

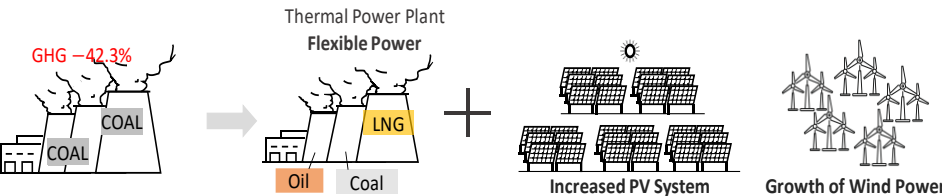
Scenario-based UC for RE Integration Considering Cost and Life Cycle Assessment with IEA Aligned Demand and Renewable Growth for Japan

Background ➡ Japan plans to increase PV and wind to 36–38% by 2030 under the Announced Pledges Scenario.

■ Despite the growth of RE, **fossil fuels are still main power source** ➡ **produce a lot of GHG emissions.**

Challenges

Much of the **RE is wasted (curtailed)** when generation is higher than demand

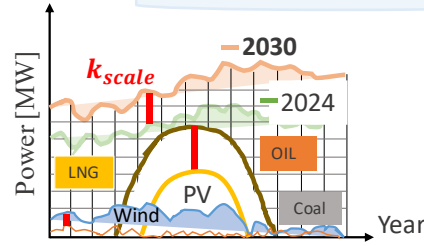


Proposal Solutions

1. Reduce wasted RE with optimal UC schedule
- 1.2. Hybrid System: **Thermal Power + PV + Wind + Hydro**
2. LCA-based **clean operation planning**

Result

Problem Formulation



$$k_{scale} = \frac{E_{IEA}}{E_{base}}$$

Epsilon (ε) – Constraint Method

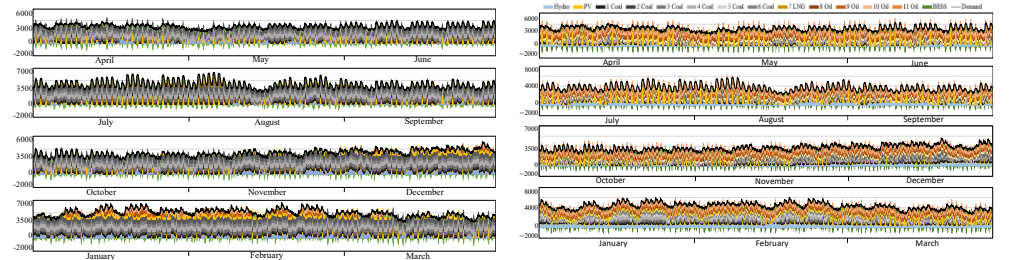
$$\min f_1(x) = OF_{cost} \quad s.t \quad f_2(x) \leq \varepsilon (OF_{LCA})$$

Operation Cost

$$1. OF_{cost} = \min \sum_{t=1}^{24} \sum_{i=1}^{11} [FC + SC_i \cdot u_{i,t} (1 - u_{i,t-1})]$$

LCA: Life Cycle Assessment

$$2. OF_{LCA} = \min \sum_{t=1}^{24} [K_{i,LCA}^{(S)} \times g_{i,t} \times u_{i,t}]$$



❑ APS-style PV and wind expansion **reduces emissions but increases material and land impacts.**

Cost Comparison by APS scale of 2023 and 2030/2035/2050

APS Scenarios	By Year	Base year 2023	2030	2035	2050
Operation Cost	10 ¹¹ JPY	2.95	−7.1%	−22.7%	−8.1%
Climate Change	10 ¹⁰ kg	2.53	−3.6%	−11.1%	−7.1%
Air pollution	10 ⁷ kg	2.00	−2.5%	−7.5%	−7.5%
Land Use	10 ⁸ m ² y	0.49	+46%	+108%	+233%
Human Health	10 ³ DALY	6.44	−3.1%	−9.6%	−7.3%
Endpoint Cost	10 ¹¹ JPY	1.23	−0.8%	−0.8%	+8.9%

Cost decreases due to RE and coal usage and lower fuel price dependence.