International Energy Agency

Integrating VRE in Thailand's power system

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Integrated power system technical analysis with VRE

High detail

VRE Phase 2&3

Power system flexibility

Time-scale: *Minutes to hours*

Production cost modelling (PCM)

- Unit commitment and economic dispatch (UCED)
- Nodal representation of transmission system
- Simulation of wind and solar outputs
- Flexibility assessment (different resources)

VRE Phase 4

Power system stability

Time-scale: *Sub-seconds to minutes*

Technical studies with high VRE

- Dynamics stability: *Transient, small-signal, frequency, voltage*
- Frequency and inertial response requirements

Long-term power sector planning

- Multi-year optimal generation portfolios and transmission plan
- Capacity value of different technologies
- Scheduling, Adequacy
- Demand forecast

- Traditionally, power sector modelling tools/studies are not integrated: cap expansion; PCM; technical
- With increasing VRE, there is a need to prioritise and integrate different existing modelling studies
  - Focus on PCM in future scenarios to assess system flexibility and the role different resources
  - Linking the modelling tools to the timescale and VRE phases (and penetration)
- These are the current modelling efforts at the IEA - a number of grid integration case studies in China, India, Thailand, ASEAN

Thailand RE integration and Flexibility studies

Context of Thailand RE Grid Integration and System Flexibility Studies

- In 2018, MoEN and EGAT requested the IEA to conduct a RE grid integration study and capacity building workshop to understand RE integration challenges and options

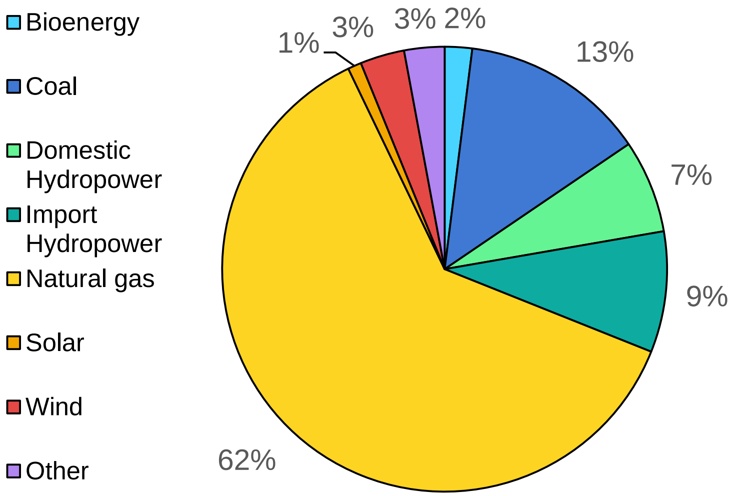
- Key findings and recommendations were considered by relevant stakeholders
  - Higher share of VRE is technically possible.
  - VRE targets have increased from the previous PDP, from **9 GW** to **15 GW** by 2037
  - VRE forecasting and the establishment of renewable control centre

- Key findings led to an in-depth system flexibility study (to be published in April 2021)
  - Two key components: **Contractual and Technical flexibility**
  - Appropriate technical flexibility options (power plant flexibility, storage) for high share of VRE (**up to 15% VRE by 2030**)
  - Appropriate options for improving the existing and future contract structures both for fuel supply and offtake of electricity

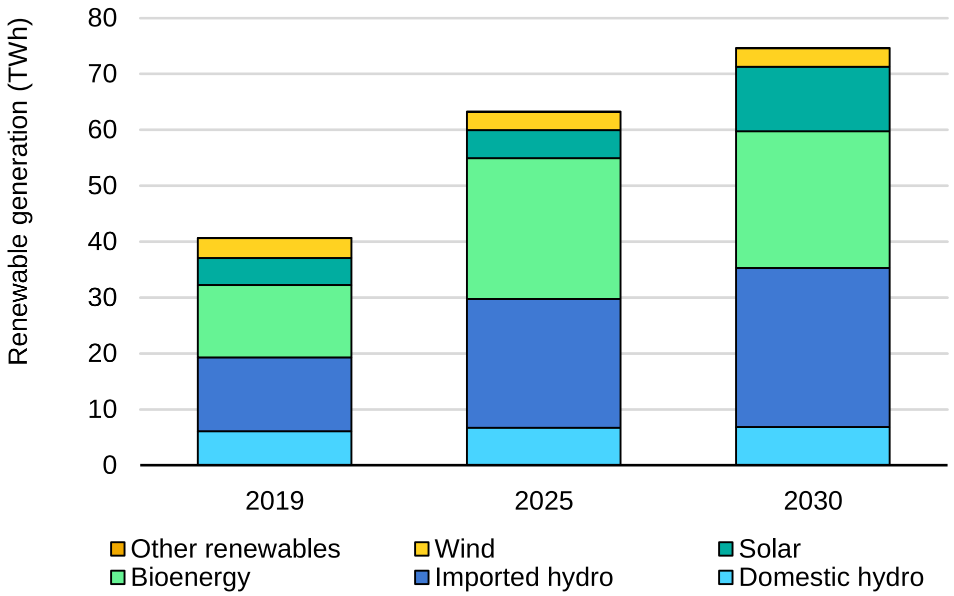
https://webstore.iea.org/partner-country-series-thailand-renewable-grid-integration-assessment

Generation mix in Thailand

Generation Capacity 2019 (MW)



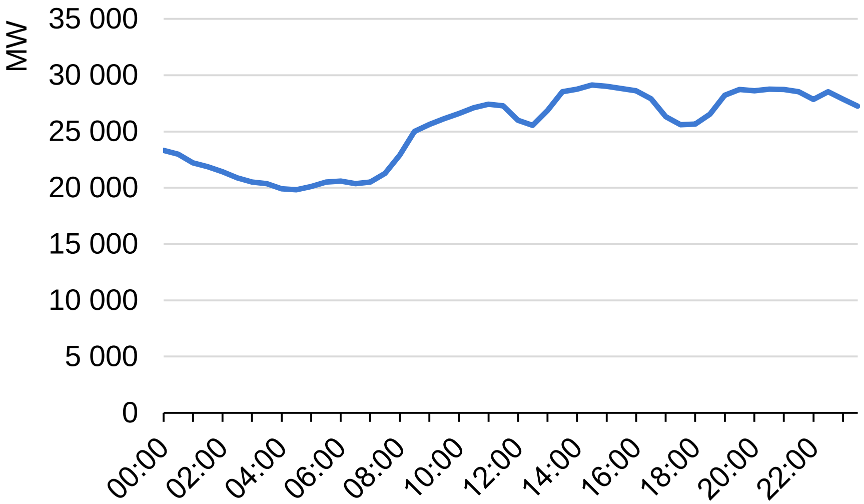
Share of RE generation according to PDP, 2019, 2025 and 2030



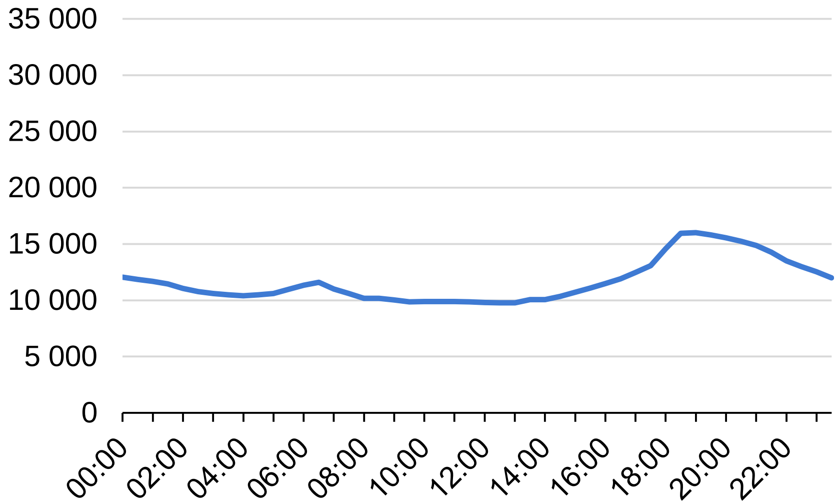
- 47 GW installed capacity and 30 GW peak demand. Gas-fired is the largest generation source
- 4% annual share of VRE in 2020
- The RE target is set at 25% in 2025 and 30% in 2037 according to the PDP (8% VRE in 2037).

Typical demand patterns in Thailand

Peak demand periods

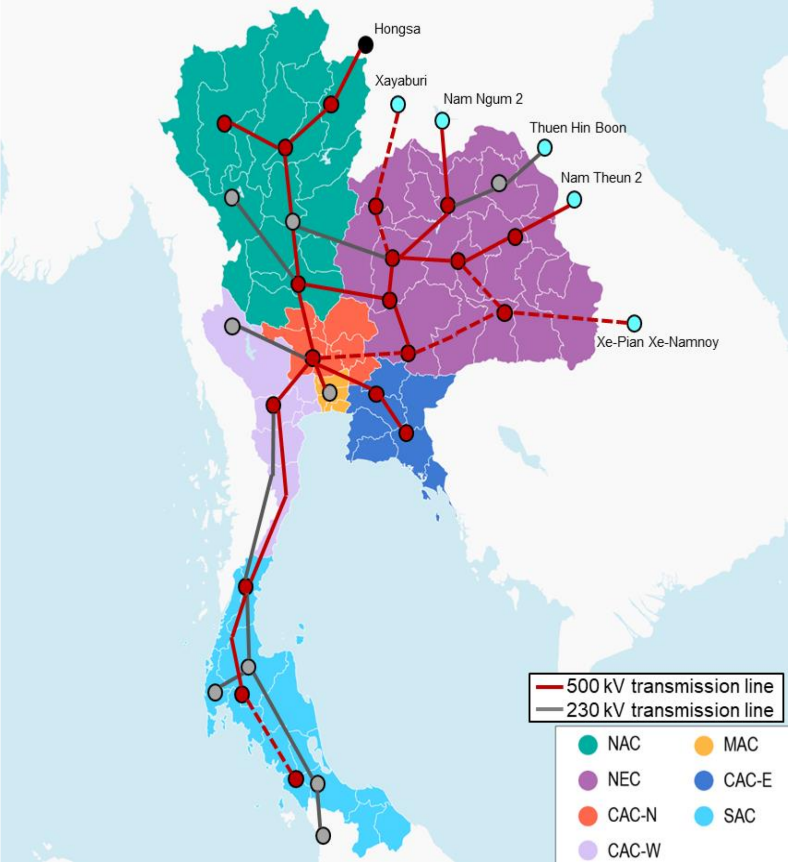


Off-peak demand periods



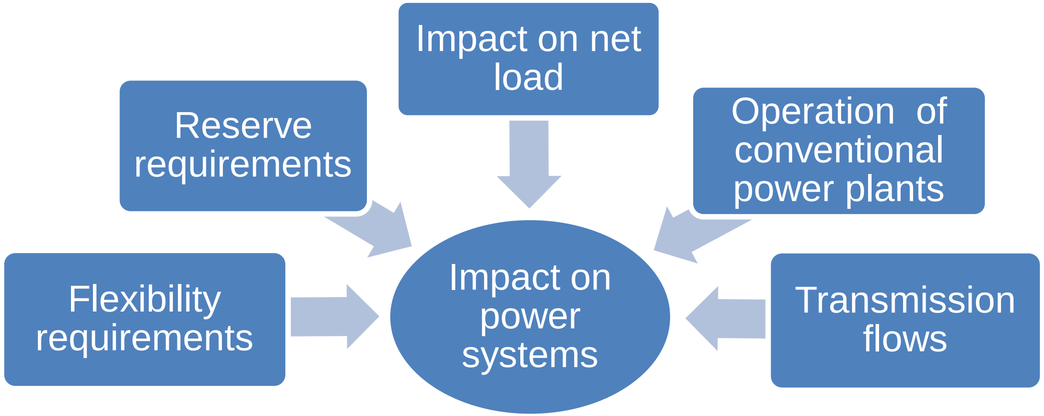
- Daily peak demand occurs in the afternoon or evening depending of seasons
- Increasing gap between daily minimum and peak demand
- Relatively high ramping is required in the evening peak on Sundays and public holidays

The flexibility of Thailand's existing power system



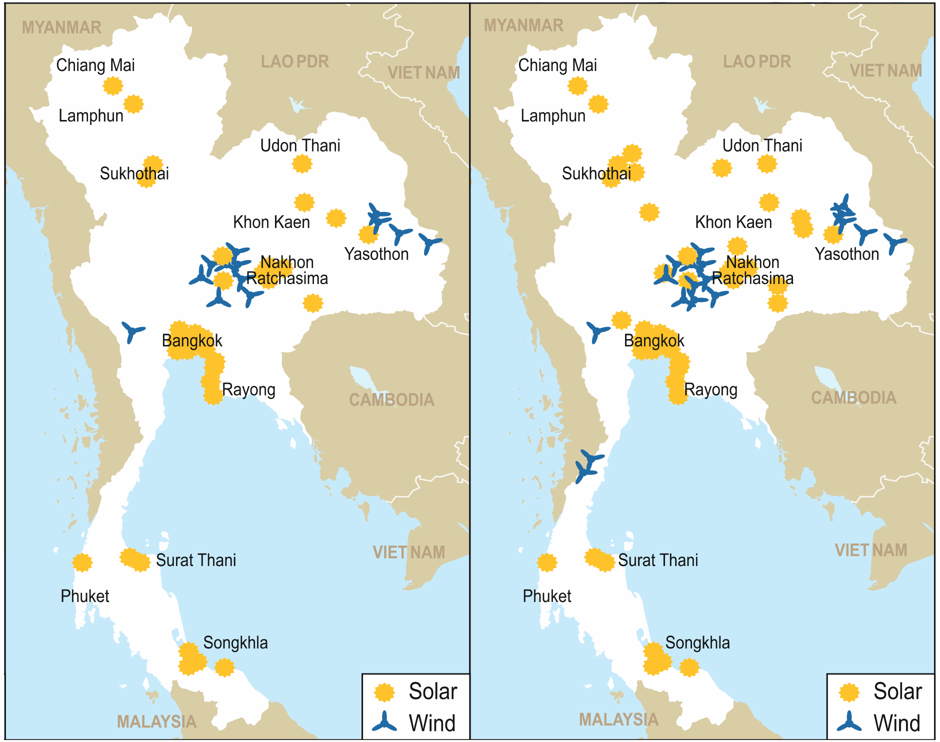
- 230kV and 500kV main transmission systems with 7 control regions
- Generation sources located throughout the country
- Southern region is the most challenging in maintaining stability due to radial connections
- Main characteristics of the existing grid
  - Speed droop, secondary control (AGC)
  - Quick start generators, synchronous condensers
  - FACTs devices to enhance transfer capability
  - Special protection schemes including load shedding using U/F relay
  - Wide area monitoring system (WAMs)

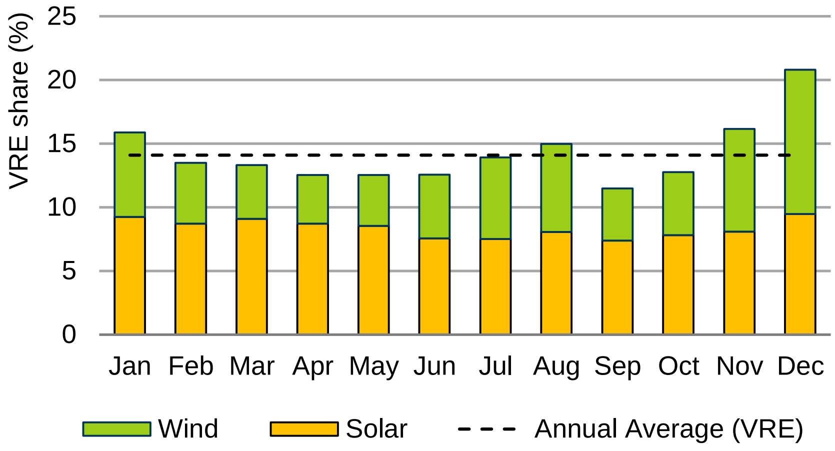
Assessing the technical impact of VRE and flexibility resources



- The main purpose is to analyse the technical capability and options for the power system to accommodate greater share of solar PV and wind
  - Impact of integrating VRE on the system must considers both technical and economic aspects
- Production cost modelling with 30-minute time resolution in 2025 and 2030
  - Assess the value of flexibility resources including: **flexible power plants**; **pumped storage hydro** (PSH); **battery energy storage systems** (BESS)
  - Different annual share of VRE were considered: **4% to 15% VRE (19 GW solar, 6 GW wind)**

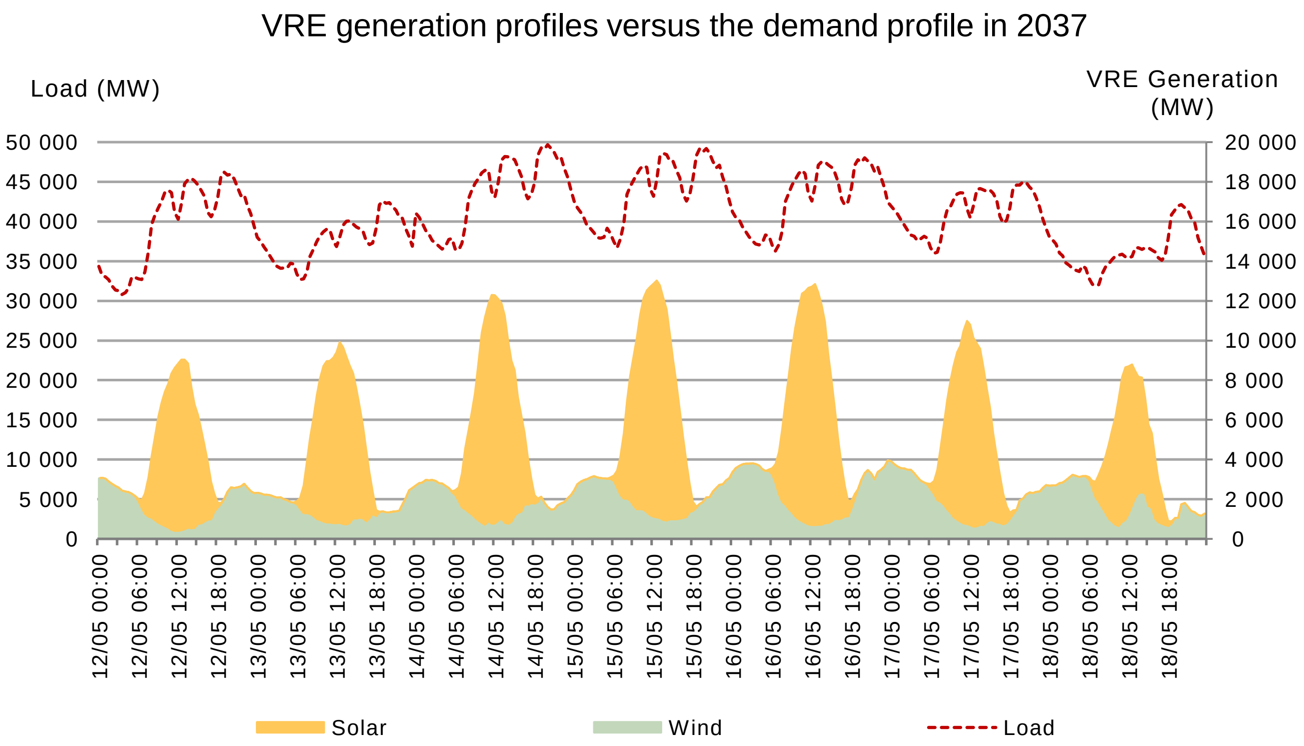
Locational and seasonal impact of solar PV and wind generation





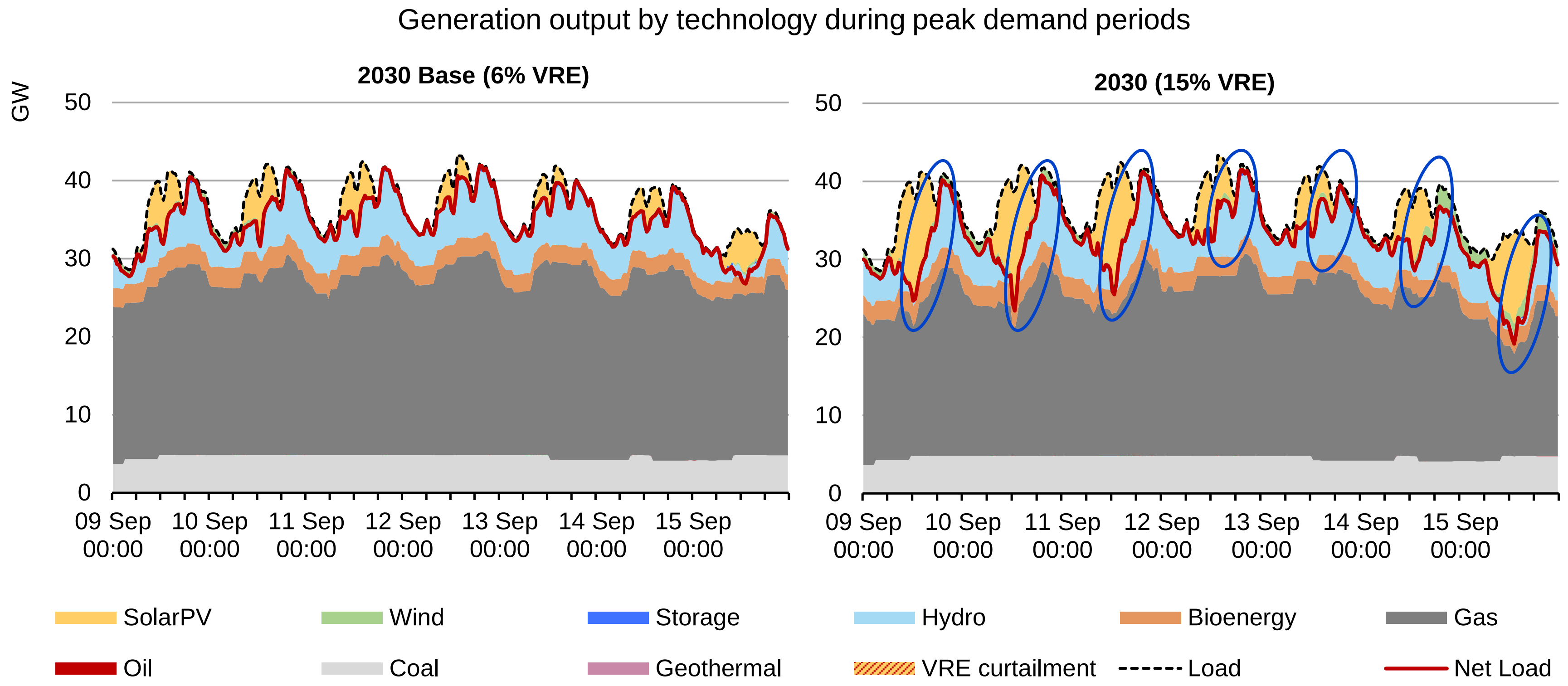
- VRE generation varies by month throughout the year.
- Solar generation varies modestly with stable average output. Wind varies more significantly

Complementary between solar and wind generation and demand



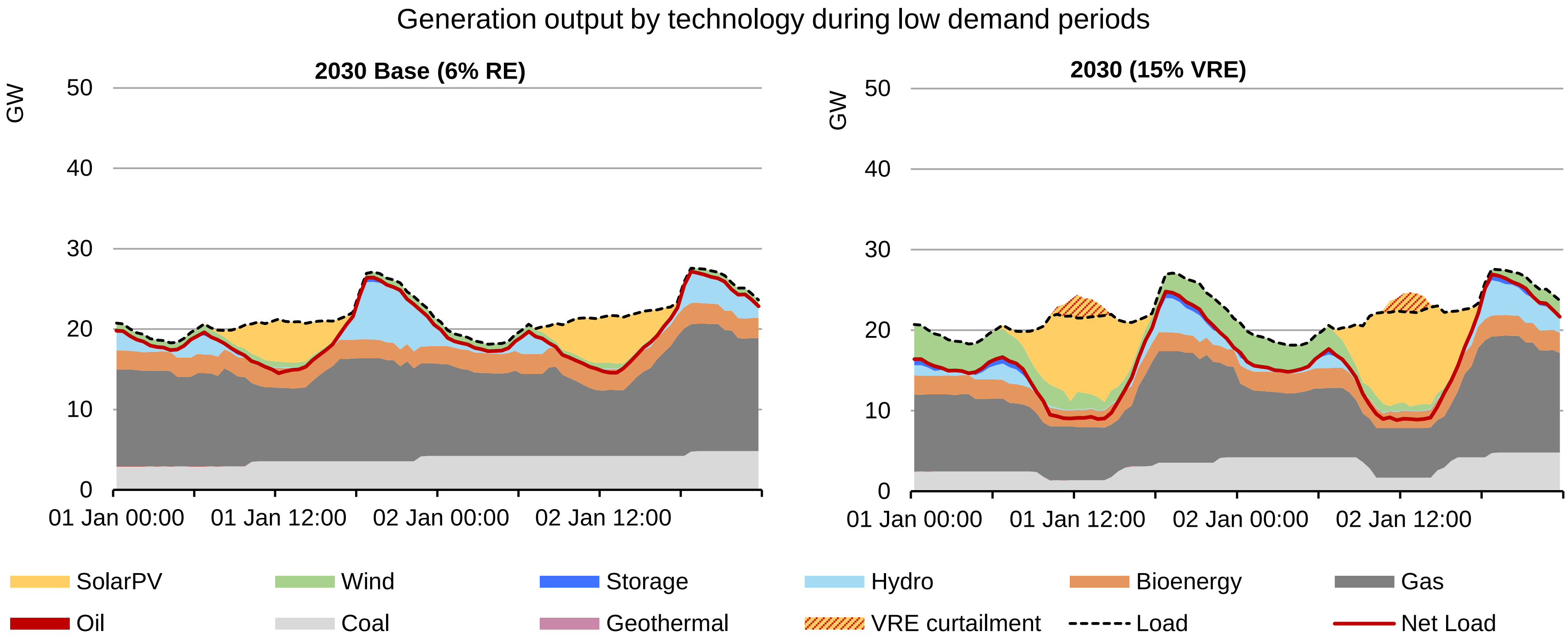
A high contribution of solar towards a midday peak demand. The wind profile generally ramps up during the evening as demand increases

Greater flexibility requirements with more solar and wind generation



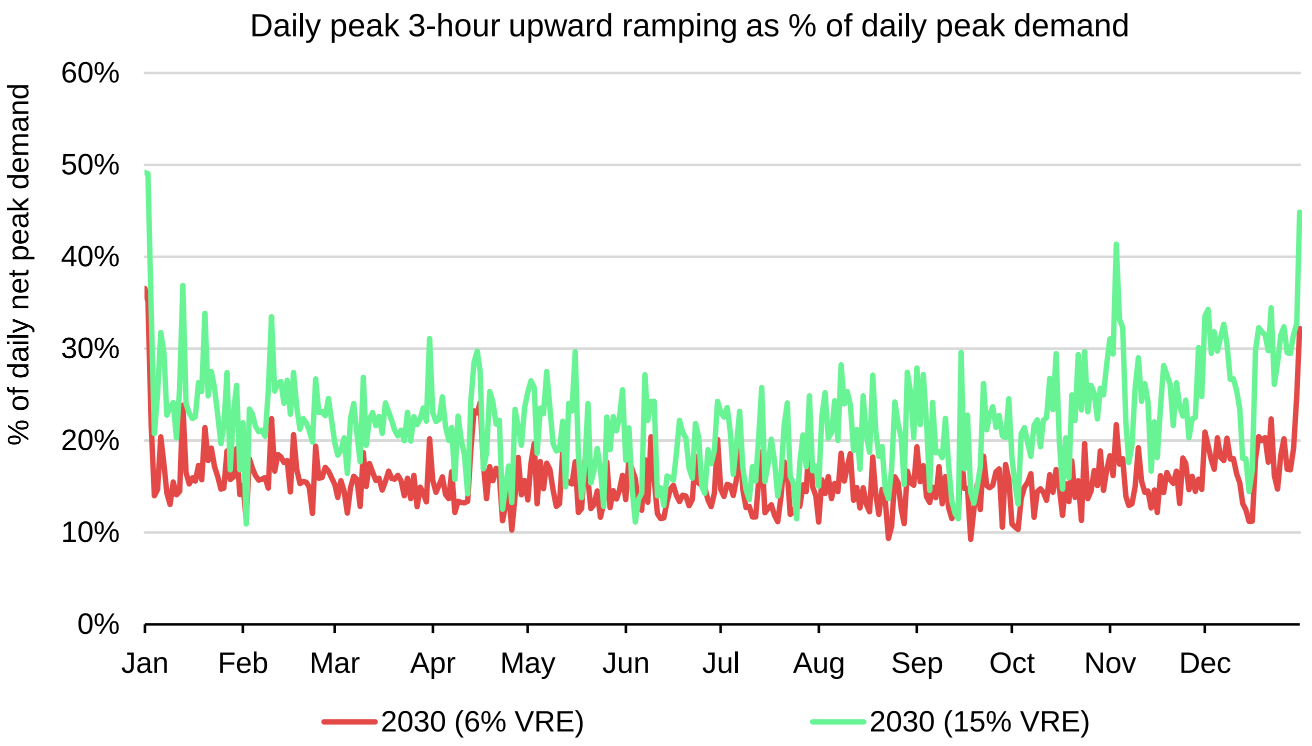
Greater variability in net load profiles with more solar PV and wind but it is still manageable. Hydropower and CCGT provide a large amount of ramping requirements to meet evening peak when solar generation reduces.

Low level of VRE curtailment



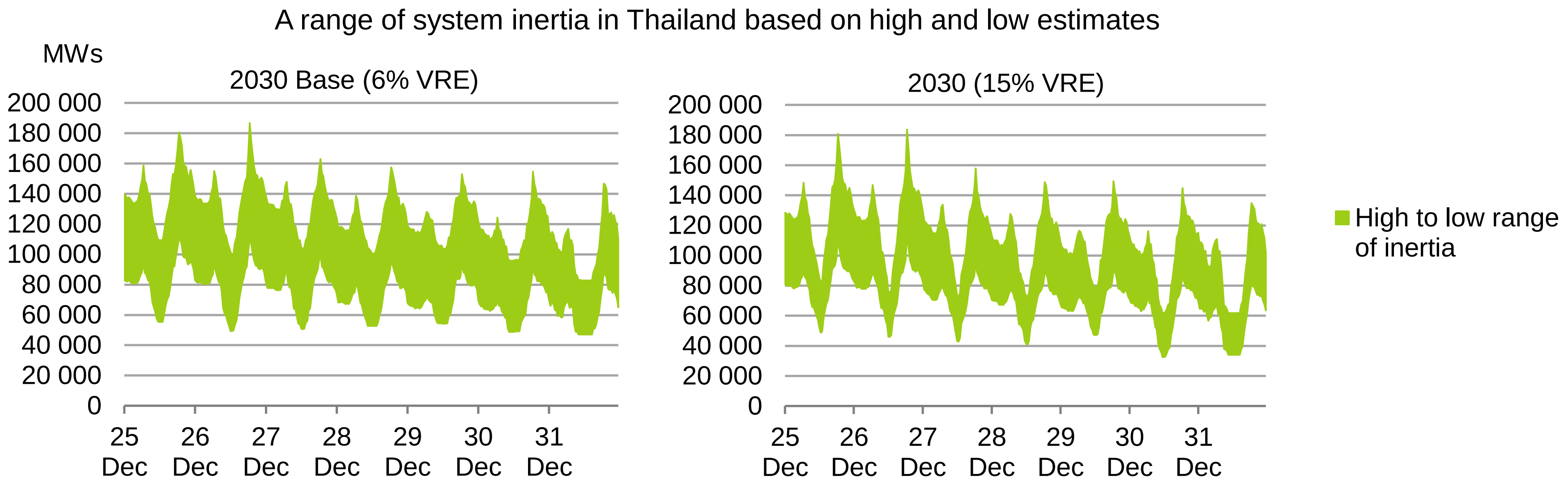
VRE generation can displaces coal and gas-fired generation. Very low levels of annual VRE curtailment, with less than 0.1%. VRE curtailment only occurs during the New Year holidays with extremely low net demand

Greater flexibility requirements with more solar and wind power



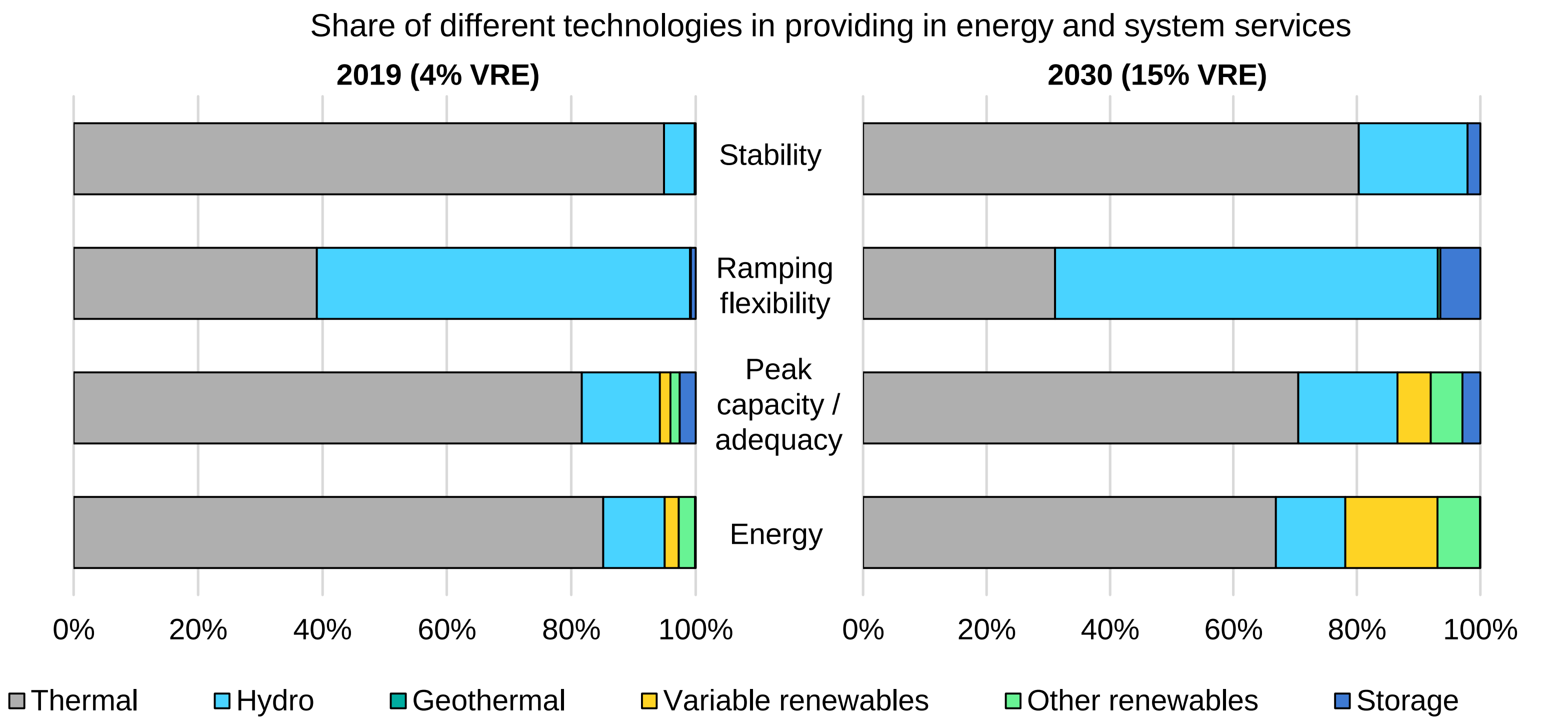
The highest upward ramps occur in the holiday seasons. With 15% share of VRE, the highest 3-hour upward ramps could reach 13.2 GW (~75 MW/minute) or 50% of daily peak demand in 2030

The impact on power system stability depends on the level of VRE



- System inertia decreases with higher share of VRE due to the displacement of synchronous generator
- Inertial can be a key challenge for the system with **a high instantaneous VRE infeed (>50%)**
- Initial approximation shows reasonable levels of inertia in Thailand’s system (>40GW.s)
- Dynamic studies are required to determine inertial requirement to limit RoCoF to a certain level (e.g. Texas, Ireland and GB)

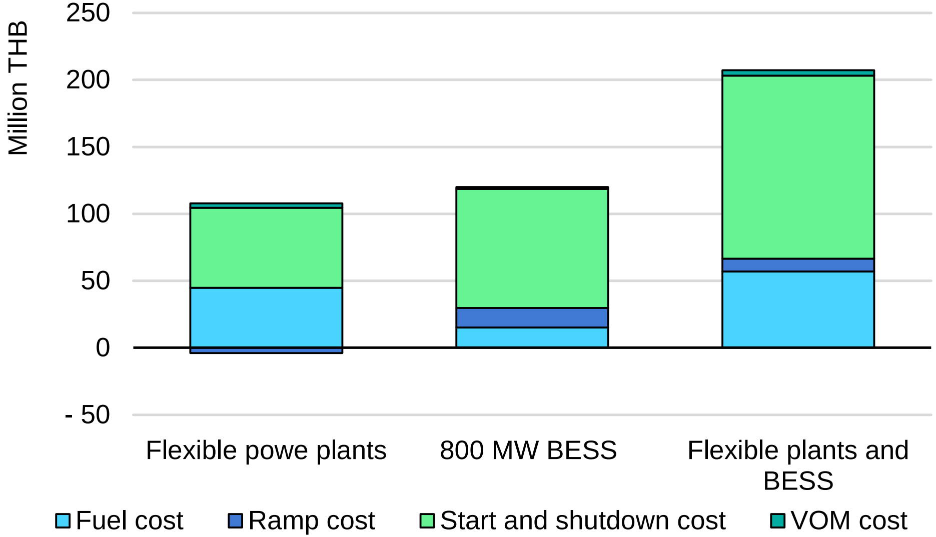
Storage and renewables can contribute in providing system services



Power systems need to reward and incentivise flexibility and capacity contributions of different technologies in providing flexibility and stability services, which they are technically capable of

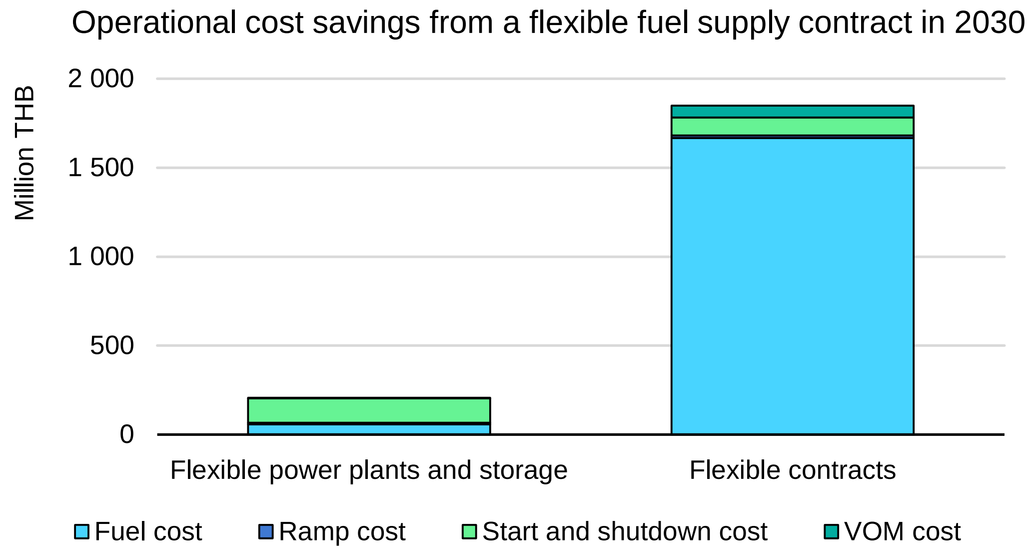
Benefits of flexible power plants and battery storage

Operational cost savings from combined flexibility options at 15% VRE share in 2030



- Flexible power plants (through plant retrofits) and battery can provide flexibility services
- With 15% share of VRE in 2030, flexible power plants and battery storage provide modest cost savings
  - The investment cost plant retrofits and storage outweigh the operational cost savings.
  - The small cost savings due largely to inflexible fuel supply and power purchase contracts

The value of technical options depends on fuel supply contracts



- The operational cost savings from a flexible fuel supply contract are significantly greater than the savings from flexible power plants and storage options combined
  - Relaxing minimum take-or-pay obligations
- A significant reduction in operational costs as system operators can access a large amount of latent flexibility in the system and dispatch the system in a more cost-effective manner.

Summary

- As the share of VRE increases, so **the power system's need for flexibility will grow**
    - Higher ramping requirements and larger gap between daily minimum and peak demand
    - Operational practices and planning should take into consideration these flexibility requirements.
- Thailand's power system **has technical flexibility to integrate up to a 15% share of VRE by 2030** (19 GW solar, 6 GW wind) but institutional and contractual constraints limit mobilising this flexibility
- With 15% share of VRE, **power system stability is not a key concern** for Thailand's power system
- New technical flexibility options (power plant retrofits and additional storage options) can provide system flexibility but they are not a priority in the short- to medium-term due to contractual constraints
- As more VRE is deployed beyond 2030, flexible power plants and storage may become highly complementary options once operational practices are addressed and there have been changes in fuel and power purchase contract.

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