Session 4 - Case Studies

# High Energy Efficient Transformer


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Overseas Environmental Cooperation Center, Japan (OECC)

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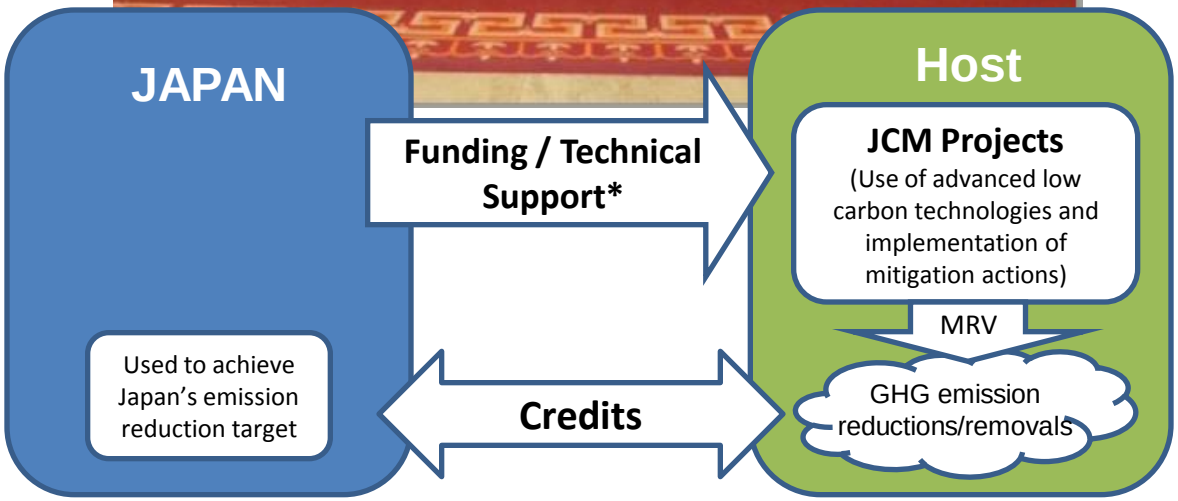
# JCM in Mongolia

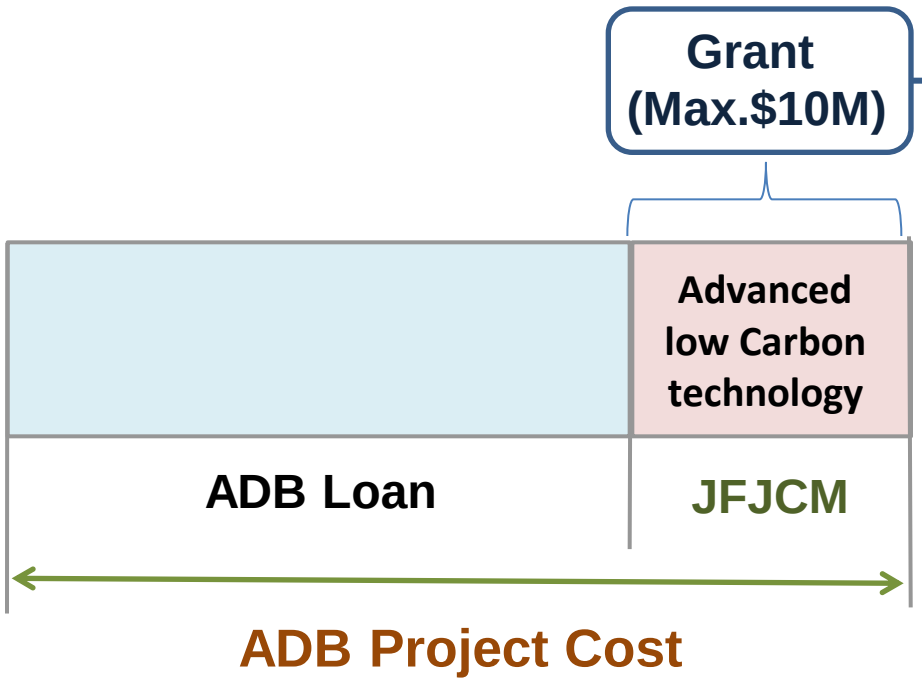
**Mongolia is the first to launch Joint Crediting Mechanism (JCM) on 8 January 2013, out of the 16 countries that signed bilateral agreements with the Government of Japan.**




*Source of funding and/or technical support is not limited to Japan.

# What is JFJCM Finance Scheme ?

- JFJCM was established and announced by MOEJ and ADB on 25 June 2014.
- The JFJCM provides financial incentives for adoption of advanced low-carbon technologies in ADB-financed projects.




**sovereign**

*(i) Max about $5 million*
*(project cost < $ 50M)*
*(ii) Max 10% of the project cost $*
*(50M < project cost < $100M)*
*(iii) Max $10 million*
*(if the project cost > $100M)*

**non-sovereign**

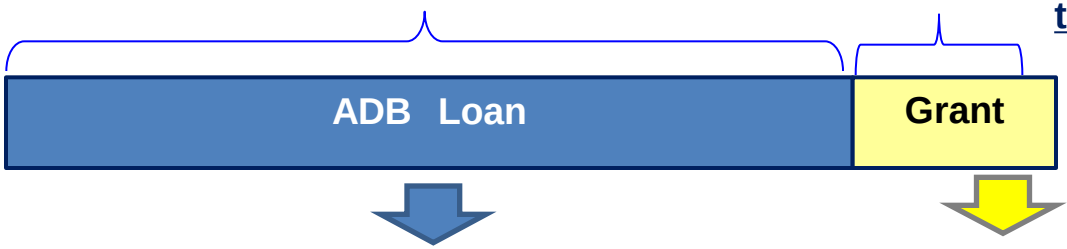
*(i) Max 10% of the project cost*
*(project cost <$100M)*
*(ii) Max $10 million equivalent*
*($100M < project cost)*

# Project approved for JFJCM in Mongolia

- 450 MW of new CHP plant in Ulaanbaatar for stable power and heat supply.
- $160 million (including $10 million financed from JFJCM) is expected to be financed by ADB for (i) power and heat evacuation facilities for new CHP plant, and (ii) UB electricity distribution network strengthening with an installation of amorphous transformers.

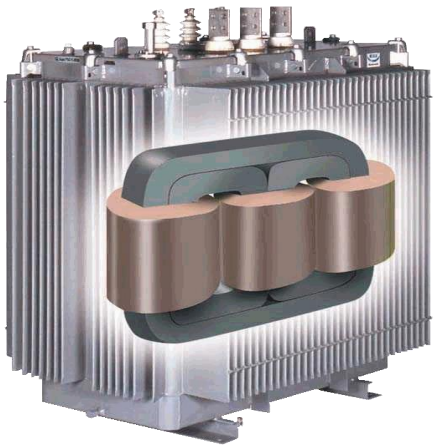
**ADB Pipeline Projects**

**JFJCM** (Equipment Directly Related to CO2 Emission Reduction)




**Grant : Exclusively for**

- **Advanced Technology**



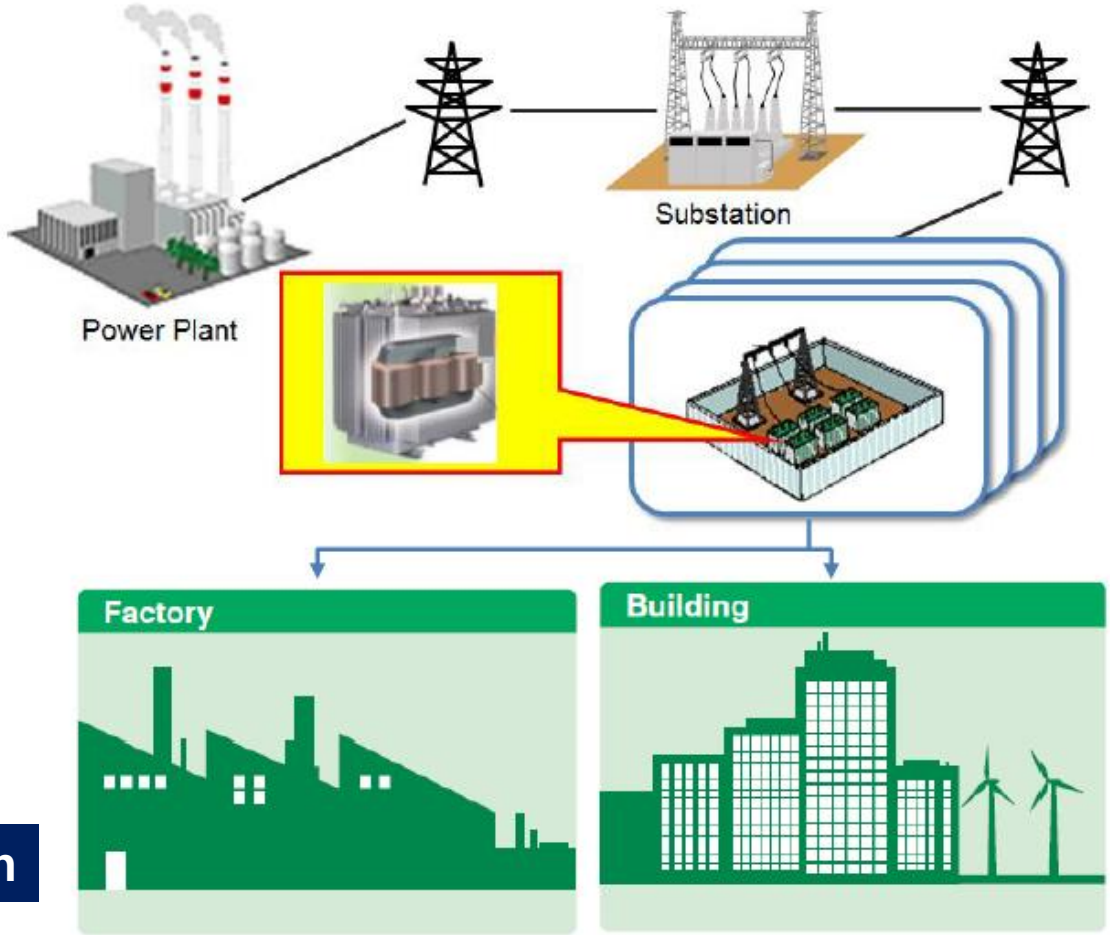
Amorphous Transformer (AMT)

# What is Amorphous Core Transformer ?

**Features:**

- Amorphous metal is used as iron core.
- Reduction of maximum 38% of total transmission loss (comparison with silicon steel transformers (SIT) )

**Oil-Immersed Type**




**Application**

# Solution for Saving Energy

- Two (2) type of losses during operation : No load loss (NLL) & Load loss (LL)
- Amorphous material has great advantage in reducing No load loss.

## No Load Loss (Iron loss)

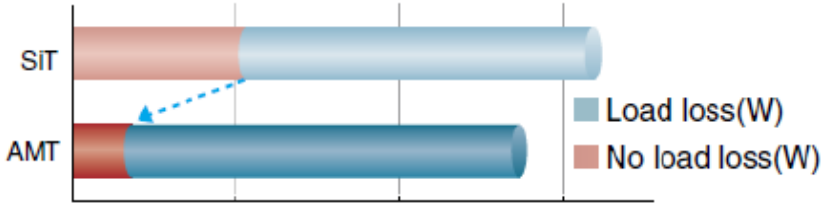
The constant loss that always occurs regardless of whether loaded or not.

## Load Loss (Copper loss)

The loss occurs because of the flow of load current when loaded.

- Reductin of No Load Loss
- Reductin of Load Loss

} **Energy Saving** $CO_2$ **Reduction**

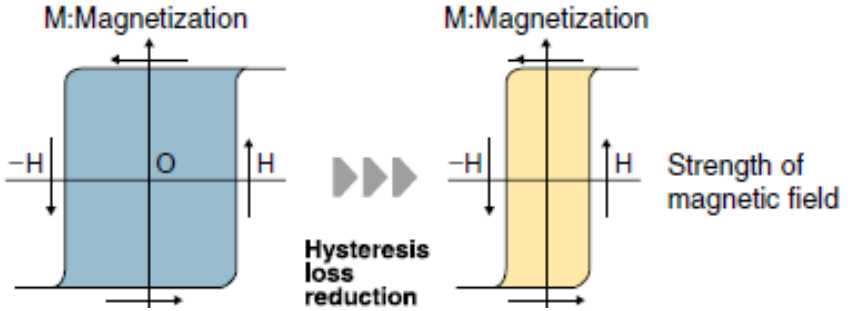


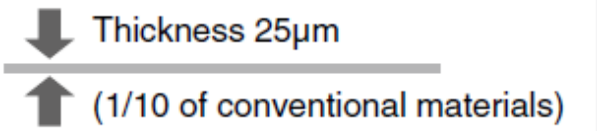

**Amorphous Transformer is the Solutions**

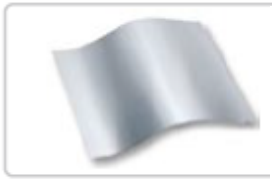
# Principle of Amorphous Core Transformer (AMT)

- The amorphous is a non-crystal substance created by rapidly freezing liquids of high temperature.
  → Because there is no rule of atomic arrangement, the energy loss (hysteresis loss) is small when the flux of magnetic induction passes the iron core.
- In addition, eddy current loss is decreased because the thickness is approx. 0.03 mm, which is about 1/10 comparing with silicon steel.
  → Therefore, the no load loss (eddy current loss and hysteresis loss) can be decreased to about 1/5 of silicon steel's.


Atomic arrangement



Ribbon thickness is 1/10 of Silicon Steel's
[Silicon Steel:0.23mm, Amorphous Alloy:0.025mm]

Thickness

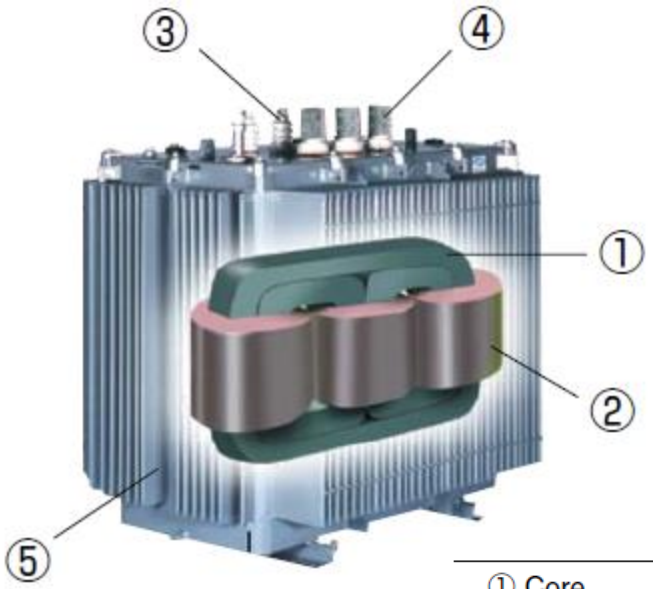
### Hysteresis loss

By magnetic induction, magnetic domain rotates to have unified direction. The loss caused by this movement is hysteresis loss.

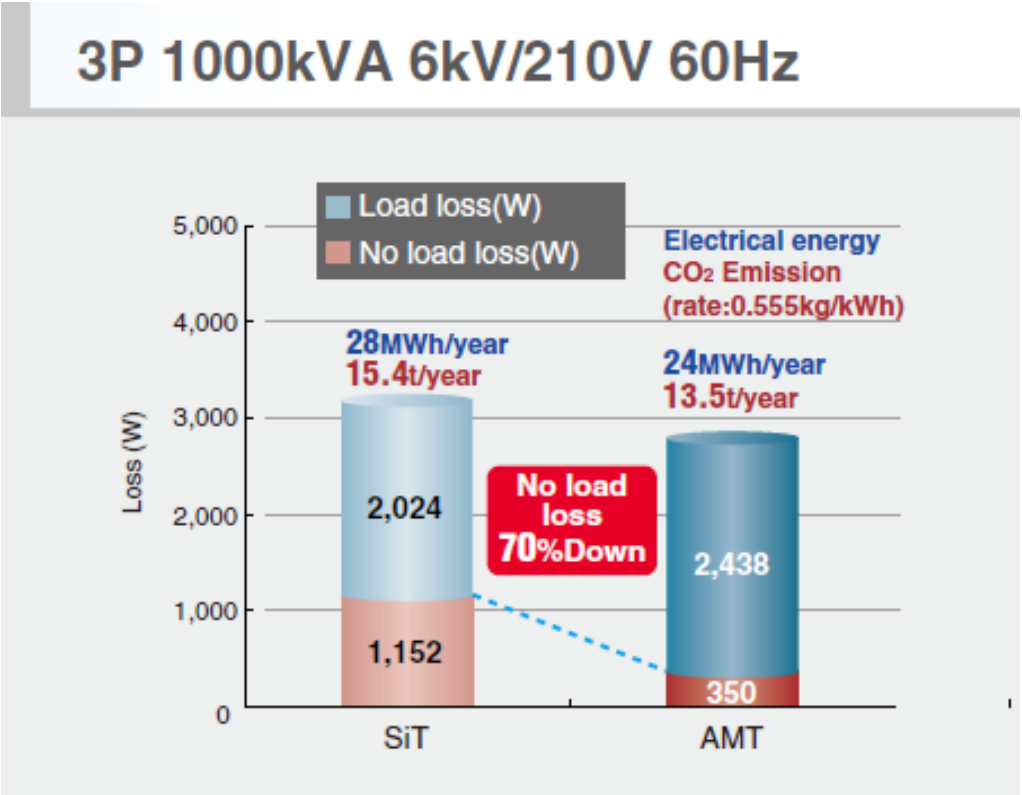
### Eddy current loss

When magnetic flux flows, eddy carrent flows to negate the flux.This eddy current cause loss proportional to the resistance.

# Example of Oil-Immersed Type AMT




| |
|---|
| ① Core |
| ② Coil |
| ③ Primary Bushing |
| ④ Secondary Bushing |
| ⑤ Tank |




## Product Range

| Products | Phase | Voltage (kV) | Capacity (kVA) |
|---|---|---|---|
| Oil-Immersed Type | Single or Three | 0.2–22 | 10–3,000 |
| Molded Type | | 0.2–11 | 10–1,500 |
| Overhead type | Single | 0.2–6.6 | 10–100 |

# Benefits of technologies for UB city

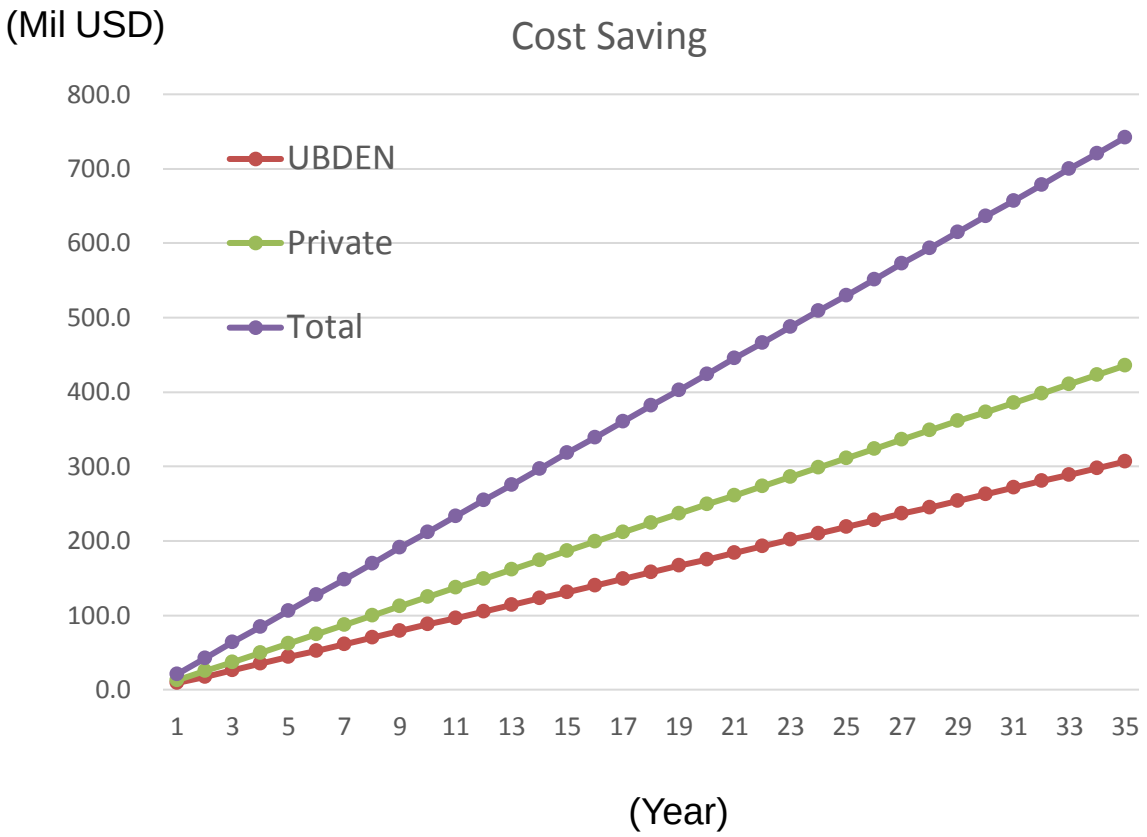
| Big CO2 Emission Reduction | UBEDN | Private | total |
|---|---|---|---|
| Number of TR in services | Approx. 1,900 | Approx. 2,700 | Approx. 4,600 |
| Typical existing TR (SIT) | S9-800/10 (China) | S9-800/10 (China) | |
| Voltage | 10kV | 10kV | |
| Rated capacity | 800kVA | 800kVA | |
| No Load-loss (NLL) | 1,400W | 1,400W | |
| Replacement of TR (AMT) | Amorphous Core | Amorphous Core | |
| Voltage | 10kV | 10kV | |
| Rated capacity | 800kVA | 800kVA | |
| No Load-loss (NLL) | 300W | 300W | |
| Blackout Rate (Br) | 0.008 | 0.008 | |
| Energizing time/year (h) | 8,760 | 8,760 | |
| Emission factor of grid (tCO2/MWh) | 1.057 | 1.057 | |
| Allowable uncertainty by IEC 60076-1 | 15% | 15% | |
| Reference Emission (t CO2 /year) (1) | 24,510 (= 12.9 x 1,900 ) | 34,830 (= 12.9 x 2,700) | 59,340 |
| Project Emission (t CO2 /year) (2) | 6,080 (= 3.2 x 1,900) | 8,640 (= 3.2 x 2,700) | 14,720 |
| CO2 Emission Reduction (t CO2 /year) (1)-(2) | 18,430 (= 9.7 x 1,900) | 26,190 (= 9.7 x 2,700) | 44,620 |

**Estimation:**
**All existing SIT are replaced with AMT.**

# Financial benefits of technologies for UB city

| Big Money Reduction | UBEDN | Private | total |
|---|---|---|---|
| Number of TR in services | Approx. 1,900 | Approx. 2,700 | Approx. 4,600 |

**Assumptions of simulation**
- **EF: 1.057 tCO2/MWh**
- **Cost of buying electricity: 0.06 USD/kWh**
- **System Losses: 14.7%**
- **Effective cost of lost electricity: 0.05 USD/kWh**
- **35 years of lifetime**

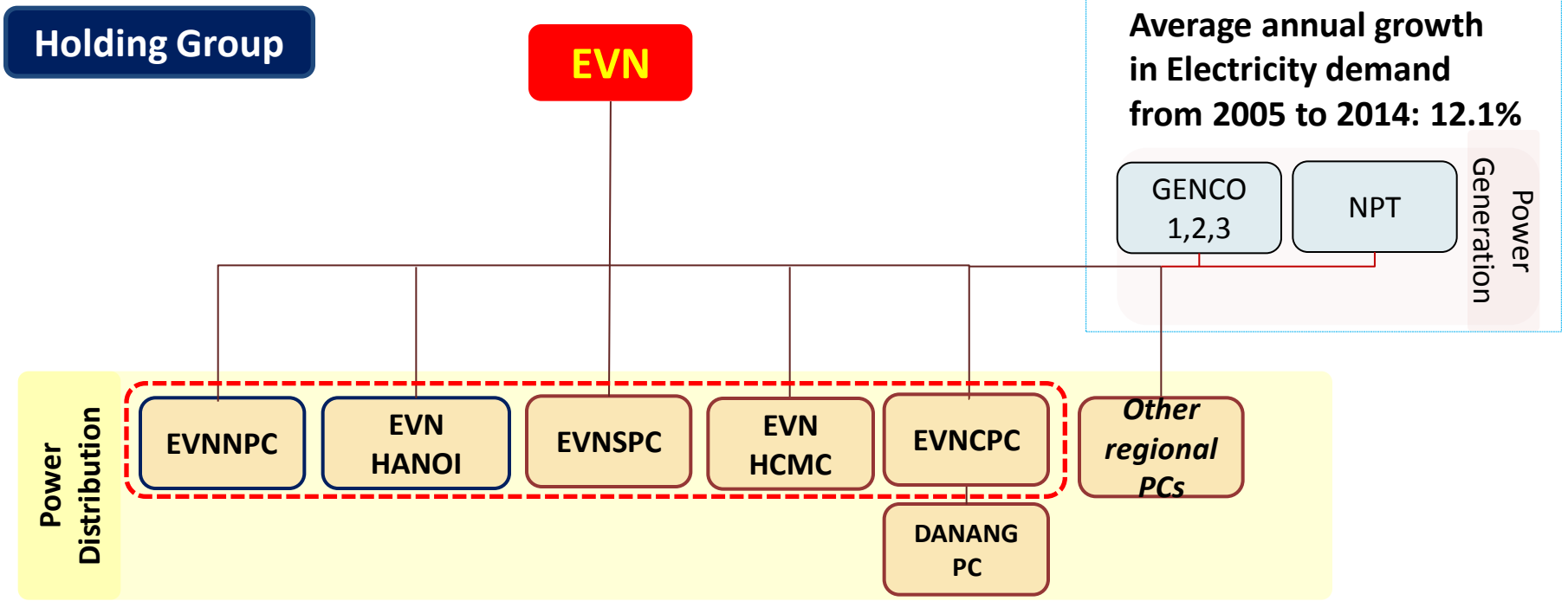



| CO2 Emission Reduction (t CO2 /year) (1)-(2) | 18,430 (= 9.7 x 1,900) = 17,440 MWh | 26,190 (= 9.7 x 2,700) = 24,780 MWh | 44,620 = 42,220 MWh |
|---|---|---|---|

# Deployment to other countries
## (Viet Nam's case)

- ✓ **The methodology "Installation of energy efficient transformers in a power distribution grid" is approved.**
- ✓ **Project "Introduction of amorphous high efficiency transformers in power distribution systems in the southern part of Viet Nam (EVNSPC)" is registered.**

# [Case study] Viet Nam's case -1/3




**Actual and forecast increases in proportion ⇒ needs finance for distribution utilities**

Table. Electricity demand : Actual(2005-2014) and Projection (2015-2030)

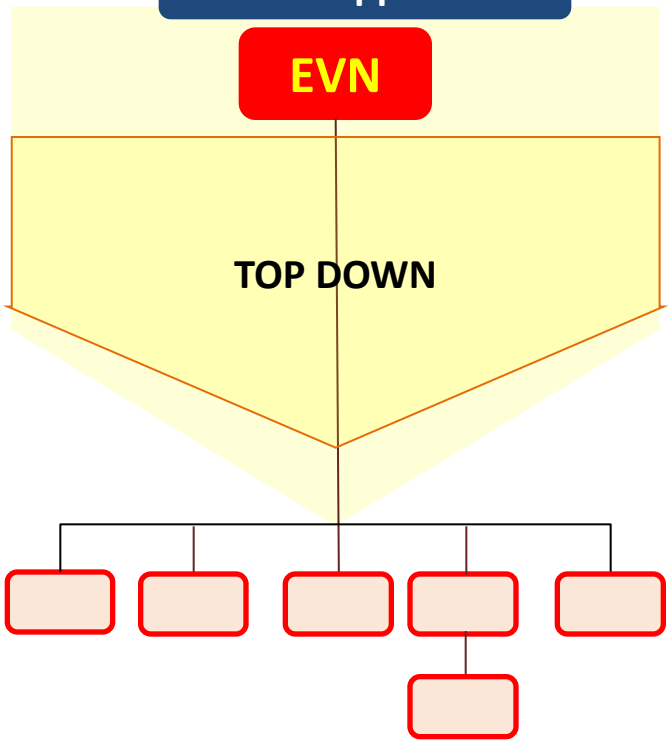
| Item | 2005 | 2009 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| Annual demand (TWh) | 45.6 | 76.0 | 128.4 | 141.8 | 234.6 | 352.3 | 506.0 |
| Annual generation (TWh) | 53.6 | 86.9 | 145.5 | 161.3 | 265.4 | 400.3 | 571.8 |
| Maximum demand (GW) | 9.5 | 13.9 | 22.2 | 25.3 | 42.1 | 63.5 | 90.7 |
| Per capita consumption (kWh) | 549.0 | 873.0 | 1,415.0 | 1,560.0 | 2,545.0 | 3,610.0 | 4,950.0 |

Source: Government of Viet Nam 2015, Revised Power Development Plan 2011-2020, Hanoi

# [Case study] Viet Nam's case - 2/3

## Regional Approach

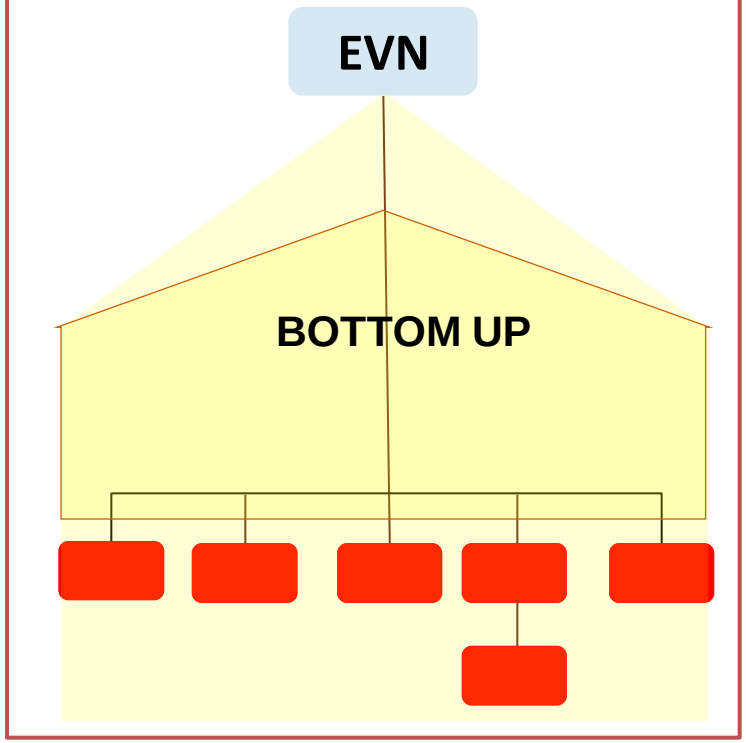
### AS IS Approach




Main issue:

- ✓ Each pc has different specs
- ✓ Individual procurement plan
- ✓ Unable to reach the actual regional demands

### OECC Successful Approach

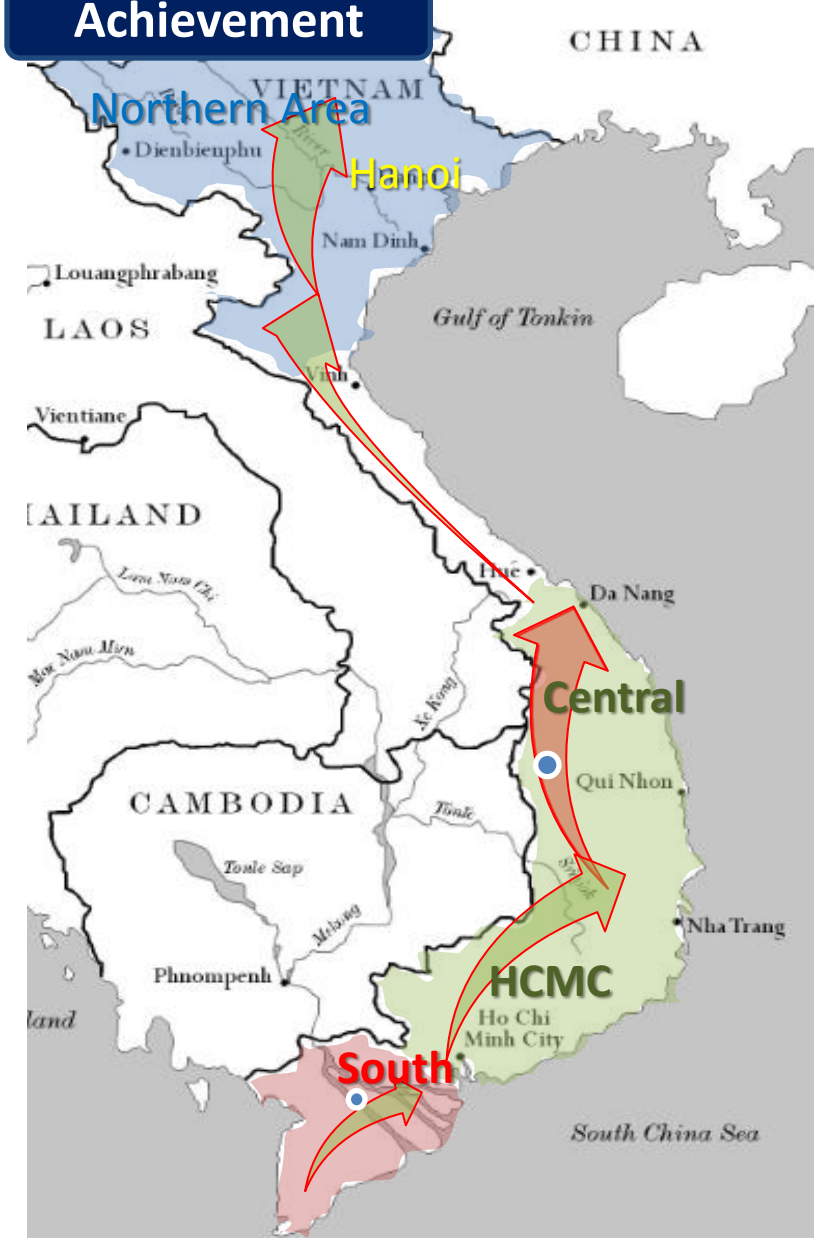



Outcome:

- ✓ Find regional needs with detailed specs and parameter

# [Case study] Viet Nam's case - 3/3

## Achievement




FY2016

| EVN | AMT Txs | FACILITIES (M JPY) |
|---|---|---|
| NPC | 1,029 | 1,763 |
| Hanoi | 186 | 406 |
| ***Total*** | ***1,215*** | ***2,169*** |

FY2015

| EVN/PC | AMT Txs | CO2 Reduction (ton/yr) |
|---|---|---|
| SPC | 2,683 | 1,502 |
| HCMC | 892 | 1357 |
| CPC | 802 | 875 |
| DANANG | 282 | 453 |
| ***Total*** | ***4,659*** | ***4,187*** |

FY2014

| EVN | AMT Txs | CO2 Reduction (ton/yr) |
|---|---|---|
| SPC | 1,618 | 623 |

**Thank you!**

# Appendix. Hysteresis property

- Hysteresis is the time-based dependence of a system's output on present and past inputs.
  The dependence arises because the history affects the value of an internal state.
  To predict its future outputs, either its internal state or its history must be known.
  If a given input alternately increases and decreases, a typical mark of hysteresis is that the output forms a loop as in the figure.

- Such loops may occur purely because of a dynamic lag between input and output.
  This effect disappears as the input changes more slowly.
  This effect meets the description of hysteresis given above, but is often referred to as rate-dependent hysteresis to distinguish it from hysteresis with a more durable memory effect.