Navigating through Thailand's PDP towards carbon neutrality

Insights from a cost-optimisation perspective based on publicly available data

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Key objectives of the analysis

→ The analysis aims to provide useful insights to support the ongoing consultation process of Thailand's Power Development Plan 2024 (PDP).

→ An alternative modelling framework was developed based on publicly available data, as to support an open discussion on modelling methodology, assumptions and results. This analysis is based on cost-optimisation.

→ With this approach, we hope to
- contribute to a better understanding of how underlying assumptions can influence modelling results,
- support the discussion on other cost-optimal pathways that may exist for Thailand,
- shed lights on aspects of the PDP that could benefit from additional transparency/analysis.

Key Findings

1 **The draft PDP 2024 put Thailand on a linear path towards carbon neutrality in 2050.** Higher ambition by 2037 would however minimise costs, reduce emissions, facilitate low-carbon electrification and mitigate uncertainties related to the last miles of decarbonisation.

2 **Tripling the solar PV target in the draft PDP 2024 to 42 GW by 2030 and doubling it to 72 GW by 2037 could reduce total system costs by 10%, with additional CO_2 emissions reductions as a co-benefit.**

3 **Integrating more renewables doesn't need additional gas power plants but requires a change of their operation towards flexibility.** It comes with a minimum need of additional battery storage (+6GW) and grid reinforcement.

4 **Assumptions and methodology delivered to the draft PDP 2024 consultation are insufficiently transparent and expose the analysis to several methodological uncertainties.** Enhancing the transparency of assumptions and methods would provide a stronger foundation for fact-based analysis and discussions.

5 **Multi-sectorial planning should be better integrated within the PDP process given the crucial role play by low-carbon electrification of end-use sectors (transport, industry) to facilitate the integration of renewables and meet carbon neutral targets.**

Agora's analysis used a 'reproduced PDP' to address the limited public data on capacity mix in the draft PDP 2024

The 'reproduced PDP' enables a clearer understanding of the potential impacts by filling data gaps and offering a more detailed representation of the capacity mix. Alternative scenarios were explored to provide a more comprehensive perspective on possible pathways and their implications for the energy transition, as follows:

Reproduced PDP
Scenario: **Rep_PDP**

This scenario is a reproduction of the draft PDP 2024 built through publicly available data

Market Dispatch PDP
Scenario: **MD_PDP**

This scenario serves as a reference to assess how the capacity mix would behave under marginal cost dispatch rules (e.g. no long-term contracts)

Cost Optimal scenario
Scenario: **OPT**

This scenario serves as a reference to assess how the capacity mix would behave dispatched under marginal cost dispatch rules (e.g. no long-term contracts)

* For example, the draft PDP 2024 didn't provide concrete capacity mix numbers for all targeted years, so the Rep_PDP scenario extracted those numbers from publicly available graphs. In addition, the generation graphs didn't show wind generation, despite significant wind capacity in the base case, so adjustment were made to reflect better this reality. Discrepancies with official PDP capacity are therefore likely.

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Fundamental cost optimisation modelling was used for this analysis, utilising published PDP data and local sources wherever possible

Inputs

- Technology-economic parameters of various technologies including , CAPEX, OPEX, efficiency, ramp limit, fuel use, emission factor, etc.
- Other macro-economic parameters like fuel costs, interest rates
- Time series and capacity factors per region for wind and solar from ERA5 and SARAH dataset
- Electricity demand timeseries per region
- …

Modelling

Total System Cost Minimisation
(using PyPSA Framework)

- Techno economic constraints
- Hourly Resolution
- Full-year co-optimisation of generation and capacity (myopic)
- Thailand represented by 5 regions

Outputs

- Optimised investments per region for each technology
- Average and hourly prices for each region
- Optimised hourly dispatch for the entire year
- Net electricity flows between each region
- Capacity factors for each technology by region
- CO_2 emission from each technology for each region
- …

Thailand is represented with 5 regions: North (NR), Northeast (NE), Center (CE), Bangkok Metropolitan Area (BKK), and South (SO). Hydropower and import generations are kept at similar levels as in the PDP data for meaningful comparison. The costs of the transmission grid were taken into account, but not the costs of the distribution grid. Transmission capacities across regions are kept constant due to a lack of information on grid development plan.

Overview of the designed scenarios

	Reproduced PDP [Rep_PDP]	**Market-dispatched PDP** [MD_PDP]	**Cost-optimal scenario** [Opt]
Narrative	Replicate the PDP2024 as closely as possible to measure (based on public data) to measure how the utilisation of different technologies differ to meet climate targets?	Reference to assess how the capacity mix would behave under marginal dispatch rules (e.g. no long-term contracts)?	Assess the cost optimal capacity expansion (without emission mitigation targets)
Capacity	Fixed as PDP	Fixed as PDP	Optimised
Generation	Optimised	Optimised	Optimised
Emission Constraint	Emission constrained to PDP (2030: 77Mt$CO_{2;}$ 2037: 63.2MtCO_2)	No	No
Hydrogen	5% blending with gas from 2030*		
Interconnection	Kept constant		

* assuming 5% increase in fuel and capital costs associated with blending, we also ran sensitivity analysis, assuming no change in costs

- All scenarios have 20% minimum must-run for coal and gas power plants.
- All scenarios include capacities of planned SPP, VSPP and IPP power plants.
- All scenarios the hydro generation, capacity and imports are matched to PDP.
- All other parameters like fuel costs, are considered constant.
- The analysis covers generation and demand from EGAT, MEA and PEA.

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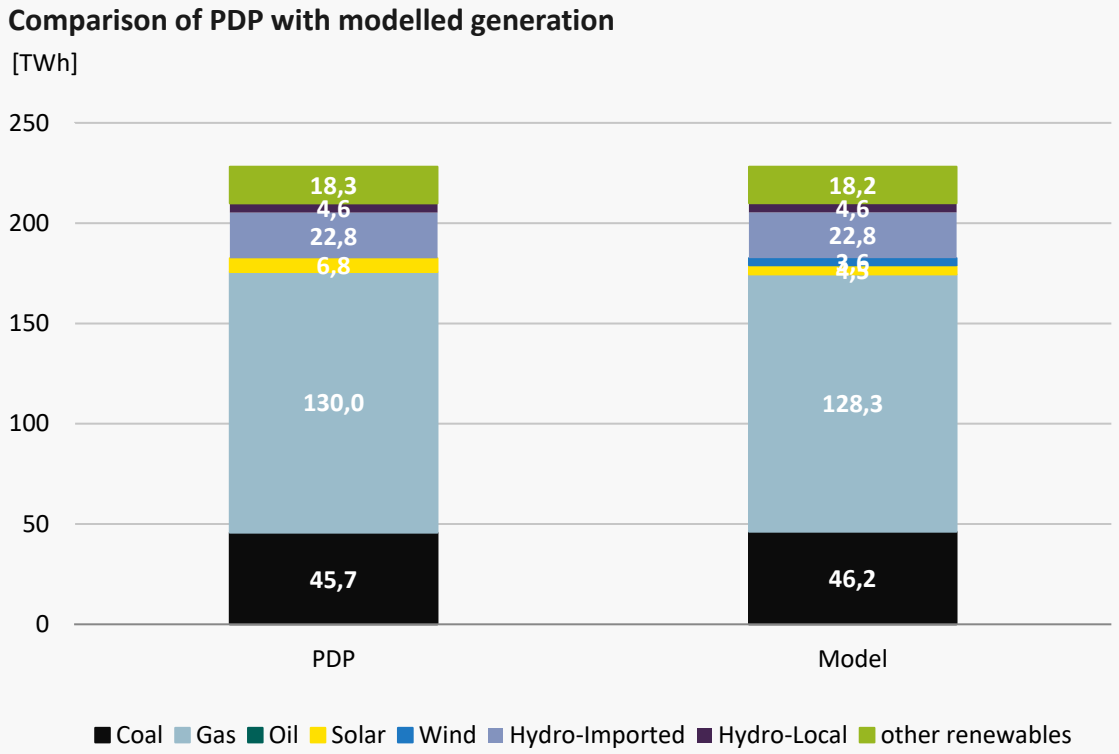
Calibrating our model to the PDP results requires the adoption of several ‘best guess’ assumptions (not disclosed in the PDP document)

The model was calibrated to match the generation in PDP for year 2023



As the methodology and several assumptions underlying the draft PDP2024 are not disclosed and publicly available, our model has been calibrated based on the following assumptions*:

- → Assumption of highly flexible operation of hydropower (local and imported)
- → Estimated fuel costs
- → Estimated coal plant utilisation rates
- → Emission factors and power plant efficiencies

With these assumptions, the model results for the base year reproduced those of publicly available data for the base year.

 * All input and output data used for our analysis can be obtained by contacting the authors of this presentation. Please send an email to tharinya.supasa@agora-energiewende.de

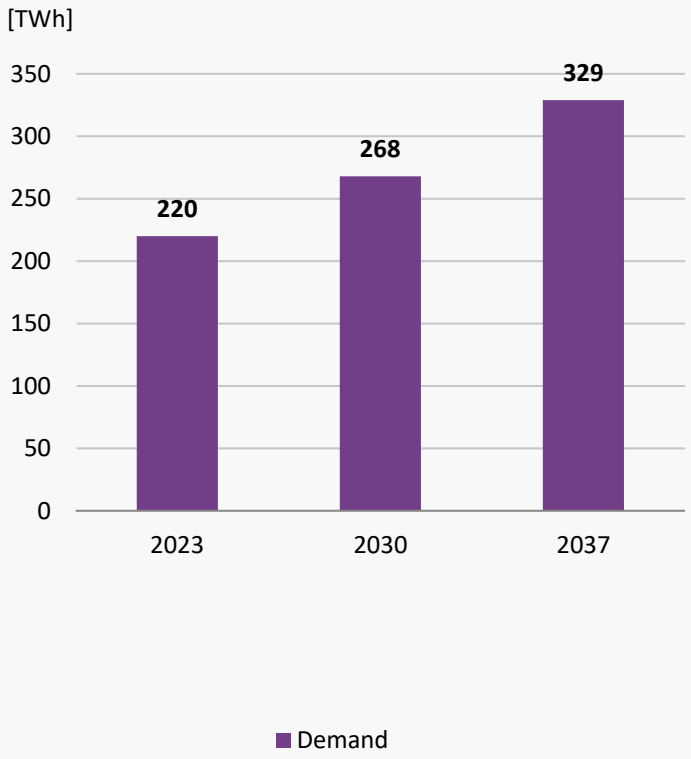
More transparent data assumptions and more information on modelling methodology would support better evidence-based analysis

Examples of a lack of disclosed methodology and assumptions:

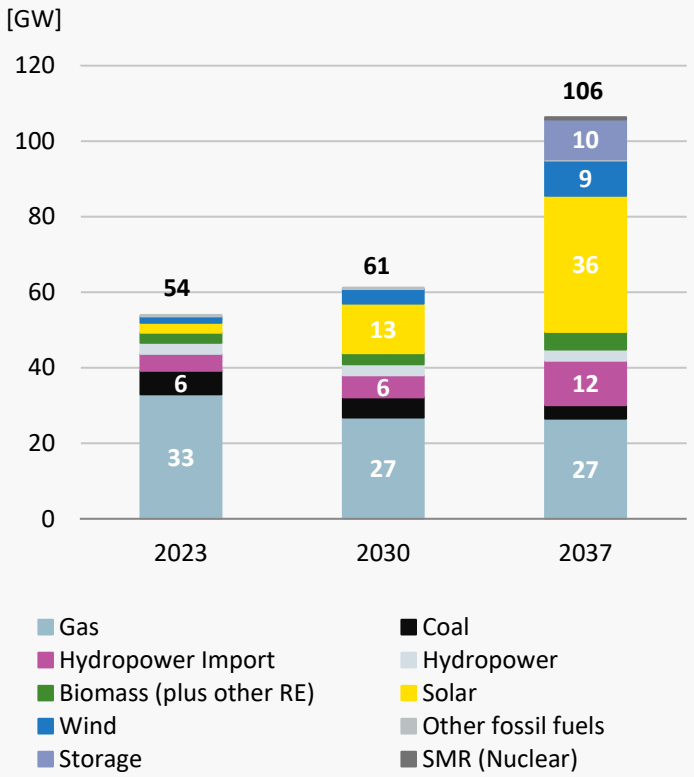
Topic	Assumption details
Interconnection between regions	No information on planned (if any) interconnection increase between the regions.
Dispatch generation	No full information about the methodology and approach to dispatch different generation technologies.
Techno-economic assumptions	Limited access to assumptions such as costs, capacity factors and operational characteristics of power plants.
Hydrogen	No full information about the source (green/blue/purple) and cost of hydrogen blending.
Batteries	The energy-to-power ratio for batteries planned in 2033 is close to 1. This is not typical for Lithium-ion batteries.

The PDP envisions a significant increase in total electricity demand and a boost in the share of generation from renewables, particularly solar, wind and hydro

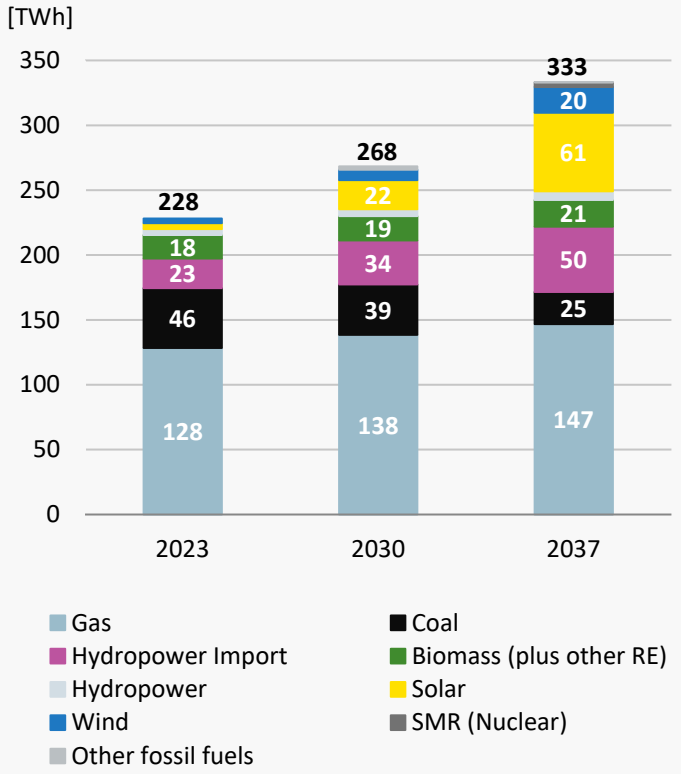
Electricity demand



Installed capacity by technology **[MD_PDP]**



Generation by technology **[MD_PDP]**



 | *From 3 utilities: EGAT, MEA and PEA

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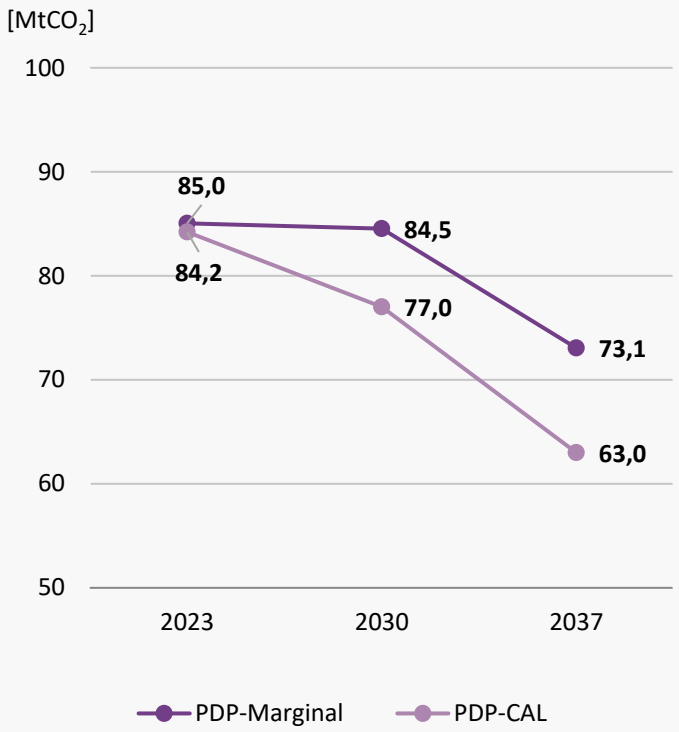
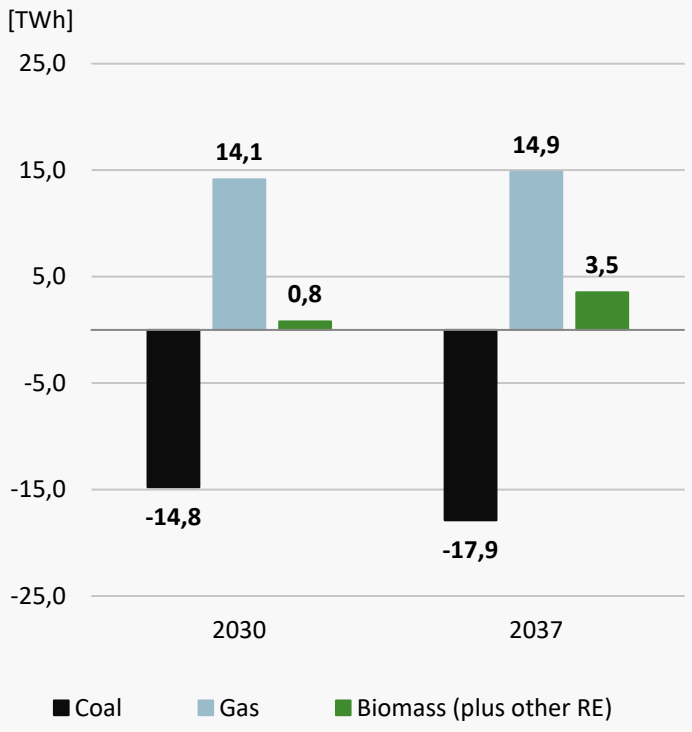
Meeting PDP emissions targets relies not only on renewables expansion but also on a coal to gas switch that requires intervention into the optimal dispatch of power plants

Difference in emissions between **Rep_PDP** and **MD_PDP**



Difference in generation in **Rep_PDP** compared to **MD_PDP**



→ In addition to the renewables capacity addition, meeting the PDP emission target requires a steep reduction of coal power generation (whose average capacity factor drops to 22% in 2037, compared to 79% under optimal dispatch conditions)

→ The average capacity factor of gas power plants reach 70% in this scenario in 2037 (compared to 63% under optimal dispatch conditions).

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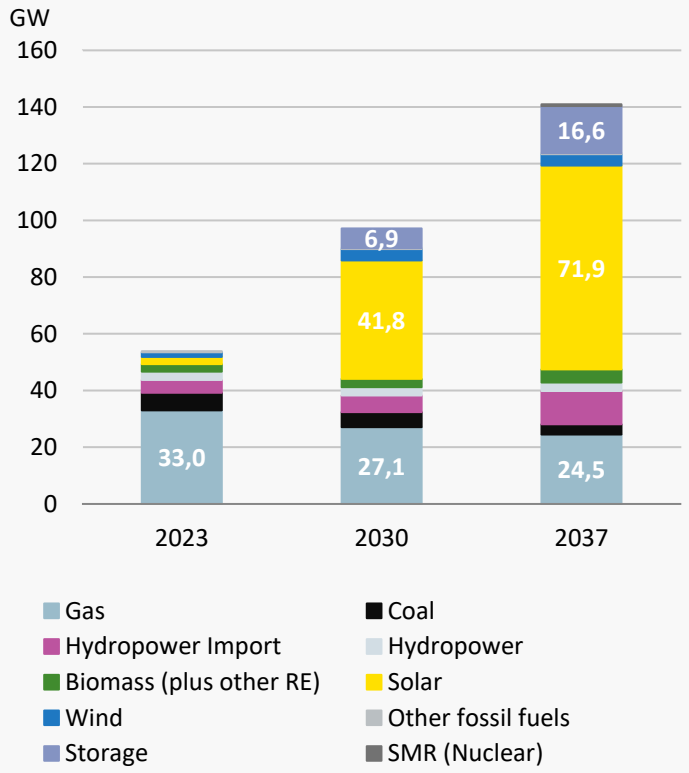
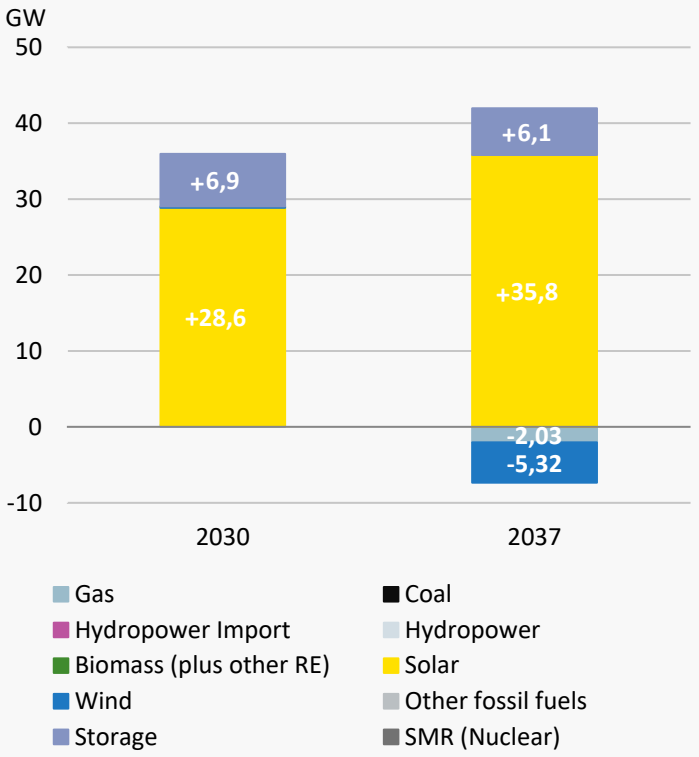
More solar PV and battery than planned in the PDP reduce overall costs. Additional co-benefits include CO_2 reduction and risk mitigation.

Installed capacity by type in **OPT**



Difference in installed capacity in **OPT** compared to **Rep_PDP**



- → Multiplying the PV target of the PDP by three in 2030 (+28 GW) and by two in 2037 (+36 GW) reduce total system costs by 10%.
- → Integrating those additional solar capacities is possible:
  - without additional gas power plant capacity but requires their flexible operation
  - requires a minimum need for additional battery storage (+6GW)
- → Additional co-benefits include emission reduction, lower LNG imports, less uncertain reliance on CCS and carbon sinks in the future

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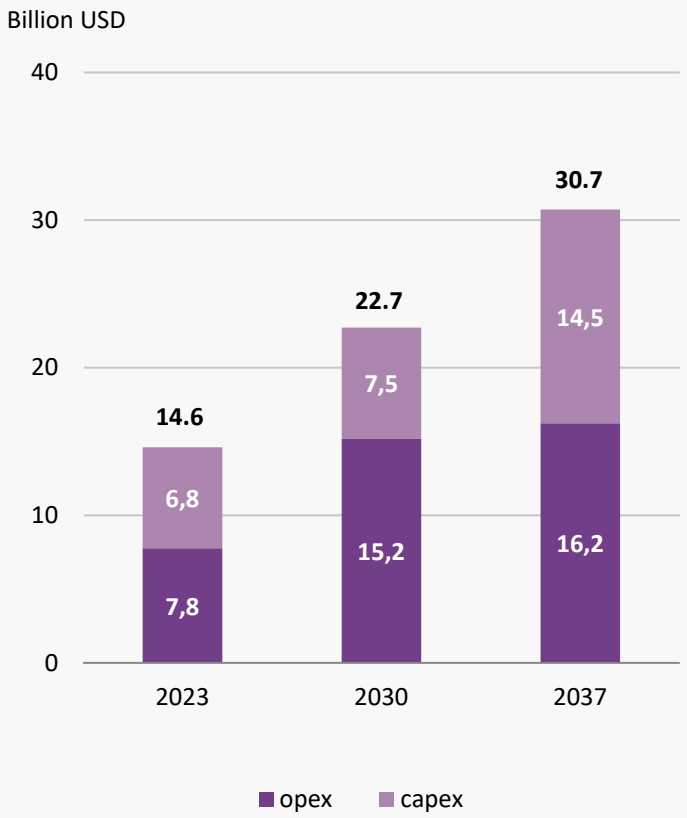
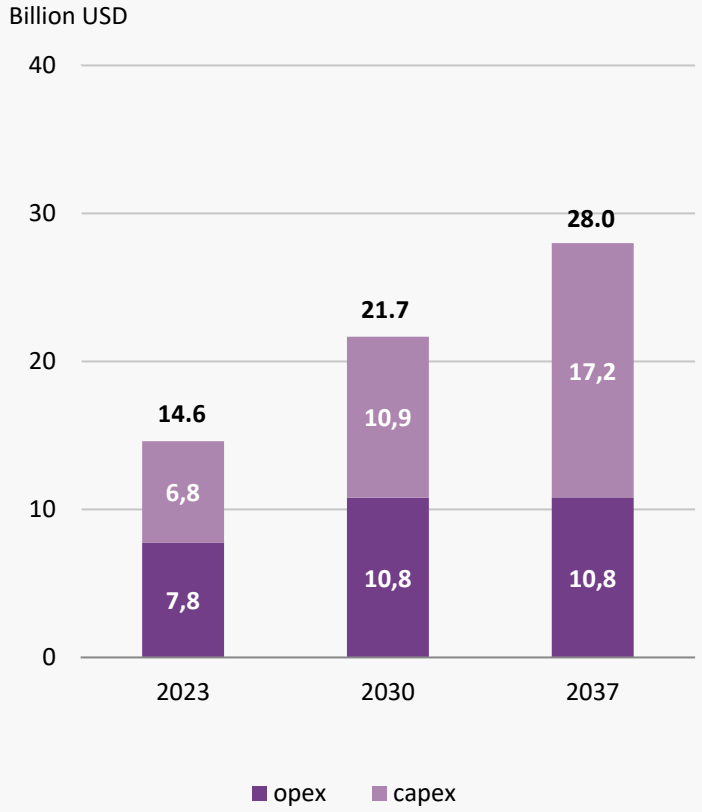
More renewables in Thailand reduce OPEX costs, in particular fuel costs, by more than five billion USD in 2037

System cost in **Rep_PDP**



System cost in **OPT**



→ More renewables lead to overall costs saving (-2.7 billion USD in 2037) thanks to a significant reduction in OPEX costs (-5.3 billion) despite higher CAPEX (+2.7 billions)

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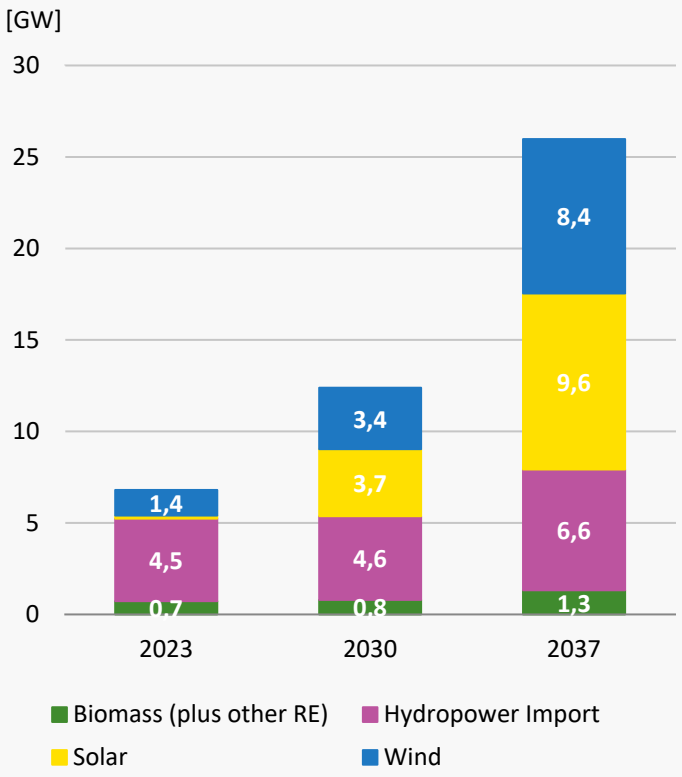
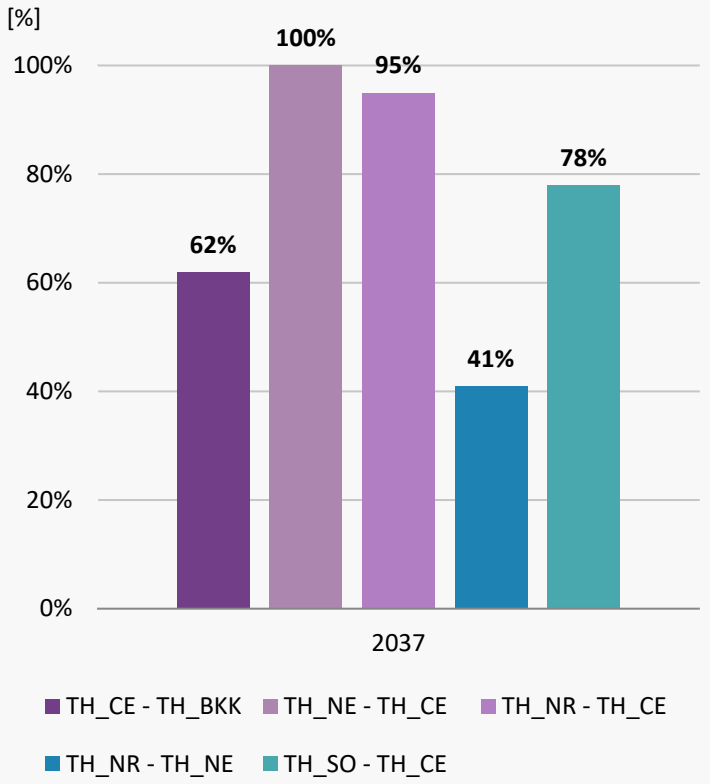
Reaping the benefit of wind and hydropower requires a reinforcement of the grid infrastructure between the north and the centre of Thailand

Capacity expansion in Northeast as planned in **MD_PDP**



Grid utilization rate in **MD_PDP**



- Northeast region has the highest wind resource (capacity factor of 25%). This is in line with PDP's plan to increase wind capacity in the region. At the same time, the PDP envisions a significant increase in hydro import and solar in the Northeastern region.
- However, to integrate this clean energy into the system, there is a need to increase the interconnection between the northeastern regions with the central region.* Further detailed analysis is required to assess the optimal capacity of interconnector.

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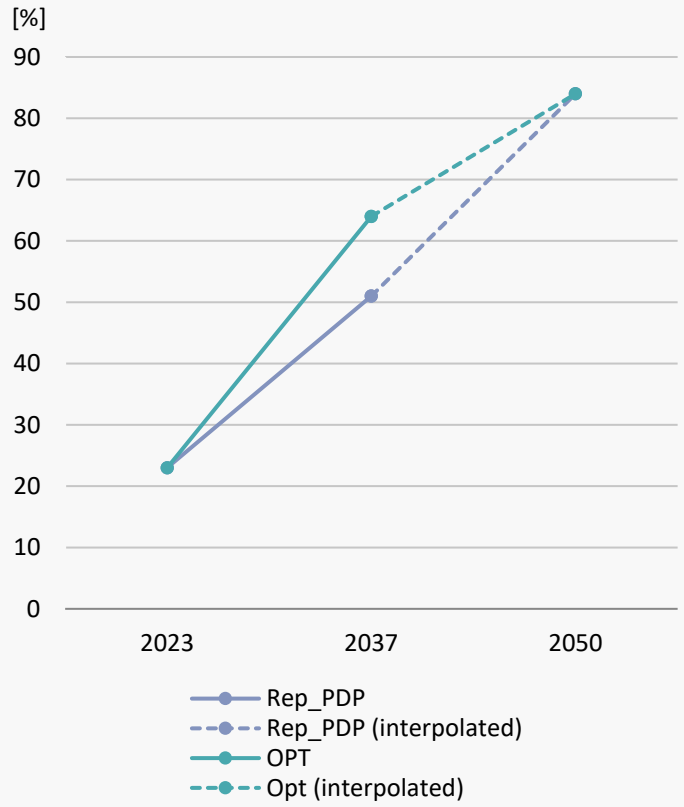
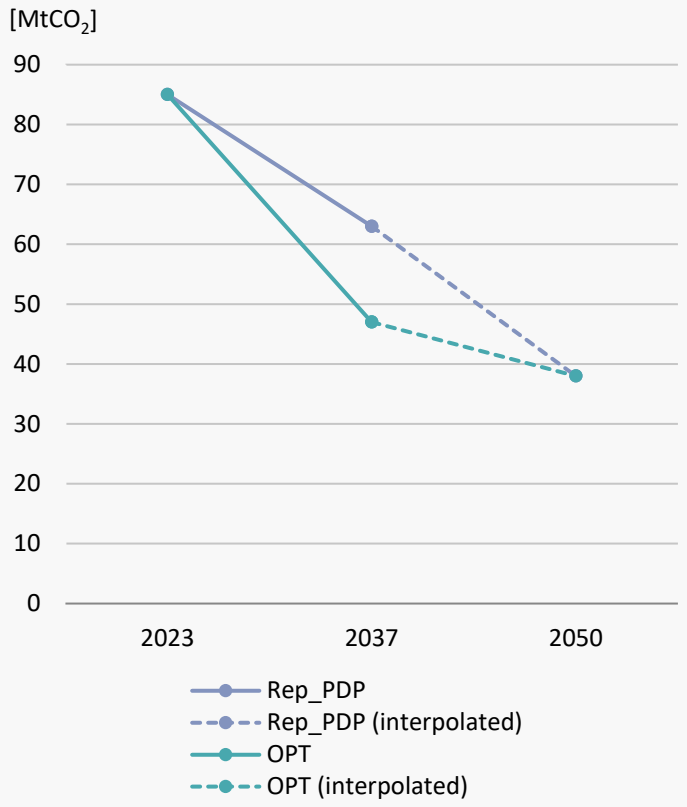
The PDP puts Thailand on a linear path to carbon neutrality. A higher ambition by 2037 would minimise costs, reduce emissions, facilitate low-carbon electrification and reduce uncertainties

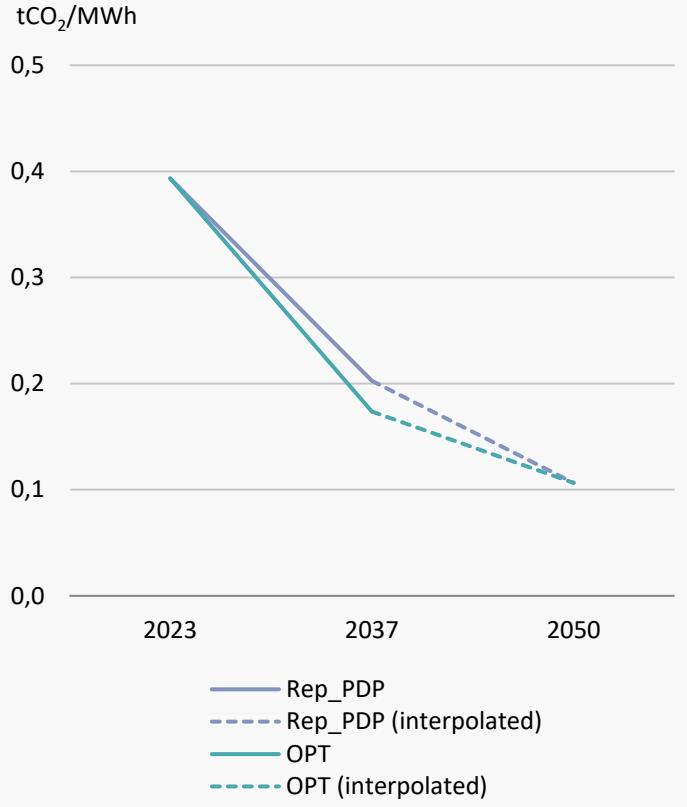
Share of Renewable in power generation



Power Sector Emissions



Grid Emission Factor



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Thank you for your attention!

Do you have any questions or comments?

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