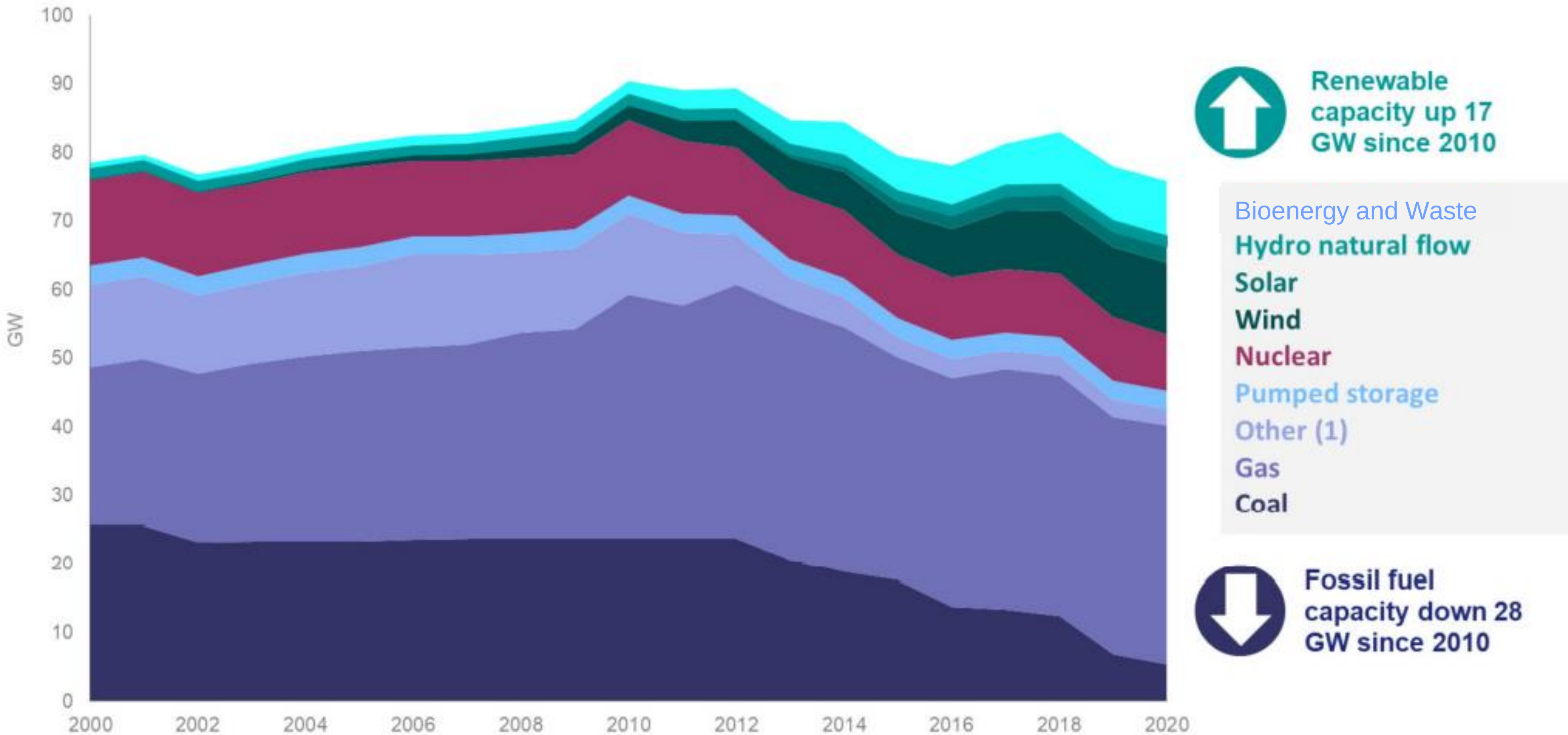
# UK Energy Sector Overview




(Source) Digest of UK Energy Statistics 2021

Fig.1 Installed Capacity of UK Electricity Generation Assets by Fuel, 2000 to 2020



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# UK Energy Sector Overview (Future Scenarios)

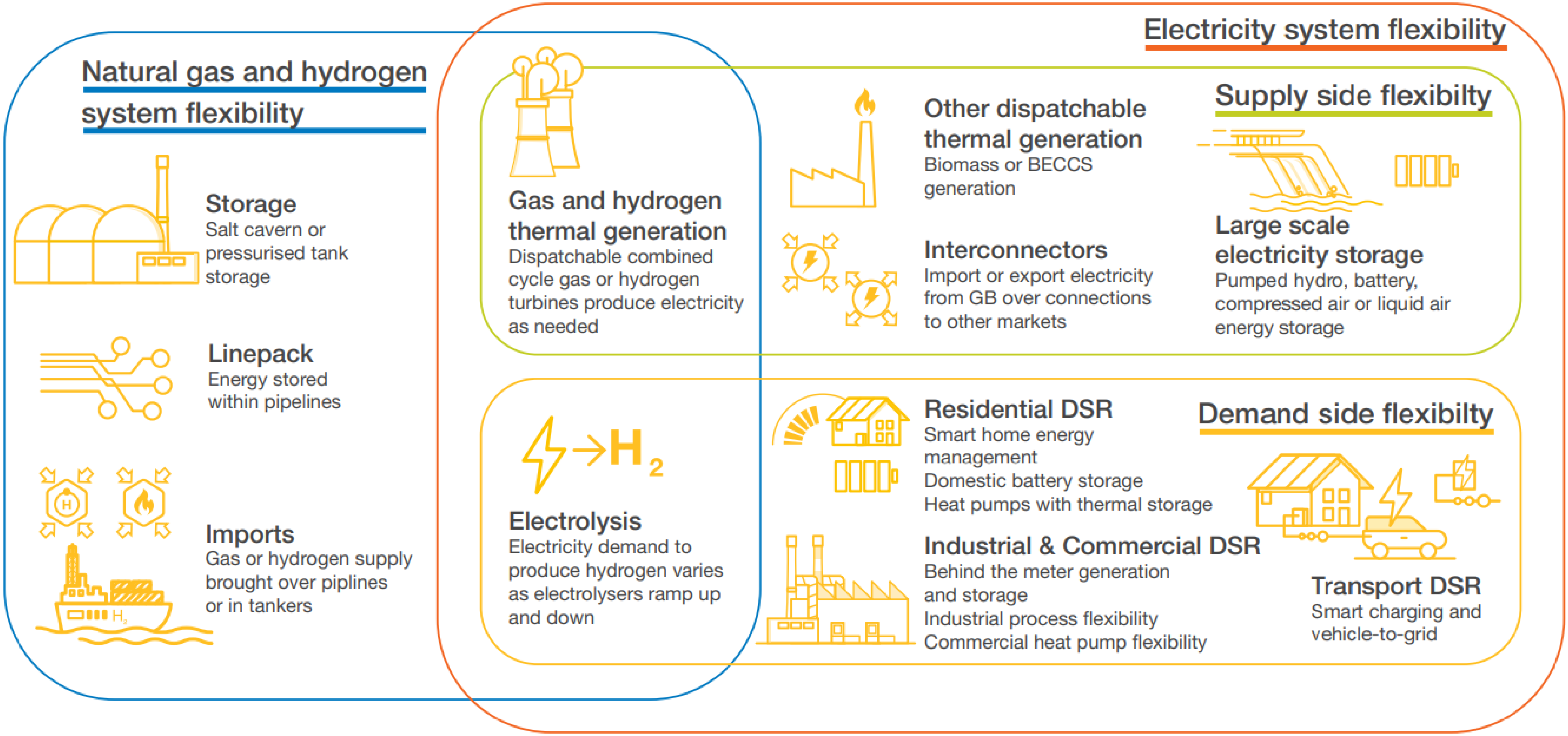


Fig.2 Flexibility in future in Power Sector

(Source) National Grid ESO "Future Energy Scenarios"
https://www.nationalgrideso.com/document/202851/download


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# UK Energy Sector Overview (Future Scenarios)

- In future, the electricity system will be supply-led. Demand will adjust to use or store energy from variable renewable generation. Solutions will include electrolysis, interconnection, demand side response and storage, particularly in the 2-4 hour range
- Large-scale interseasonal energy storage is essential to meeting net zero, National Grid’s net zero scenarios use hydrogen to meet this need. No sites currently exist, so the right policy and economic incentives for investment need to happen to bring this forward.

(Source) Japan Electric Power Information Center Report


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# 2 Outline of Balancing Market in UK

# Institutions Related to UK Power Market

>Decision of reliability policy in UK with information from National Grid and Ofgem
>Capacity is procured through Capacity Market held once in a year
>Keeping reserve margin in case of emergency
https://www.gov.uk/government/organisations/department-of-energy-climate-change

>Keeping power market stable
>Monitoring National Grid
>Approval of introduction of adjustment services to power sector
>Approval of procurement of adjustment power by National Grid
https://www.ofgem.gov.uk/

>Licensed for mandatory on stable power supply
>Analysis of power system
>Decision of necessary volume of ancillary & adjustment services
>Making contracts on adjustment services
https://www.nationalgrideso.com/

(Source) Mitsubishi Research Institution Co., Inc. Report


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# UK: Process related to Balancing Market

- Balancing between supply and demand is totally adjusted through the Balancing Market

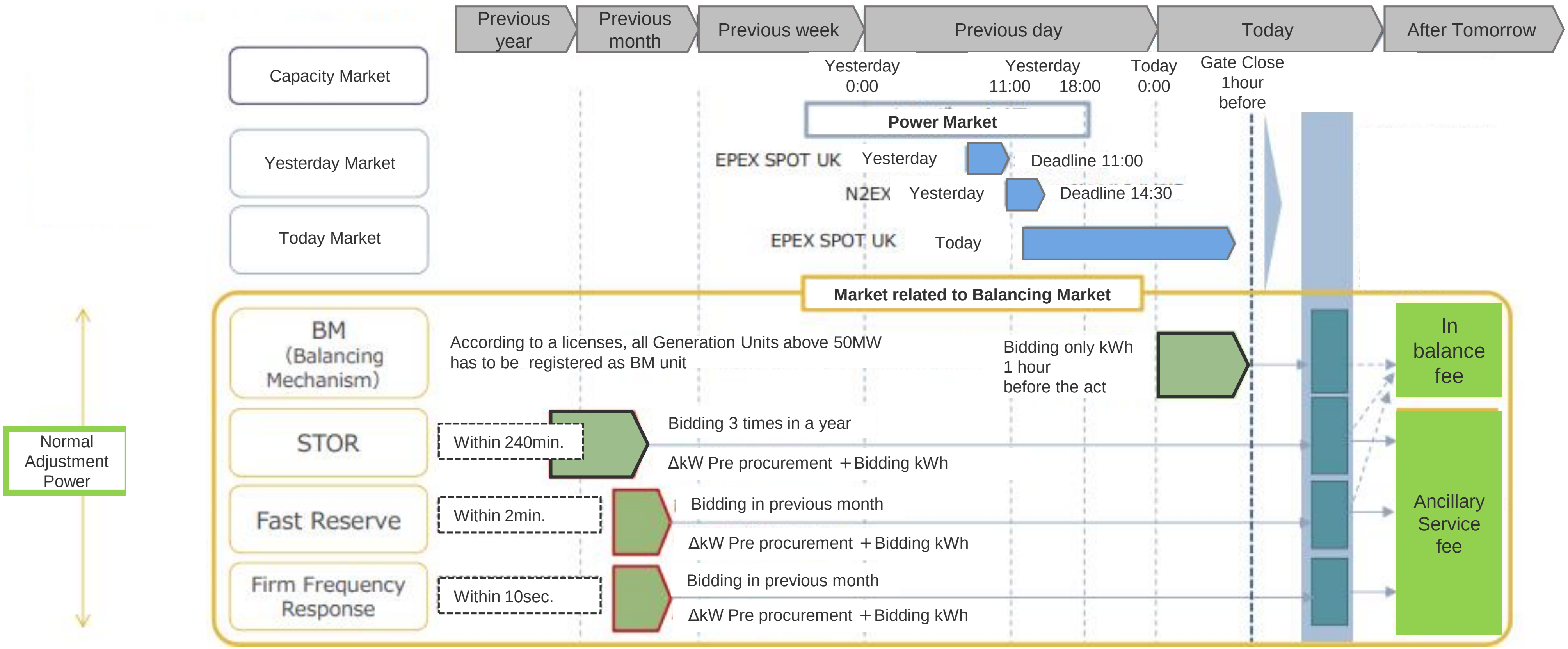


Fig.3 Power Market outline in UK

(Source) Mitsubishi Research Institute Inc. Report

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# UK: Process related to Balancing Market

- Balancing between supply and demand is totally adjusted through the Balancing Market

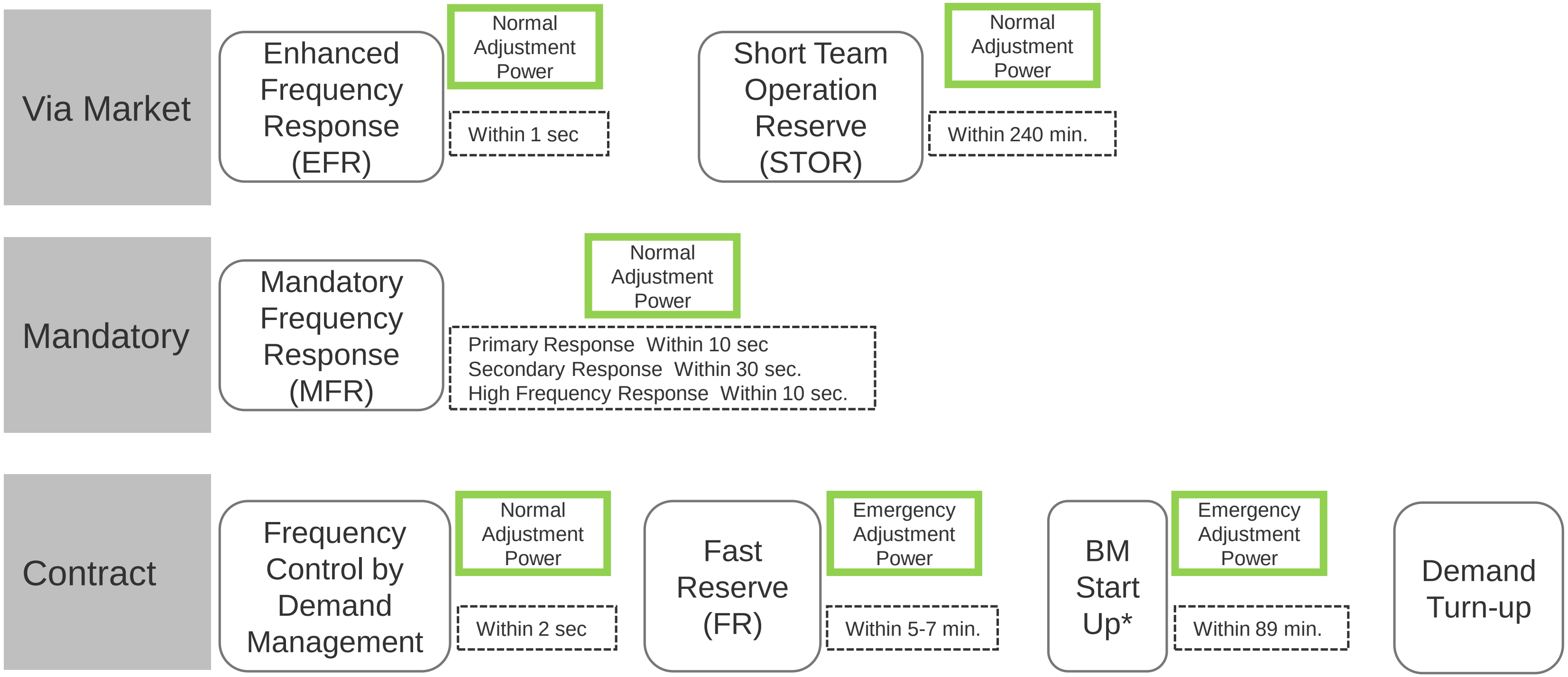


Fig. 4 Various ways are considered and mixed in the Balancing Power Market.

* Start up: The BM start up service gives us on-the-day access to additional generation. The service is open to any Balancing Mechanism (BM) participants who expect to be unavailable within BM timescales of 89 minutes.

(Source) Mitsubishi Research Institute Inc. Report

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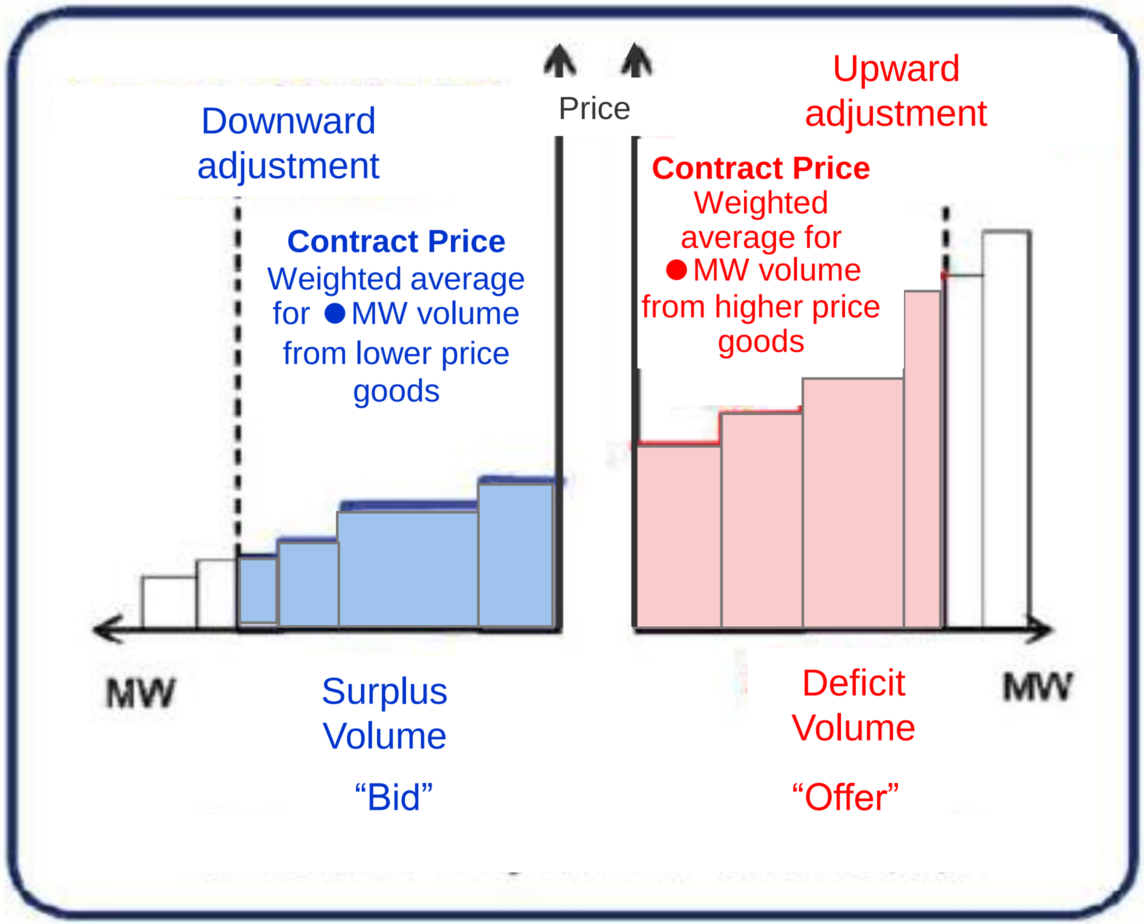
# 2-1 Balancing Mechanism

# UK：Balancing Mechanism

- Balancing Mechanism is the bidding market working after Gate Close for Balancing Mechanism Unit (who participated in Balancing Mechanism (BMU)) to procure adjustment power by NG.
- Each BMU has to submit their intention of bidding on power increase or demand decrease (as ”Offer”) and on decrease power or demand increase (as “Bid”) .
- NG decides the Offers and the Bids to deal with actually based on a lot of information such as location, response speed, variable capacity, price, etc.




(Source) Mitsubishi Research Institute Co., Inc. Report

Fig.5 Adjustment of fee on Balancing Mechanism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# UK : Balancing Mechanism

- All participator to the market have to submit the Initial Physical Notification (IPN) by 11:00 AM on one day before the operation day. National Grid is able to grasp the power and demand situation on the operation day from the information and it makes possible to consider countermeasures to resolve the power transmission congestions.
- Power Producers and Suppliers have to submit the Final Physical Notifications (FPN), which describes final generation or demand plan, to National Grid by the Gate Close time.

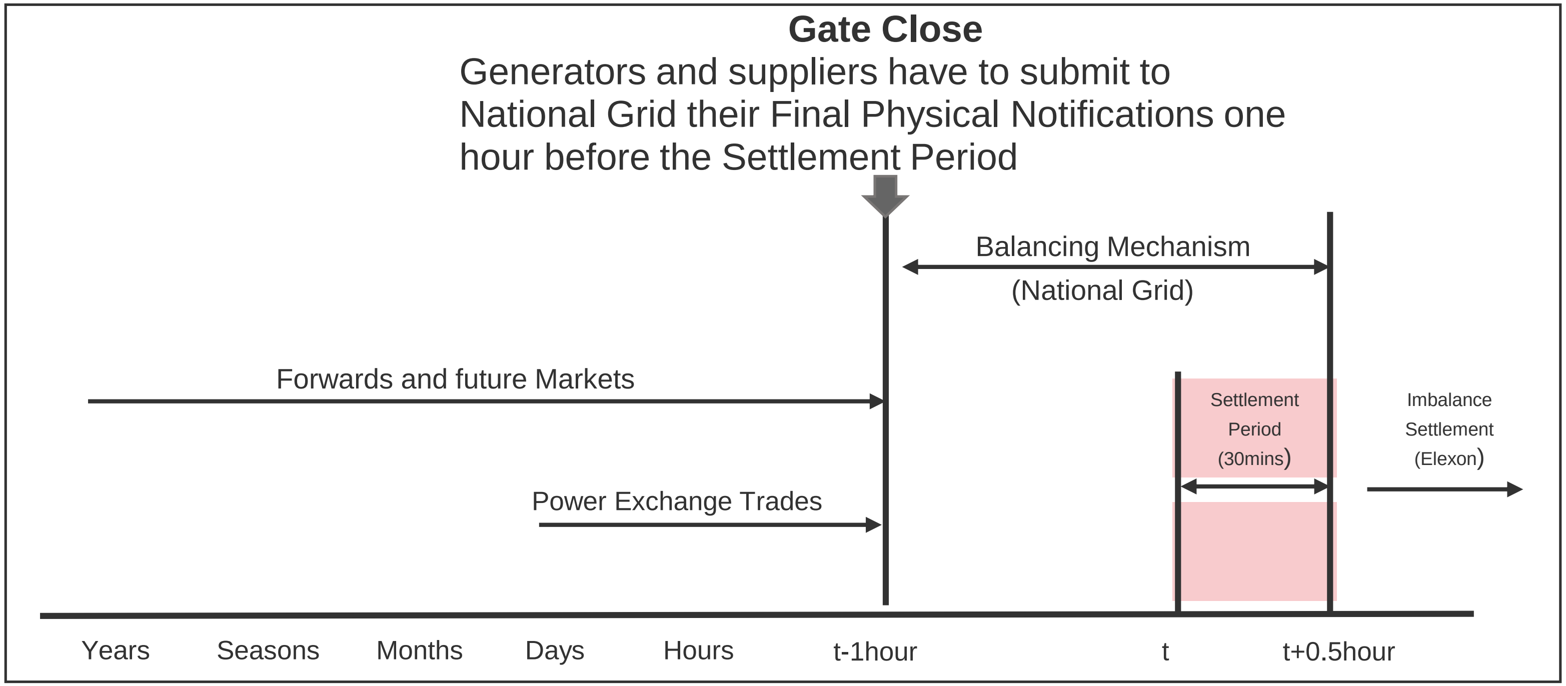


Fig.6 Timeline related to Balancing Mechanism

(Source) Mitsubishi Research Institute Co., Inc. Report using Ofgem


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# 2-2 Frequency Response Services

# UK: Frequency Response Services of National Grid

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## Frequency Response Services

Frequency Response Services for keep frequency between 49.5Hz and 50.2Hz

| Mandatory Frequency Response (MFR) | Demand Management (DM) | Enhanced Frequency Response (EFR) | Firm Frequency Response (FFR) |
| --- | --- | --- | --- |
| Grid Code It's mandatory for large capacity power producers | Demand reduction when frequency goes up<br><br>by Contract | Target is Battery<br><br>Frequency response within one second<br><br>Via Market | Bidding more than 10MW Frequency response<br><br>By Contract |

(Source) Mitsubishi Research Institute Co., Inc. Report using Det Norske Veritas information


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# UK: Frequency Response Services of National Grid

## Enhanced Frequency Response (EFR)

- Enhanced Frequency Response (EFR) has introduced by National Grid in 2015 for quick response to frequency fluctuation. EFR should be responded within one second, i.e. targeted on mainly battery.

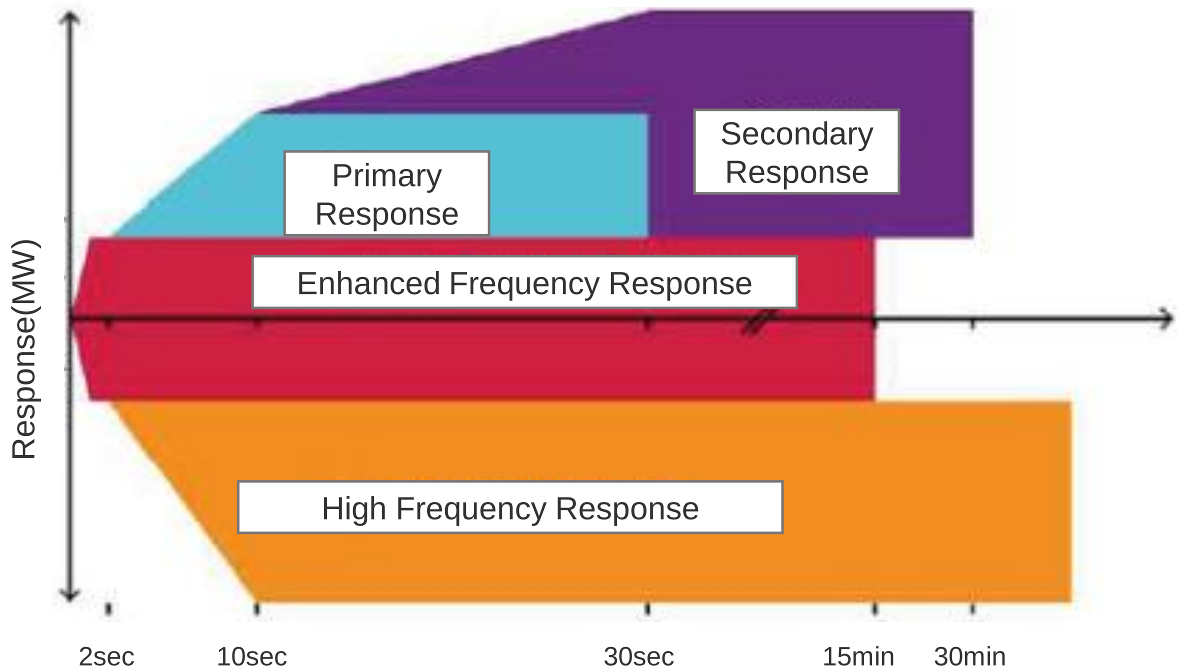


Fig. 7 Image of Frequency Response Services

(Source) Mitsubishi Research Institute Co., Inc. Report


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# UK: Frequency Response Services of National Grid

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## Frequency Response Services in National Grid

| Service | Outline | Technical Matter |
|---|---|---|
| Mandatory Frequency Response | ✓ Frequency have to be kept between 49.5Hz and 50.2Hz automatically<br>✓ All of power producers have a obligation<br>✓ There are three types of response, Primary Response, Secondary response and High Frequency Response | i) Primary Response (for high freq.)<br>Response time: less than 10 sec.<br>Duration time: more than 20 sec.<br>ii) Secondary Response (for high freq.)<br>Response time: less than 30 sec.<br>Duration time: more than 30 min.<br>iii) High Frequency Response (for low freq.)<br>Response time: less than 10 sec.<br>Duration time: No limit |
| Firm Frequency Response | ✓ Supporting for frequency response obligation<br>✓ Procurement by bidding once in every month<br>✓ There are three types of response same as MFR | At least 10MW |
| Demand Management | ✓ Cutting supply more than 30min.<br>✓ Automatically shut down in case frequency goes down below threshold value<br>✓ Relative contract | ✓ Response time less than 2 sec.<br>✓ Duration time: over 30 min.<br>✓ Minimum load: 3MW |
| Enhanced Frequency Response | ✓ Targeted battery for rapid response within 1 sec.<br>✓ By competitive bidding and four years contract<br>✓ Established in 2015 | ✓ Response time less than 1 sec.<br>✓ Duration time: over 15 min. |

(Source) Mitsubishi Research Institute Co., Inc. Report


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# 2-3 Reserve Services

# UK: Reserve Services of National Grid

**Fast Reserve**

Fast Reserve provides the rapid and reliable delivery of active power through an increased output from generation or a reduction in consumption from demand sources, following receipt of an electronic dispatch instruction.
There are three categories of Fast Reserve: Firm Fast Reserve, Optional Fast Reserve and Optional Spin Gen.

National Grid use fast reserve, in addition to other energy balancing services, to control frequency changes that might arise from sudden, and sometimes unpredictable, changes in generation or demand.

The fast reserve service is open to both Balancing Mechanism (BM) and non-BM providers who can meet the technical requirements.
This might include generators connected to the transmission and distribution networks, storage providers and aggregated demand side response.

https://www.nationalgrideso.com/industry-information/balancing-services/reserve-services/fast-reserve

(Source) National Grid ESO web site


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# UK: Reserve Services of National Grid : STOR

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**Short Term Operating Reserve (STOR)**
STOR is a well-established service providing extra power to meet extra demand at certain times of day or if there's an unexpected drop in generation. NGESO aim to procure 1700MW of STOR to cover the largest loss.

Where it is economic to do so, NGESO will procure sources of extra power ahead of time through the STOR service. Providers of the service help to meet the reserve requirement either by providing additional generation or demand reduction.
The requirement for STOR varies depending on time of year, week and day.

The service is open to any technology with the ability to increase generation or reduce demand by at least 3 MW.

https://www.nationalgrideso.com/industry-information/balancing-services/reserve-services/short-term-operating-reserve

(Source) National Grid ESO web site


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# 2-4 Reactive Power Services

# UK: Reactive Power Services of National Grid : ORPS/ERPS

**Obligatory Reactive Power Service (ORPS)**

The obligatory reactive power service (ORPS) is the provision of varying reactive power output. At any given output generators may be requested to produce or absorb reactive power to help manage system voltages close to its point of connection. All generators covered by the requirements of the Grid Code are required to have the capability to provide reactive power.

ORPS can be provided alongside other balancing services.
Generally, all power stations connected to the transmission network with a generation capacity of over 50MW are required to have the capability to provide this service, as set out in the Grid Code.

**Enhanced Reactive Power Service (ERPS)**

Generators who can provide reactive power over and above the Grid Code requirements may also choose to participate in ERPS.
The enhanced service may also be of interest to owners or operators of plant or apparatus that can generate or absorb reactive power but isn't required to provide the ORPS.

(Source) National Grid ESO web site


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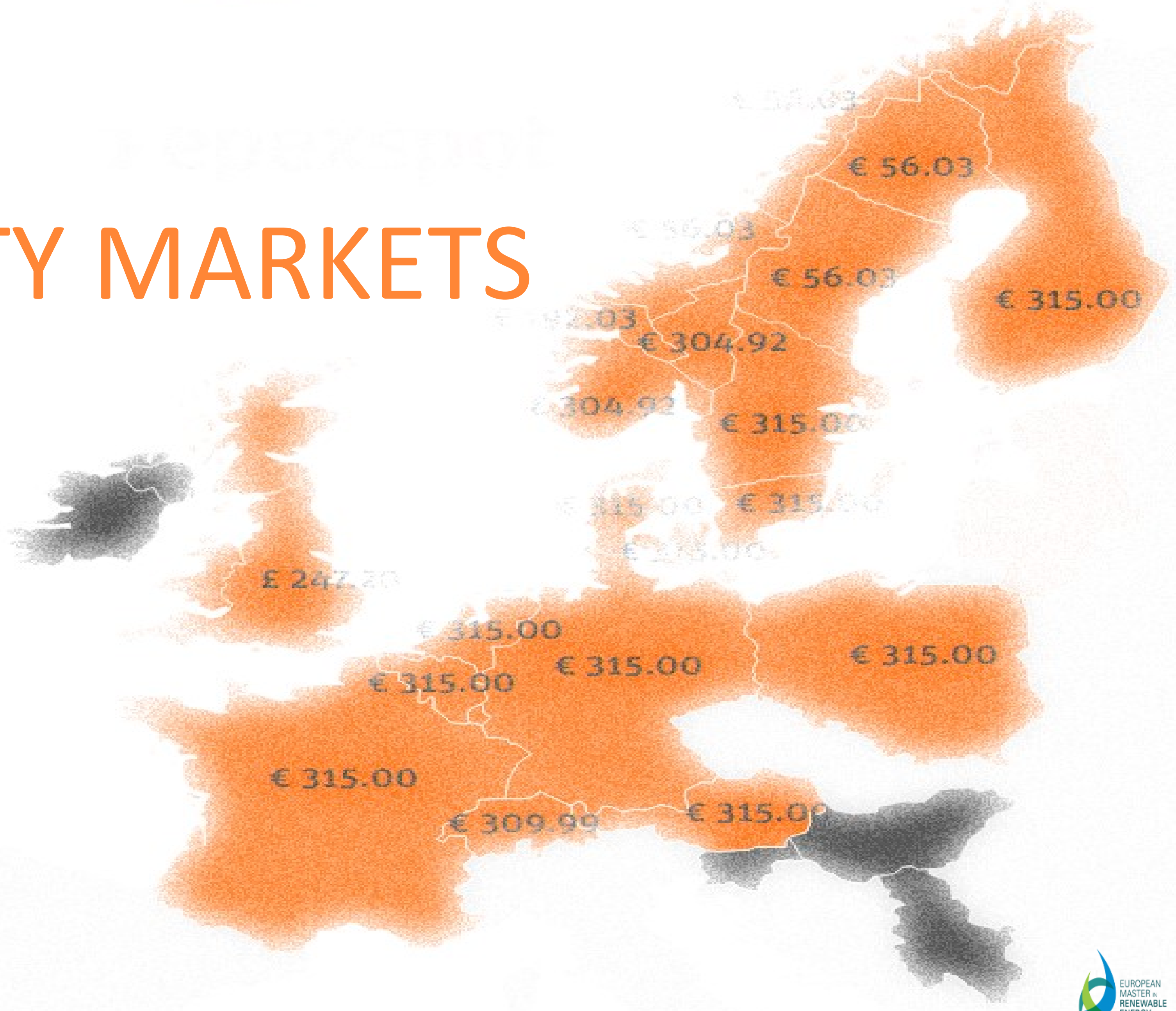
# ELECTRICITY MARKETS




**D.Bowatte**
**Ceylon Electricity Board**

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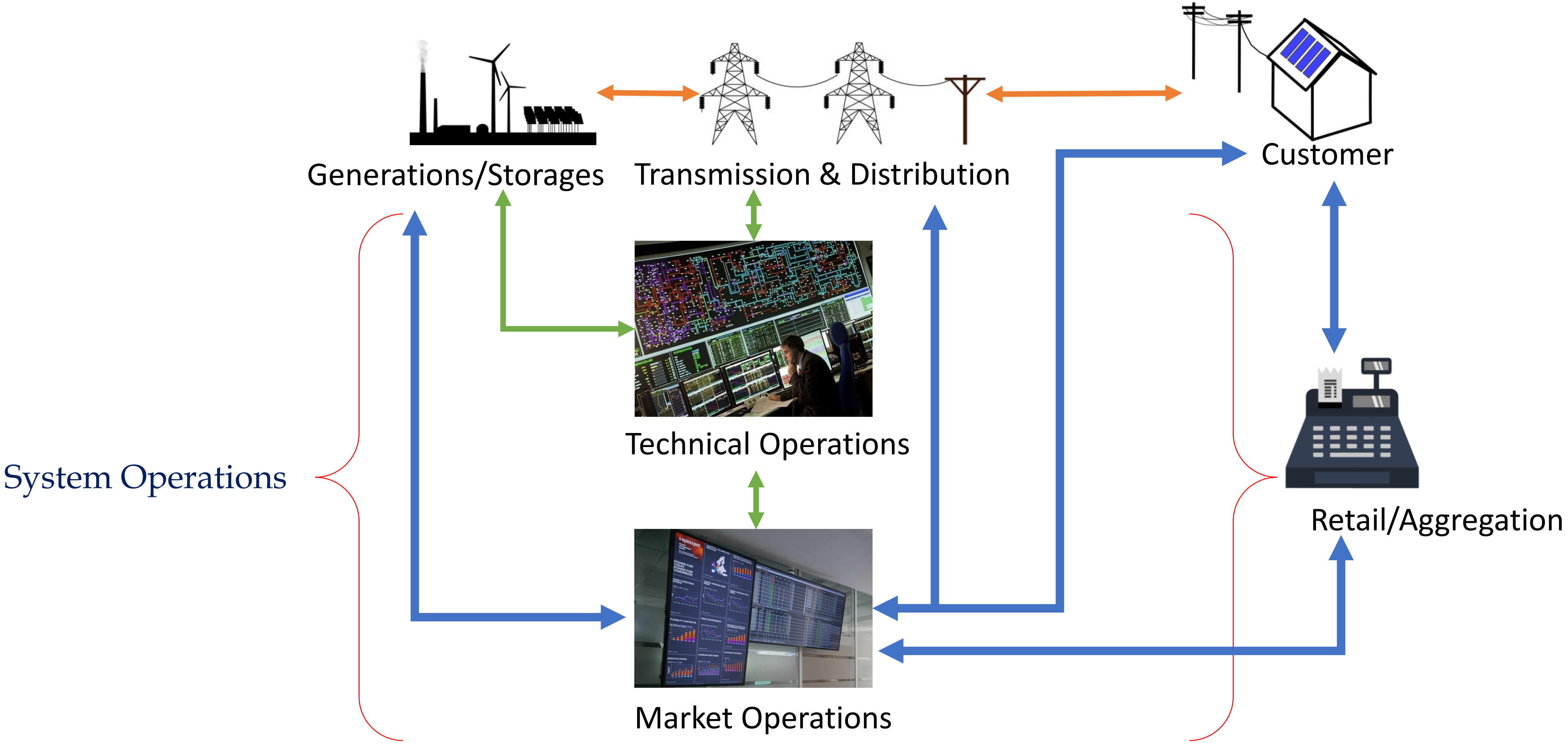
# Contents

- Introduction
  - Power System Structure
- Electricity Market
  - Fundamentals
  - Market Power
  - Technical Constrains
  - Ancillary Market
  - Capacity Market
- Market Reforms
  - Market sequence
  - Consumer price components
  - Initiatives on sector reforms

# Power system structure



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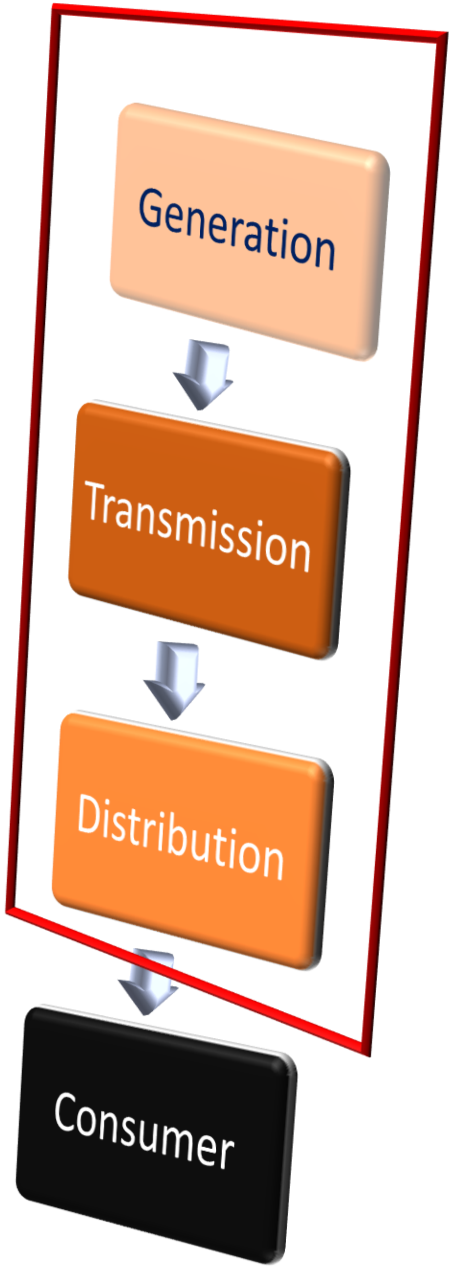
# Fundamentals

- Legacy Power systems :
  - Vertically integrated businesses
  - Iron out the operational complexities
  - Cross subsidizing among divisions
  - Mainly due to lack of enabler technologies



# Fundamentals

## Market equilibrium:

In a Perfect Market,

- Individual Buyer or suppliers shall not effect the market clearing price
- The quantity that suppliers are willing to sell , shall be equal to the amount buyers are willing to buy.
- Marginal Price
- Price settle at highest cost supplier (when capacity remains for supply)
- Value for Last buyer

# Fundamentals

## Market stability equilibrium:

- Higher demand compel suppliers to raise Ask price, Clearance price move upwards ,upward price exert pressure on demand to settle.
- Similar scenario when limited supply.
- Excess supply drives Ask price to low ,downward price exert pressure on supply to settle.
- Similar scenario when low demand

# Fundamentals

## Market stability equilibrium:

- Higher demand compel suppliers to raise Ask price, Clearance price move upwards ,upward price exert pressure on demand to settle.
- Similar scenario when limited supply.
- Excess supply drives Ask price to low ,downward price exert pressure on supply to settle.
- Similar scenario when low demand

# Fundamentals

## Competitiveness of technologies in Market:

- Renewables cause downward price pressure
- Nuclear has no options but to keep running
- Low-Loss highly efficient /flexible Gas plants sets the price ( 64% efficient )
- RDK8 type plants (47% efficient) will be phased out in coming years.
- LNG plants will dominate the Market order.

# Fundamentals

## Basic requirements for a competitive Market:

- Demand Side:
  - Number of buying entities
  - Market signal sensitive buyers (elasticity of demand side)
- Sellers Side:
  - Many Sellers
  - Sellers without “Market Power”
  - No oligopoly

# Fundamentals

## Market Power:

- Gen 1,2,4,6,7 owned by one Genco.
- In first round, marginal unit removed from market place
- Complete manipulation of price point.

- Not a possibility  but a constant reality ,example:

# Fundamentals

## Technical constraints:

- causes mostly upward price pressure
- Results in Market Splitting
- Common constrains :
    - Transmission bottle necks
    - Resource availability
    - Ramp rates
    - Minimum output

# Fundamentals

## Technical constraints:

- causes mostly upward price pressure
- Common constrains :
    - Resource availability
    - Realtime supply and demand balance for unforeseen scenarios

# Fundamentals

## Ancillary Services:

- Two types of services:
  - Active Power services
     Design to acquire necessary supply and demand balance
    - Load frequency control
      - Primary ,
      - secondary and tertiary
    - Real time balancing requirement
    - Black start provision
  - Voltage control services.
    Designed to maintain voltage profiles in the system
    - Reactive power supply

# Fundamentals

## Ancillary Services:

- How to solve this in a liberal Market?

- By using optimum combination of Long term and Spot Market, The ISO reduce its operational Risks.

# Fundamentals

## Ancillary Services:

- Advantages of Ancillary Market
  - Economically efficient than compulsory provision because:
  - ISO procure only the required amount of resources.
  - Providers participate, only if they have a business case.
  - True cost of services revealed
  - Open up for innovation like demand side management

# Fundamentals

## Ancillary Services:

- Advantages of Ancillary Market
    - Economically efficient than compulsory provision because:
    - ISO procure only the required amount of resources.
    - Providers participate, only if they have a business case.
    - True cost of services revealed
    - Open up for innovation like demand side management

# Fundamentals

## Ancillary Services:

- Advantages of Demand side responses:
  - Large number of providers
  - Efficient utilization of resources
  - Providers participate, only if they have a business case.
  - Downward price pressure
  - Open up for innovation like demand side management

# Fundamentals

## Ancillary Services:

- Disadvantages of Ancillary Market
  - Associated Complexity
  - High potential for Power Play type abuses
  - May be not applicable for all type services
    - Example : Reactive Power services.

    High potential for abuse of power in remote regions of network.

# Fundamentals

## Ancillary Services:

- What is the right amount of reserves ?:
  - ISO/TSO has to perform cost benefit analysis
  - Some out of bound scenarios require structured incentives mechanisms to safeguard the vulnerable users

# Fundamentals

## Ancillary Services:

example

- System can be operated optimized for lowest energy cost.
- System can be operated for optimum sharing of reserves and Energy in transmission line.

# Fundamentals

## Ancillary Services Settlement:

- Balance responsible Parties(BRP)
  - Load consumers
  - Generators
- Balance Service providing Parties
  - Organized by System operator.

# Fundamentals

## Ancillary Services Settlement:

- Basis for settlement(German reBAP):

1. + IP & BRP Over consumed:

BRP pays to TSO

2. + IP & BRP Less Consumed:

TSO pays to BRP

3. - IP & BRP Over Consumed :

TSO pays to BRP

4. - IP & BRP Less Consumed:

BRP pays to TSO

# Fundamentals

## Ancillary Services Settlement:

Singular events can effect profoundly in some cases,

Causes:

- A football match
- Insufficient demand forecast from TSO (1000 MW less)
- Trip of CCGT (500MW)
- Forecast error in wind (1500 MW)

Results:

- Deviation of 3000 MW inside last 2 MWh.
- Ancillary service cost 10000 €/MWh


Liverpool's James Milner, who played in the thrilling 4-0 win against Barcelona. Photo: Shutterstock.com

# Fundamentals

## Final piece of the puzzle :

## Market system deals with the existing production but how do we guarantee the future demand security ?

- In a vertically integrated legacy systems, the responsibility is vested on the monopolistic firm to forecast , and implement future capacity requirements.

# Fundamentals

## Capacity Market:

- The very purpose of the existence of capacity market is to establish the future energy security for the growing demand.
- It provides a predictable revenue scheme for investors.
- The revenue amount shall be decided on a competitive auction basis.
- All successful providers should comply as per the agreed come-online horizon or face penalties.
- Market is technology neutral
- Developments Already falls under CFD ,Feed in tariff, renewable obligation schemes are not eligible.
- A last resort Market intervention by states which may involve state aids.

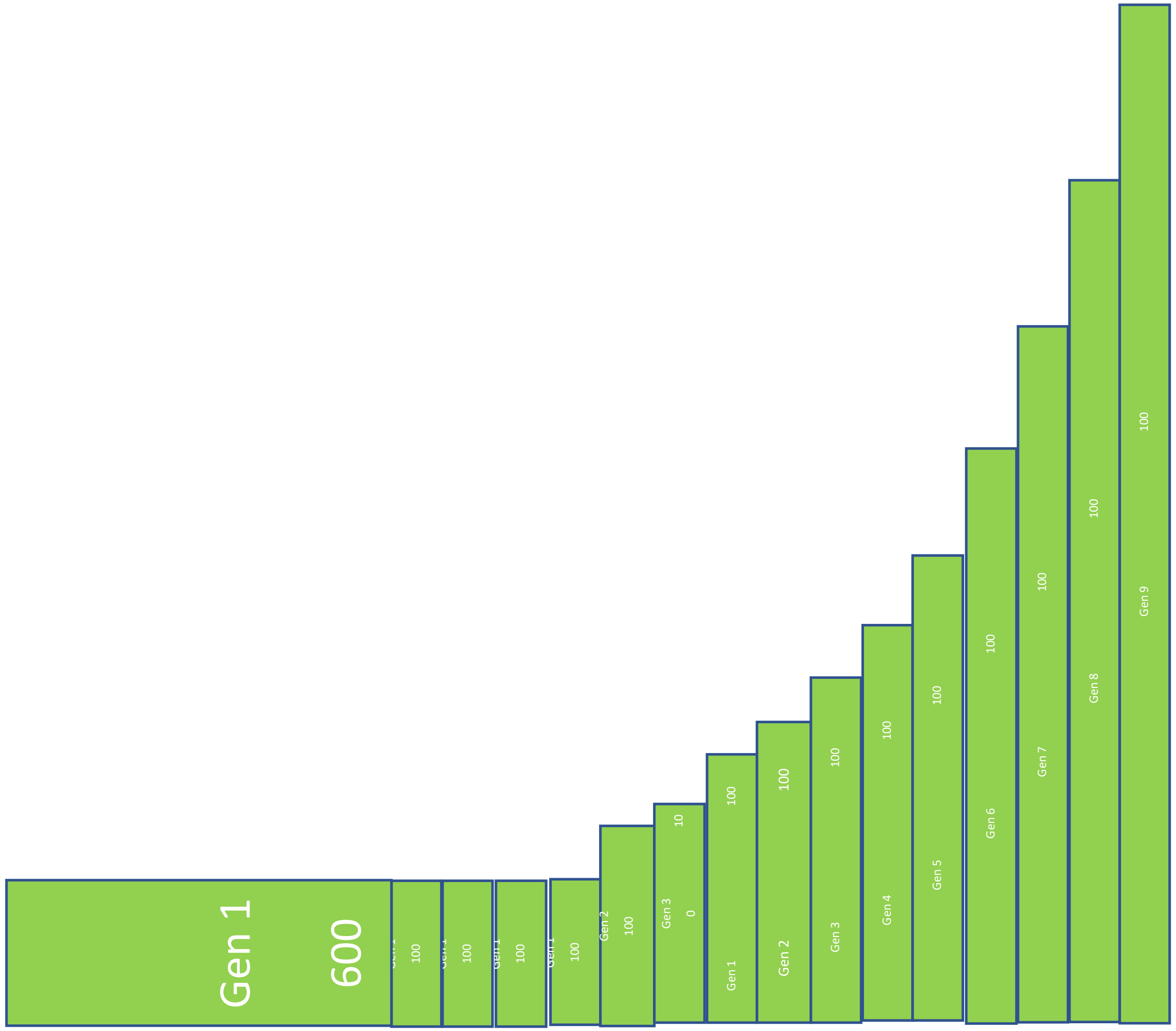
# Fundamentals

## Stages of Capacity Market:

# Fundamentals

## Capacity auction price :

- Target sets the optimum Capacity to establish required standards.



# Market Reforms

## Market Sequence:

# Market Reforms

## Market Sequence:

- EPEX  operation sequence
  - Gate close for Day ahead Market at 12:00 hrs.
  - Intraday nominations start at 14:30 hours.
  - Facilitate continues, hourly and sub hourly RE-balancing.
  - Can bid up to 5 minutes before delivery. (high economic value in forecasting )

# Market Reforms

## Market Sequence:

- Daily Market
  - Participants :
    - Sellers
      - All production quantities not bound by any bilateral obligations
    - Buyers:
      - Retailers for obligatory buying or as a last resort to supply regulated bracket customers
      - Resellers that purchase energy to supply Direct Consumers or as an Investment.
  - Participation:
    - Bids can be simple or Complex

# Market Reforms

## Market Sequence:

- Balancing Market
  organized in steps,
  - Frequency containment (aFCR)
  - Frequency restoration(aFRR)
  - Frequency restoration reserve(mFRR)
  - Replacement reserves (RR)

# Market Reforms

## Market Sequence:

- Balancing product
  - Product definition carried out by regulatory authority with the advice from TSO/ISO

  - Bidding conditions can be included by the respective providers.

# Market Reforms

## Market Sequence:

- Bid processing of Balancing products
  - Different products have different gate close times
  - All Bids from respective TSO areas are processed in a Central platform

# Market Reforms

## Market Sequence:

- Bid processing of Balancing products
  - All TSOs received bids are evaluated in CMOL
  - The difference between costs and revenues during an activation get pass down to BRPs



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# Market Reforms

## Consumer Price Components:

- Final Energy Cost
- Retailer Margin
- Network Access

  Tariff

# Market Reforms

## Consumer Price Components:

- Final Energy Cost
- Retailer Margin
- Network Access Tarif

{
- Spot Market Price / Bilateral Contract price or combination
- Ancillary service charges
- Incentive schemes components
- Capacity Payments
- TSO Regulated costs
}

# Market Reforms

## Consumer Price Components:

- Final Energy Cost
- Retailer Margin
- Network Access Tarif

- Regulated Margin if the Consumer in regulated bracket
- Depends on the pre agreed terms in retail offer.

# Market Reforms

## Consumer Price Components:

- Final Energy Cost
- Retailer Margin
- Network Access Tariffs

- Distribution system costs.
- Normally ,a capacity based tariff system
- Includes reactive power  components in some countries



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# Market Reforms

## Consumer Price Components:

- Final Energy Cost in

  Germany ,including

  TAX components

# Market Reforms

## Consumer Price Components:

- Advantage of differentiation between consumer types

Thankyou for your attention.