QVIST CONSULTING

THE ESTONIAN POWER SYSYEM

Future Security of Supply

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FERMI.

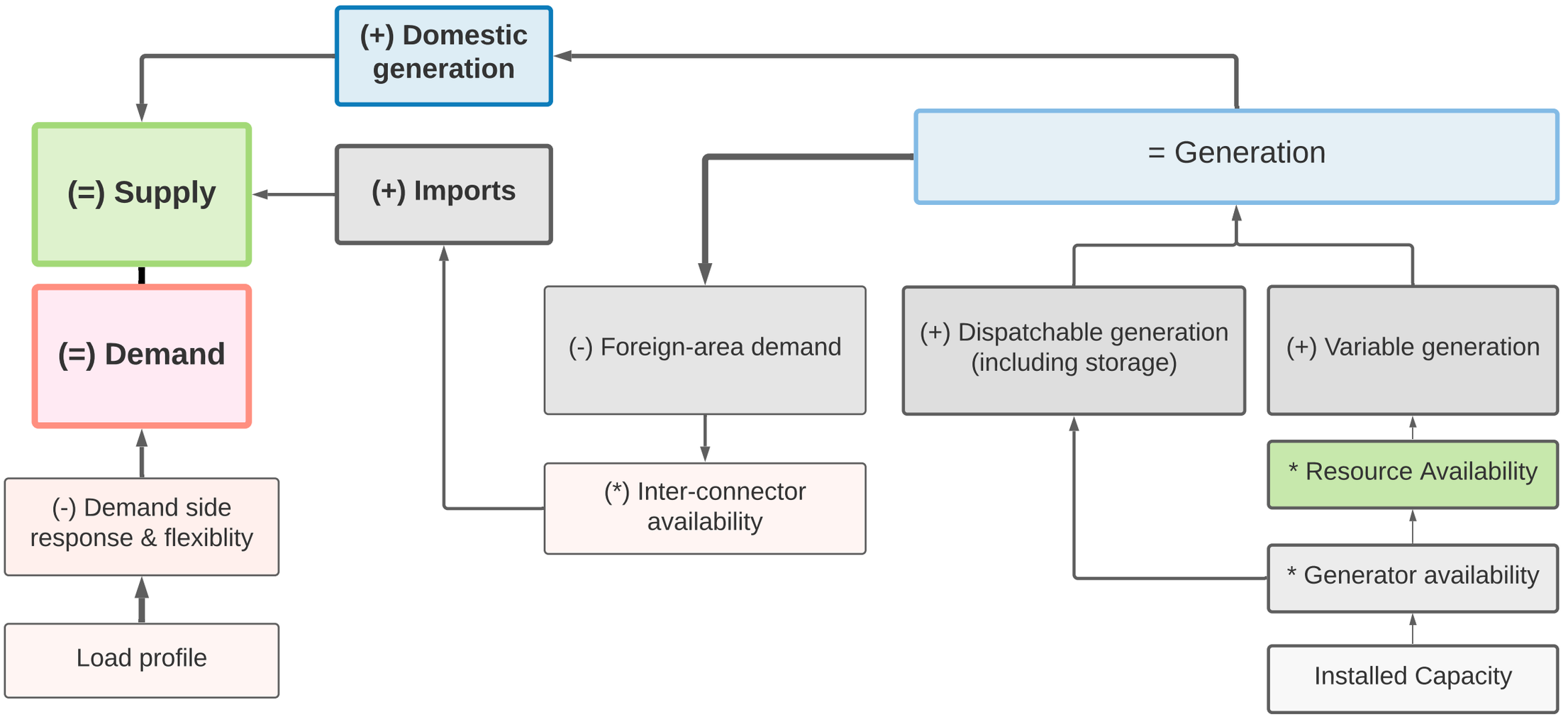
The current system

- The Estonian energy system is unique globally, historically based almost entirely on local oil shale (põlevkivi)
- Electricity production from oil shale (80+ % of total) is centered around the Narva power plants (Eesti, Balti, Auvere)
- Until recently, oil shale was supported as a resource for ensuring Estonia's electricity supply and energy security
- Extremely high emissions, up to 1500 gCO_2/kWh, means continued longer-term operation is untenable
- Oil shale is now shutting down, to be “replaced” mainly by imports. What are the implications for security of supply?

Ensuring security of supply

Simplified supply pathways:

Domestic dispatchable generation + Domestic variable generation + Imports



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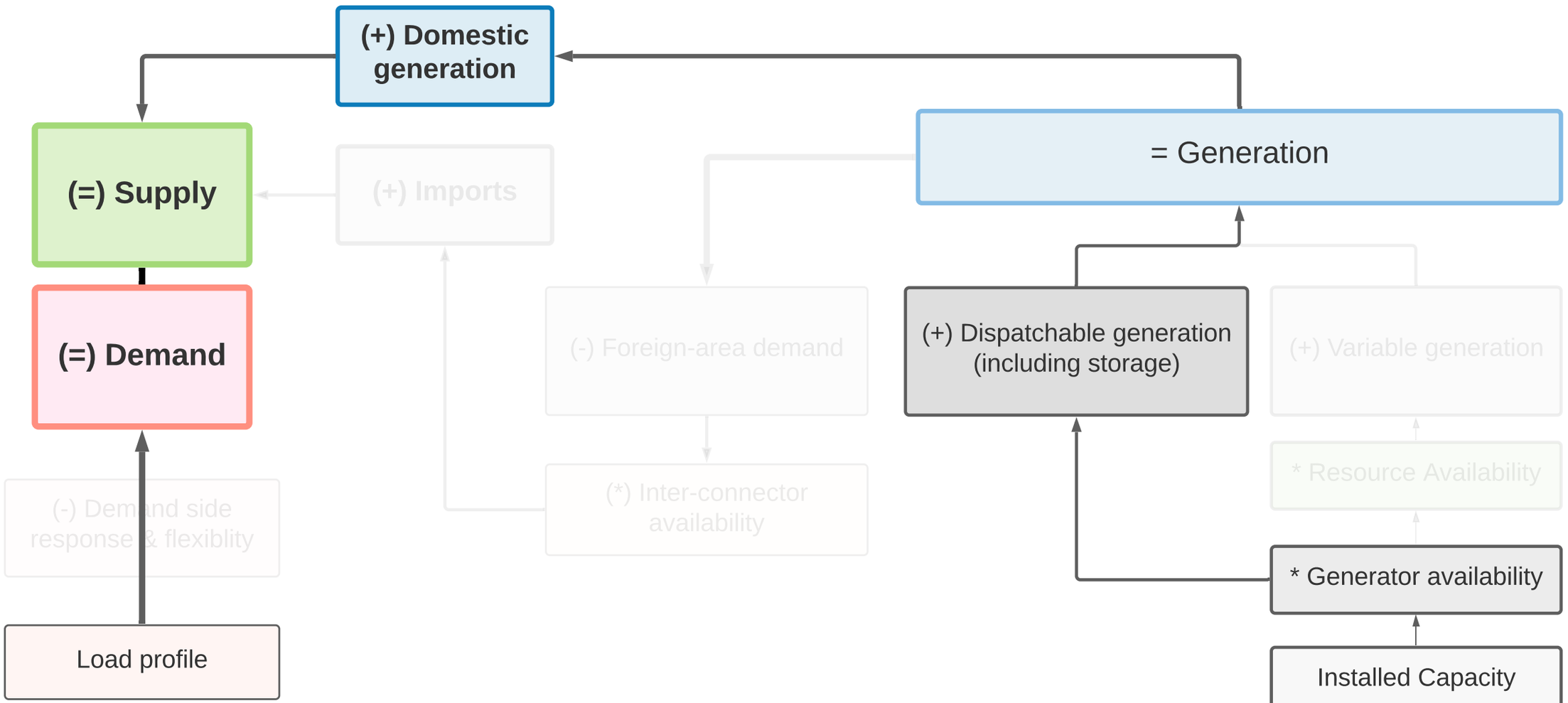
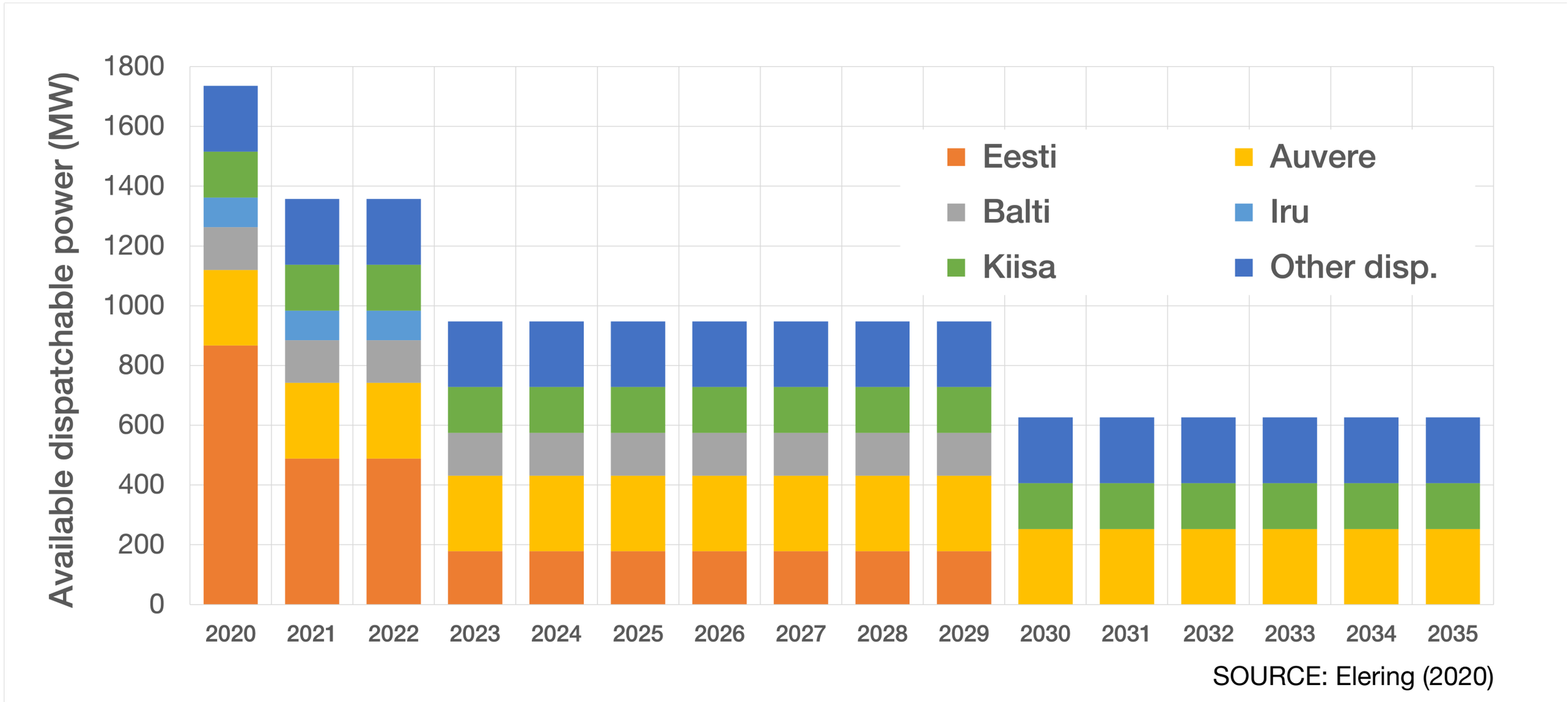


Domestic dispatchable

Balti and Eesti power plant: gone by 2030?

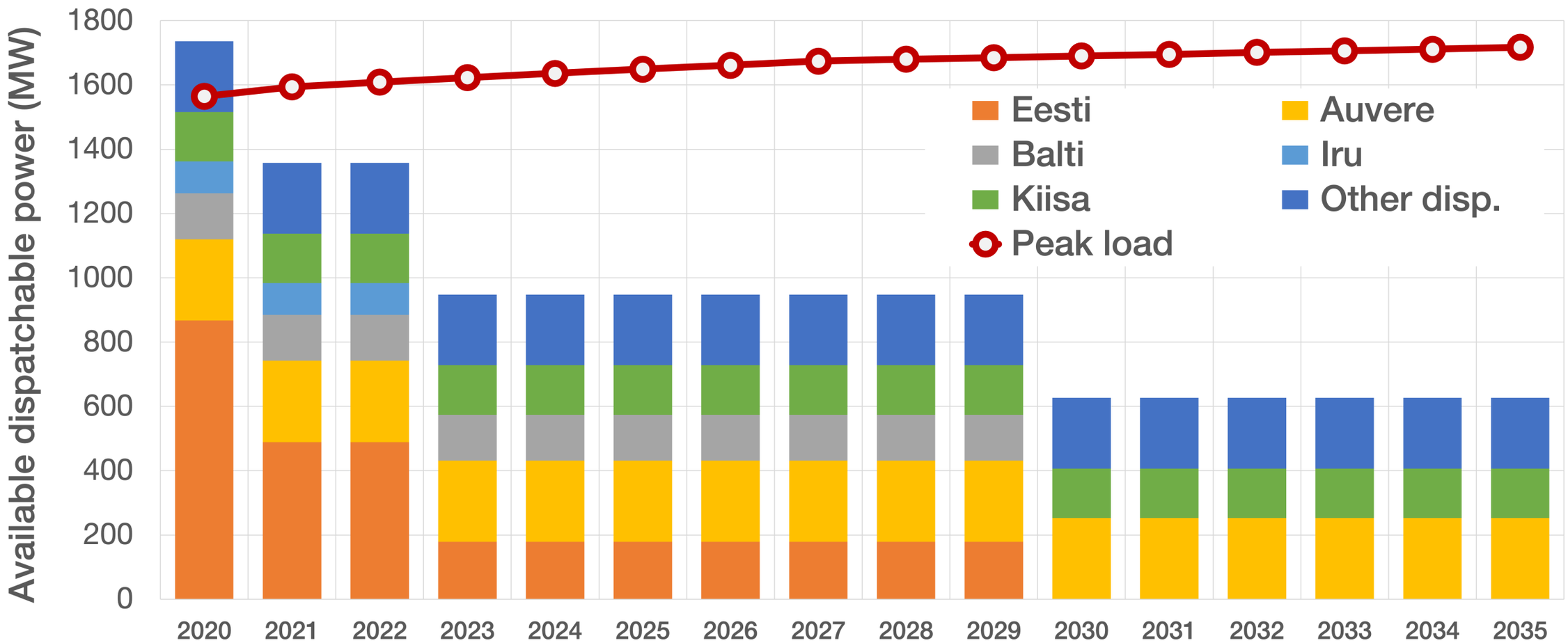
Iru power plant: gone by 2023?



SOURCE: Elering (2020)

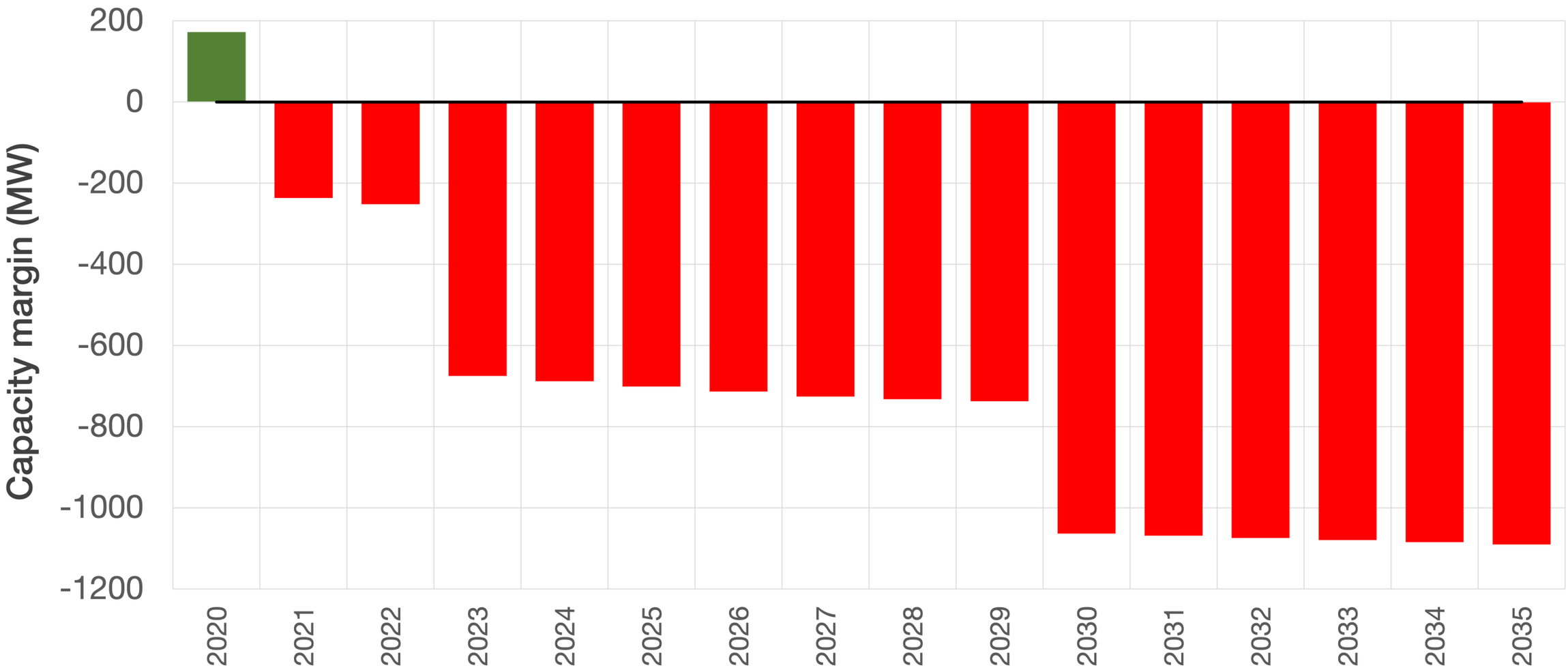
Domestic dispatchable

Expected peak load is slowly rising: 1564 MW in 2020 to 1717 MW in 2030



Domestic dispatchable

Capacity margin compared to peak demand from dispatchable generation is already negative. Dropping to -675 MW in 2023 and maybe -1 GW in 2030.



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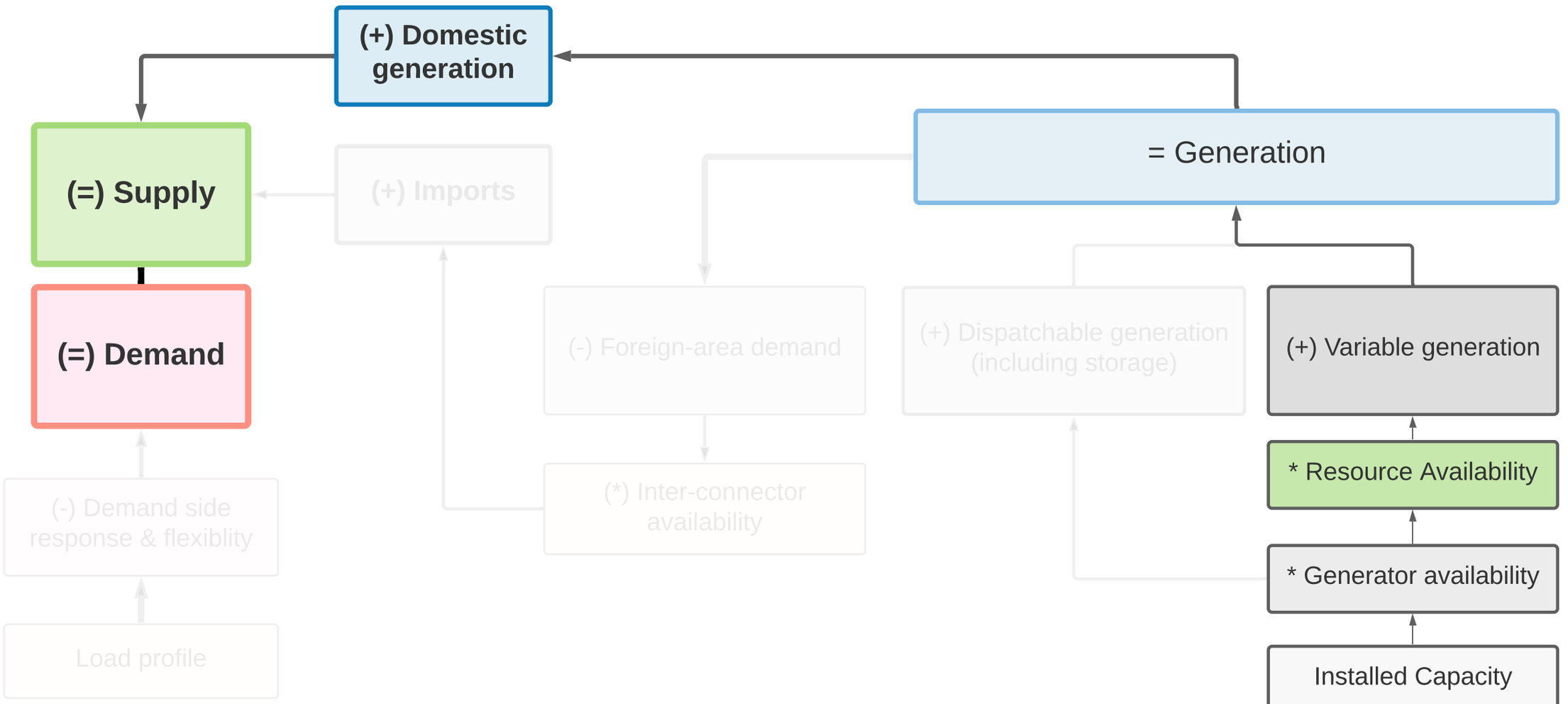
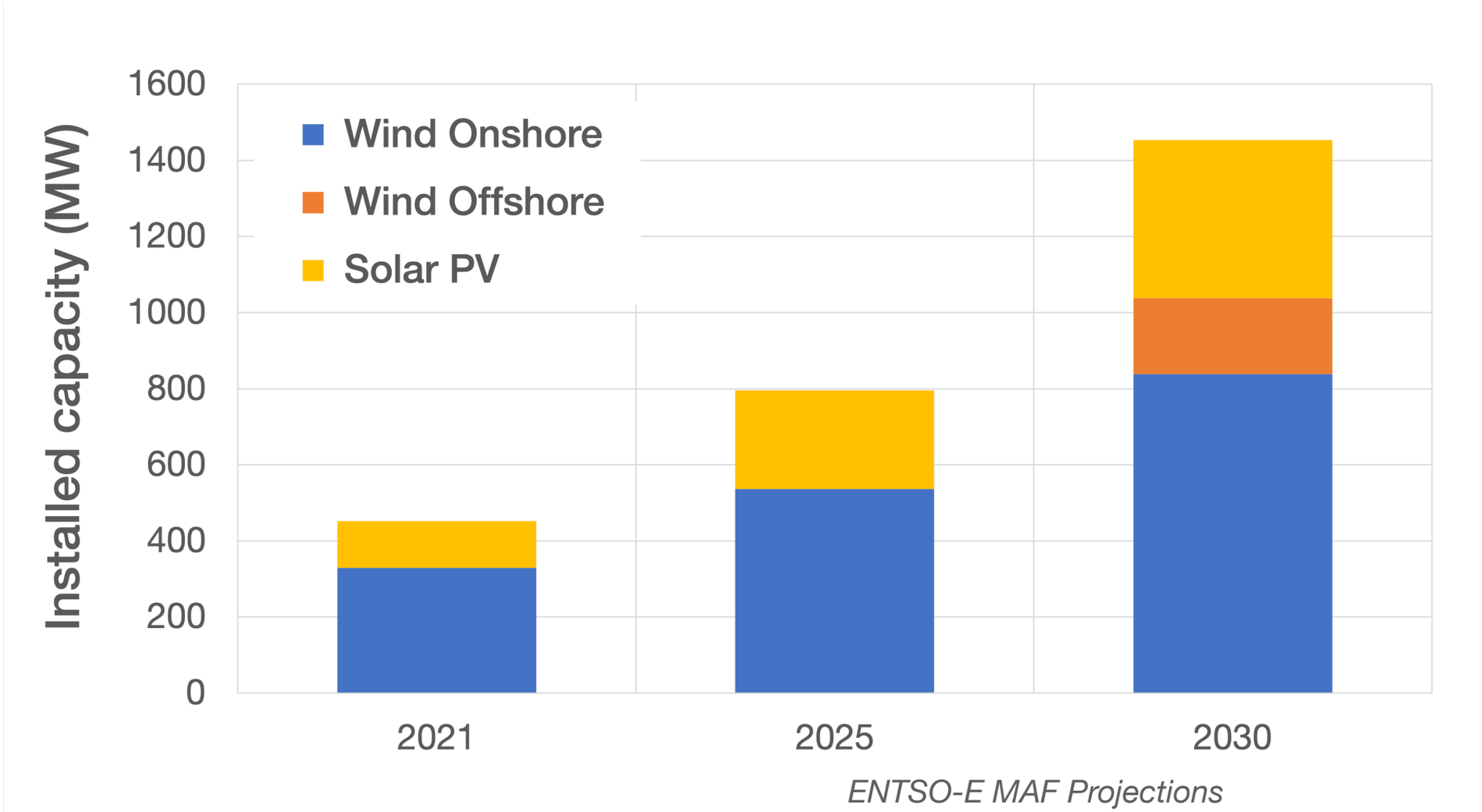


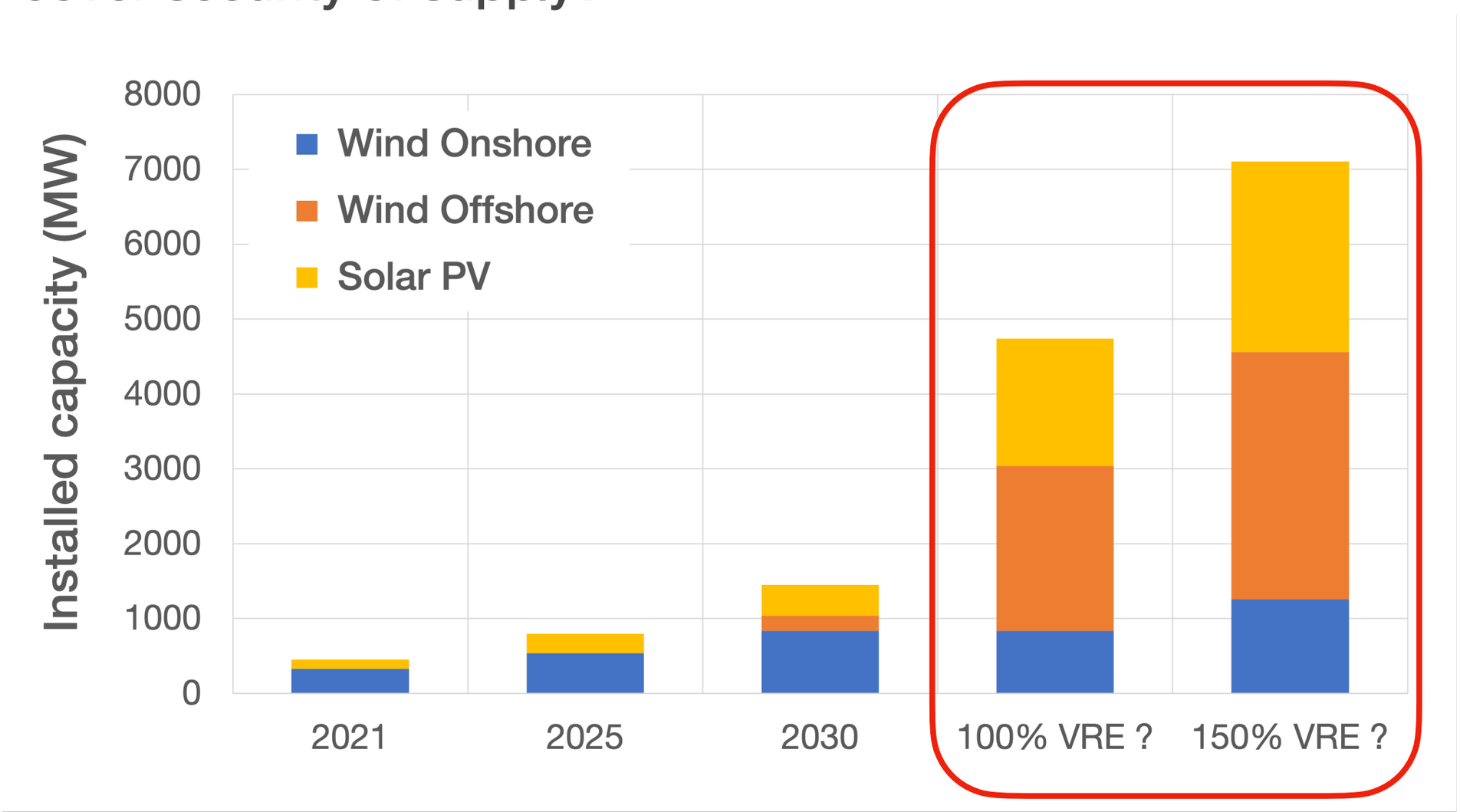
Domestic Variable Renewable

- Estonian variable renewable generation (wind and solar PV) is expanding. Expected to to be able to generate up to 1/3rd of annual demand by 2030.
- Elering (grid operator) assigns zero capacity credit to VRE, meaning they do not count toward security of supply. Is this reasonable going forward?



Domestic Variable Renewable

- At a VRE capacity equal to annual demand (“100% RE”) or 1.5 times annual demand, what capacity credit could be assigned to VRE?
- How much additional *dispatchable* capacity is required to *domestically* cover security of supply?



Domestic Variable Renewable

Data

Study of 35 years weather data (1982 to 2017) for hourly capacity factors of solar and wind (resource adjusted with *modern technology*) and hourly load profiles adjusted for historic temperature conditions from ENTSO-E

Question

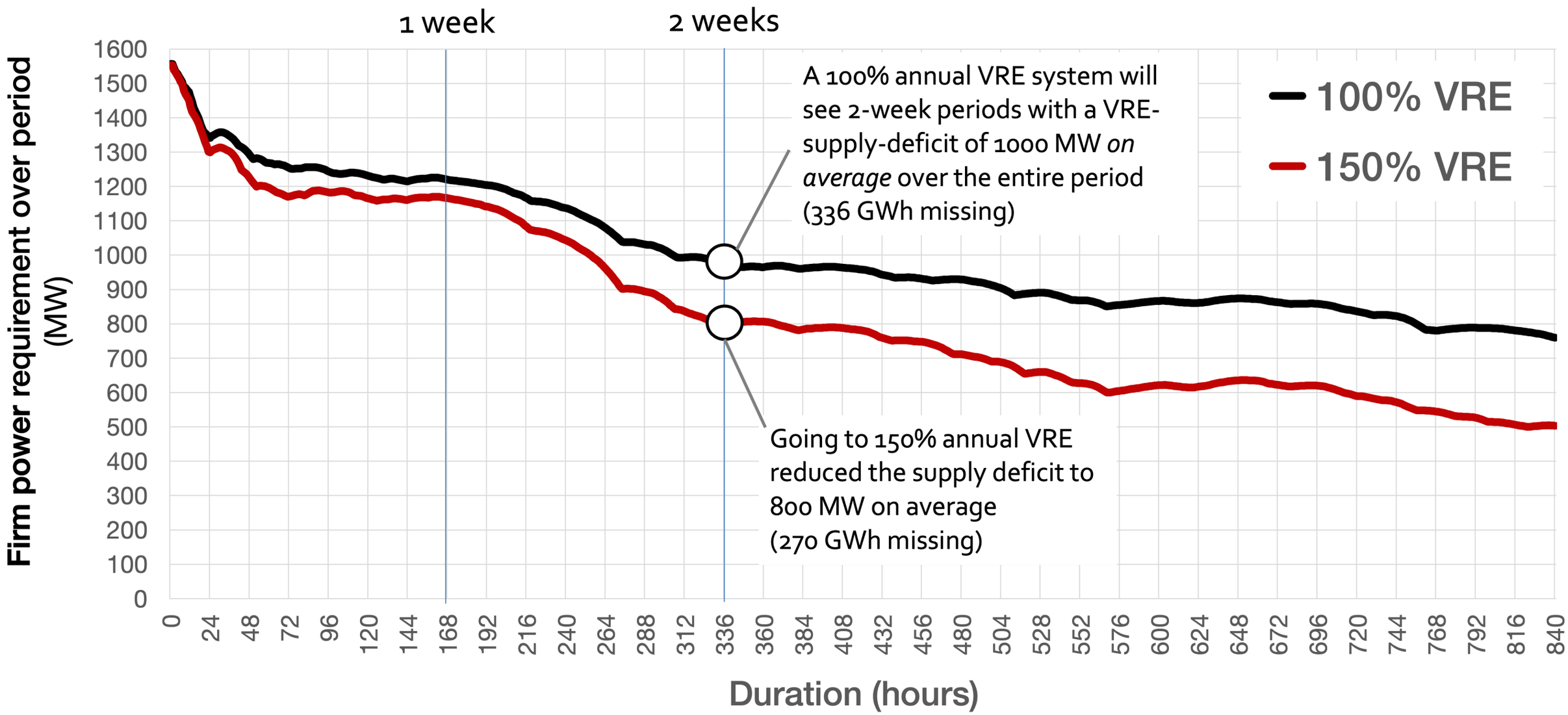
What is the biggest difference between VRE output and demand over a certain time period, stretching from a single hour to 4 weeks?

Follow-on study (not yet performed)

What is the frequency of occurrence (probability) of various VRE supply deficit events over different time periods?

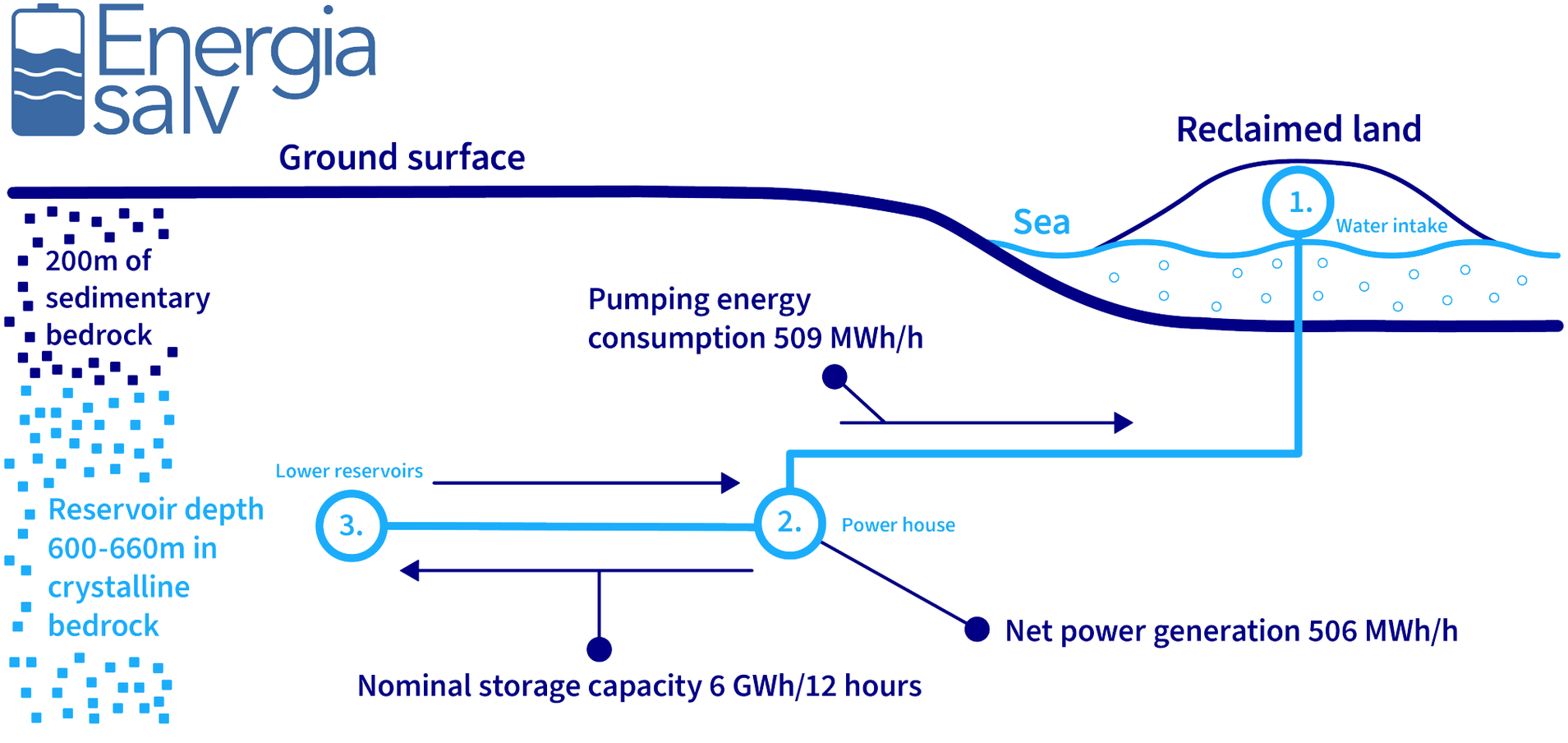
Domestic Variable Renewable

How does the amount of required dispatchable capacity change with increasing levels of VRE capacity over time periods from 1 hour to 4 weeks?



Large scale storage

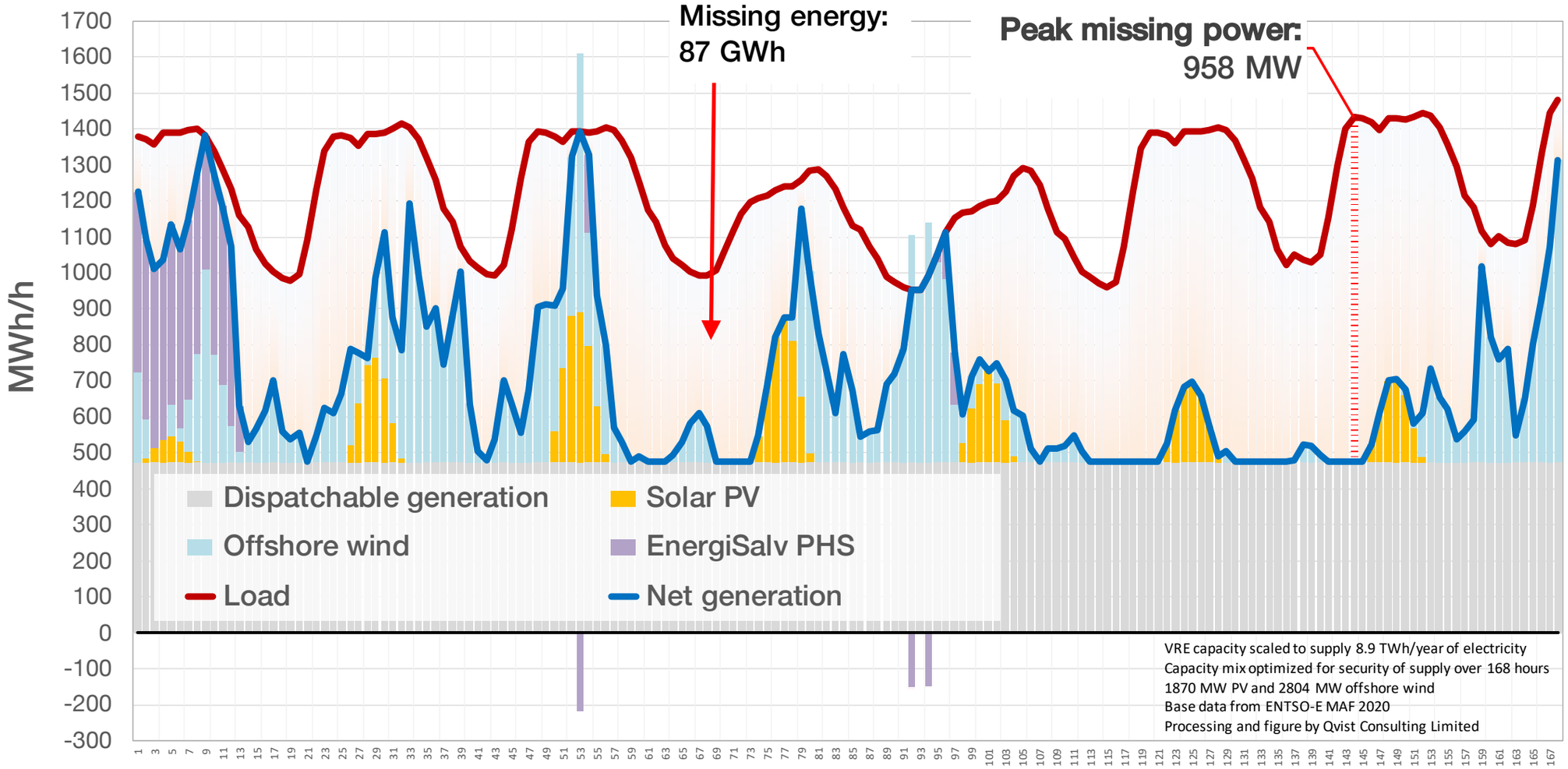
The EnergiaSalv project aims to have a 6 GWh / 500 MW pumped hydro storage plant in operation in Paldiski by 2028



Challenging weather week

All dispatchable power running (475 MW), storage fully charged (6 GWh), and an *optimized* VRE system large enough to supply 100 % of annual electricity needs (1.87 GW PV, 2.8 GW offshore wind).

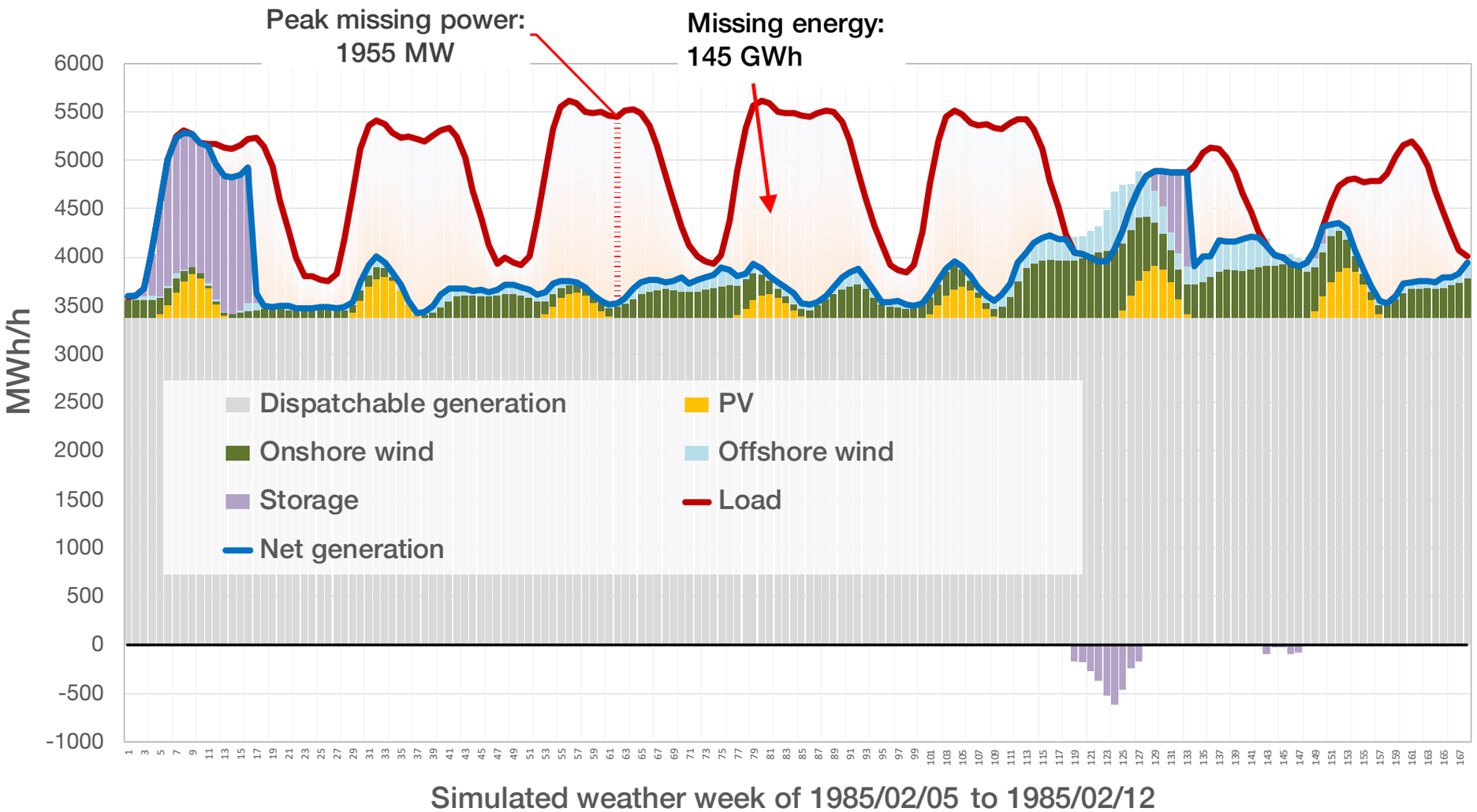
- **Still missing: 87 GWh of energy over the week, 958 MW of capacity!**



Baltic Integrated Power System

Very optimistic dispatchable capacity (3.4 GW), EnergiaSalv+Krounis fully charged (17 GWh), and 4900 MW of installed VRE capacity (ENTSO-E target for 2030)

- **Still missing: 145 GWh of energy over the week, 1955 MW of capacity!**



Ensuring security of supply

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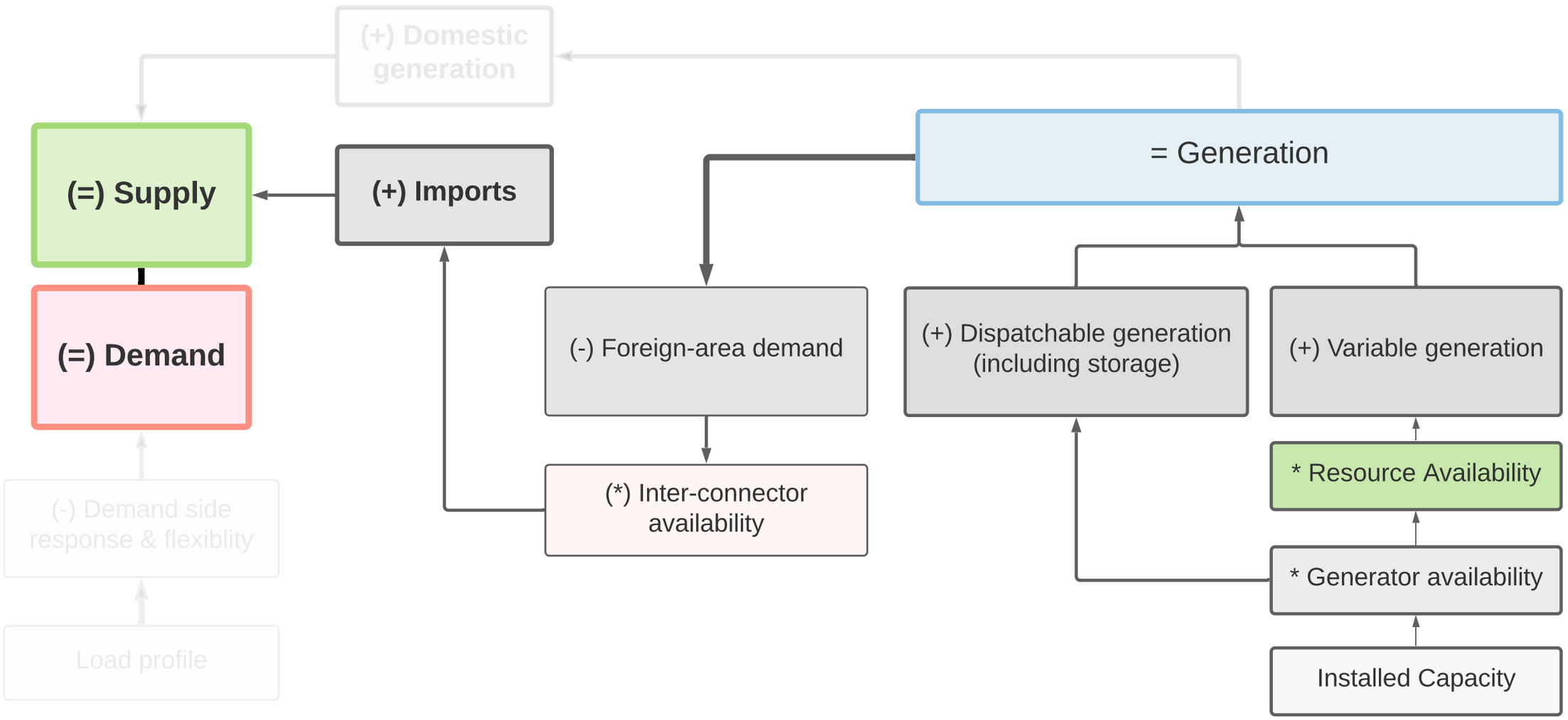
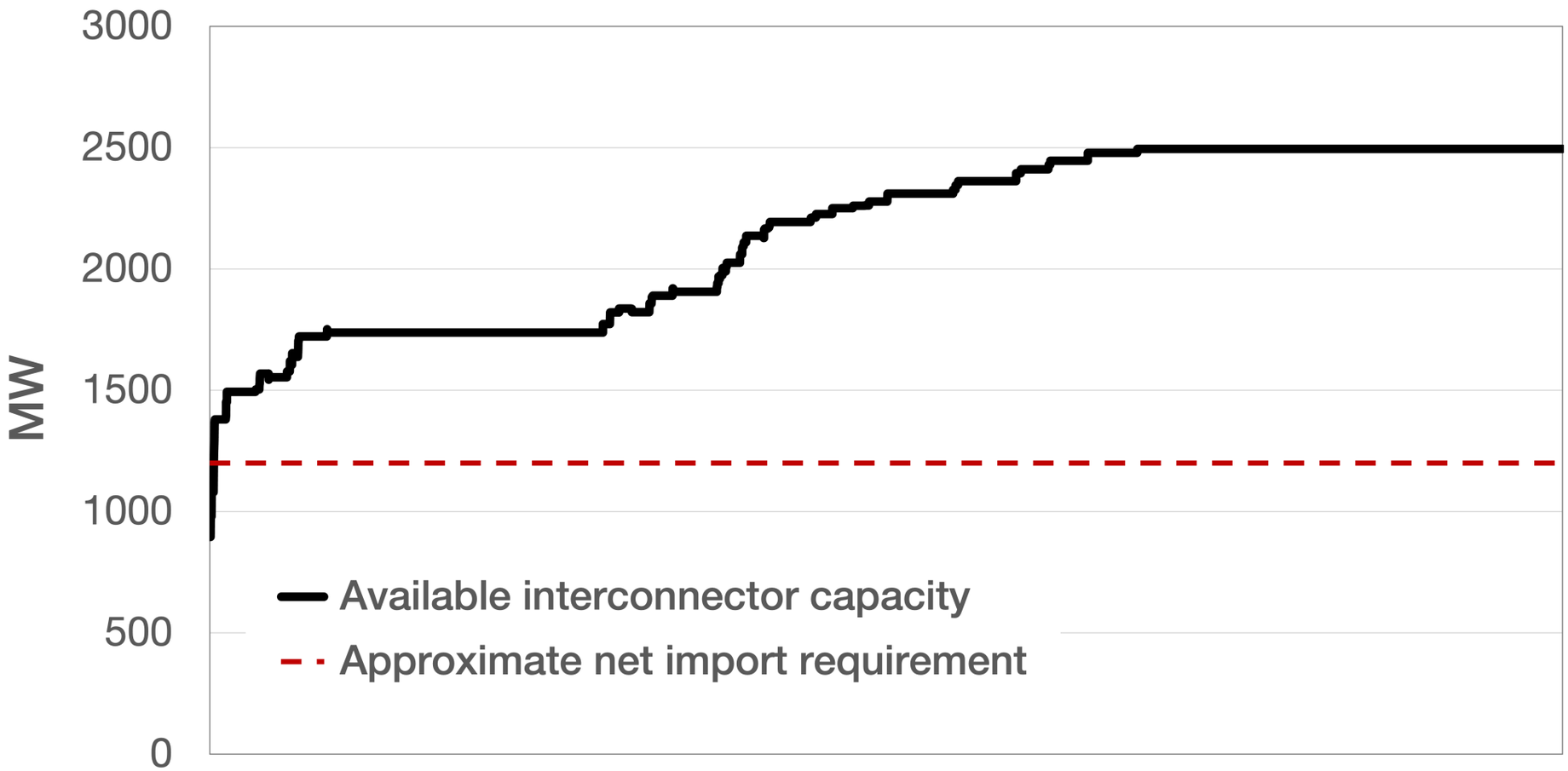


Estonia Direct Imports

Future total interconnector capacity, once the third Latvia-Estonia cable is in operation, appears sufficient to cover import needs. Our statistical analysis predicts sufficient capacity available >99.7% of annual hours.



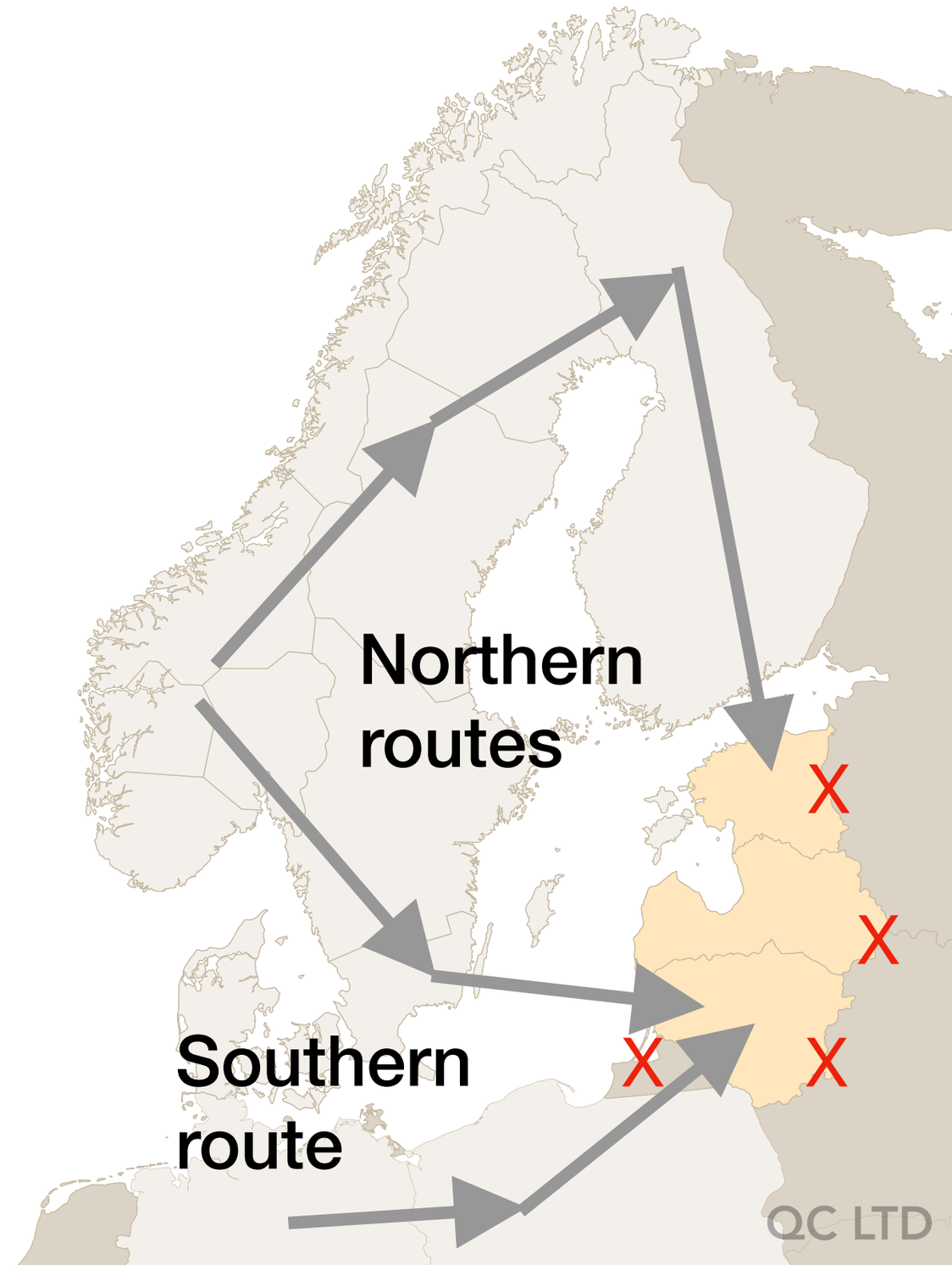
Interconnector capacity duration curve (based on hourly Nordpool data 2013-2020)

Importing security of supply

Baltic area disconnect from Russia (incl. Kaliningrad) and Belarus by end of 2025 means Baltic security of supply needs to be guaranteed by:

Northern routes:
Norway + Sweden

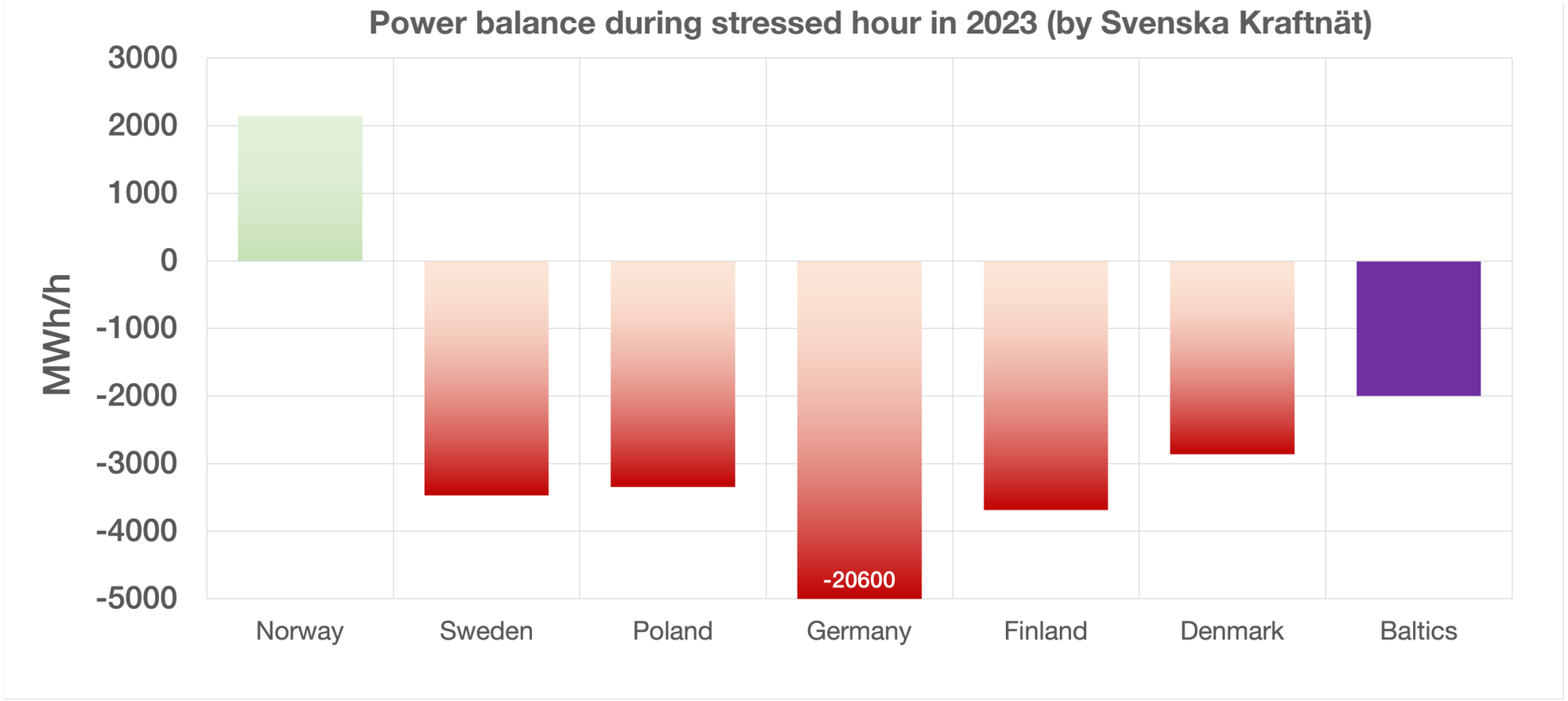
Southern route:
Germany + Poland



Importing security of supply?

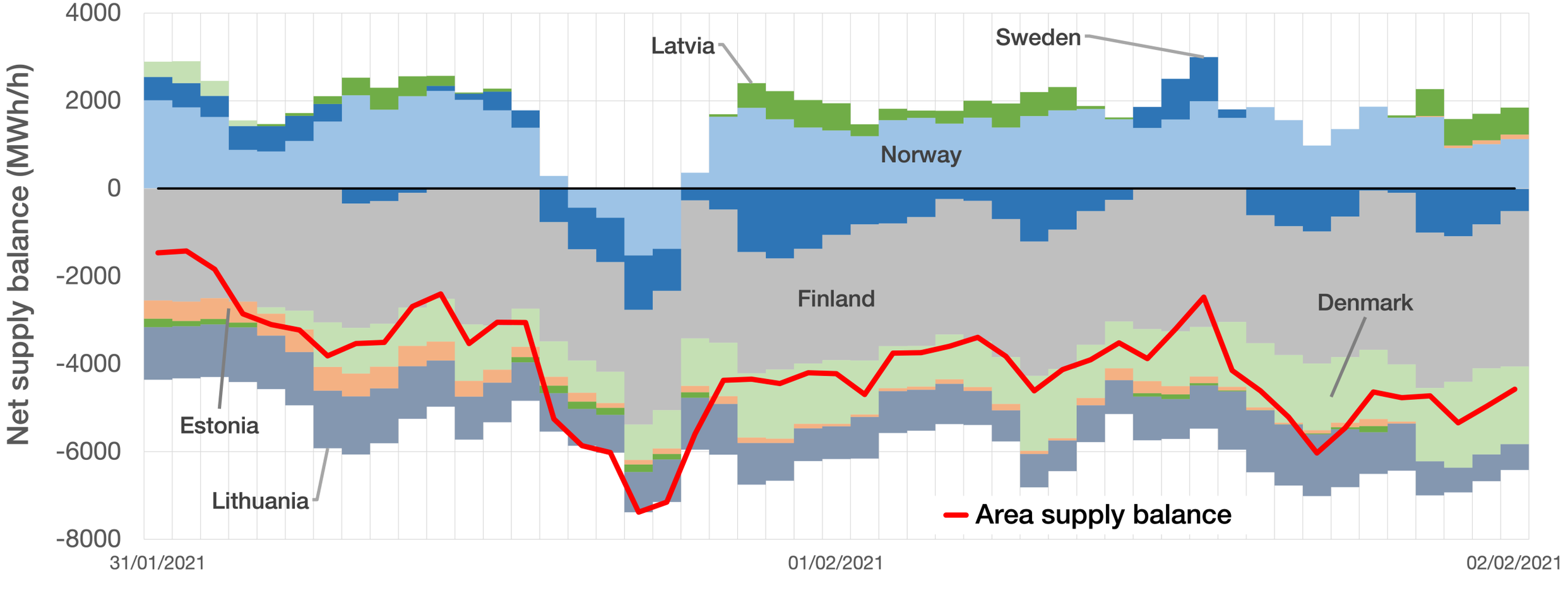
Who has available *export* capacity? Power balance during stressed periods *on both routes* is negative already. On top of this:

- Norway is building large new interconnectors (UK, Germany etc.)
- Demand in Sweden and Norway set to increase dramatically (+30 to +70%)
- Dispatchable capacity is closing (DE/SWE nuclear, PL/DE/FI/DK coal)



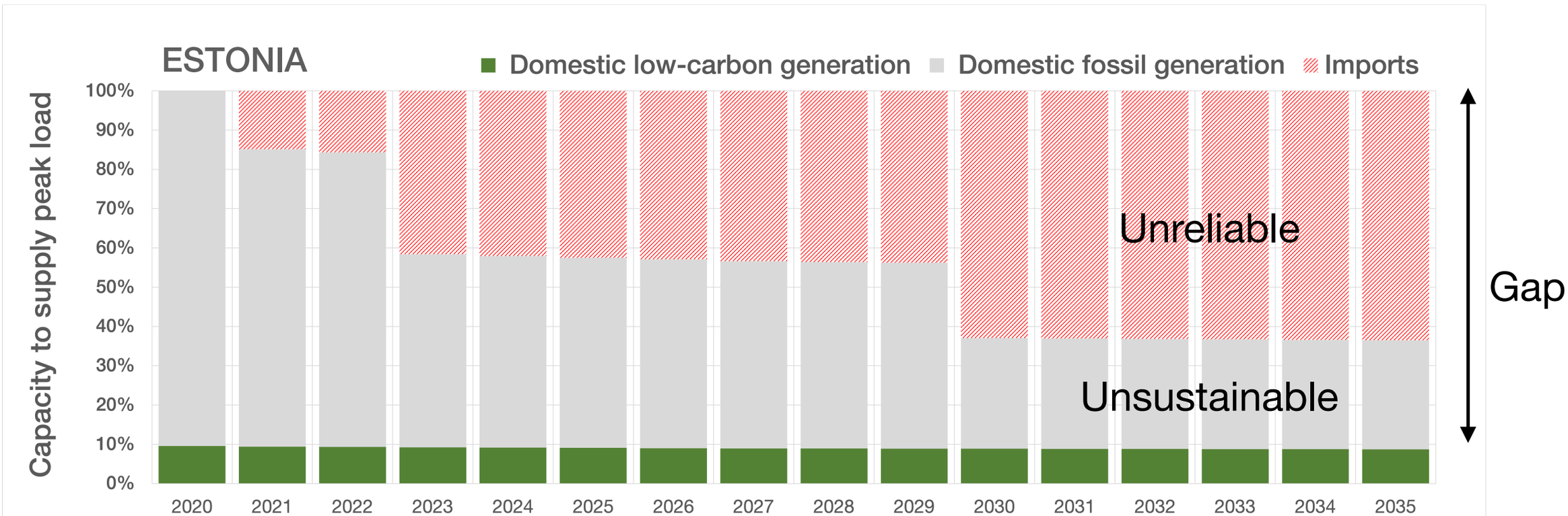
Start of February 2021

- Last days of available data — No wind, relatively cold weather
- Nordic region total supply balance between -2 GW and -7 GW (!)
- Imports from Russia+Belarus, German coal+nuclear and Polish coal
- *None* of these import sources will be available longer term



Summary

- Estonian security-of-supply betting on imports is a *very risky strategy*
- Economic impacts are both short term (high costs, blackouts) and long-term (low willingness to invest or re-invest in industrial development)
- Import dependence on *all time-scales* makes the case new for domestic dispatchable low-carbon capacity, especially CHP for district heating co-generation, extremely attractive
- Ideal opportunity for ~600 MW_e of SMR (CHP) capacity in the early 2030?



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