Role of Energy Storage in Grid Balancing in Low-Carbon 2050 Scenarios

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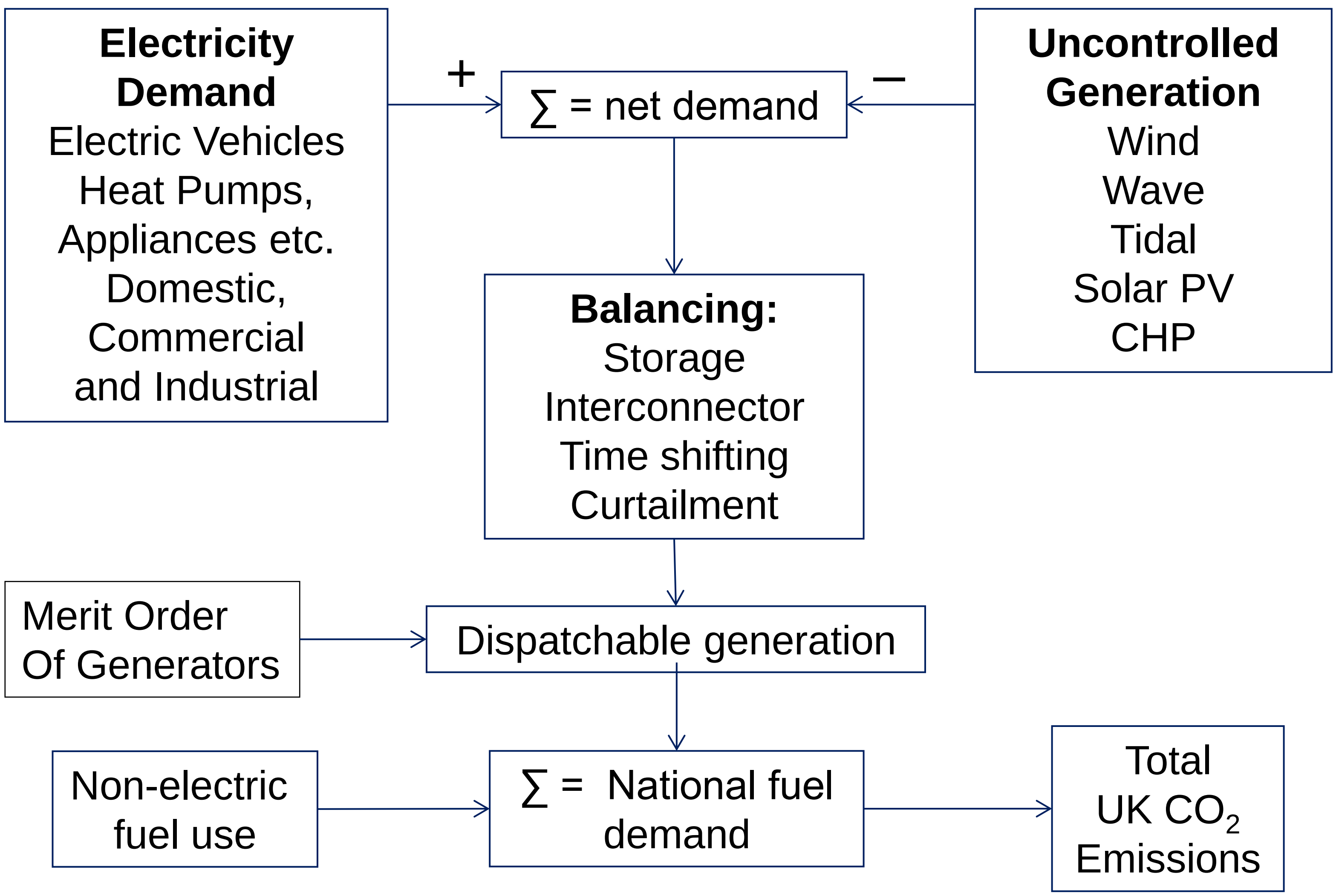
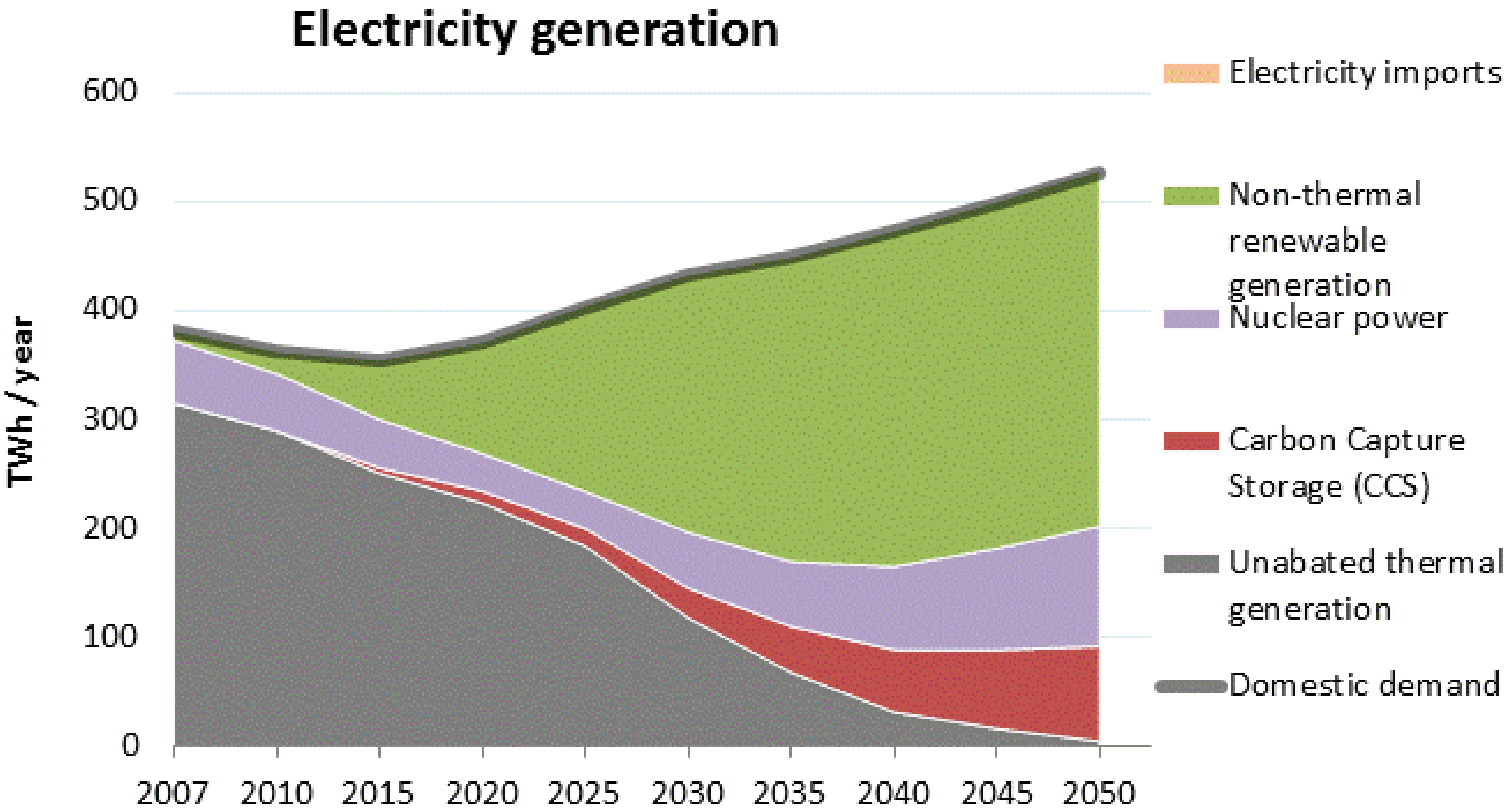
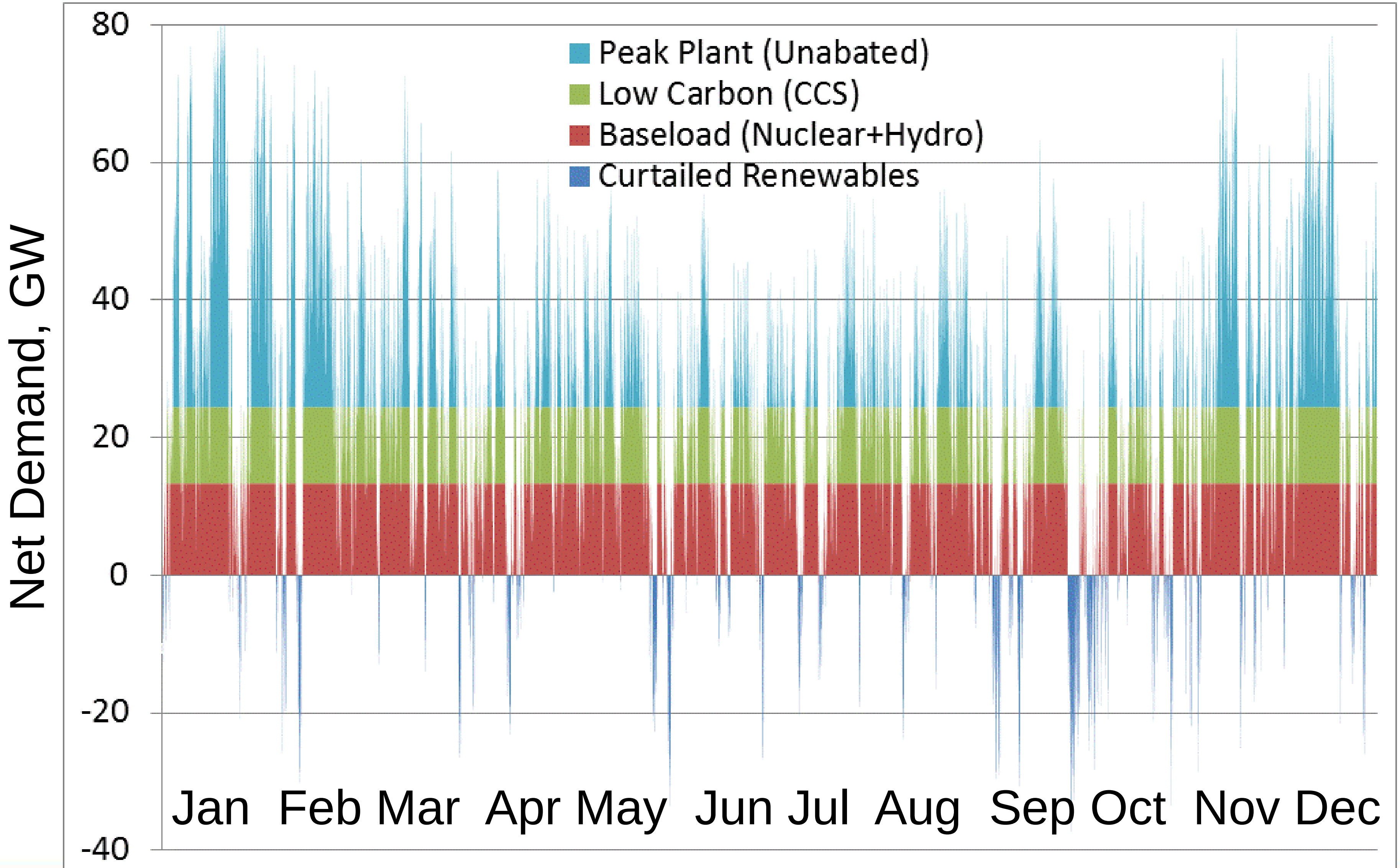
FESA (Future Energy Scenario Analysis)



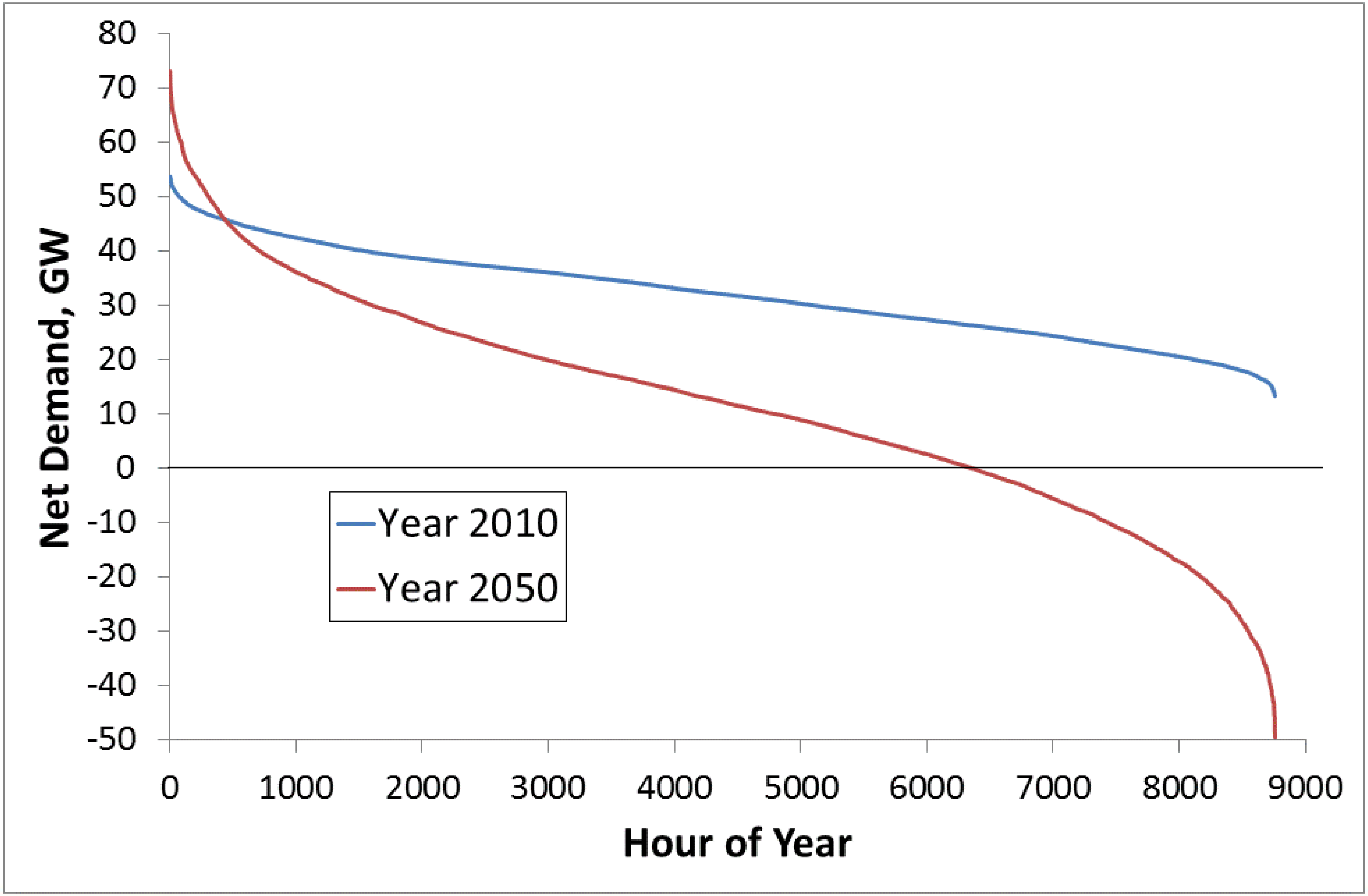
Input data: DECC 2050 Calculator
Eg: Higher Renewables Scenario



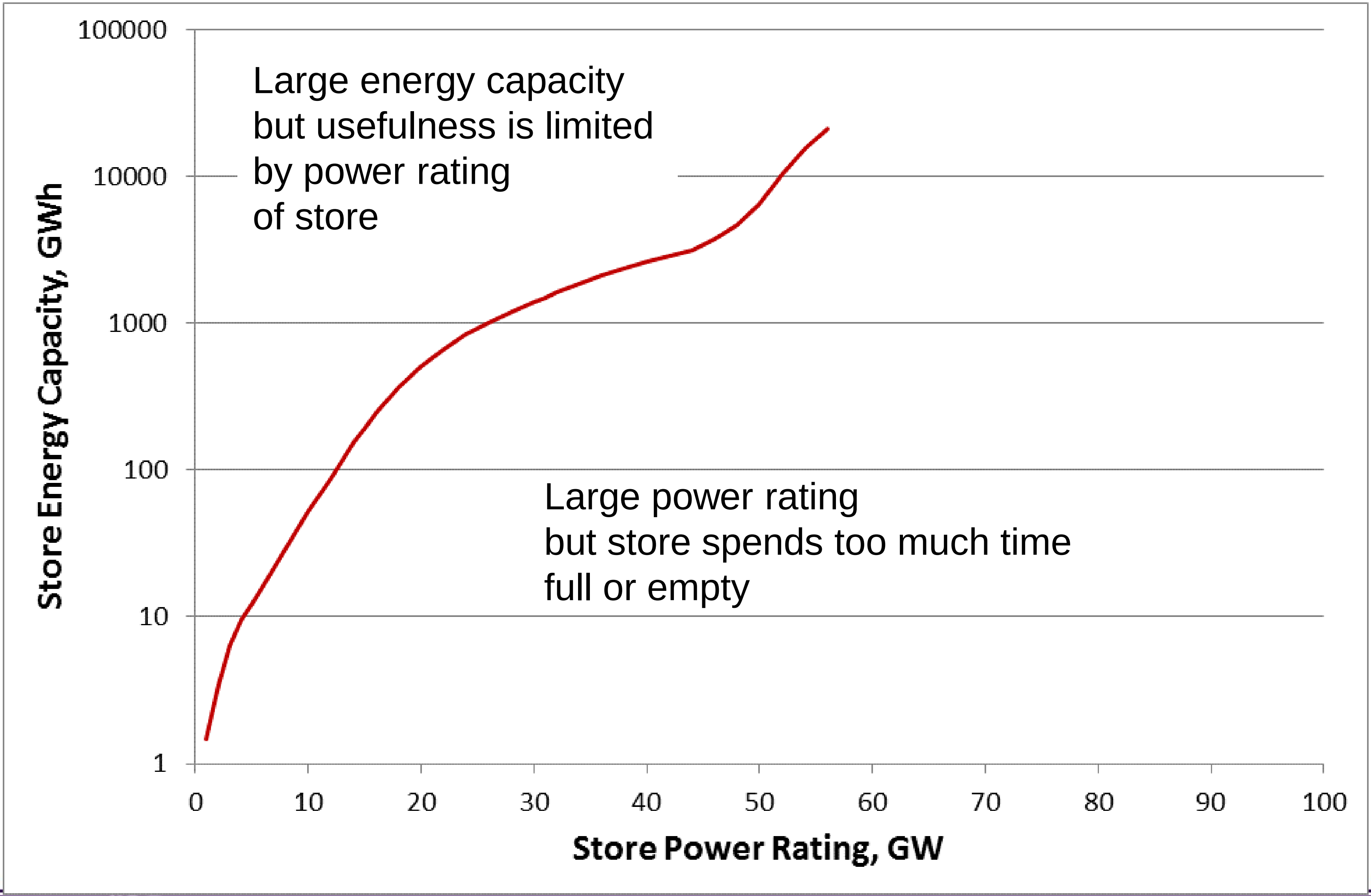
Output from FESA (Higher Renewables Scenario in 2050)



Steeper Load-Duration Curve



Optimum Ratio of energy Capacity to Power (GWh/GW)



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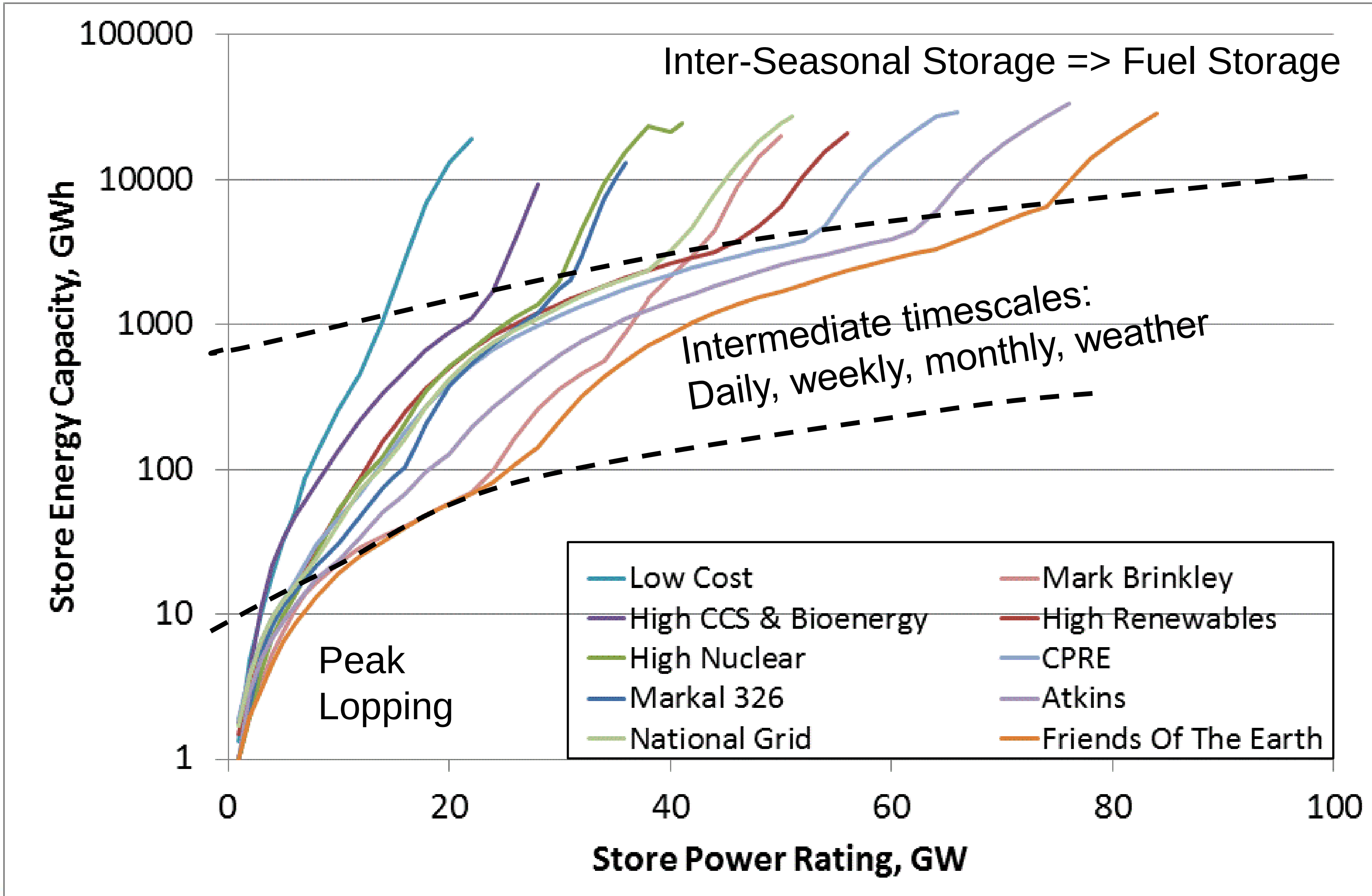
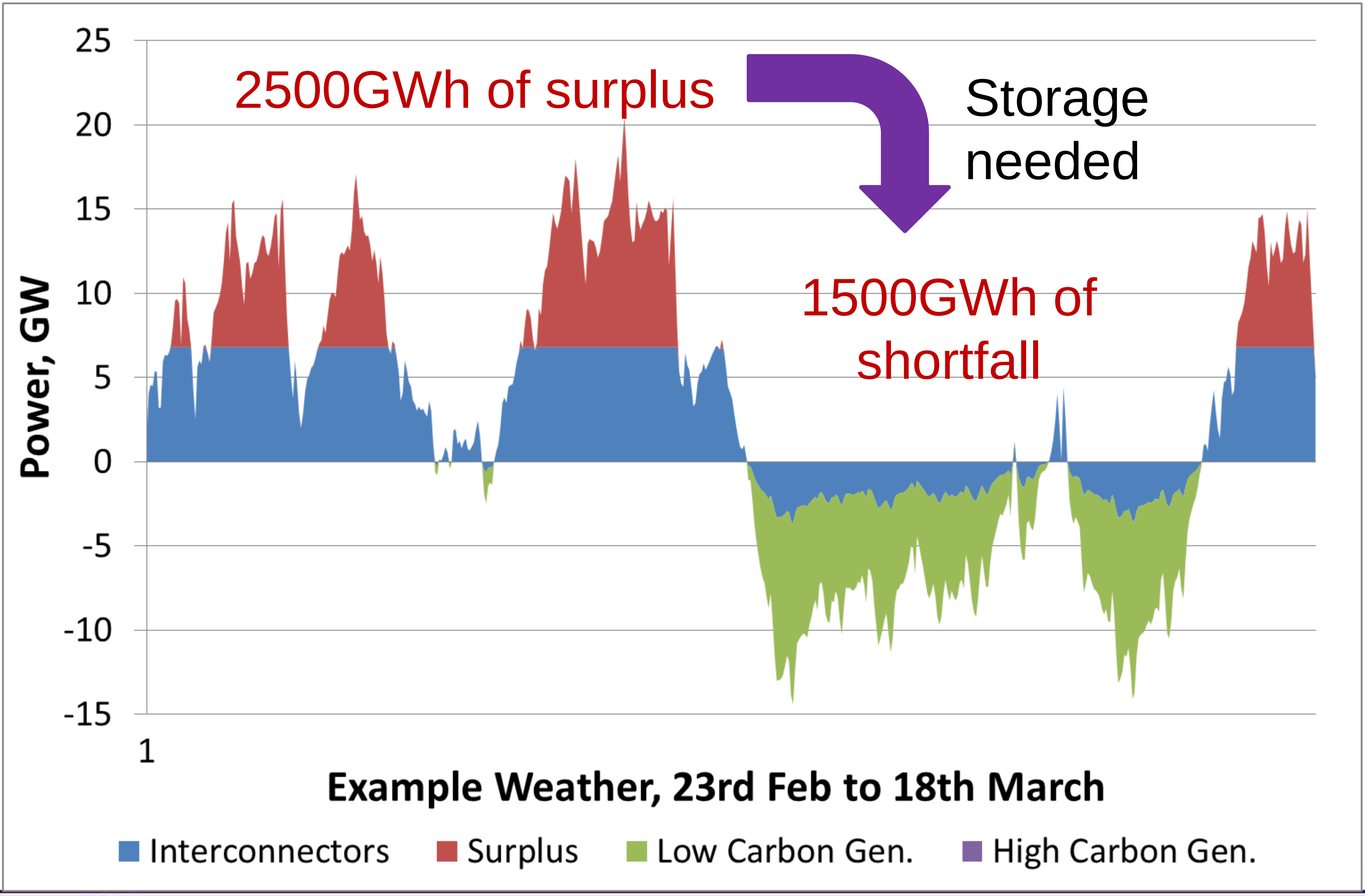
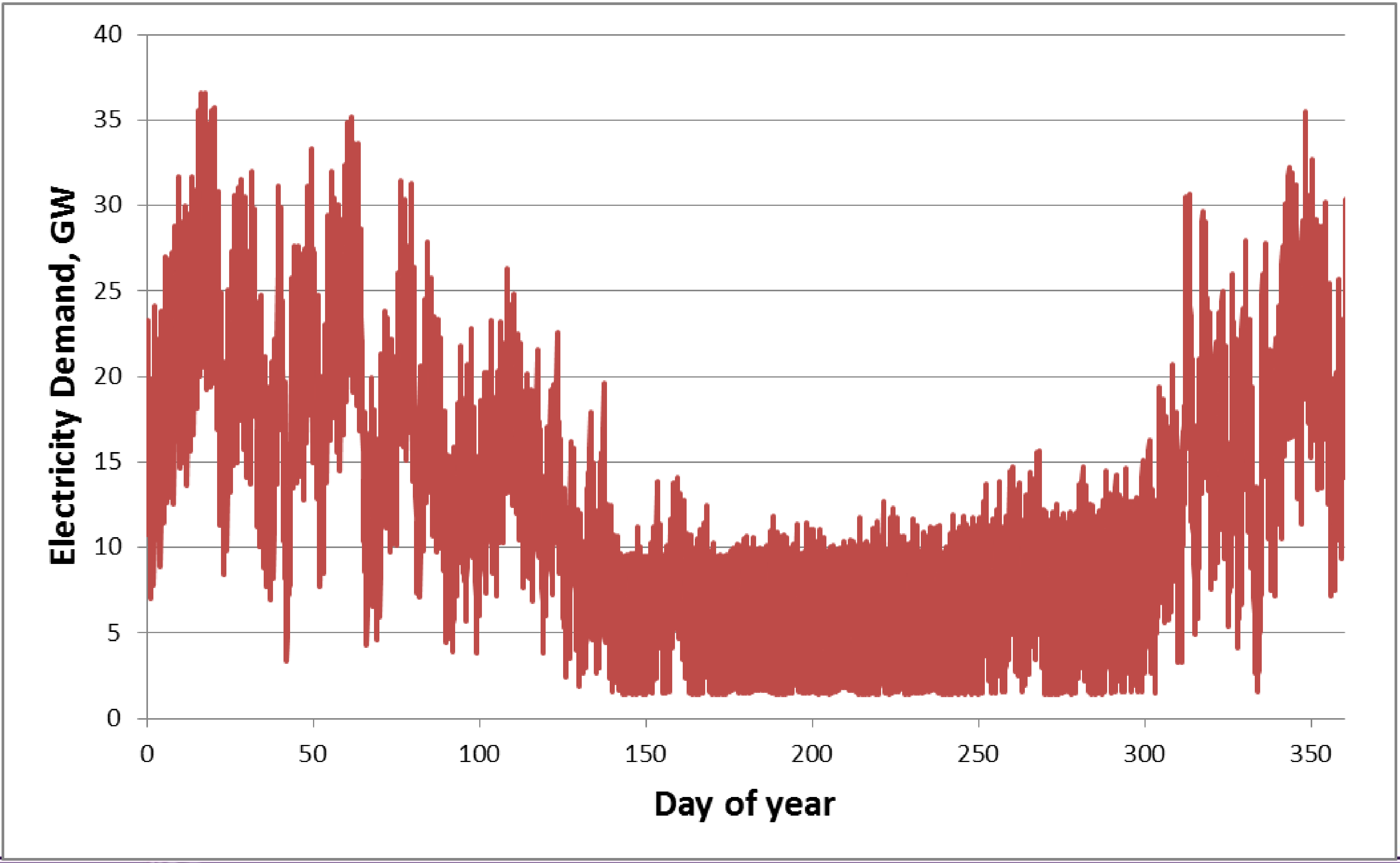


Weather-related variation
12 days of surplus, 10 days of deficit, 2 days surplus



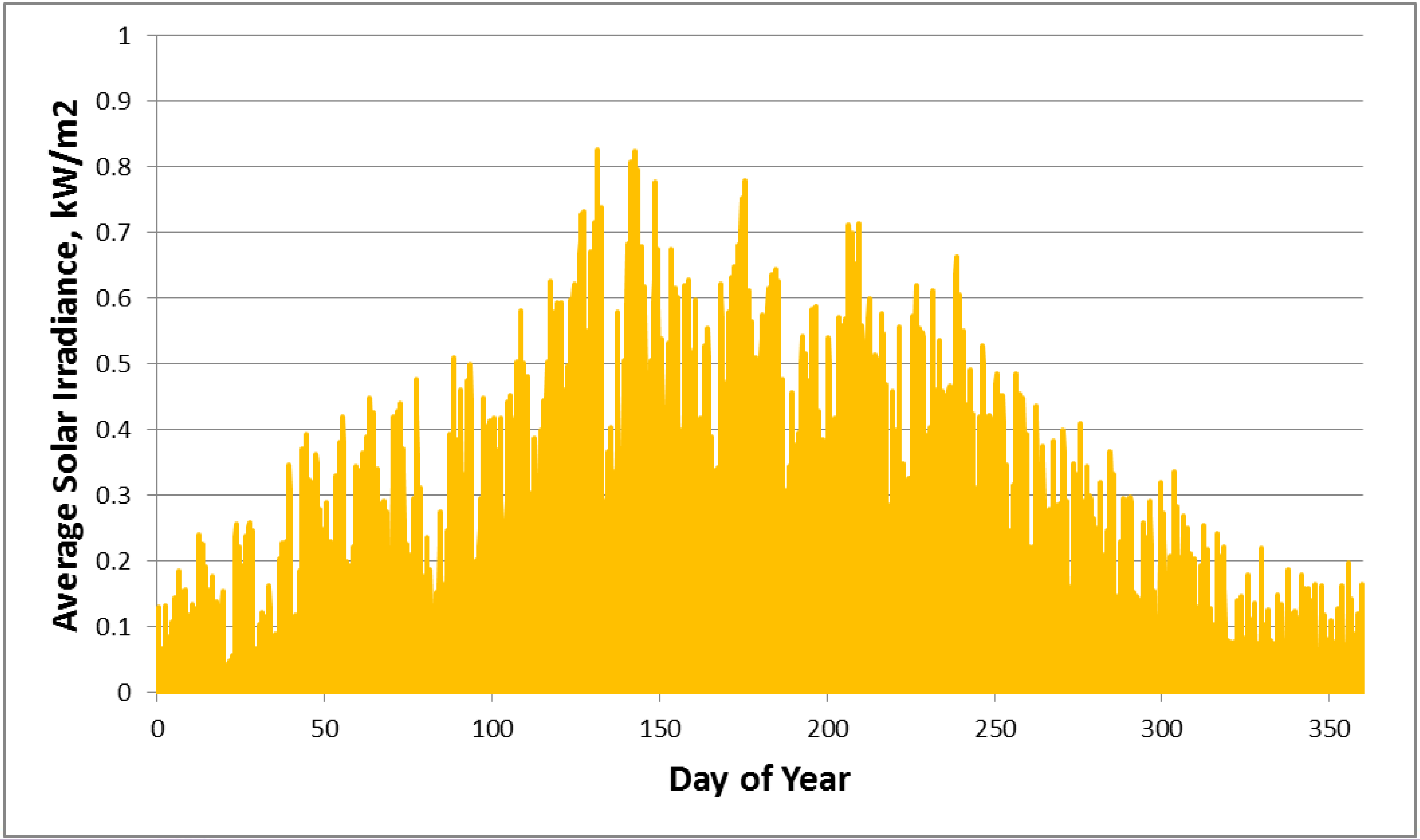
Seasonal variation is dominated by heating demand



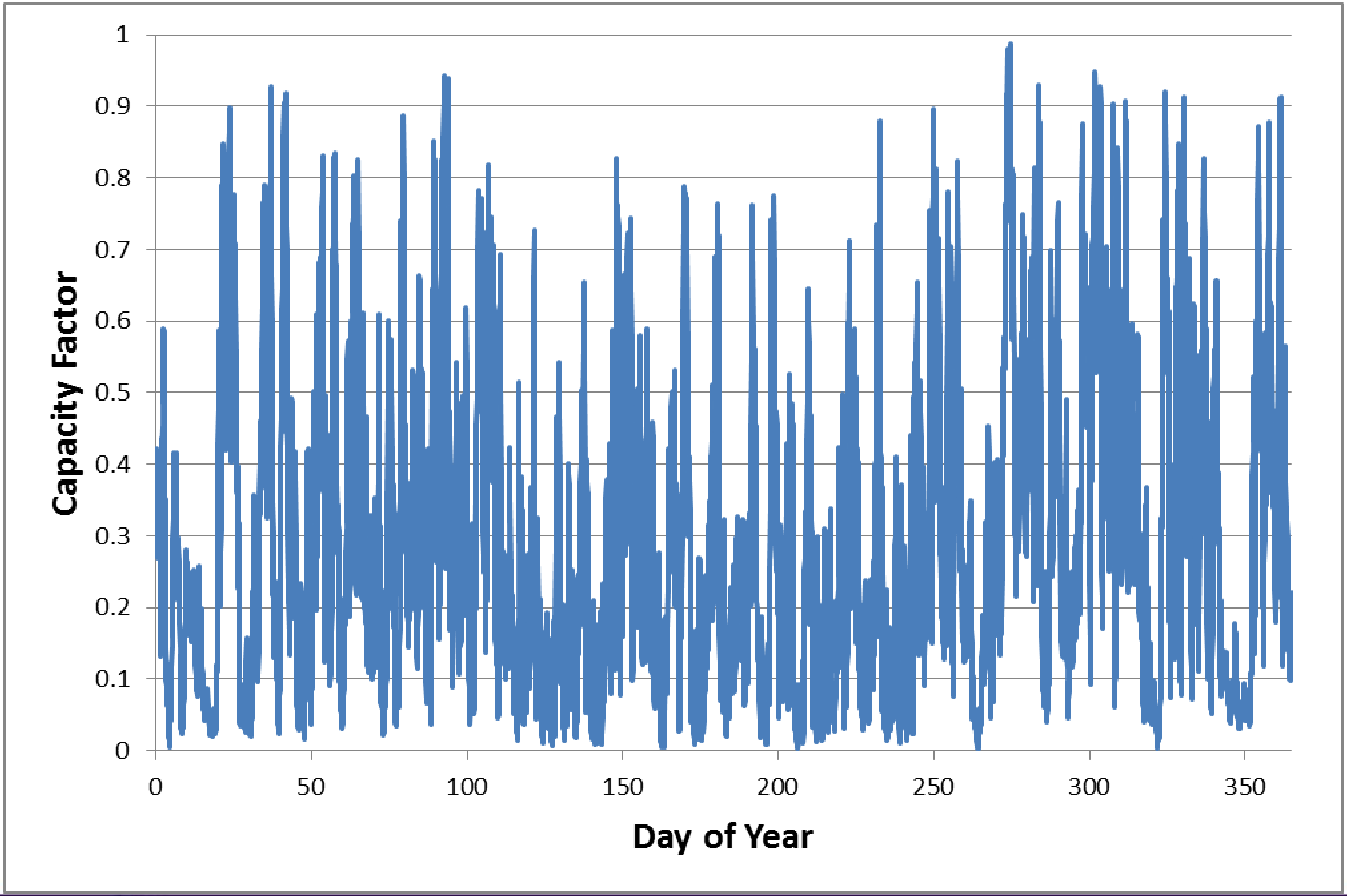
Existing scenario pathways

- Each pathway was constructed to a specific objective
  - Eg: high renewables, high nuclear, high CCS, low cost, central coordination, market rules, thousand flowers
- None was constructed to minimise required storage

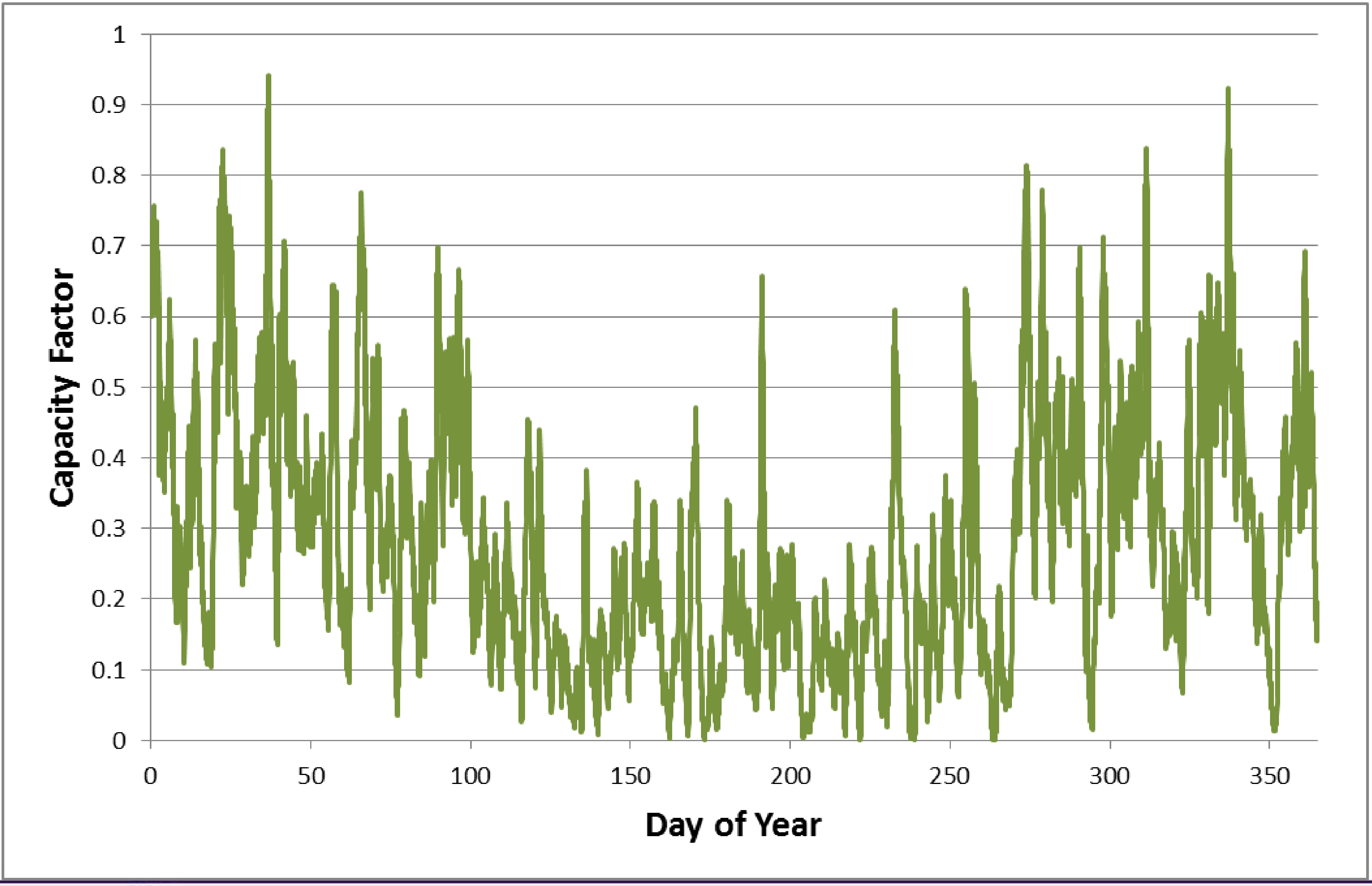
Solar is strong in spring and summer



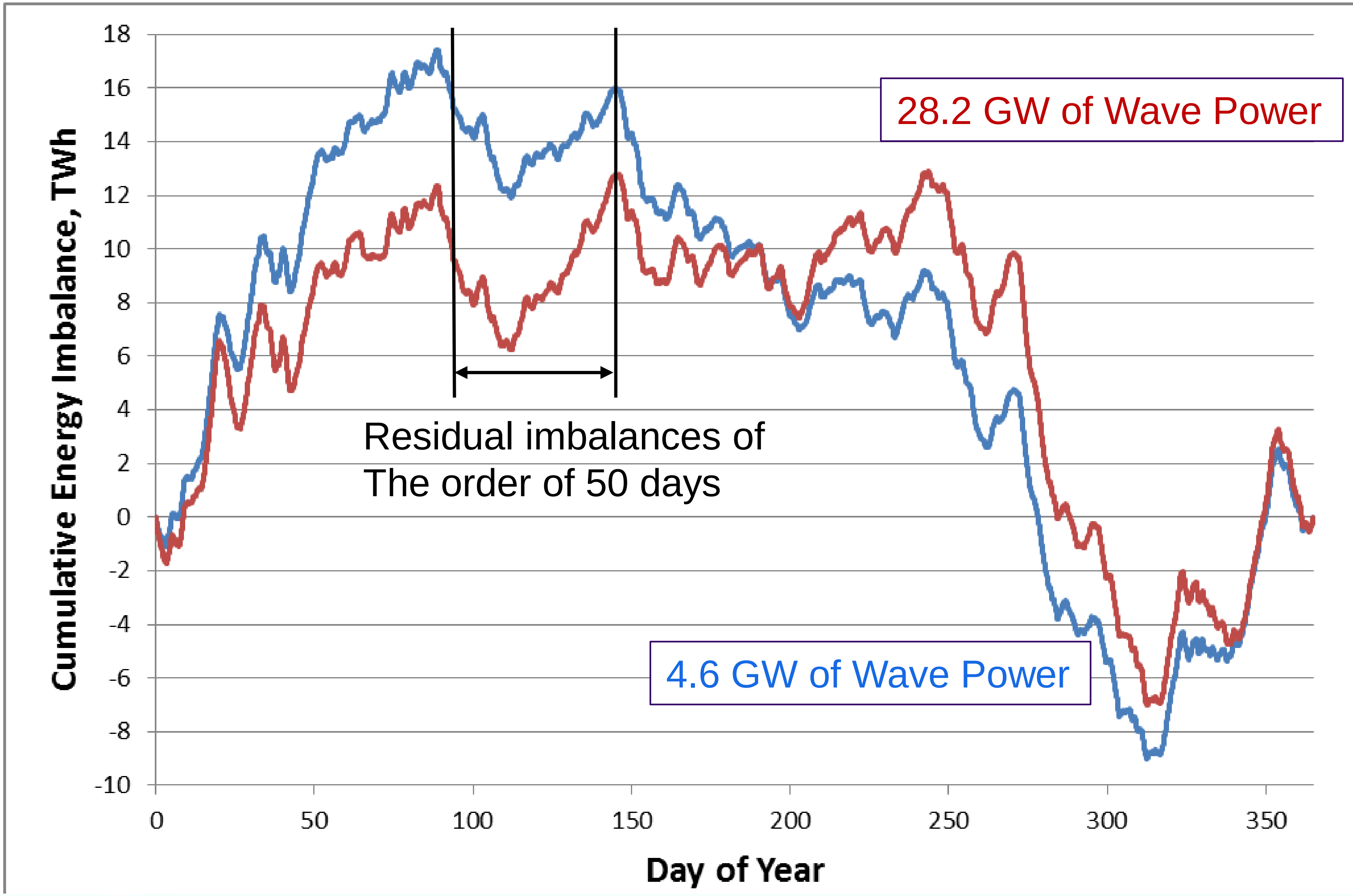
Wind power very variable



Wave power is less variable, and stronger in winter



An increase in wave power reduces cumulative imbalance



Thus:

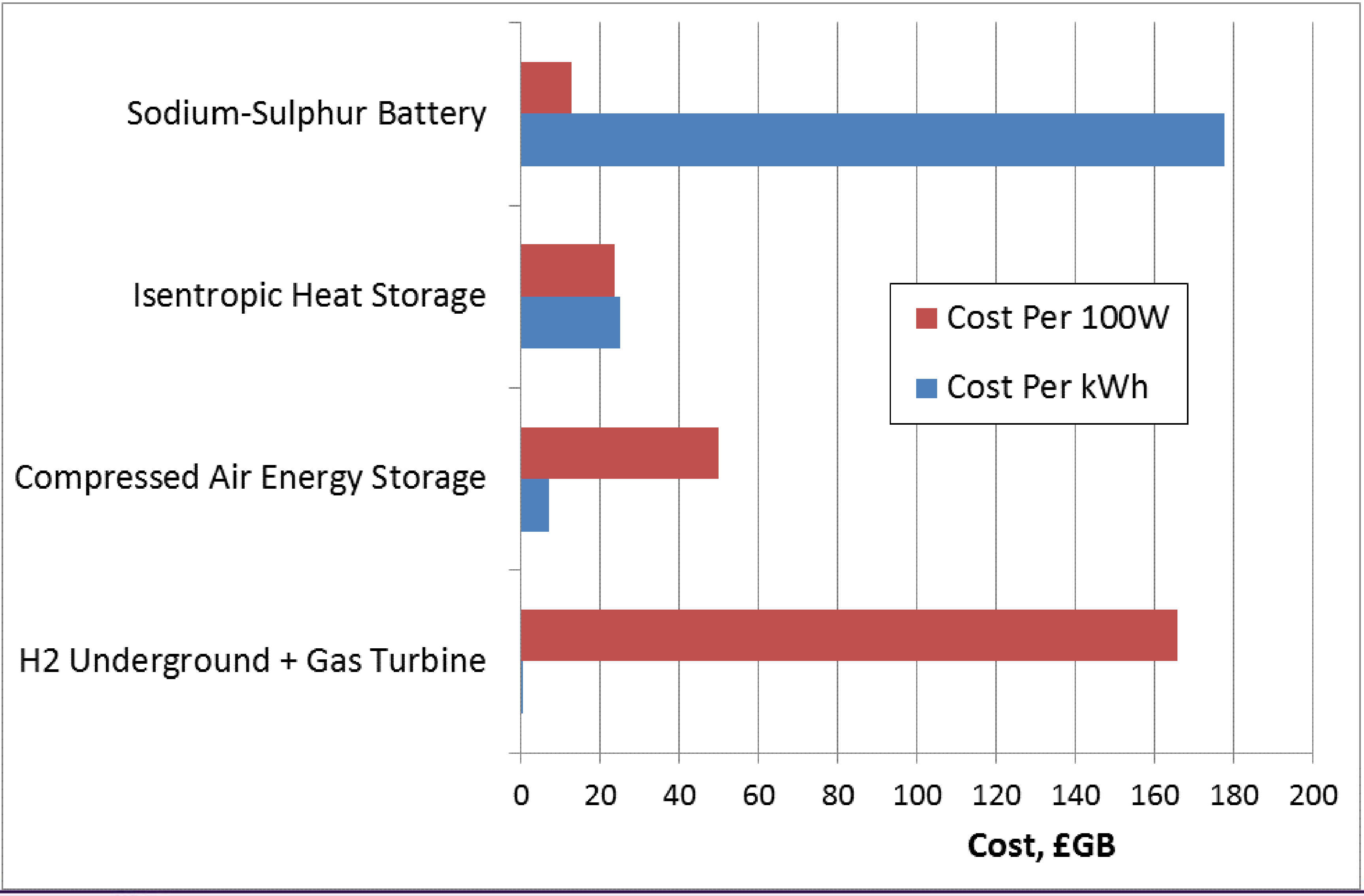
- A high-wave-power scenario
  reduces the need for inter-seasonal storage

But:

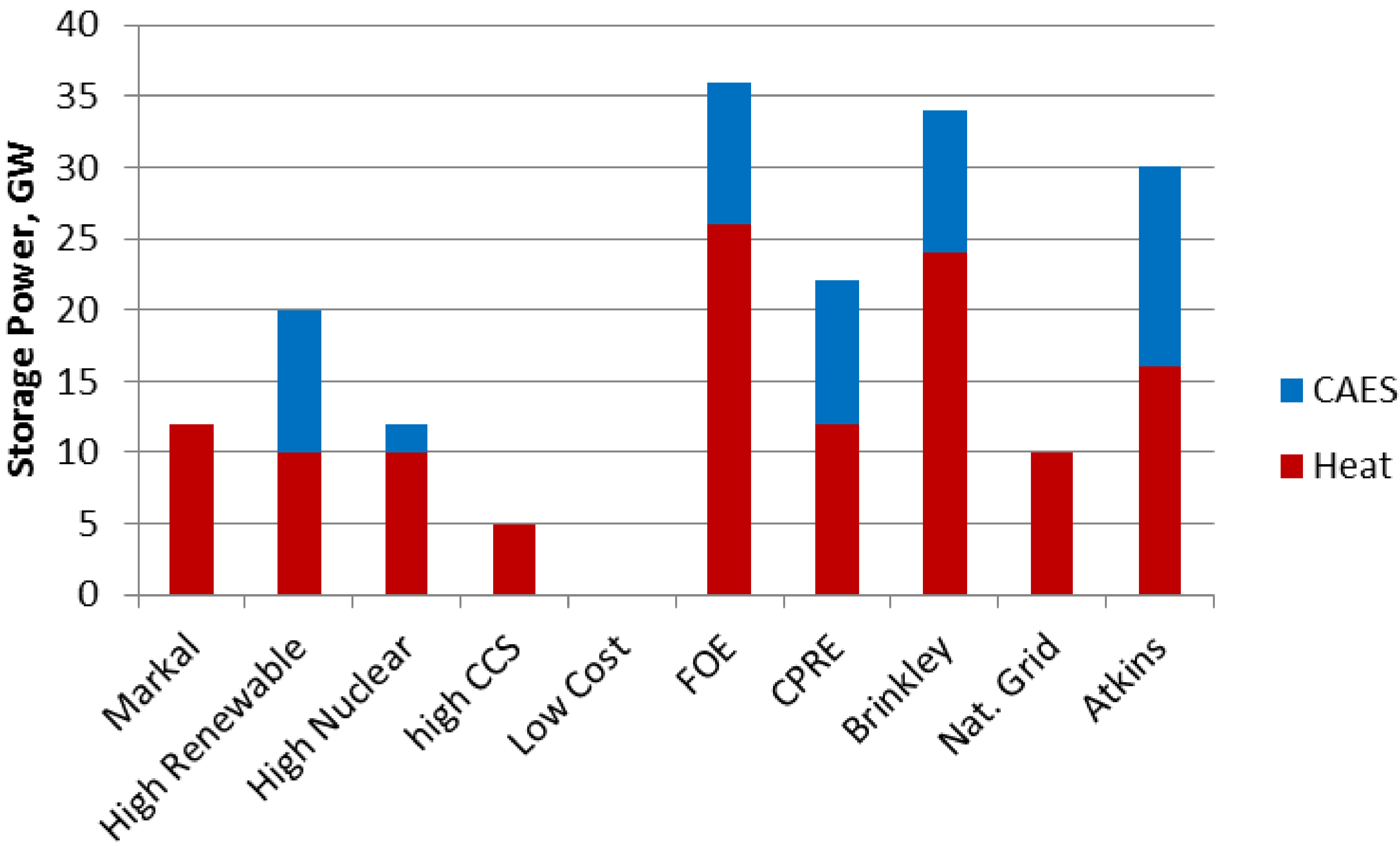
- Some long-term weather-related and
  inter-seasonal variations remain:
  - 10 to 50 GW of power rating
  - 2 to 10 TWh of energy capacity
  - = Time constant of about 200 hours
  - But forecasting cycle time of ~50 days

This was a first pass – we propose further research

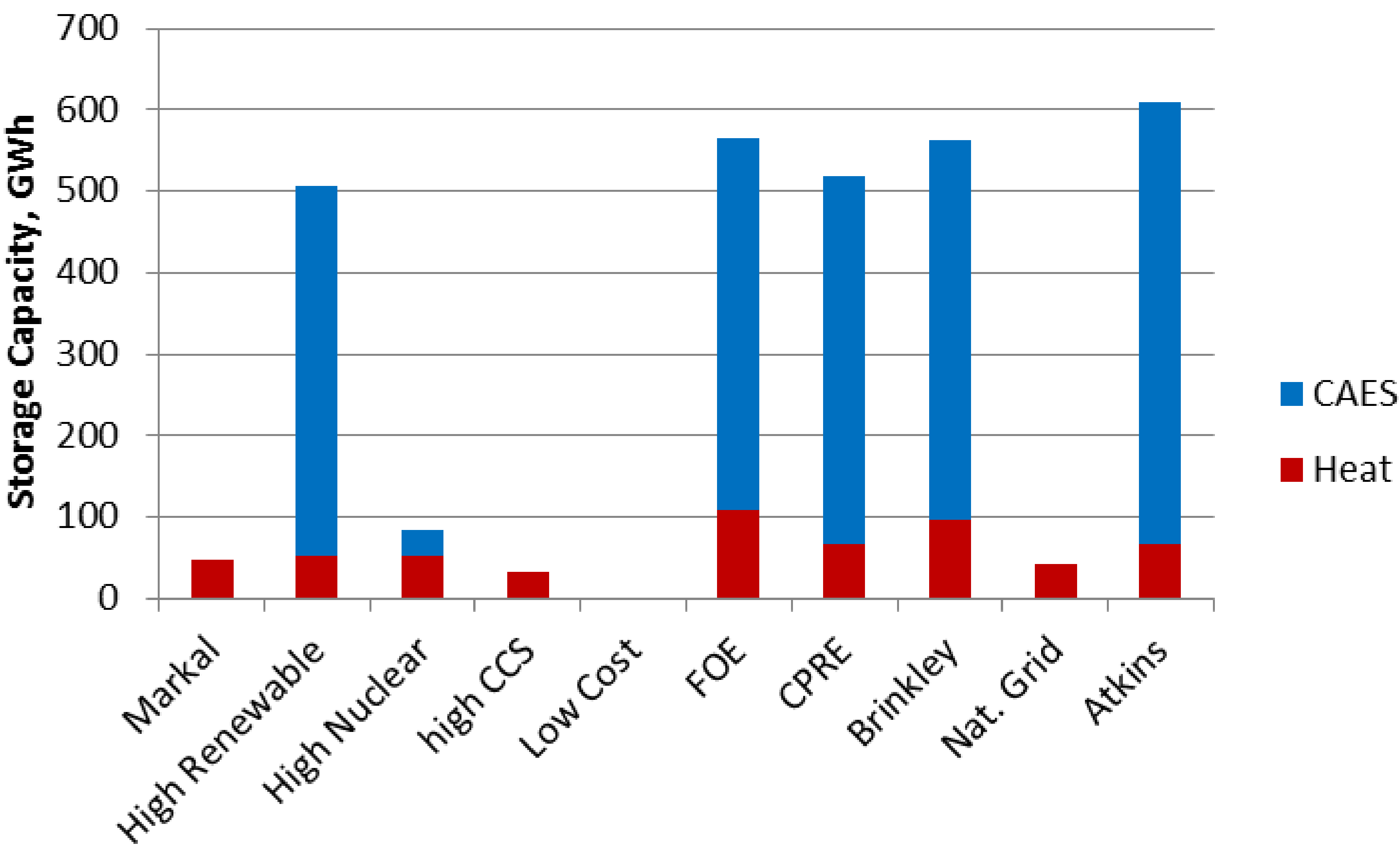
Capital Costs Per Power and Energy for Energy Storage



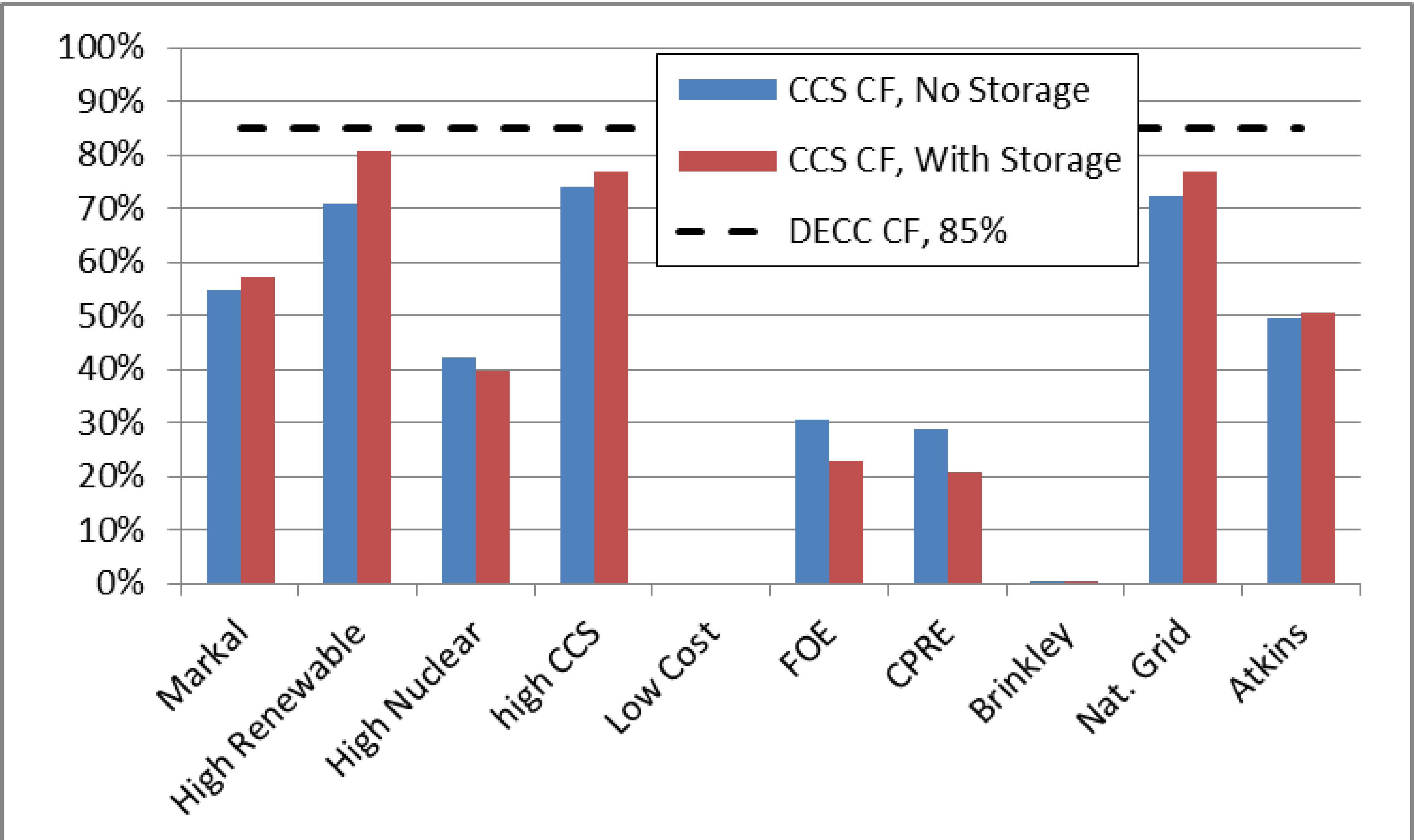
Optimum Storage Power



Optimum Storage Energy Capacity



Load Factor of CCS Remains Poor



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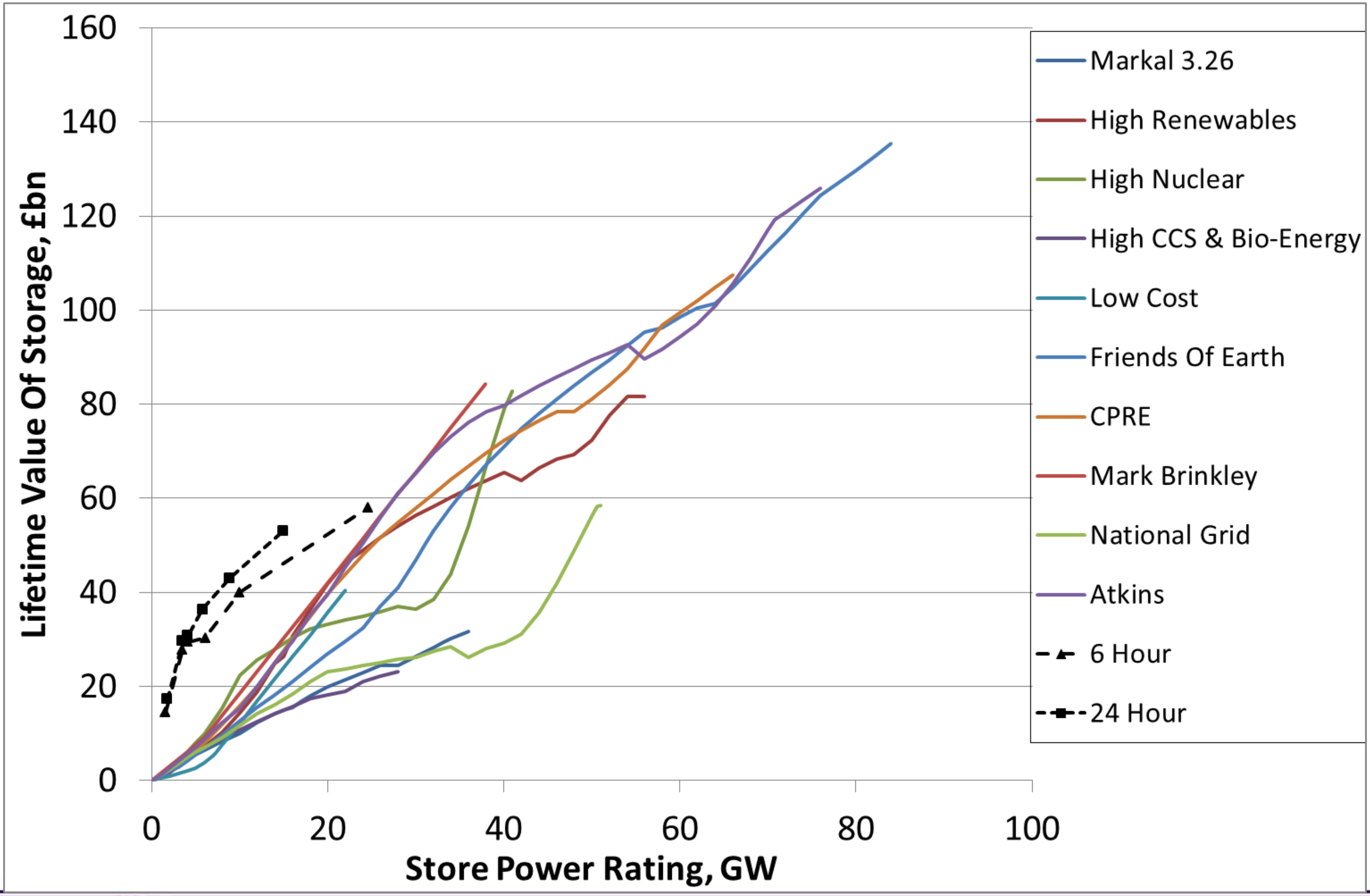
Economics of long-term storage

- CAES and thermal energy storage can give up to 30 GW and 600 GWh
- That's a time constant of 20 hours
- But long-term variations are ~200 hours
- CAES costs: $12/kWh, $800/kW
- Underground hydrogen: $0.16/kWh, $2700/kW
- Hydrogen electrolysis is too expensive to compete with natural gas at $830/kW and 20% capacity factor

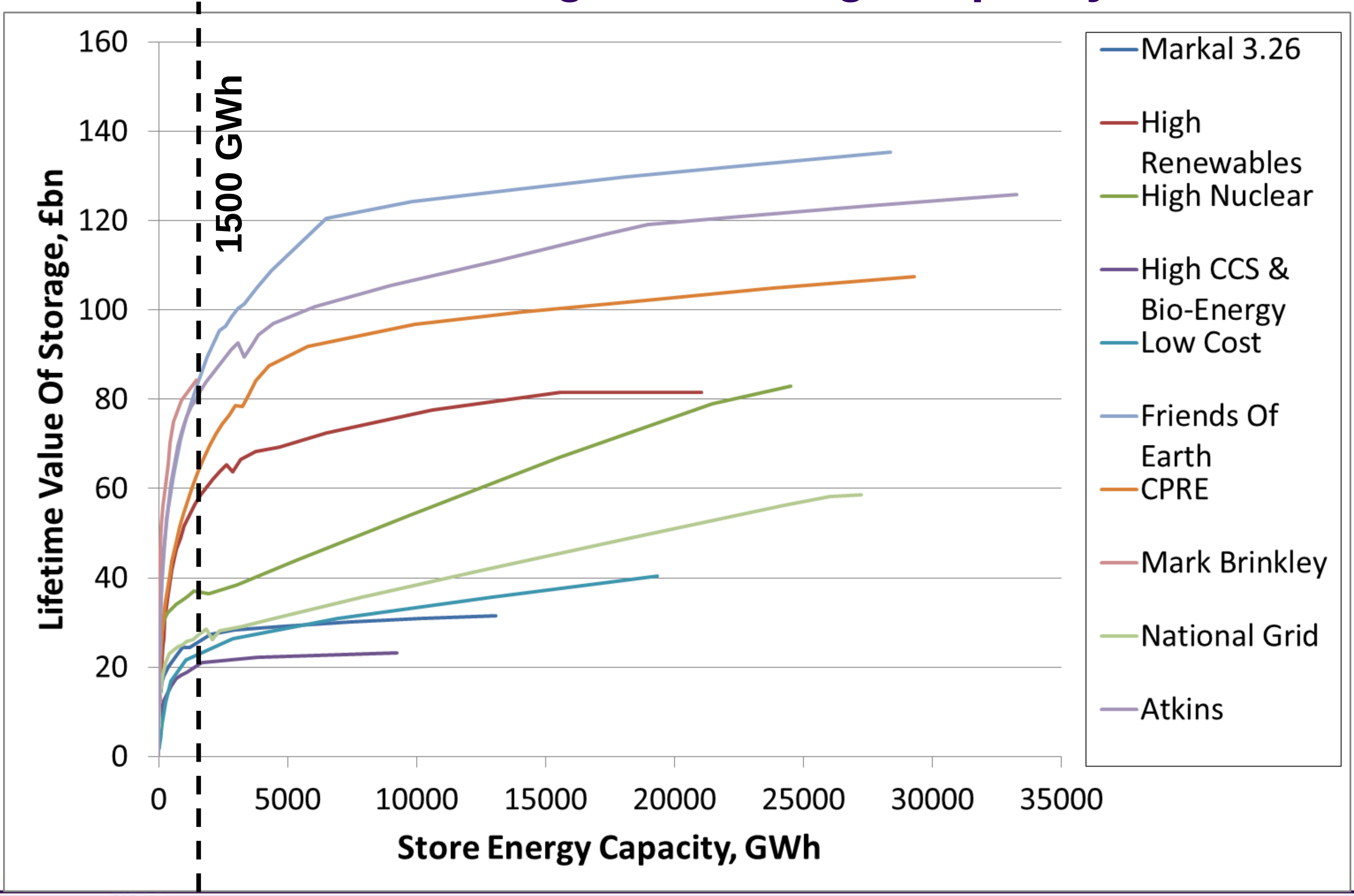
Conclusions

- Low carbon scenarios suffer from long-term weather-related and inter-seasonal variations
- Mainly caused by winter heating demand
- Better selection of renewables can reduce but not eliminate long-term variations
- Gap between 20 hours and 200 hours time constant of storage
- We need CAES to be cheaper per kWh or hydrogen electrolysis to be cheaper per kW

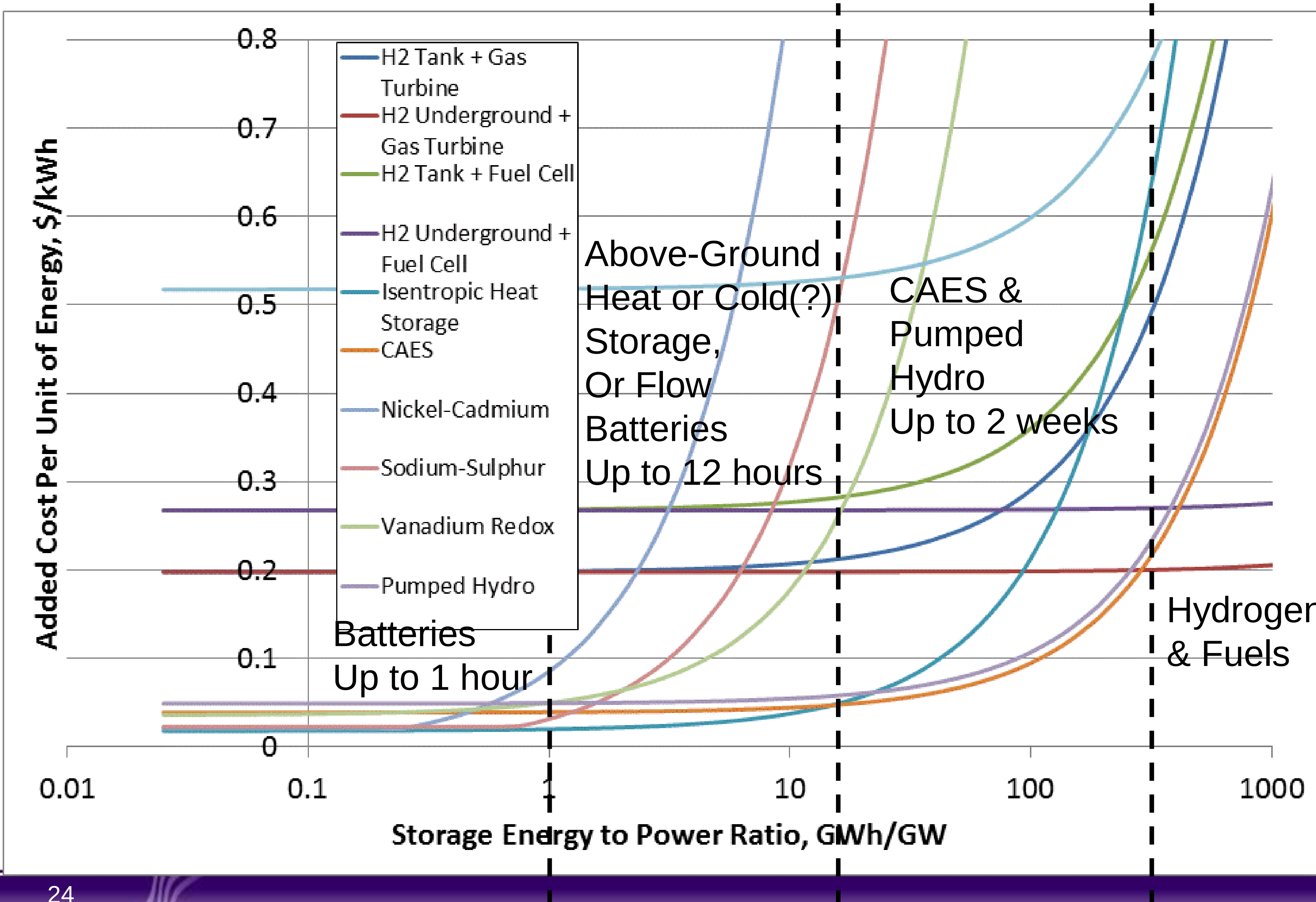
Value of Storage vs. Store Power



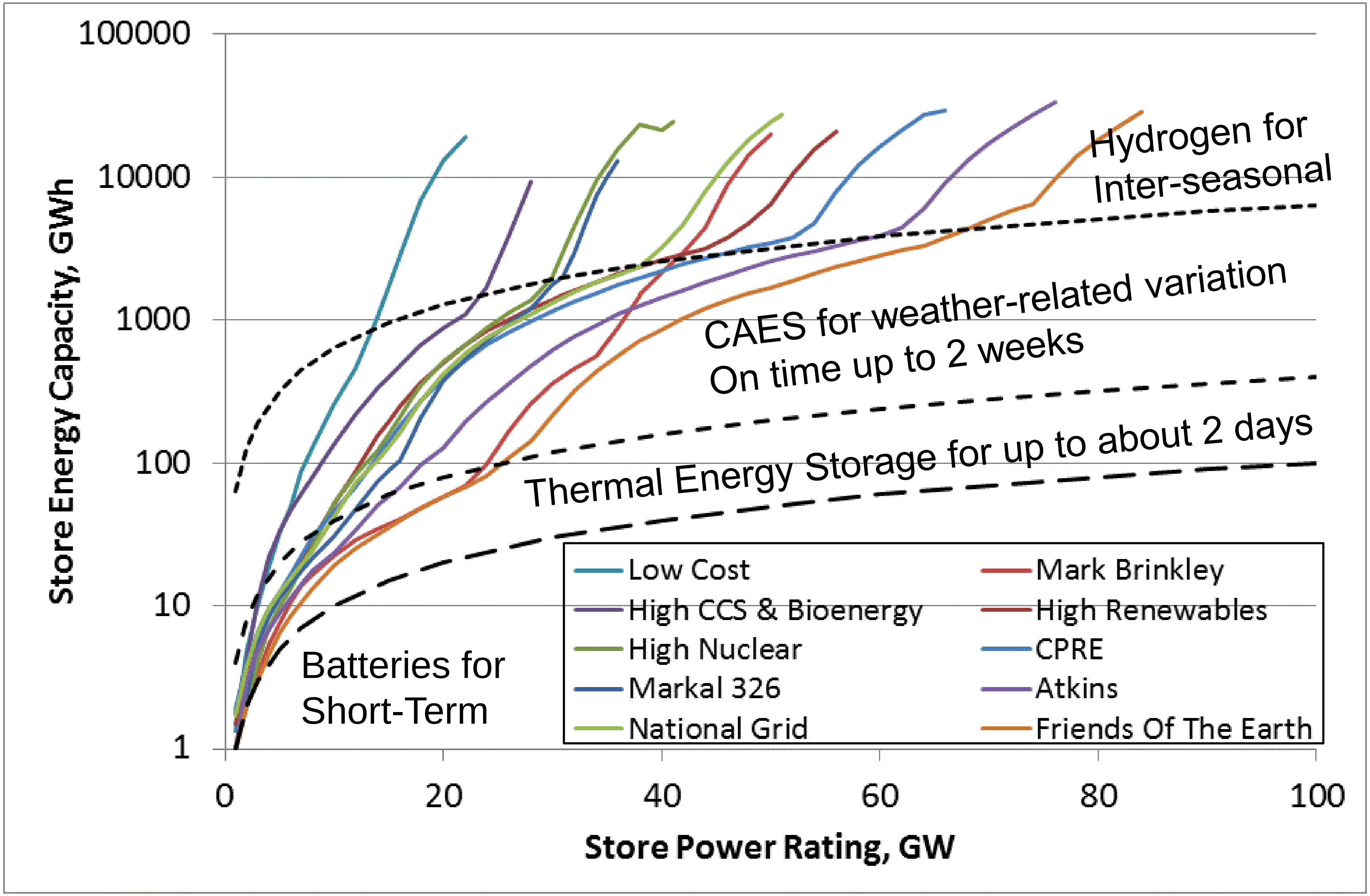
Value of Storage vs. Storage Capacity



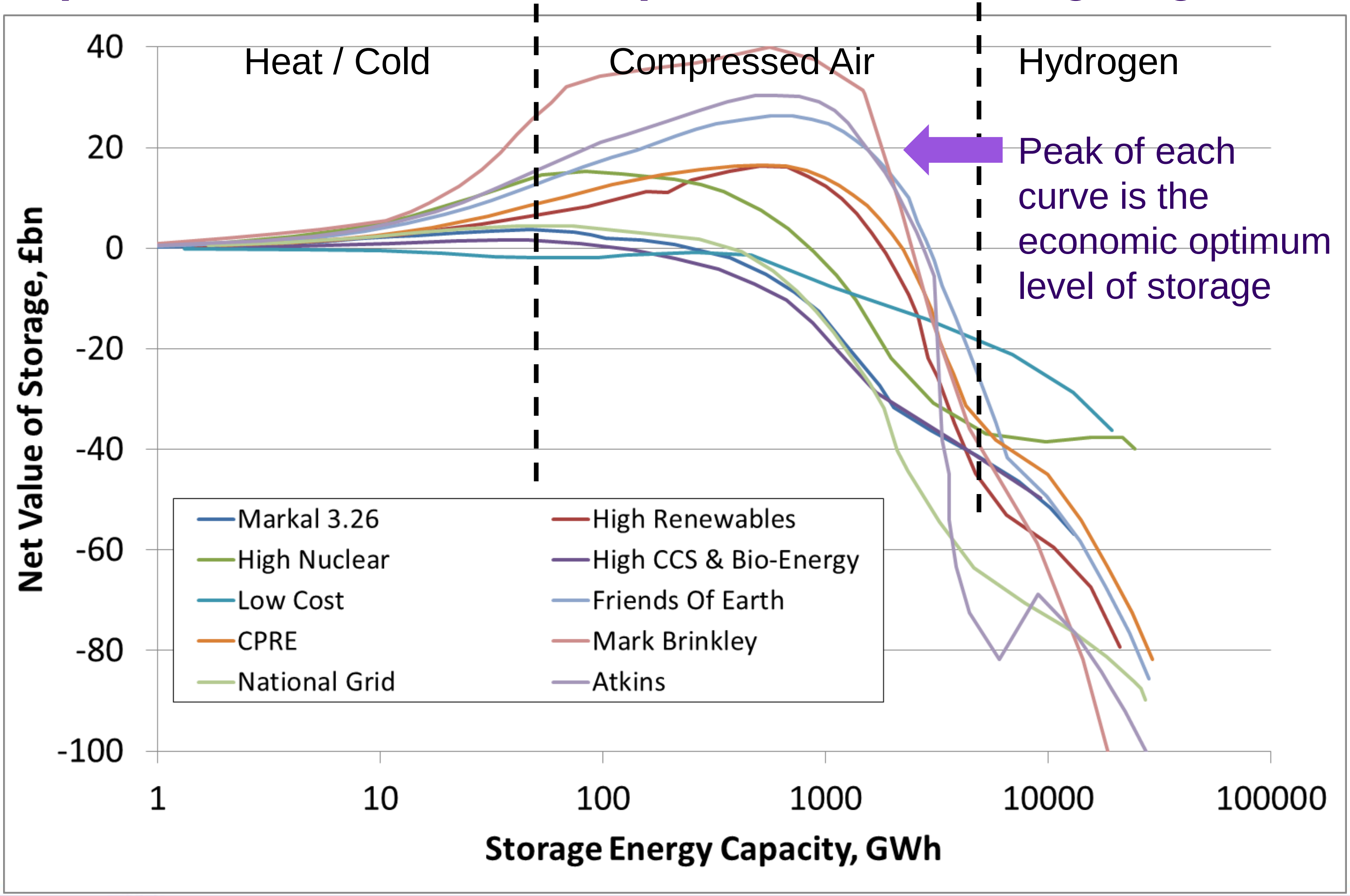
Cost of Storage with Increasing Timescales



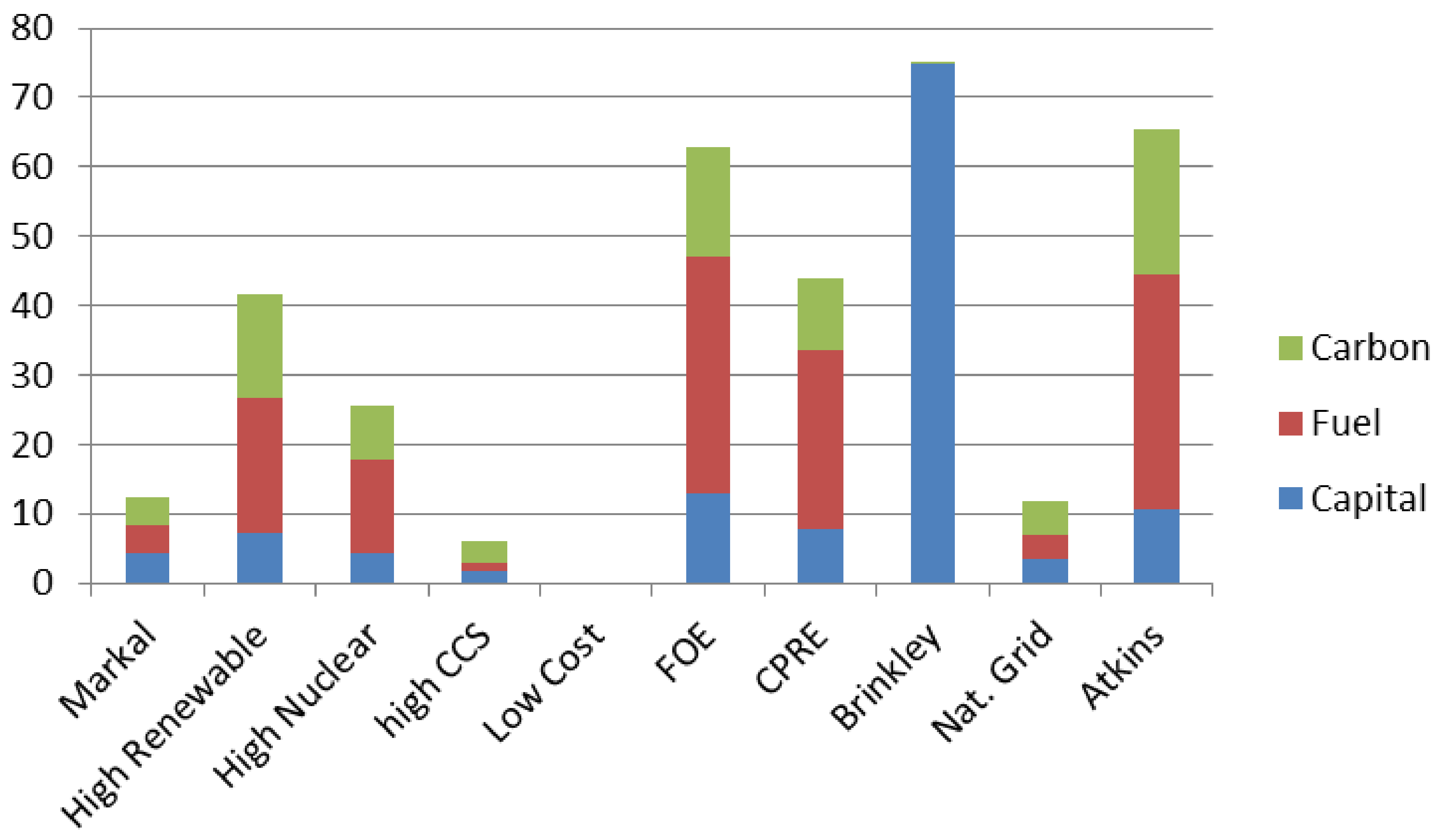
Size of Storage and Appropriate Technology by Application



Optimum Solution is Multiple Stores Working Together



Components of Value of Energy Storage



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Energy Storage Cycle Time vs. Weather Predictability