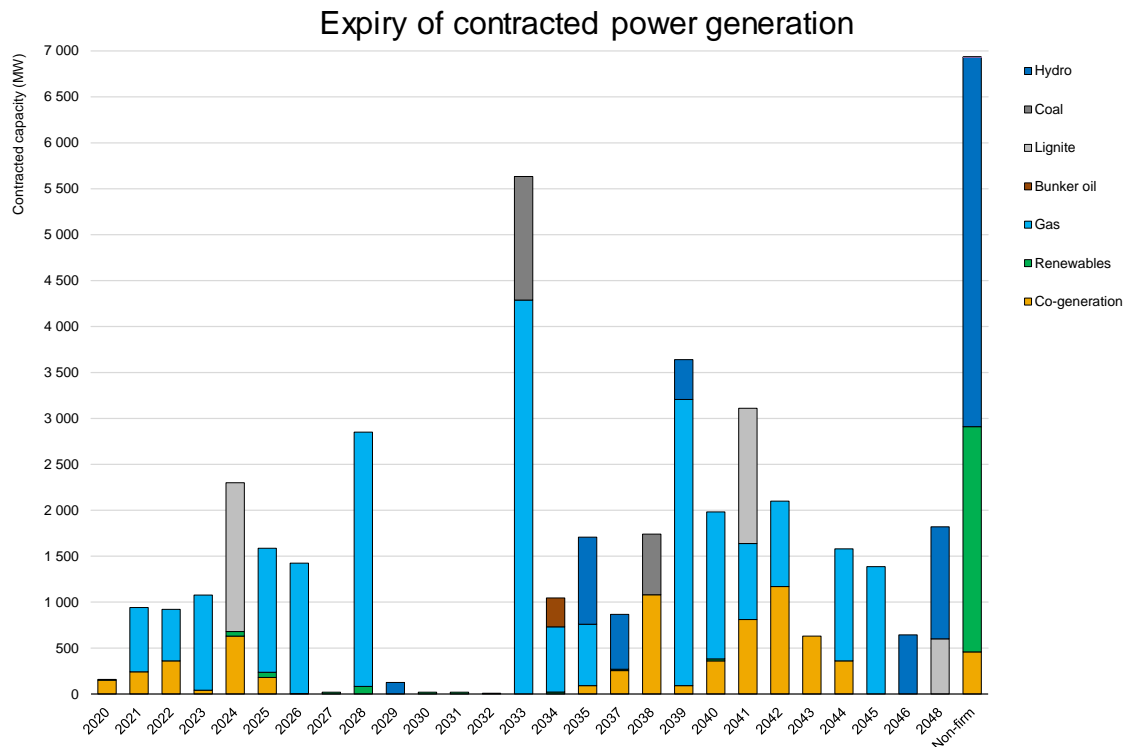


Contractual flexibility

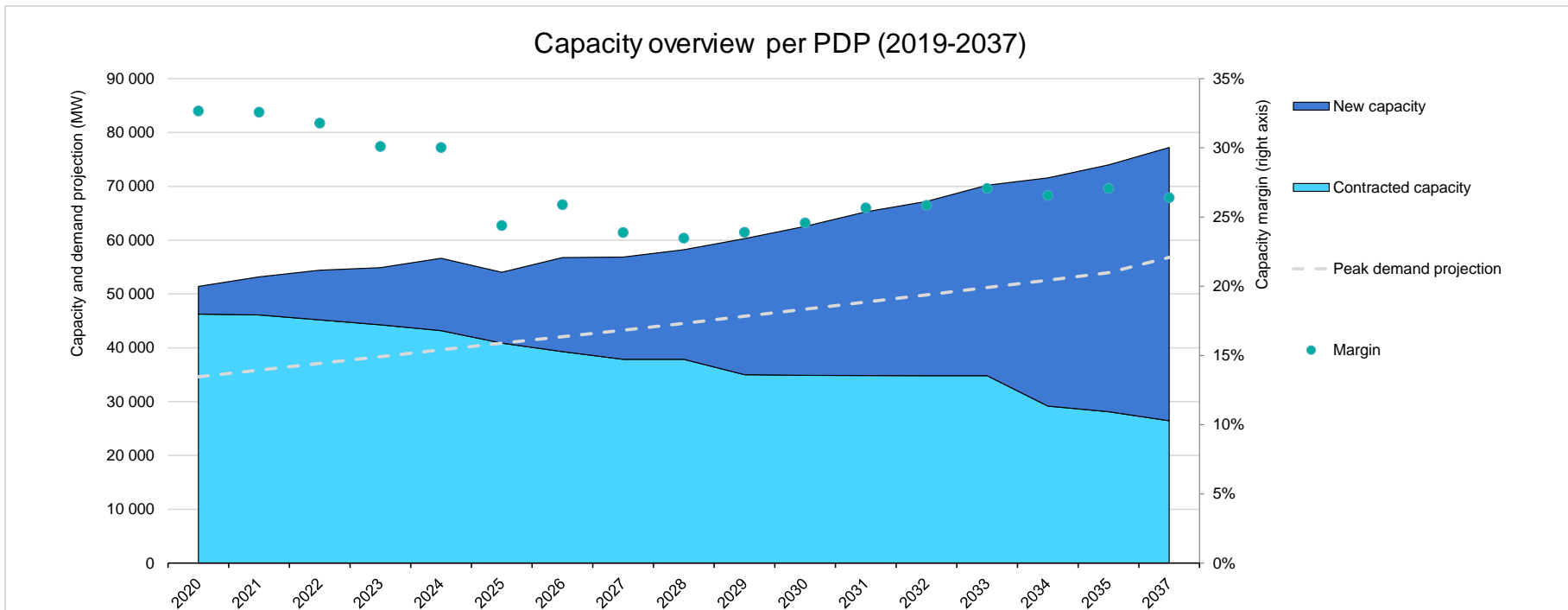
- Commercial flexibility is provided by underlying contractual structures and institutions.
- It plays a big role in unlocking the flexibility potential of electricity demand and supply (i.e. power generation assets).
- This section examines the need for increased commercial flexibility in the Thai system, both in PPAs and fuel supply contracts.
- The data used from this analysis was provided by EGAT (i.e. PPAs, PDP 2019-2037 and demand details)



Note: does not include imported hydro capacity (3 500 MW) and geothermal projects included in the 2018 PDP.

Source: EGAT

Some gas and co-generation contracts expire before 2030, while no hydro expires before 2035



Note: Capacity includes VRE and is not adjusted by capacity factor; this means that the capacity margin reflects a situation where all generation produces at full capacity

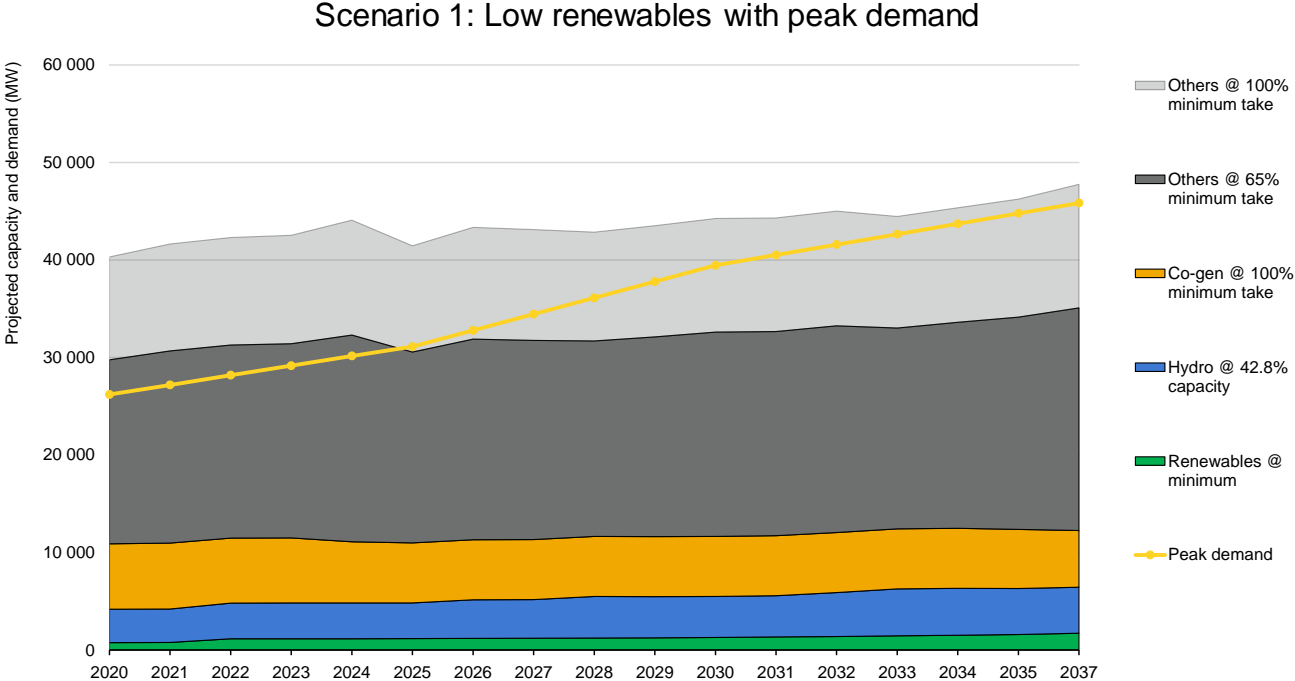
Thailand's capacity margin remains above 20% beyond 2037

Assumptions for flexibility stress test scenarios

Scenario	Level of resource availability and minimum-take obligations for conventional generation and co-generation			
	Renewables	Hydro	Conventional generation and co-generation	Demand
1	Normal VRE scenarios Minimum: per lowest capacity factor for wind (12.4%), solar (0.8%) and biomass (2.4%) Date: 26 Oct 2019 07h30 Capacity based on PDP developments	% of hydro capacity available during this period (42.8%)	Co-gen @ 100% (peak)	Peak *
2			Conv. gen @ 65%	Off-peak *
3			Co-gen @ 65% (off-peak)	Peak **
4			Conv. gen @ 65%	Off-peak **
5	High VRE scenarios (6 GW wind and 19 GW solar by 2030) Maximum: per highest capacity factor for wind (100%) and solar (93.5%) Date: 7 December 2019 13h00 Capacity based on PDP developments	% of hydro capacity available during this period (55.2%)	Co-gen @ 100% (peak)	Peak *
6			Conv. gen @ 65%	Off-peak *
7			Co-gen @ 65% (off-peak)	Peak **
8			Conv. gen @ 65% and 45%	Off-peak **

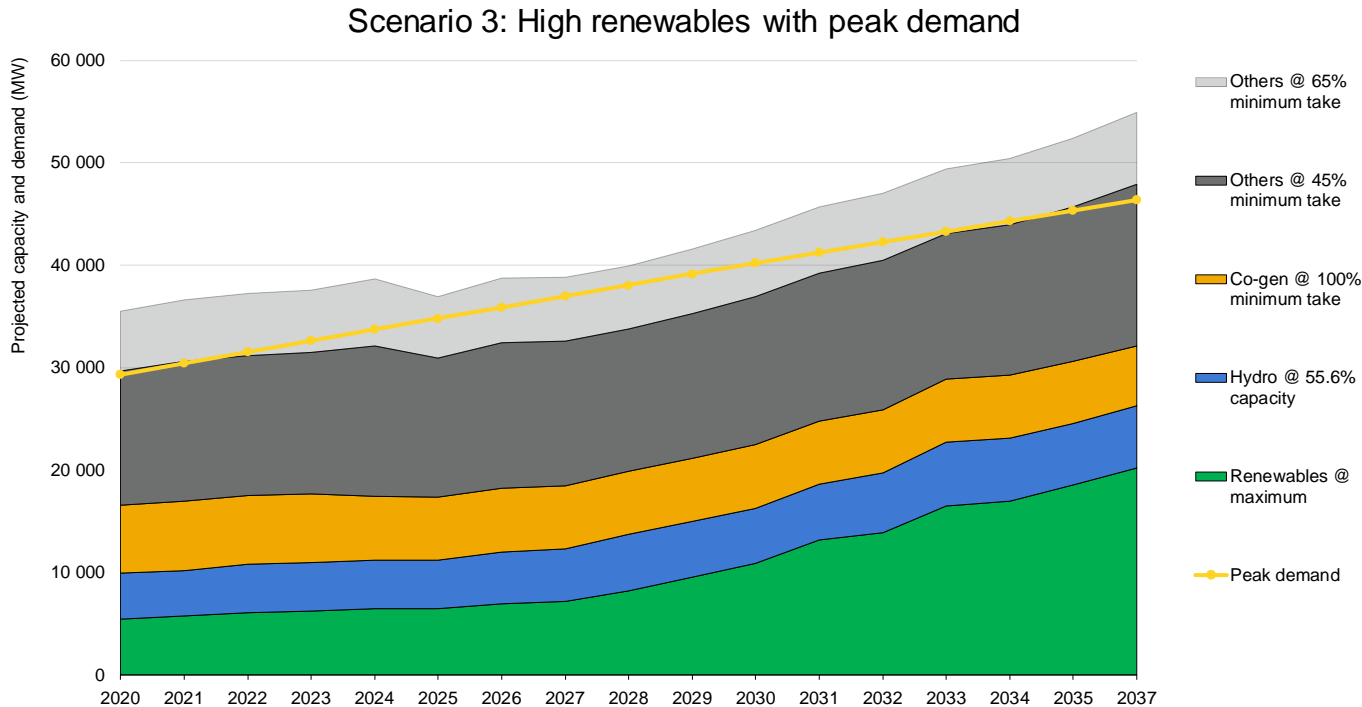
- Maximum and minimum demand during 26 October 2019 (minimum demand 04h00 to 04h30 and maximum demand 07h00 to 07h30).
- ** Maximum and minimum demand during 7 December (minimum demand 03h30 to 04h00 and maximum demand 06h30 to 07h00). Off-peak timing in Thailand varies according to the season, and are not fixed night-time hours.

Flexibility analysis results



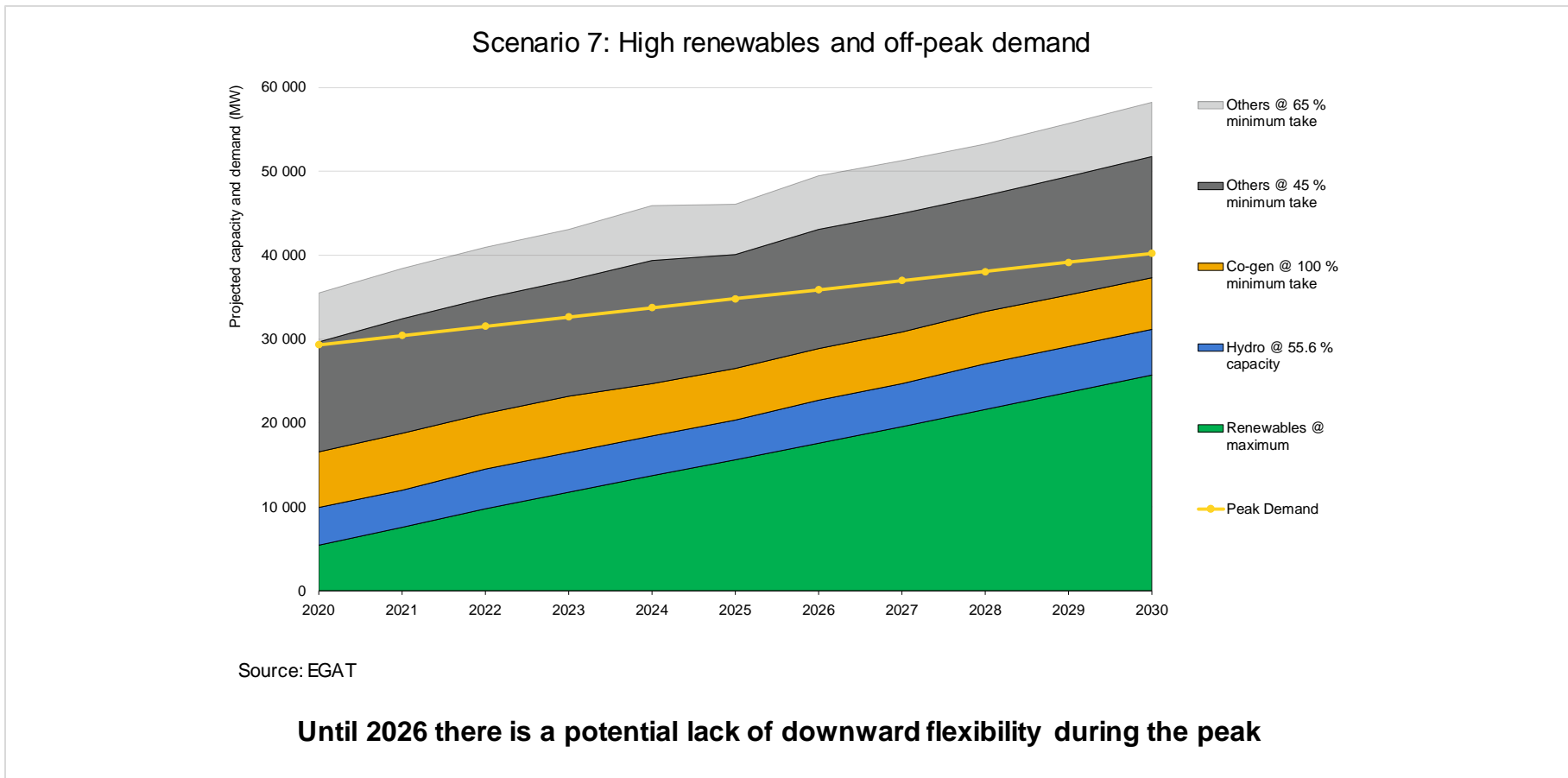
Source: EGAT

Until 2026 there is a potential lack of downward flexibility during the peak



Source: EGAT

The peak demand absorbs most of the minimum-take generation during the peak

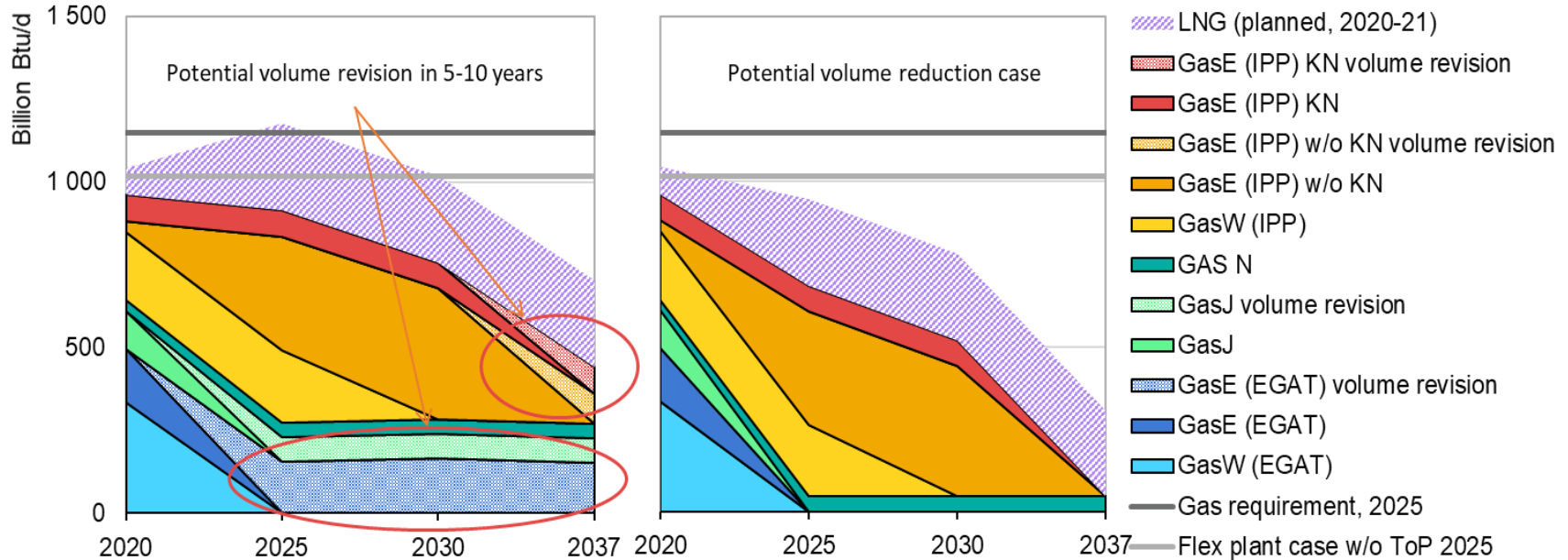


- Restructuring active contracts opens an opportunity to utilise technical flexibility.
- With multilateral power trade, EGAT can establish more flexible market solutions.
- Relaxing minimum take obligations gives EGAT the option of optimally dispatching on the basis of a Marginal Cost of Production
- Restructuring of contracts needs to be done with extreme care to ensure a healthy investment environment. An auction principle could allow voluntary and competitive provision of flexibility.

- Changing contractual structures should not be taken lightly
- If done incorrectly it can damage investor confidence and increase the cost of the clean energy transitions
- Creating an auction is a good option for increasing flexibility
- The auctions can define what characteristics should change and contract holders can bid for it
- Before launching an auction it is important to hold stakeholder consultations
- EGAT and IPPs should be able to bid in on equal terms

- Like minimum take obligations in PPAs impact flexibility so does fuel supply contracts
- In Thailand especially gas contracts impact power system flexibility
- Take or pay obligations impact the marginal cost of generation for example daily take or pay obligations
- Gas turbines are technically some of the most flexible thermal plants
- They can ramp very fast and thus are able to contribute positively to the ramps created for example by Solar PV
- However when take or pay obligations are present they may effectively have the same marginal cost as renewable energy because fuel is a sunk cost

Reduction of take-or-pay volumes



Adjustments to current contracts can help ensure flexibility from gas turbines

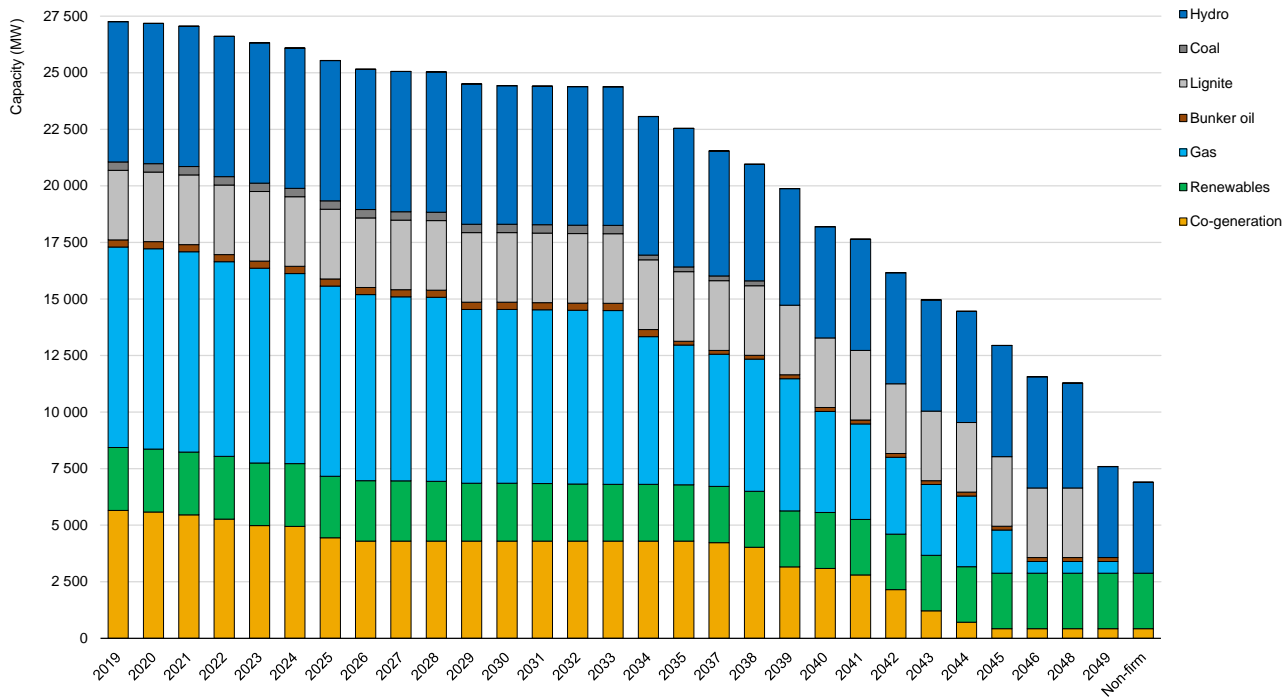
- Ensuring fuel needs to take three considerations into account
 - Security of supply
 - Flexibility
 - Affordability
- LNG is a very flexible with offtake obligations that are monthly or even yearly
- Other instruments like options can also be used to ensure security of supply
- While the flexible gas contracts are more expensive overall fuel costs should go down with the portfolio approach
- The minimum stable fuel can be bought via inflexible contracts but they should be supplemented by more flexible contracts to account for demand that can vary due to VRE

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Additional slides

Yearly evolution of minimum-take capacity in all contracts



Source: EGAT

Minimum-take capacity only starts to significantly decline after 2034

Assumed minimum-take capacity by technology

Technology	Minimum-take capacity
Cogeneration (firm)	100% (peak) and 65% (off-peak) of declared capacity
Cogeneration (non-firm)	100% of declared capacity
Renewables (firm and non-firm)	100% of declared capacity
Gas, bunker oil, lignite, coal, hydro (imports)	Minimum generation of declared capacity per unit
Geothermal	100% of declared capacity
Diesel	None
Hydro (EGAT)	100% of declared capacity

The assumptions represent the restrictions in current PPAs and form the basis of our commercial flexibility analysis