The road to 2050: The need for flexibility in a high renewables world

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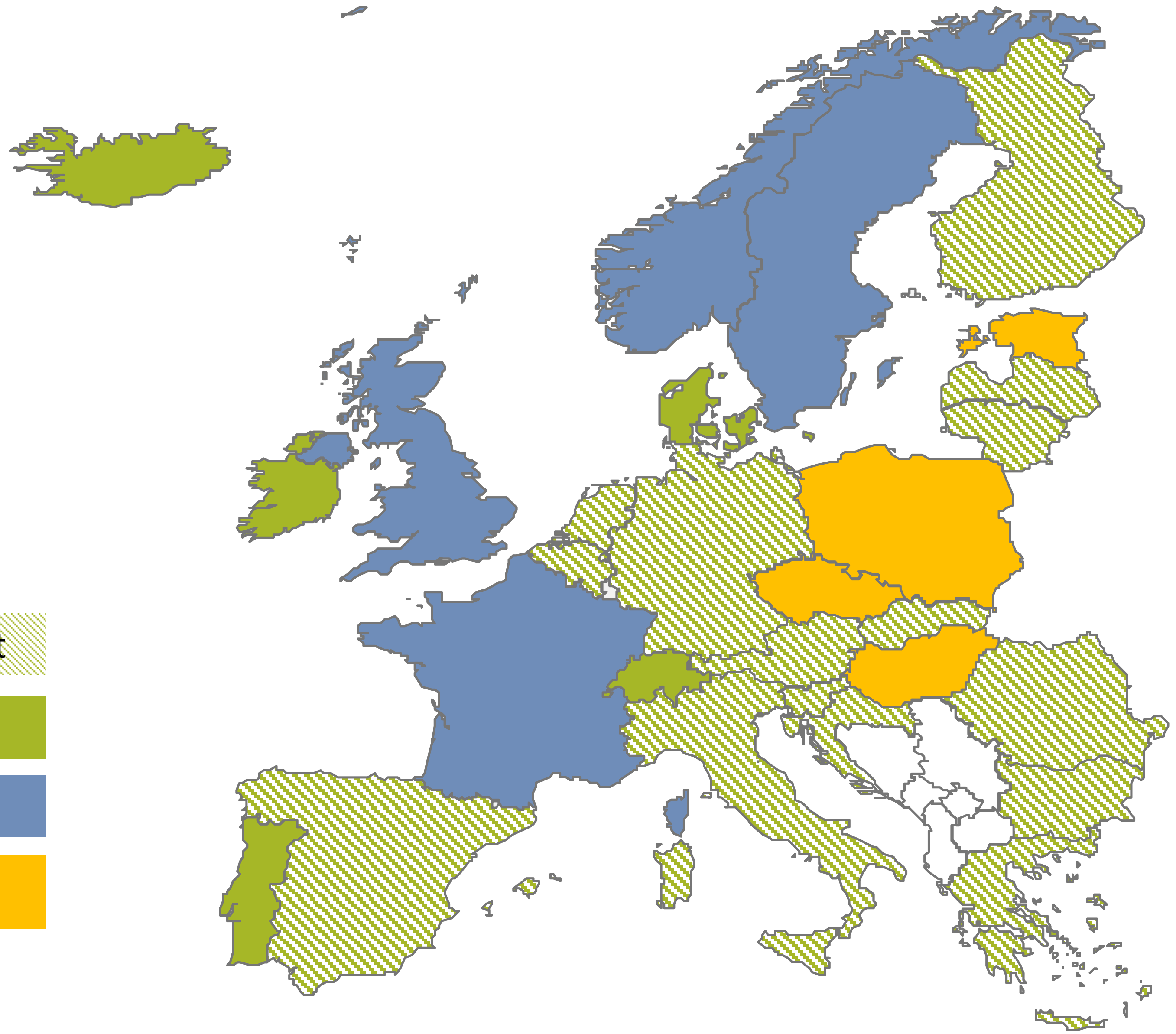
@AuroraER_Oxford #BattConf19

Climate change is becoming a legislative priority in Europe



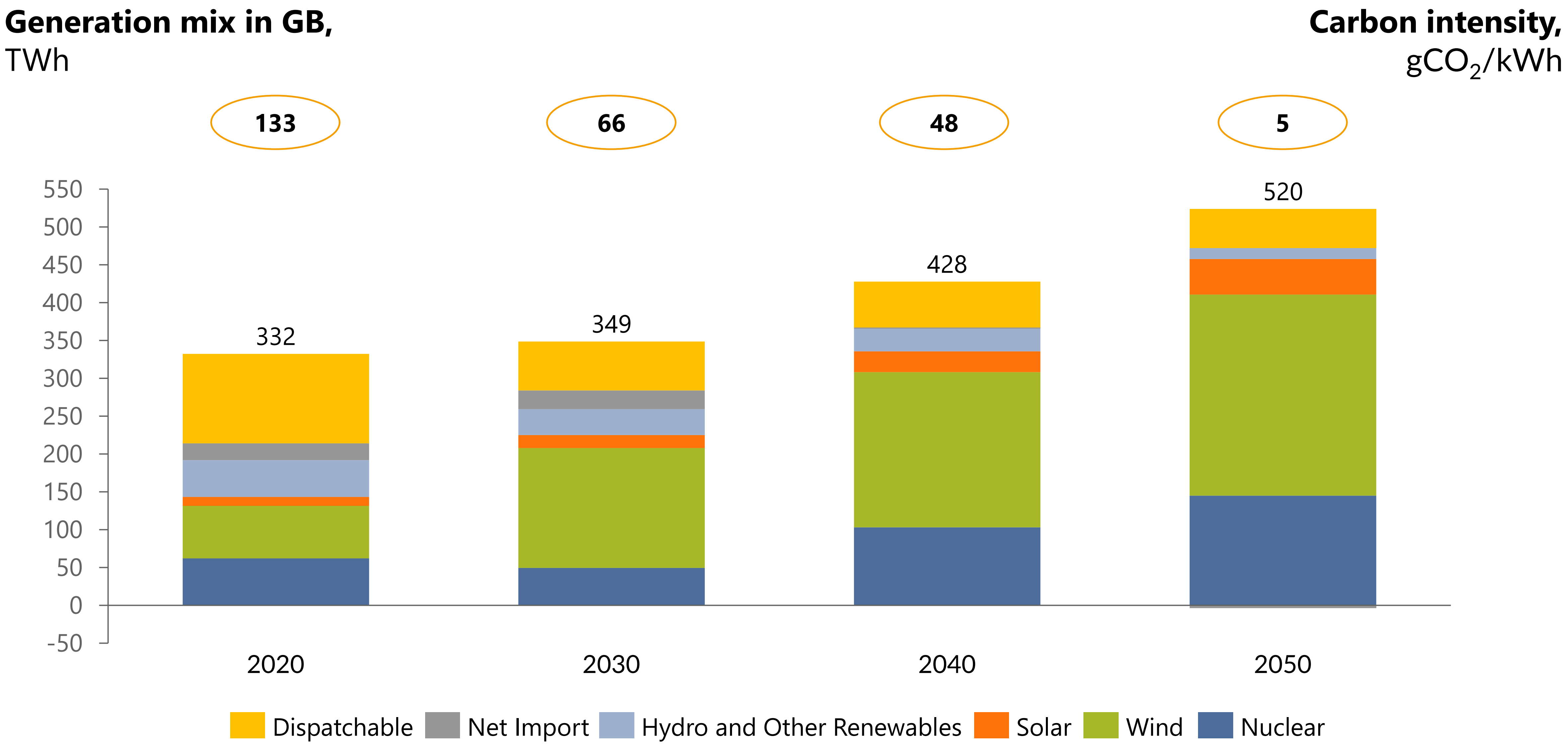
Supporting net-zero target

Policy position

In law

Rejecting net-zero in law

To reach net zero by 2050, the GB power market will have to transform completely: power generation up 60%; CO_2 emissions down 100%



A high-renewables system increases the need for flexibility and reliability, and creates opportunities for storage

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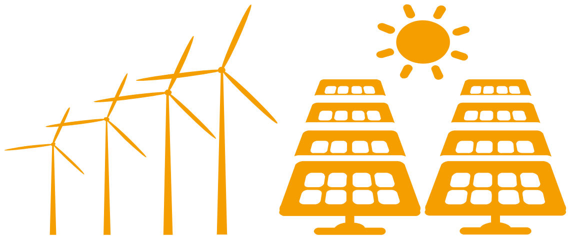
Characteristics of renewables



- Unpredictable
- Variable
- Undispatchable

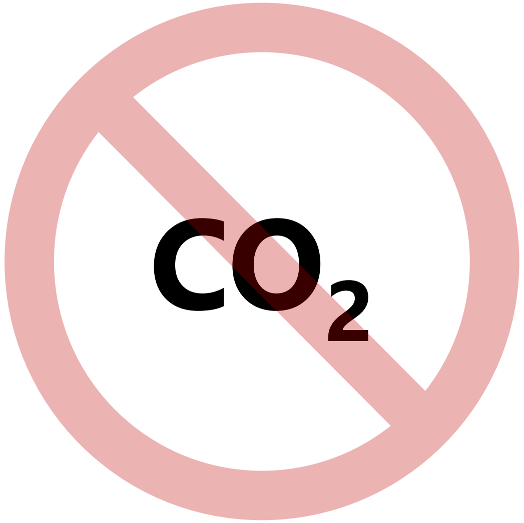
Near-term system requirements

Flexibility

- **A** Supply-demand matching
- **B** Ramping
- **C** Reliability

\+

2050 system requirements



A

Demand-supply matching: as we approach 2050, storage becomes necessary for the proper utilisation of renewables

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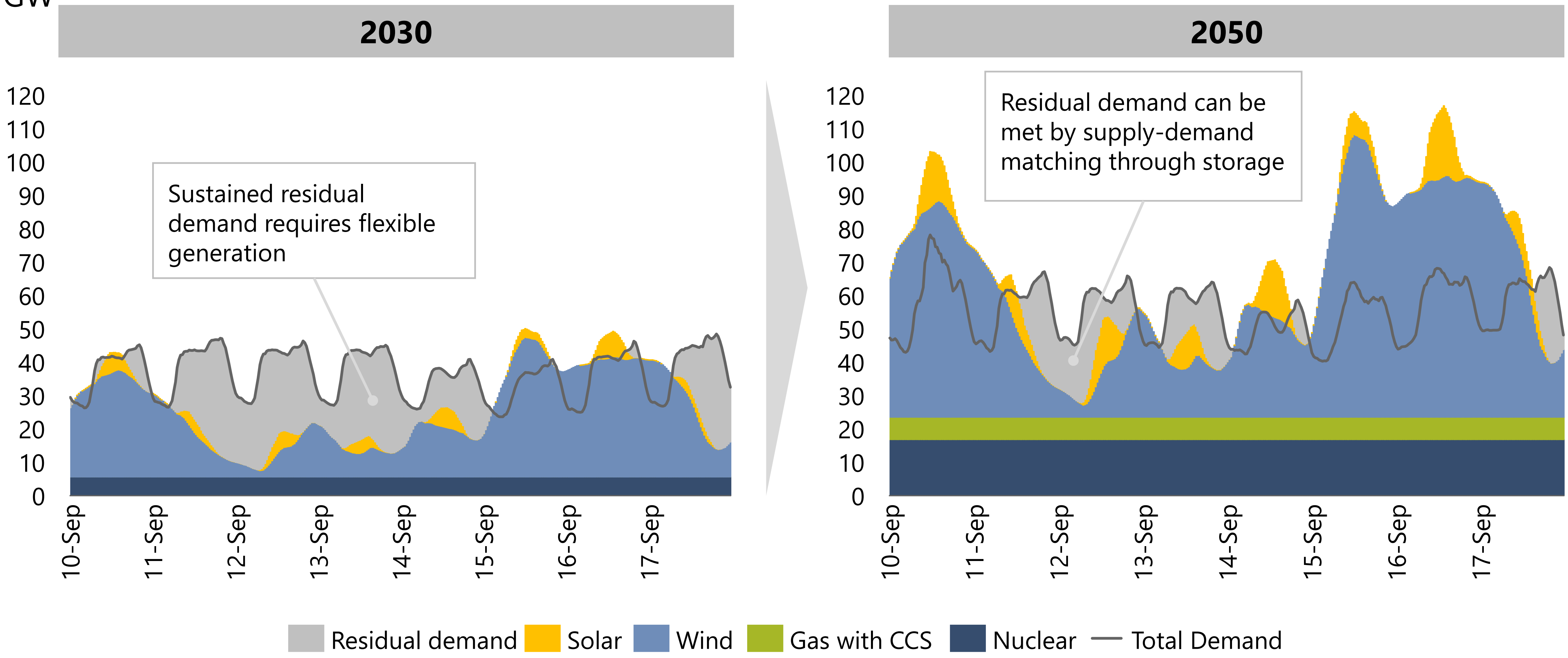
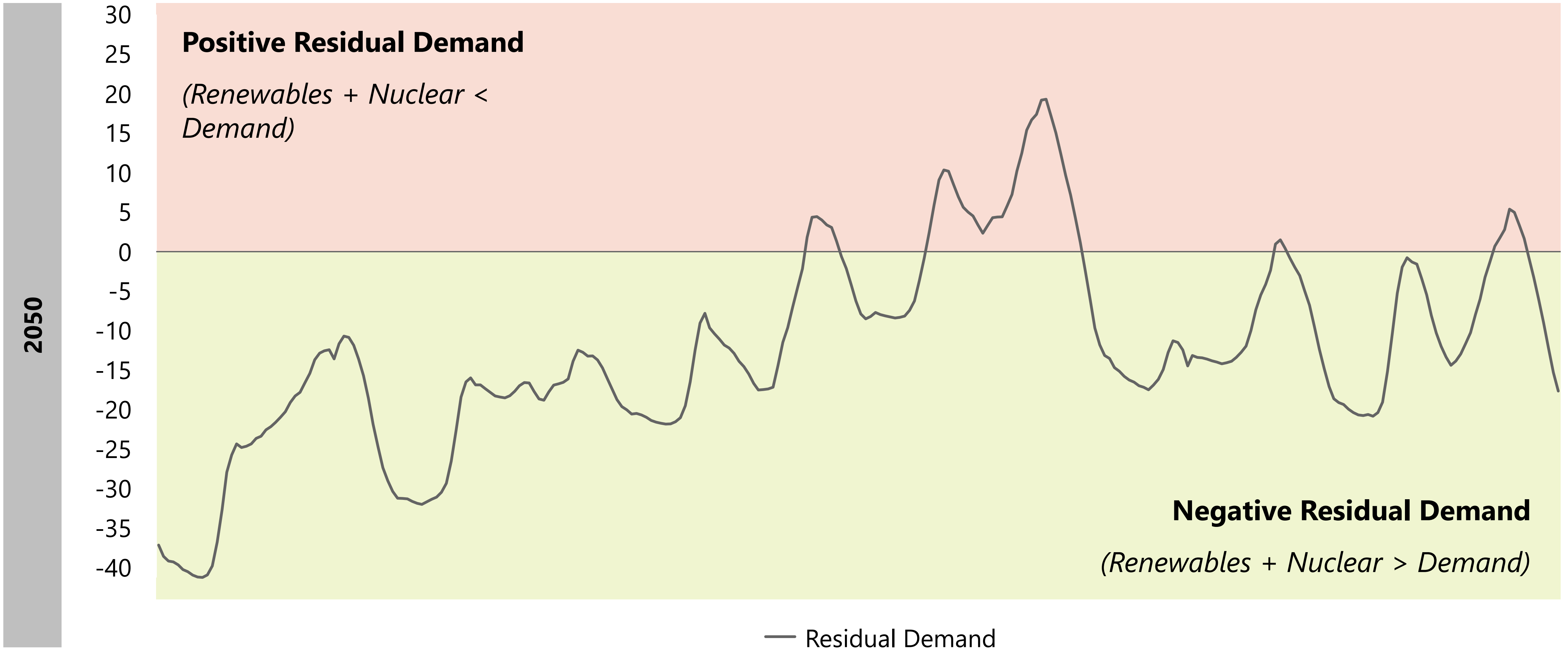
Illustrative power demand in two typical weeks,
GW



A

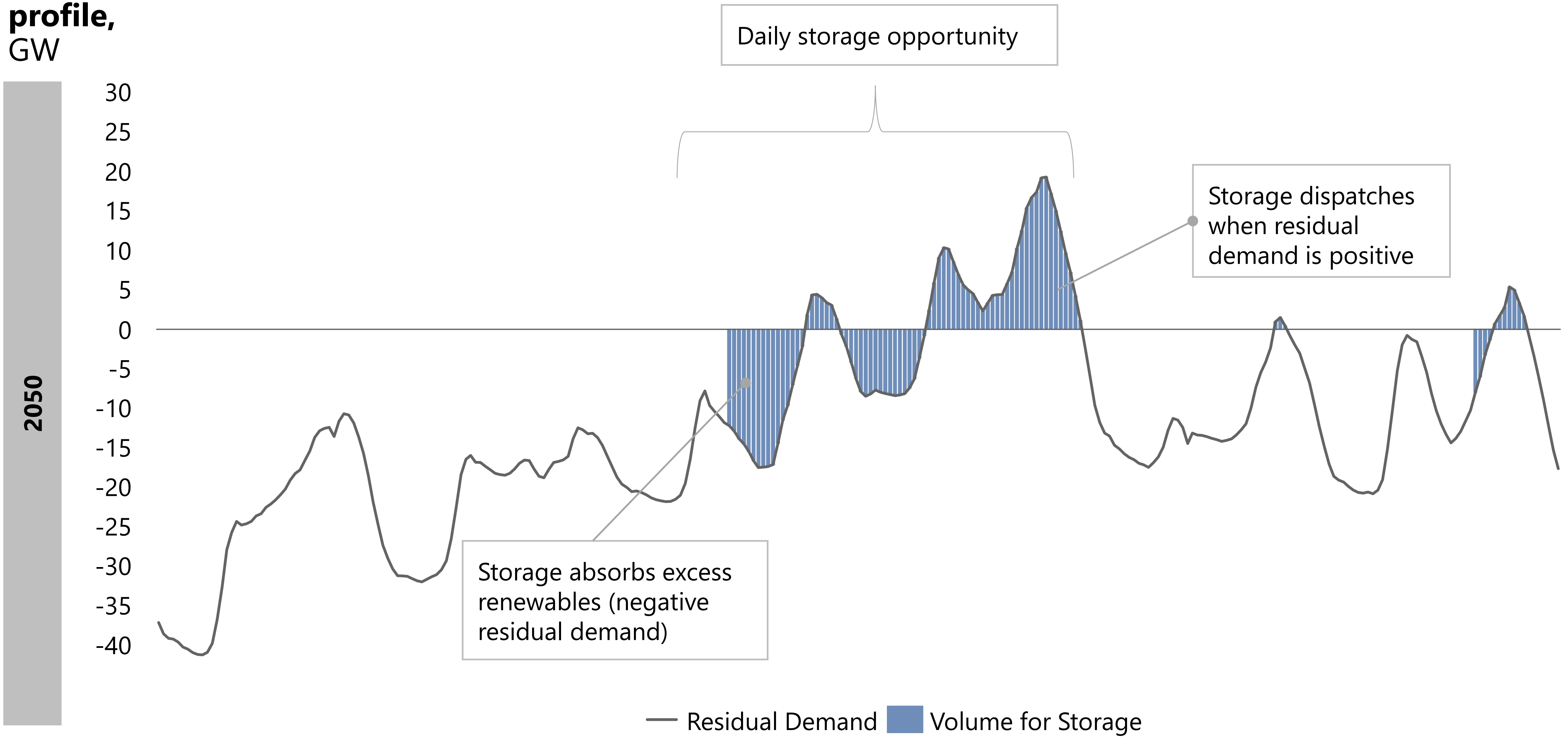
Demand-supply matching: the shape of residual demand determines the size and type of storage opportunities

Illustrative weekly residual demand profile,
GW



A Demand-supply matching: daily storage can be used to move power from when it is generated to when it is needed

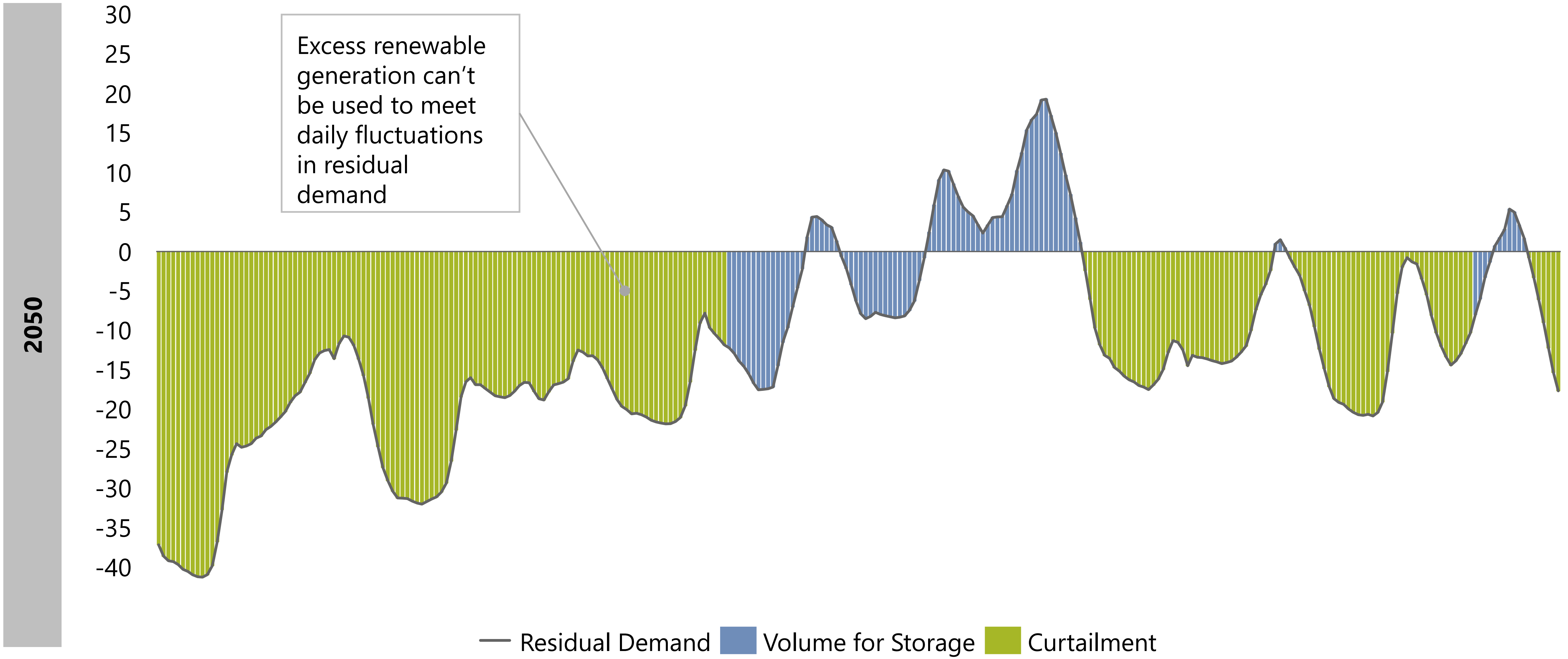
Illustrative weekly residual demand profile,
GW



A

Demand-supply matching: excess renewable generation needs to be stored for longer periods of time

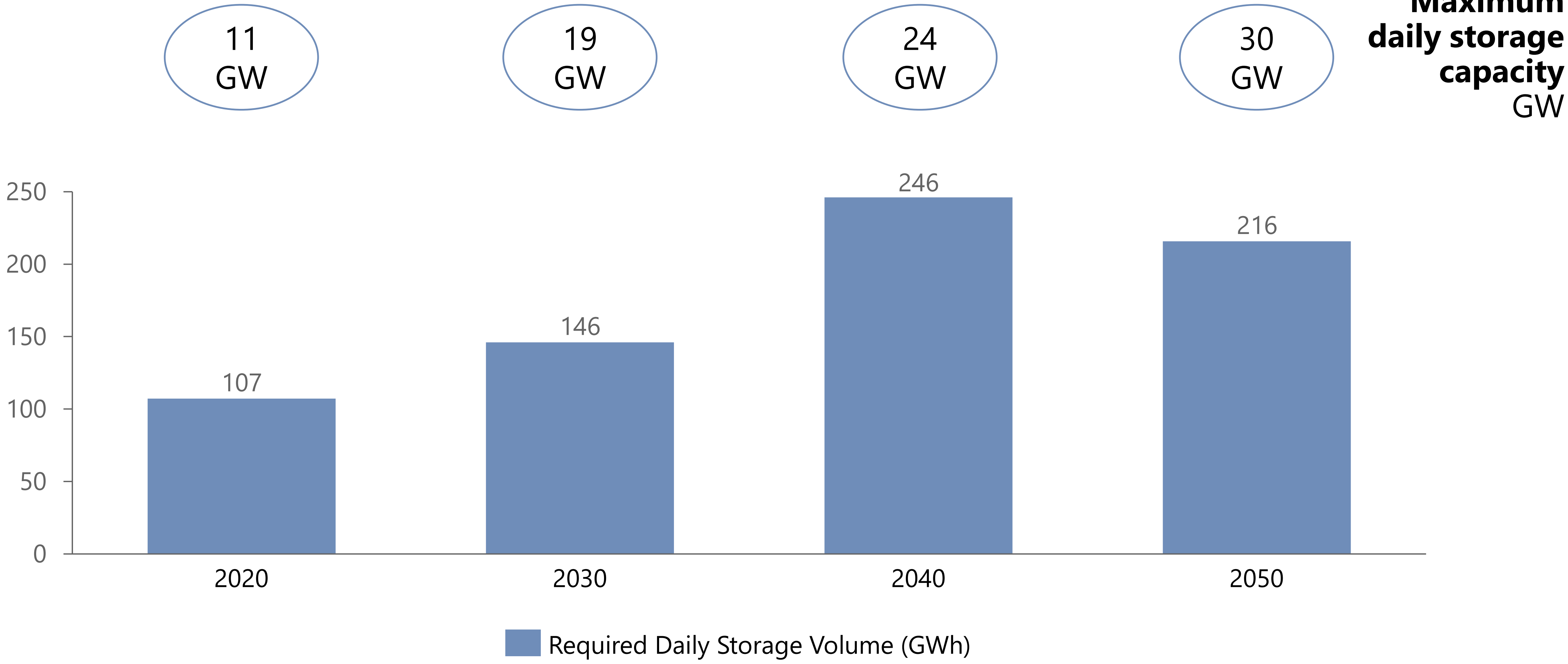
Illustrative weekly residual demand profile,
GW



Demand-supply matching: the need for daily storage increases over time, but it is capped by the amount of positive residual demand

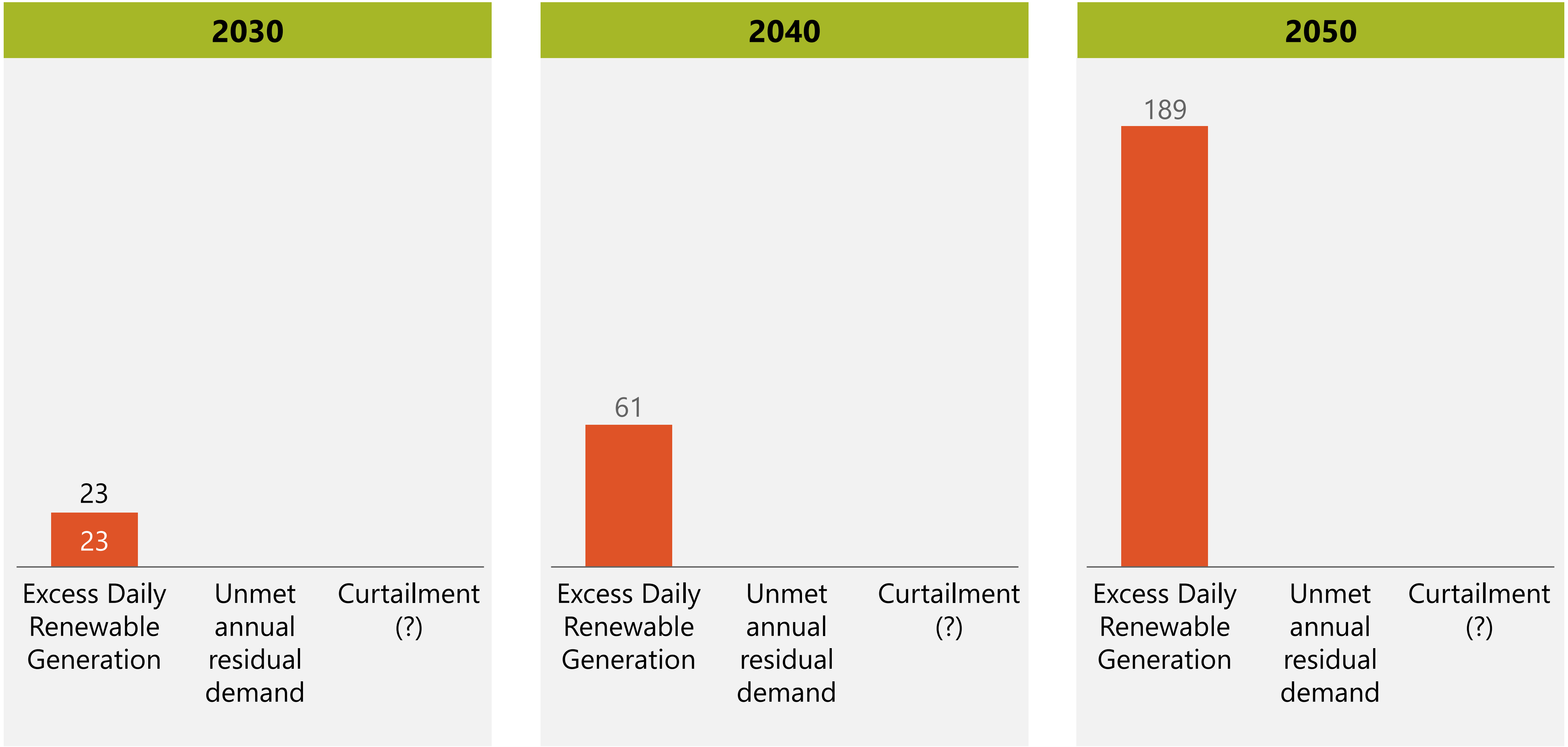
A

Maximum daily storage volume
GWh



A Demand-supply matching: absorbing all excess renewable generation by 2050 would require large volumes of long-duration storage

Use case for inter-seasonal storage,
TWh



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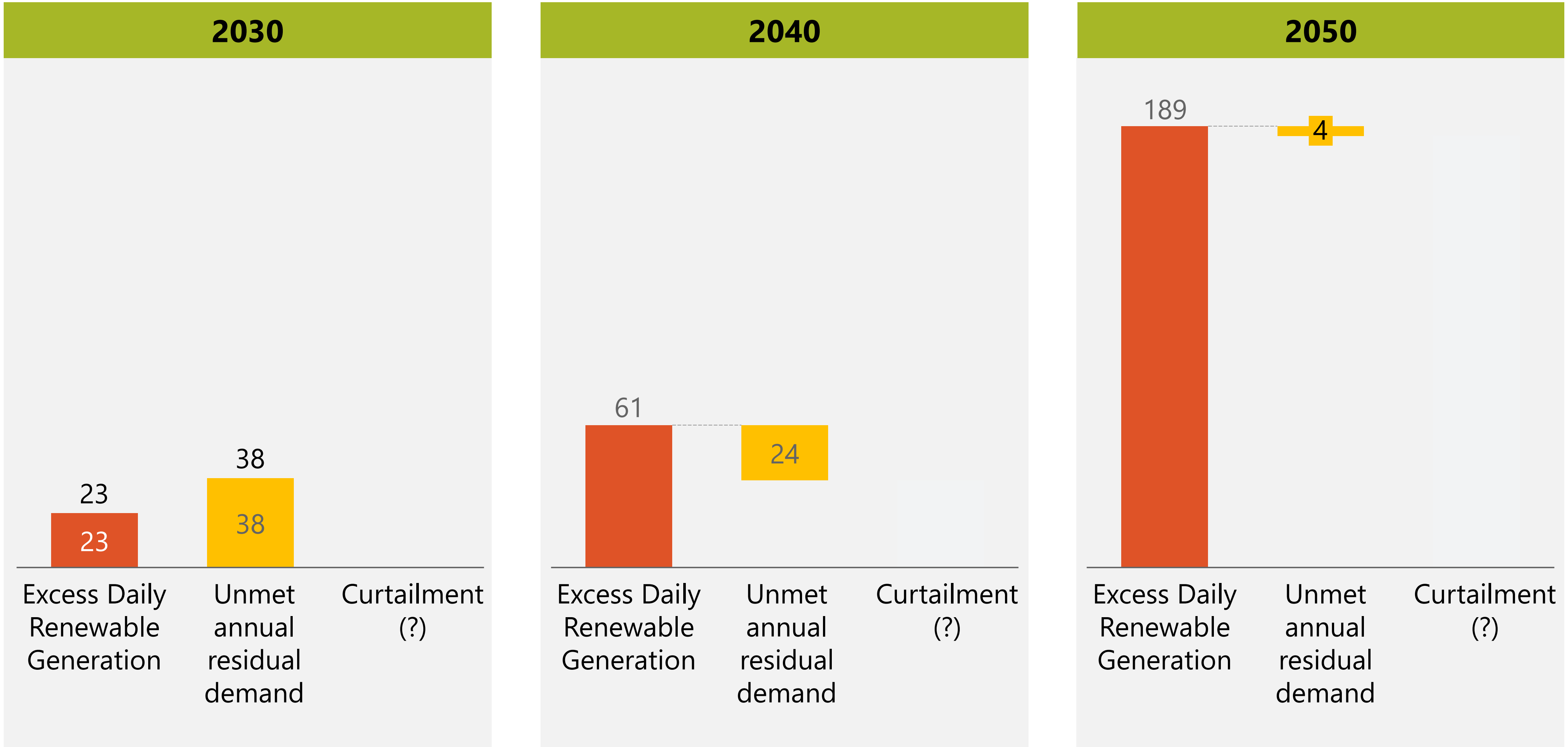

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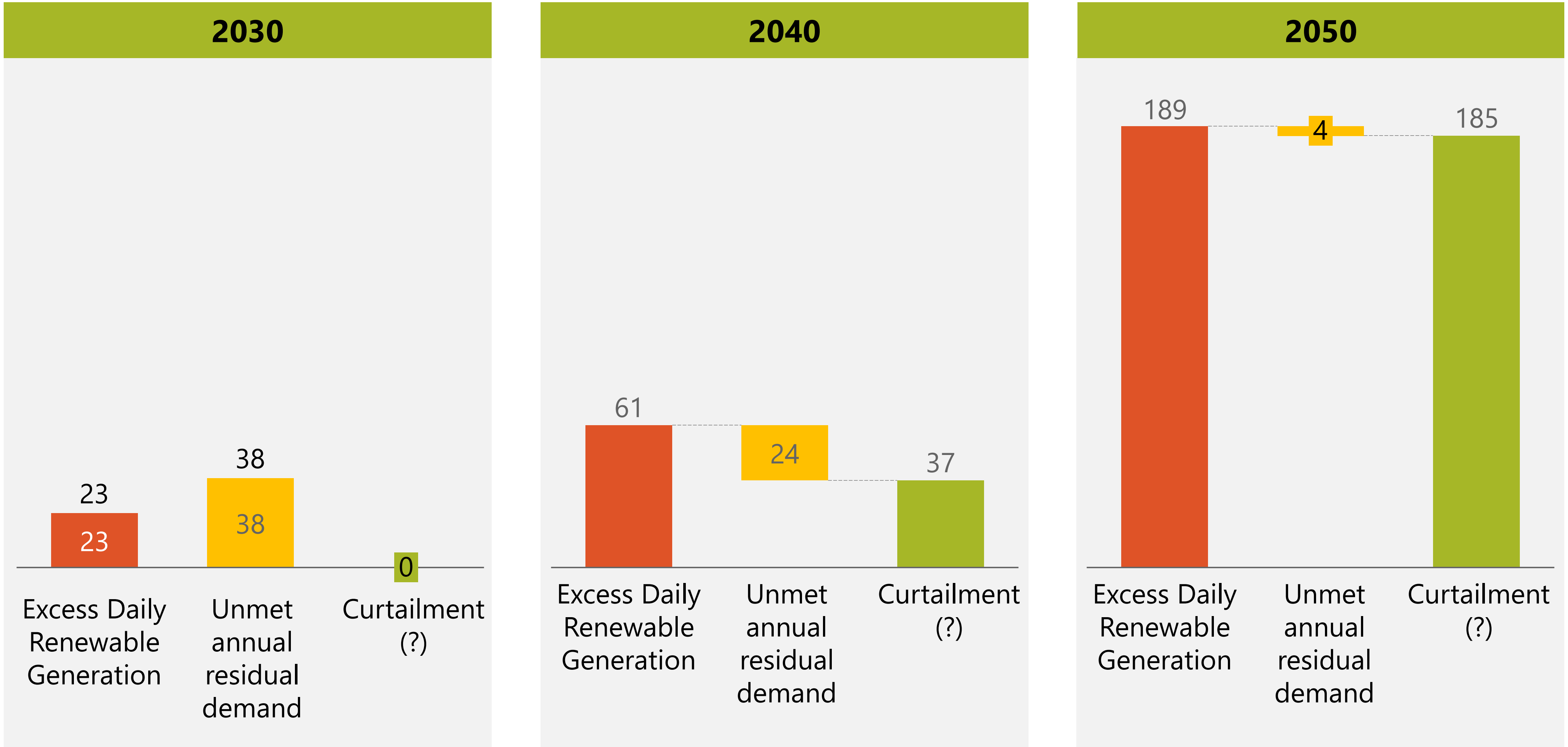

A

Demand-supply matching: by 2050 the opportunity lies in converting excess renewables to non-electrical energy for use in other sectors

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Use case for inter-seasonal storage,
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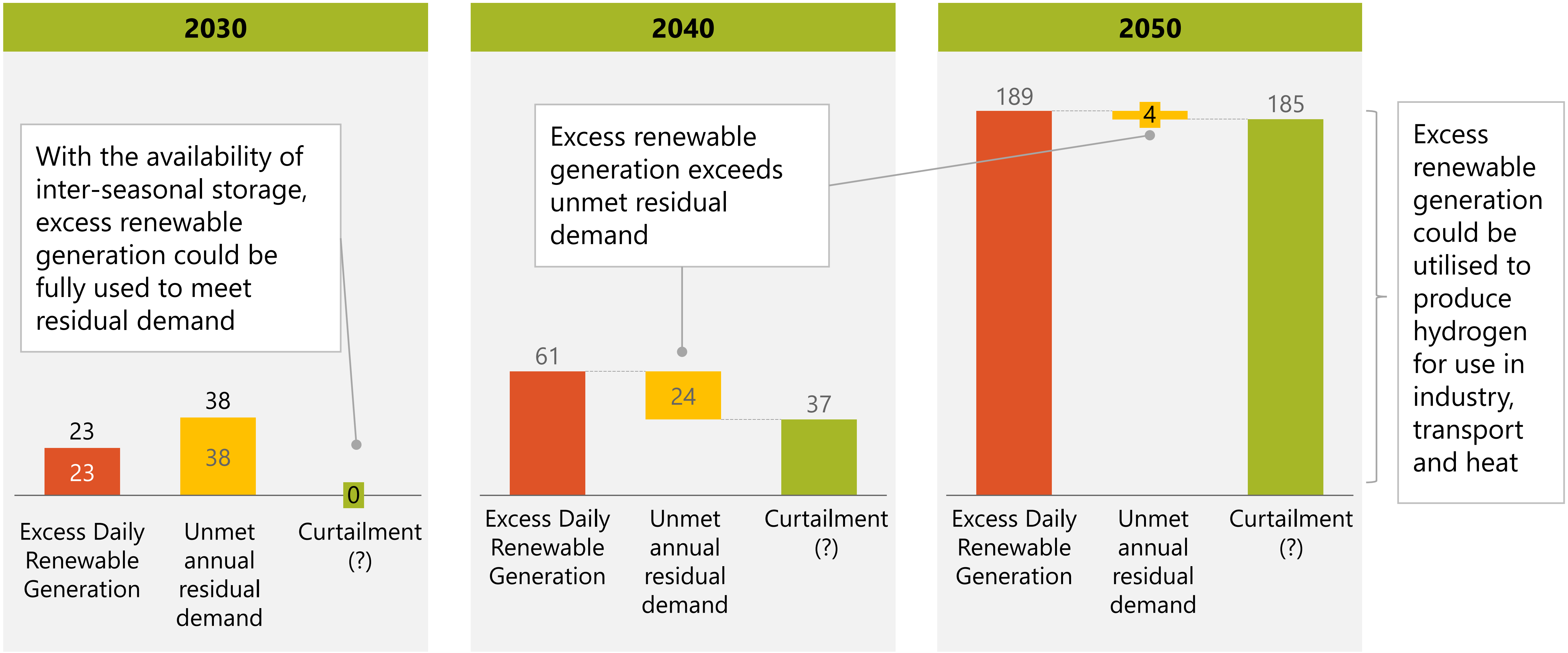

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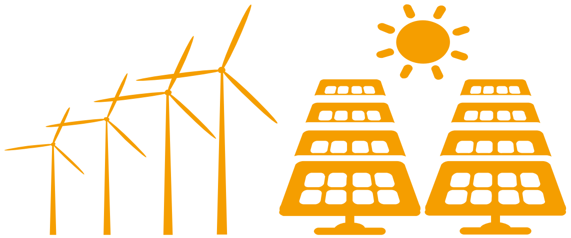

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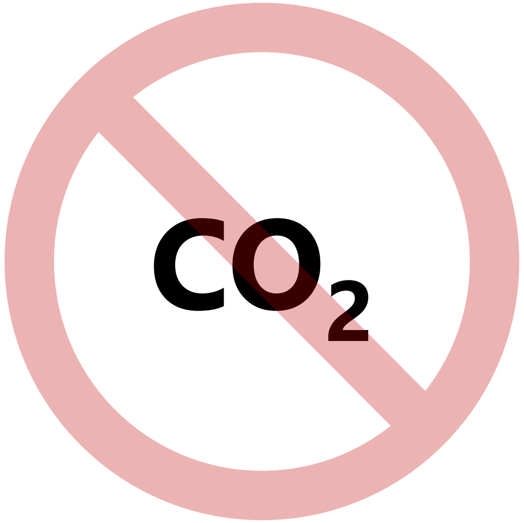
2050 system requirements



B

Ramping: quick fluctuations in demand and supply require generation that can ramp quickly to meet residual demand

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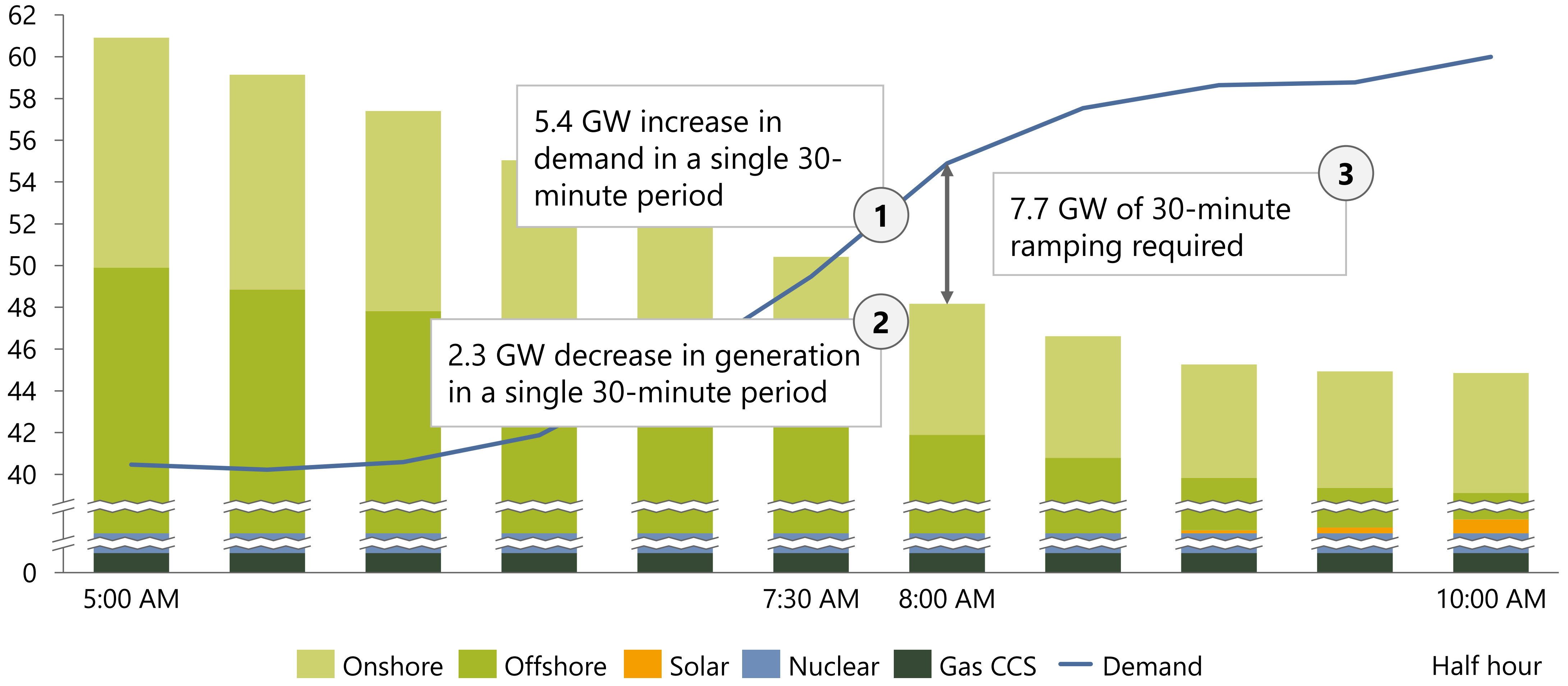
Demand and supply on one day in Winter 2040
GW/HH

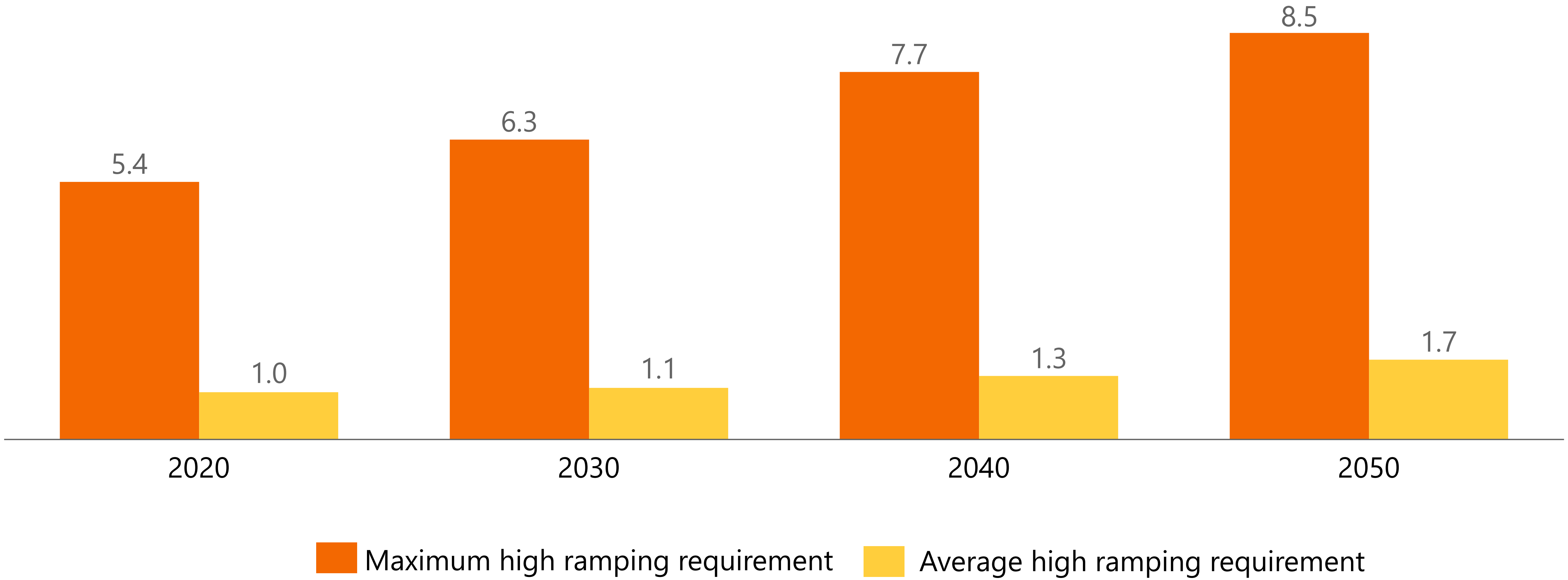


B

Ramping: the need for fast-ramping generation increases as supply volatility increases

High ramping requirements
GW/half hour

By 2050, the system will need around 8.5 GWs that can respond in under 30 minutes



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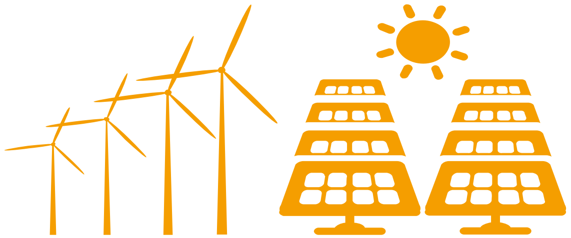

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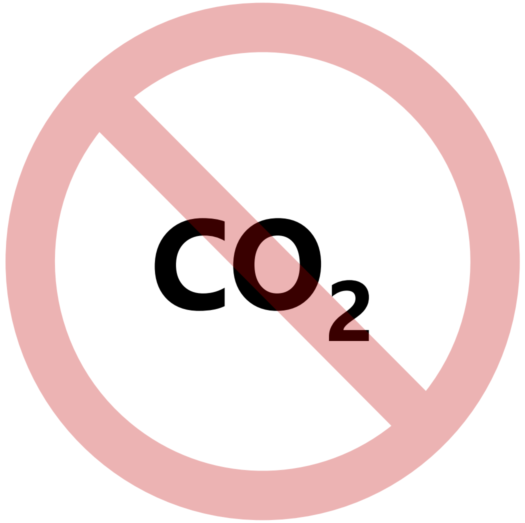
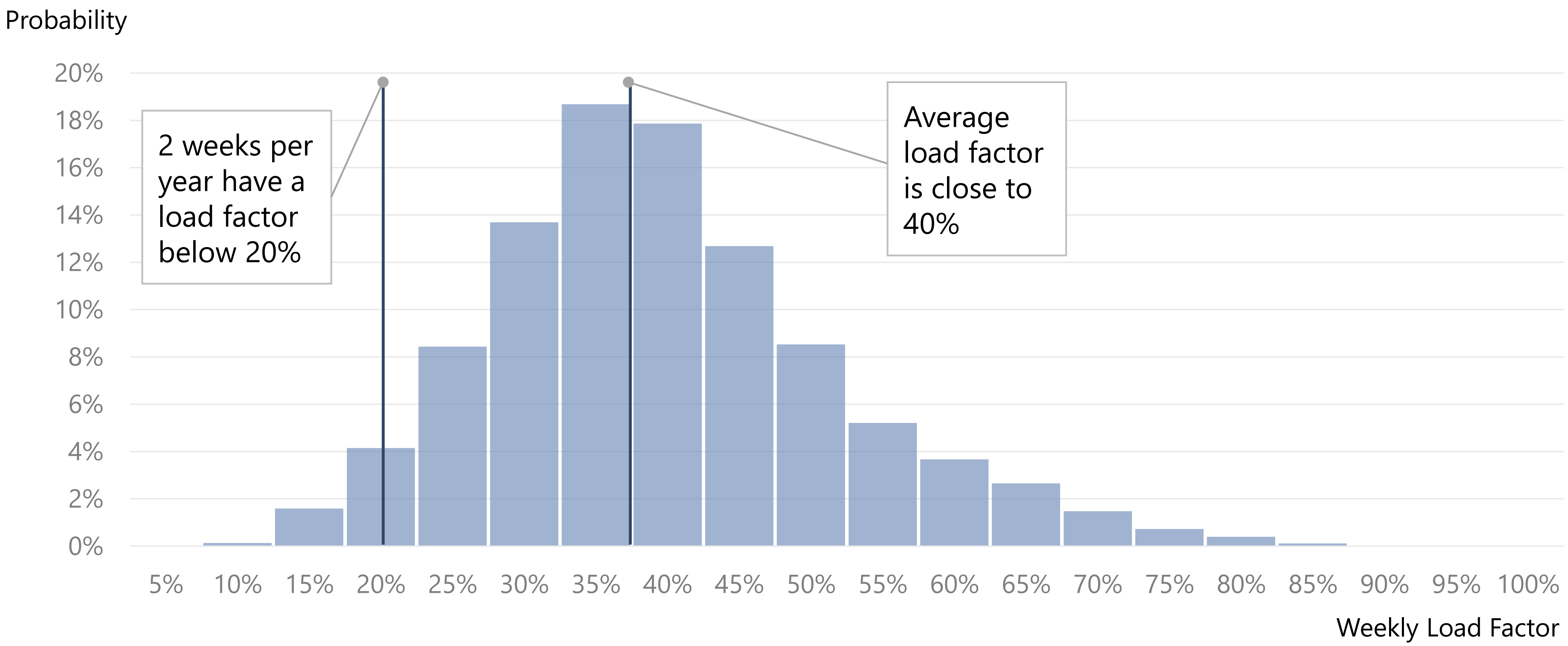


C

Reliability: wind load factors can vary significantly from expected values

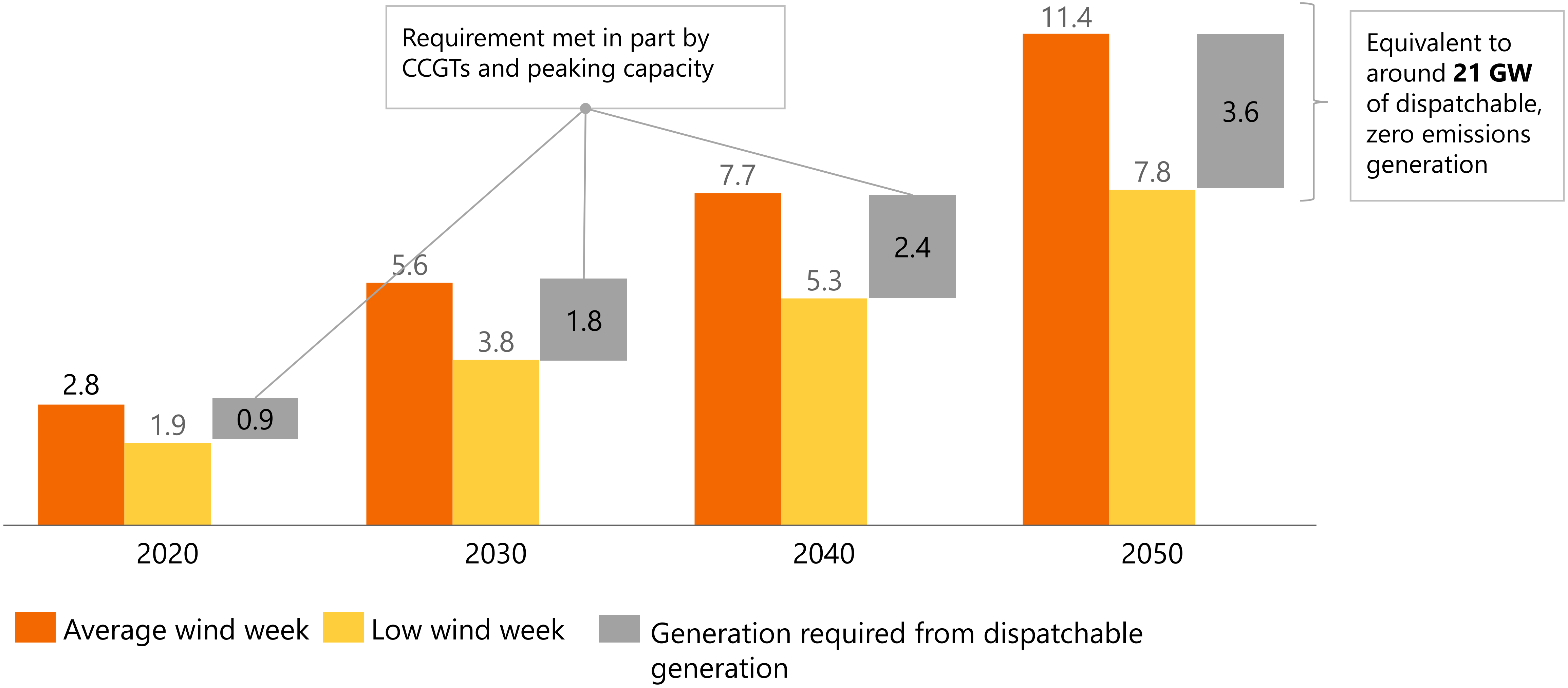
Load factor probability distribution, 2050
%



C

Reliability: Maintaining system reliability in a high-renewables world requires large amounts of dispatchable, long-duration generation

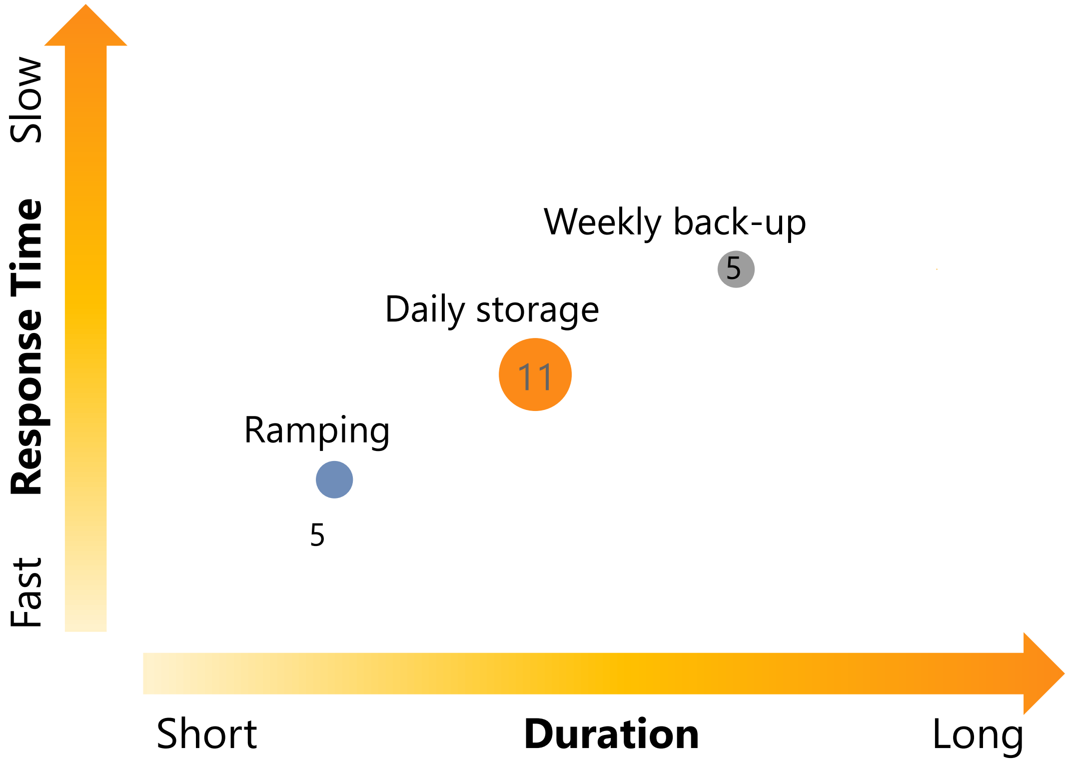
Incremental TWh required to meet one week of low wind
TWh



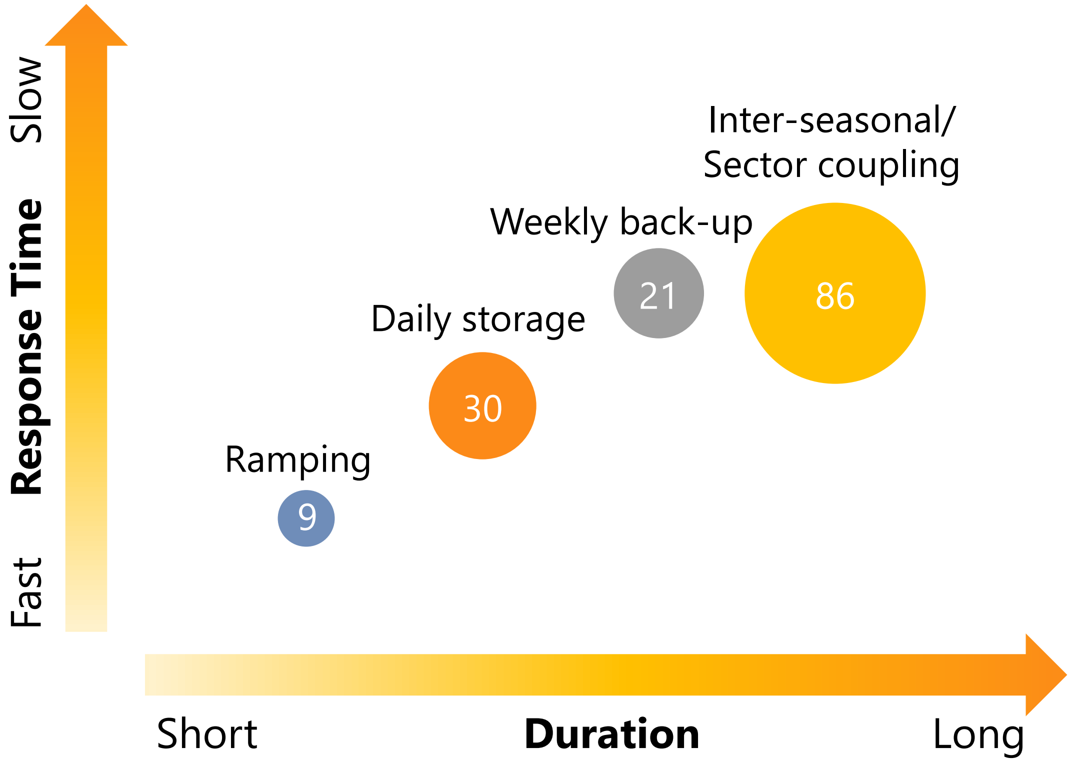
The system's requirement for quick-response, long-duration generation increases as renewable penetration increases

2020	2050
Max carbon intensity: 133g CO_2/kWh	**Max carbon intensity: 0**g CO_2/kWh

Capacity requirement
GW



Capacity requirement
GW



Notes: Inter-seasonal storage/sector coupling based on full amount of curtailed renewables following use of daily storage. GWh estimate converted to GW based on 100% LF for three months of the year

The complexity of meeting such requirements increases with zero emission targets and excess renewable generation

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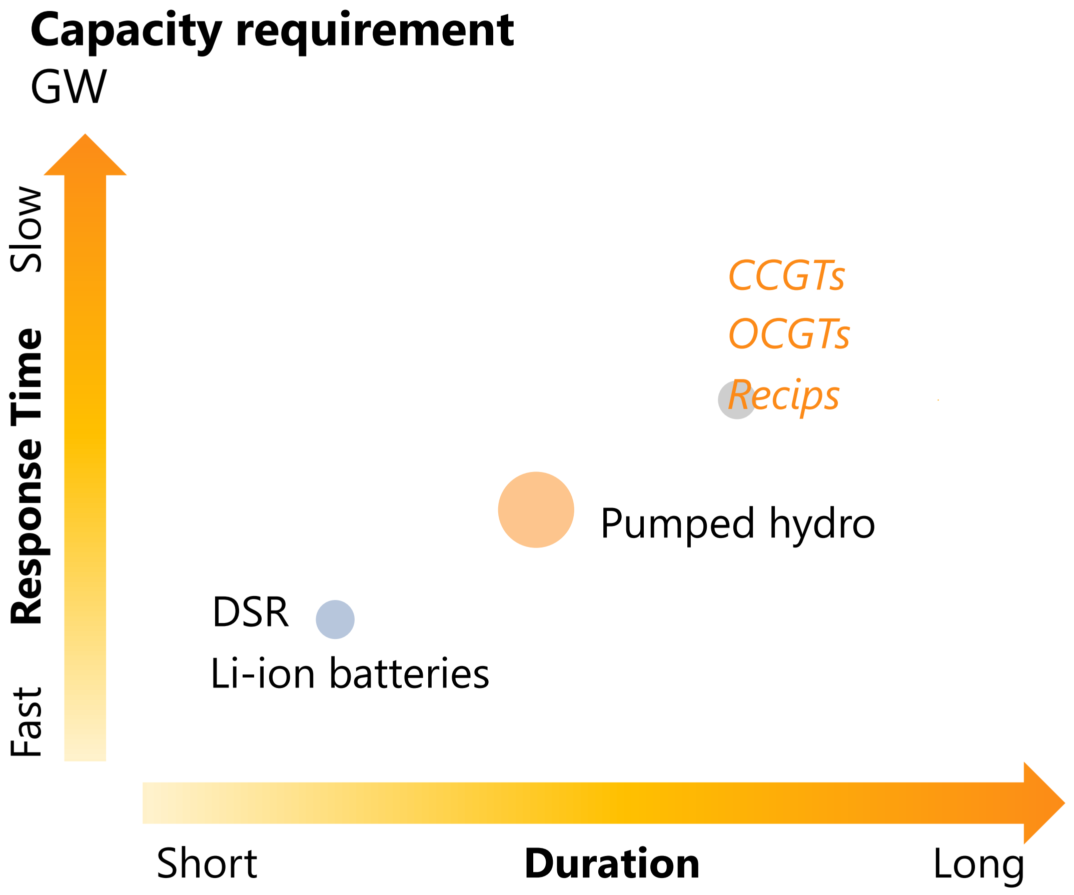
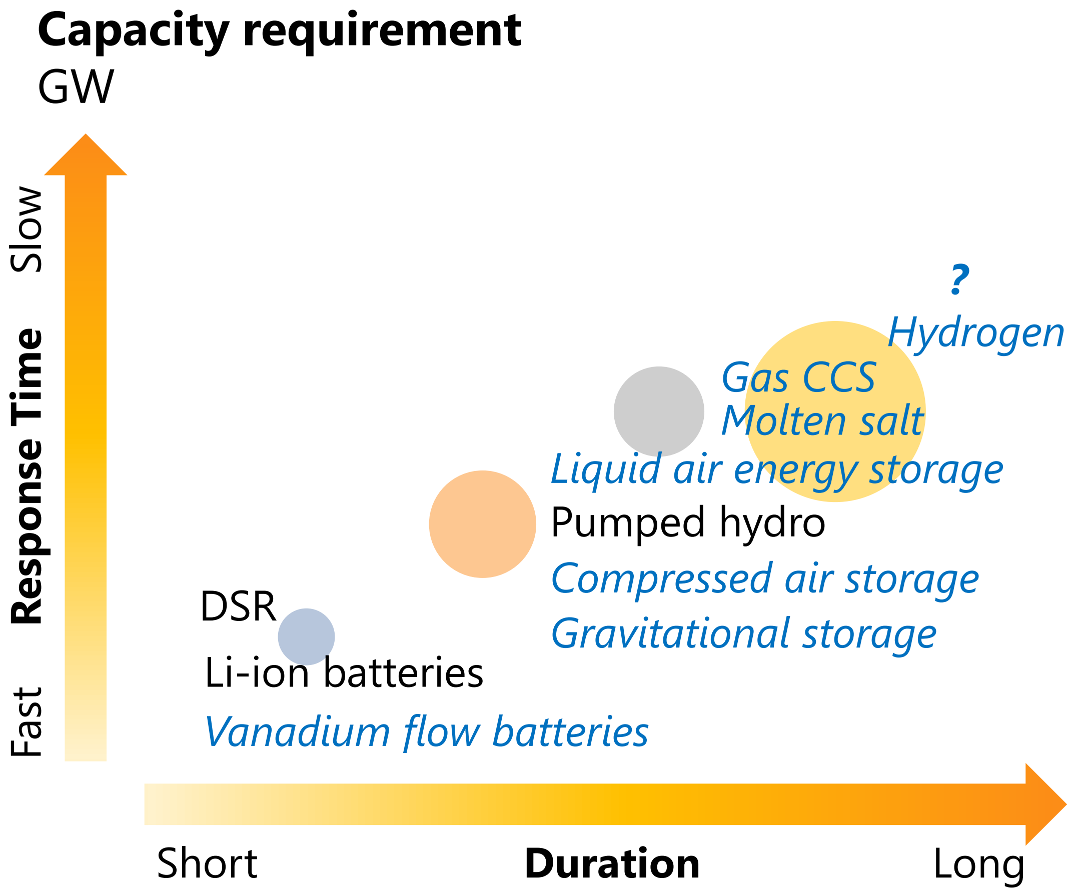
Max carbon intensity: 133g CO_2/kWh	**Max carbon intensity: 0**g CO_2/kWh





Notes: (1) Inter-seasonal storage/sector coupling based on full amount of curtailed renewables following use of daily storage. GWh estimate converted to GW based on 100% LF for three months of the year

A robust policy framework structured around system requirements would help drive the needed investment in flexibility

Net zero challenges	Policy principles
Scale of investment	Price the externalities
Need for R&D	Define the system needs
Inadequate policy framework	Let the market decide