High-Temporal-Resolution Analysis of UK Power System Used to Determine the Optimal Amount and Mix of Energy Storage Technologies

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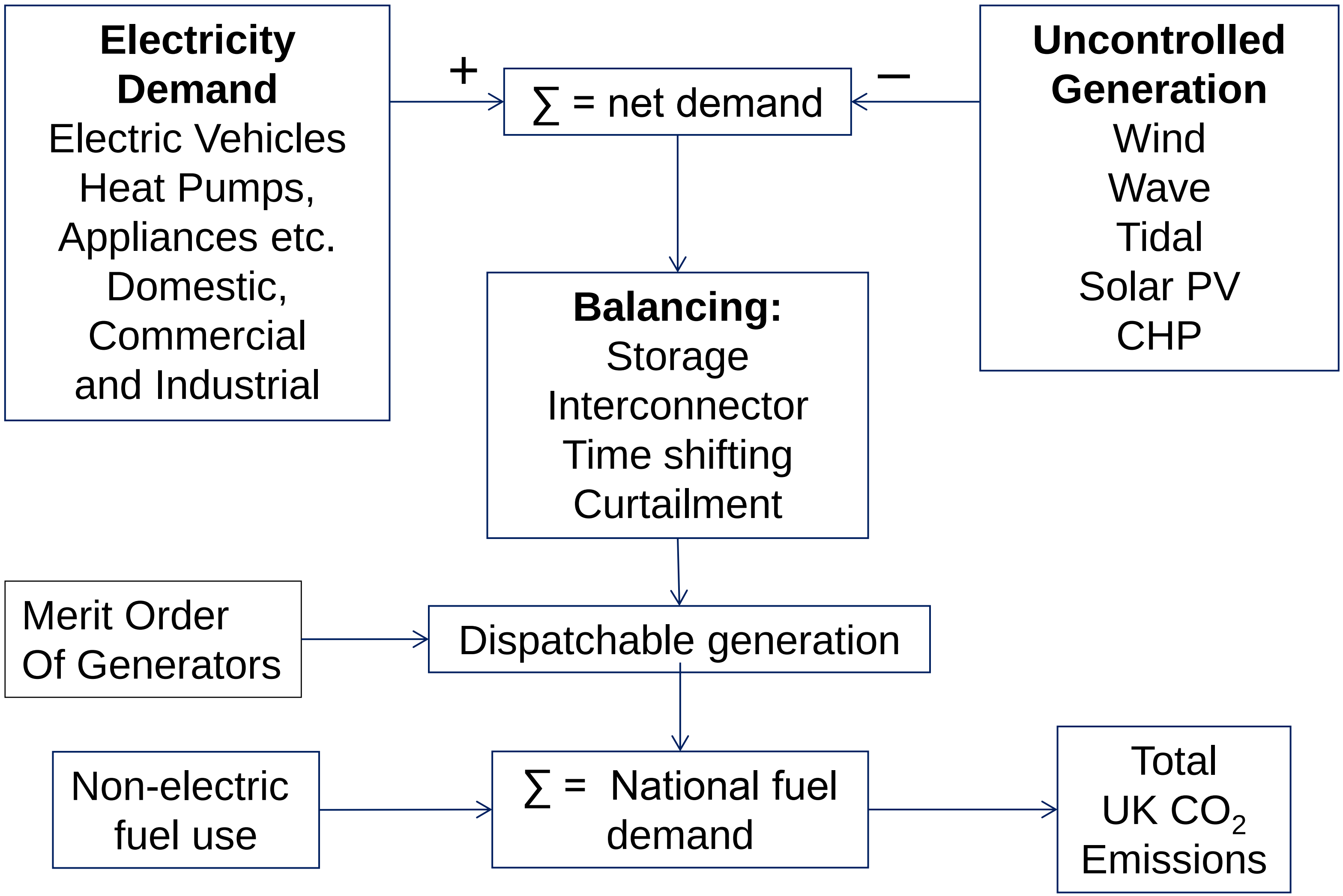
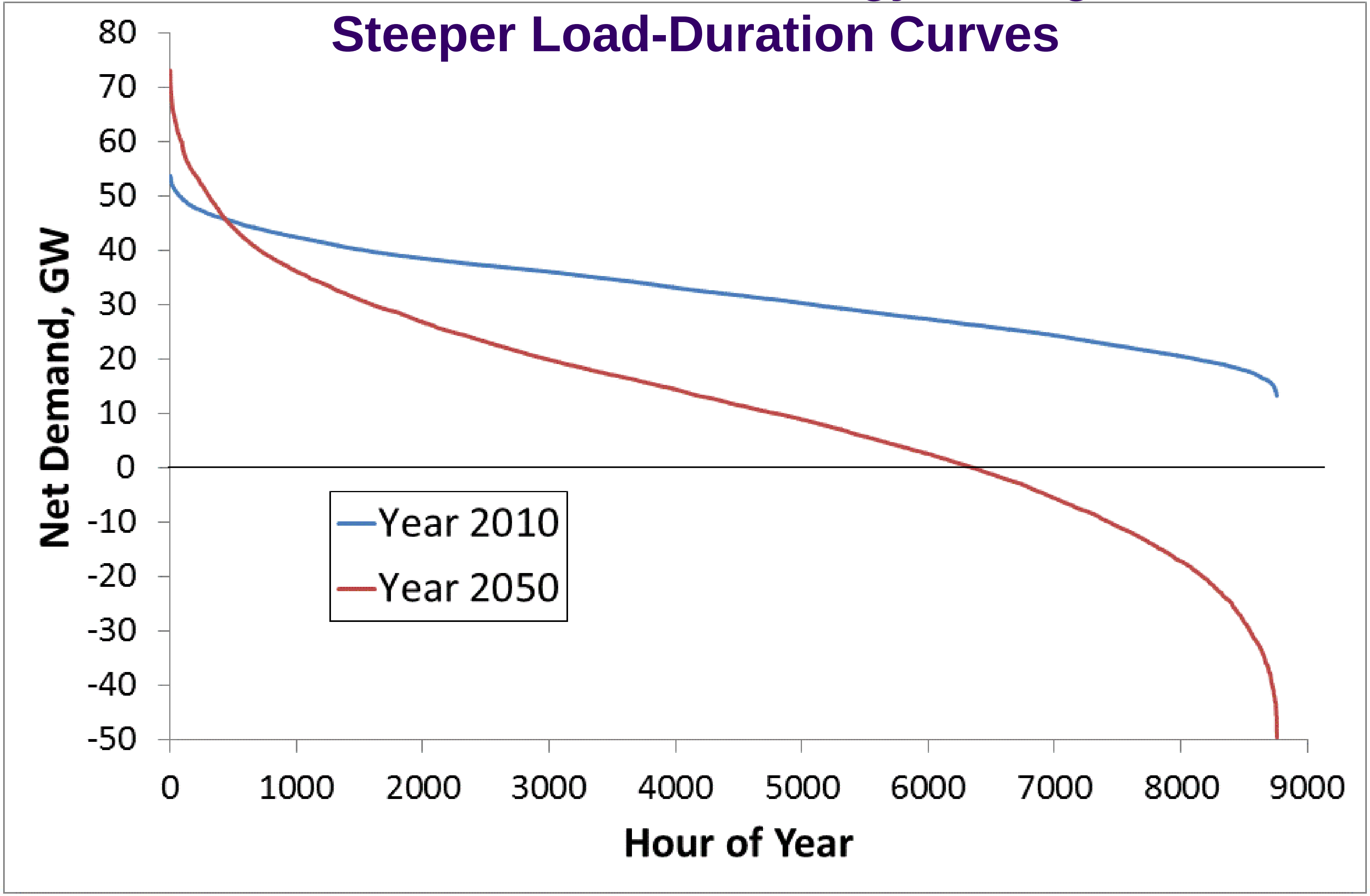
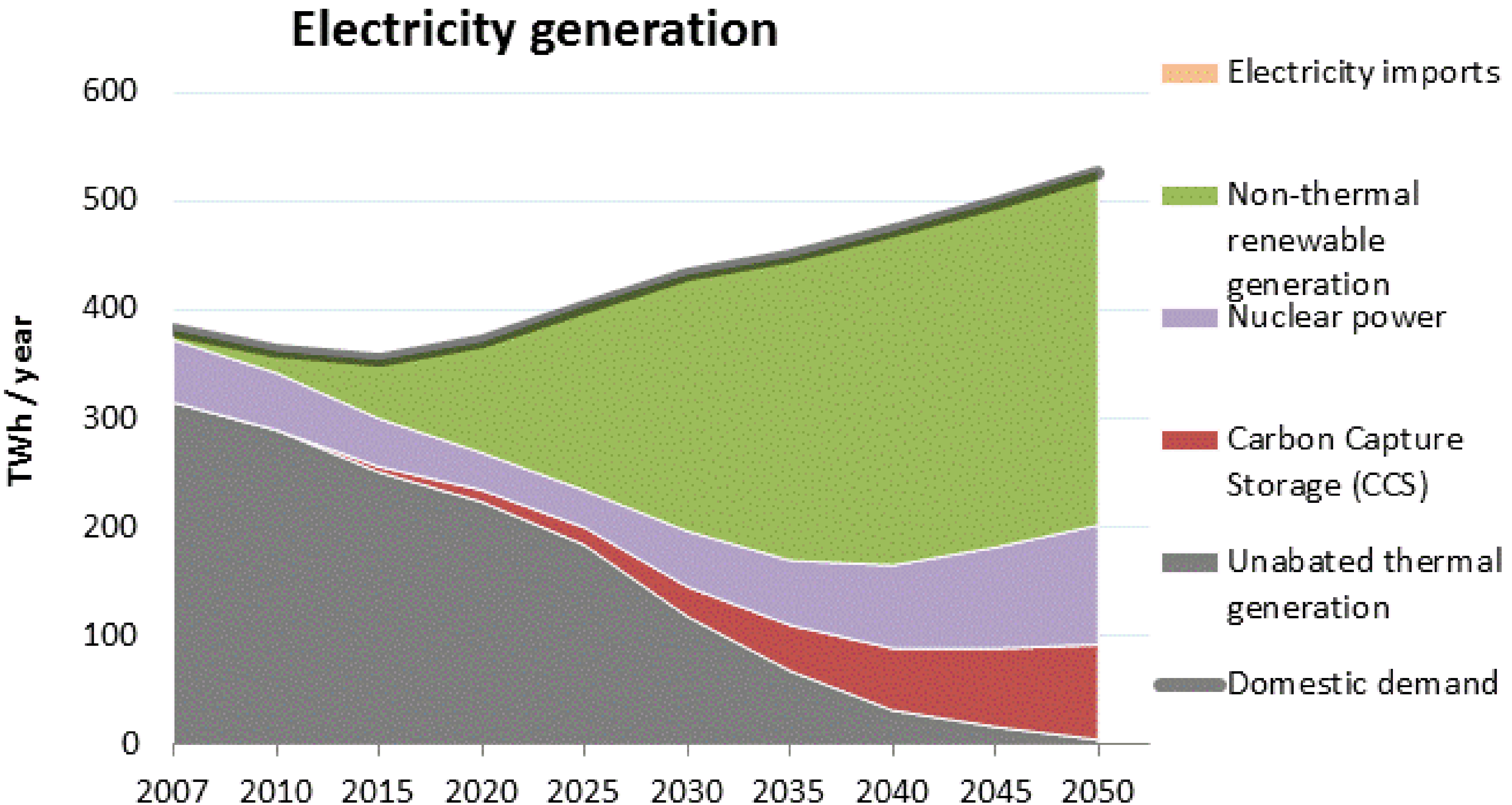
Overview of FESA, “Future Energy Scenario Analysis”



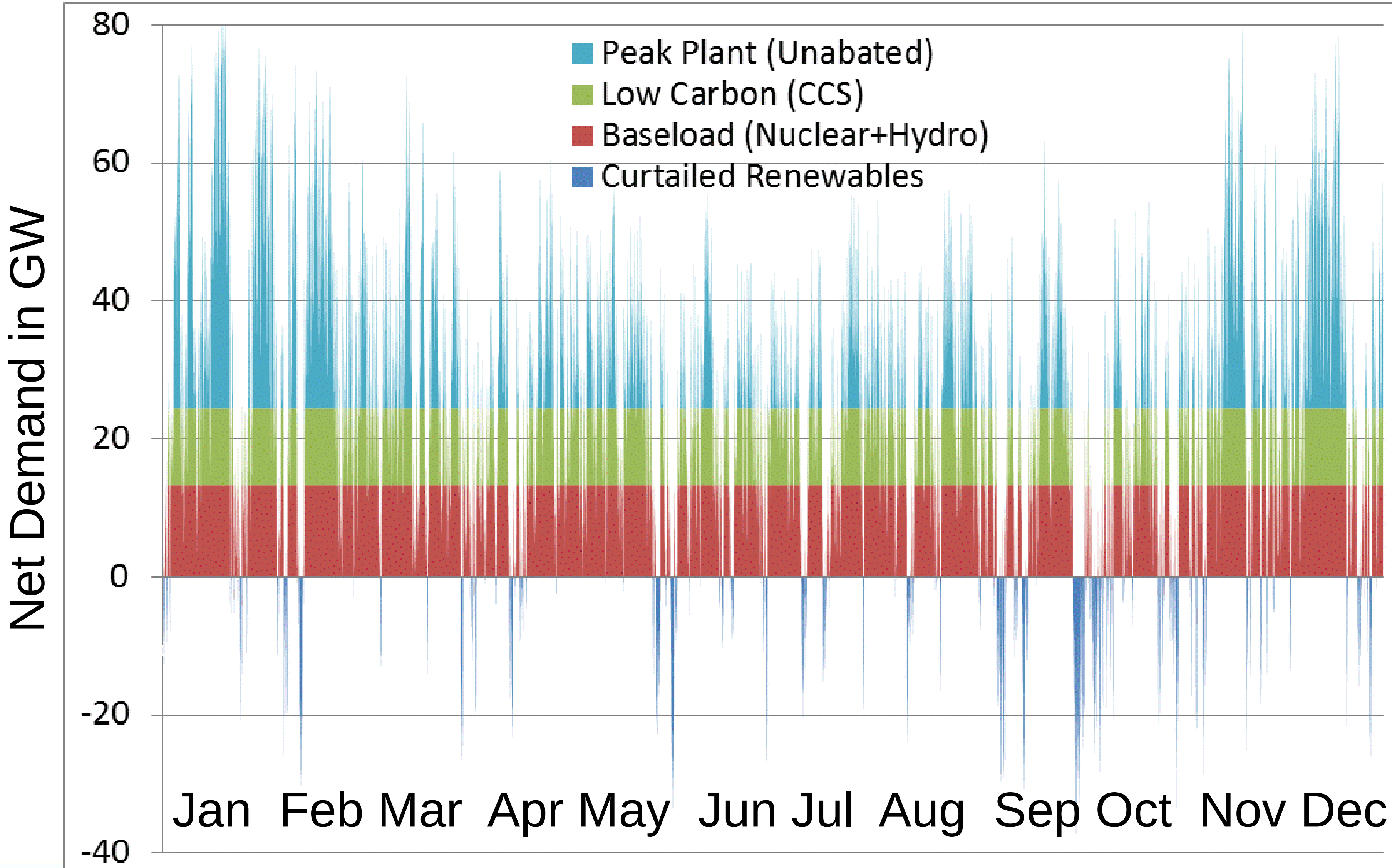
The Future Need for Energy Storage: Steeper Load-Duration Curves



DECC 2050 Calculator – (e.g. High Renewables)



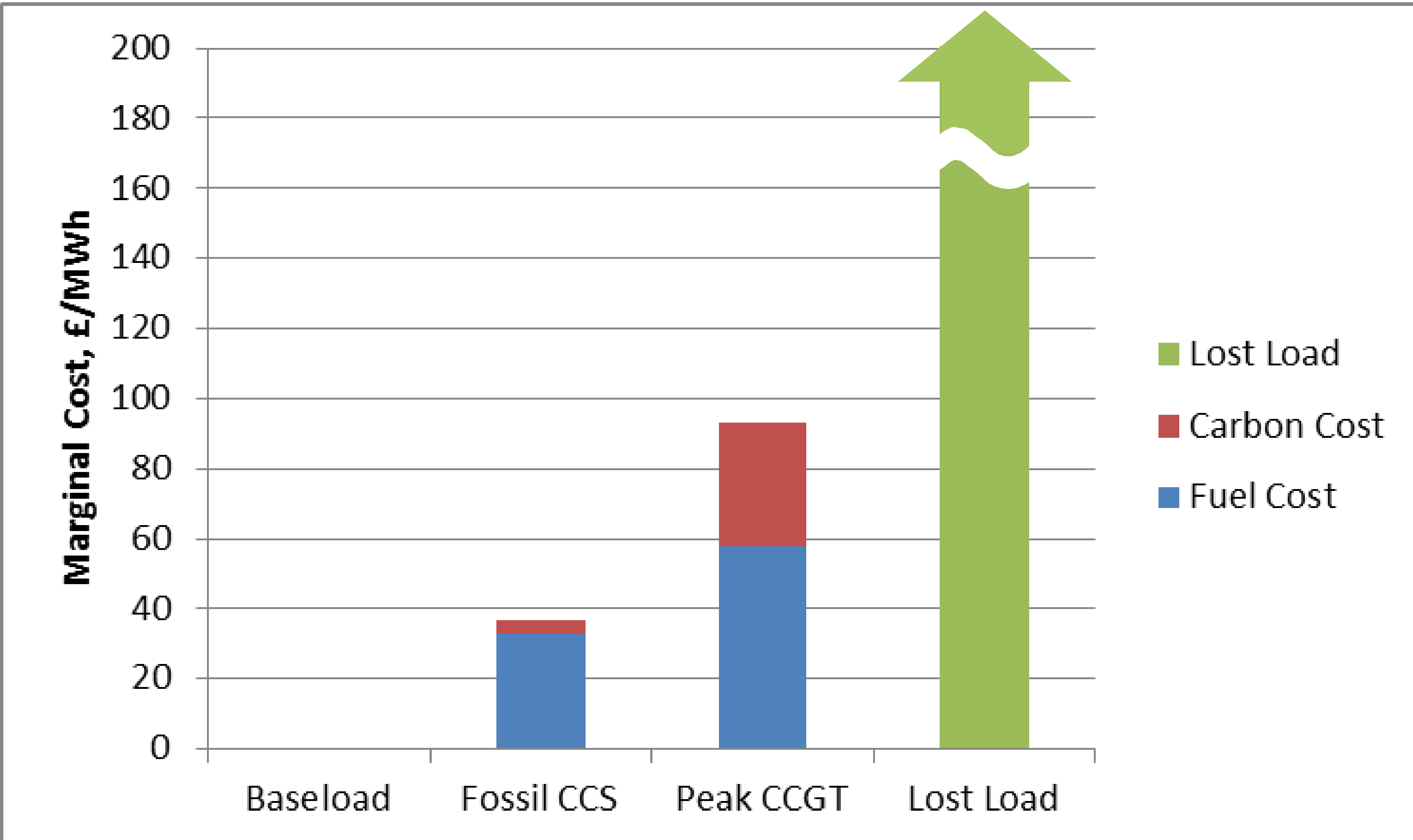
DECC 2050 Calculator (Higher Renewables Scenario)



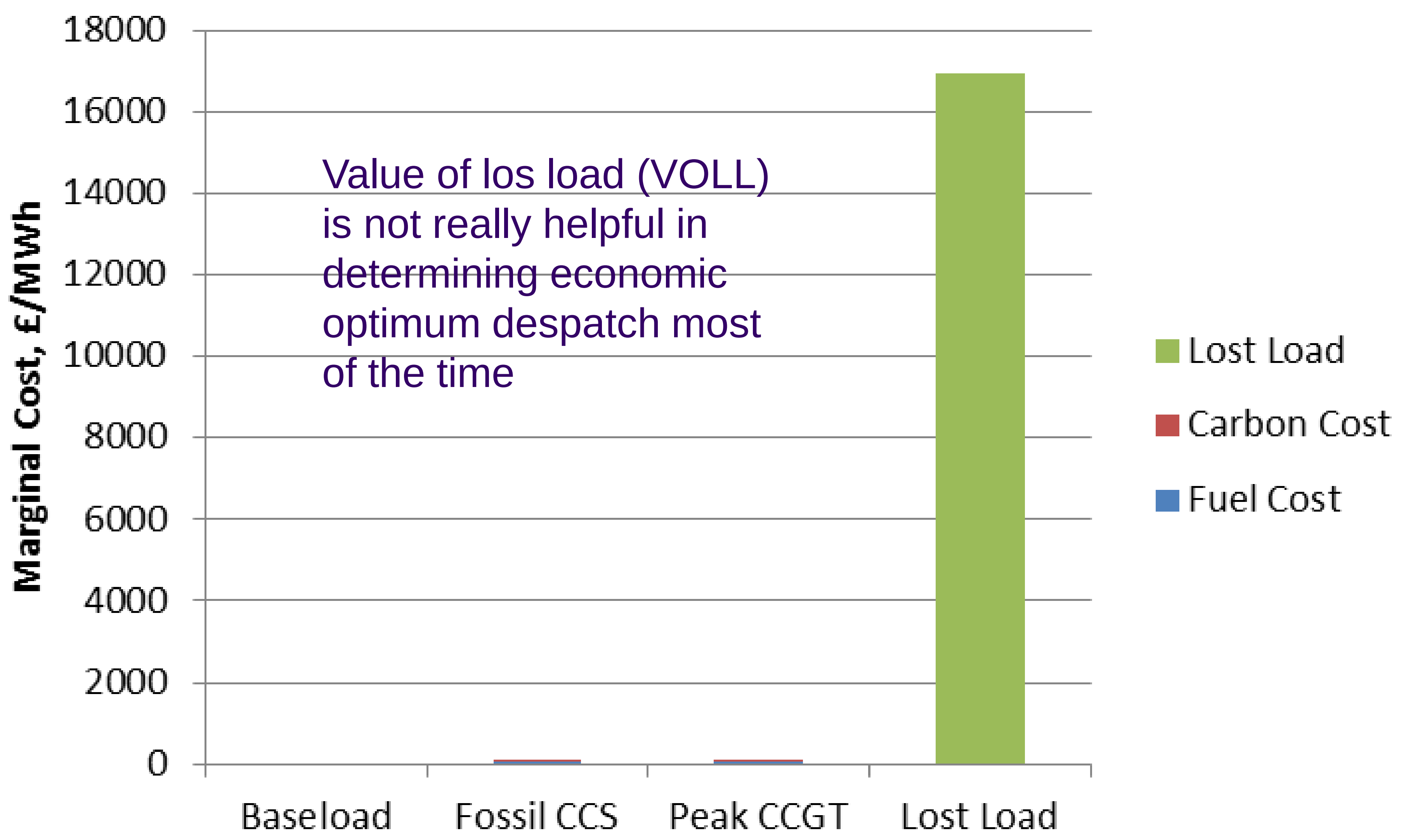
Costs of Electricity Generation

- Baseload and renewables: High capital cost but ‘free’ running costs
- Fuel costs:
  - £16/MWh_e for CCS,
  - £23/MWh_e for peak gas-fired plant
- Carbon price: £76/tonne of CO_2 equivalent
  - Peak gas plant 460kg/MWh_e
  - CCS plant 50kg/MWh_e
- Value of Lost Load (DECC & Ofgem) £16,940/MWh_e !

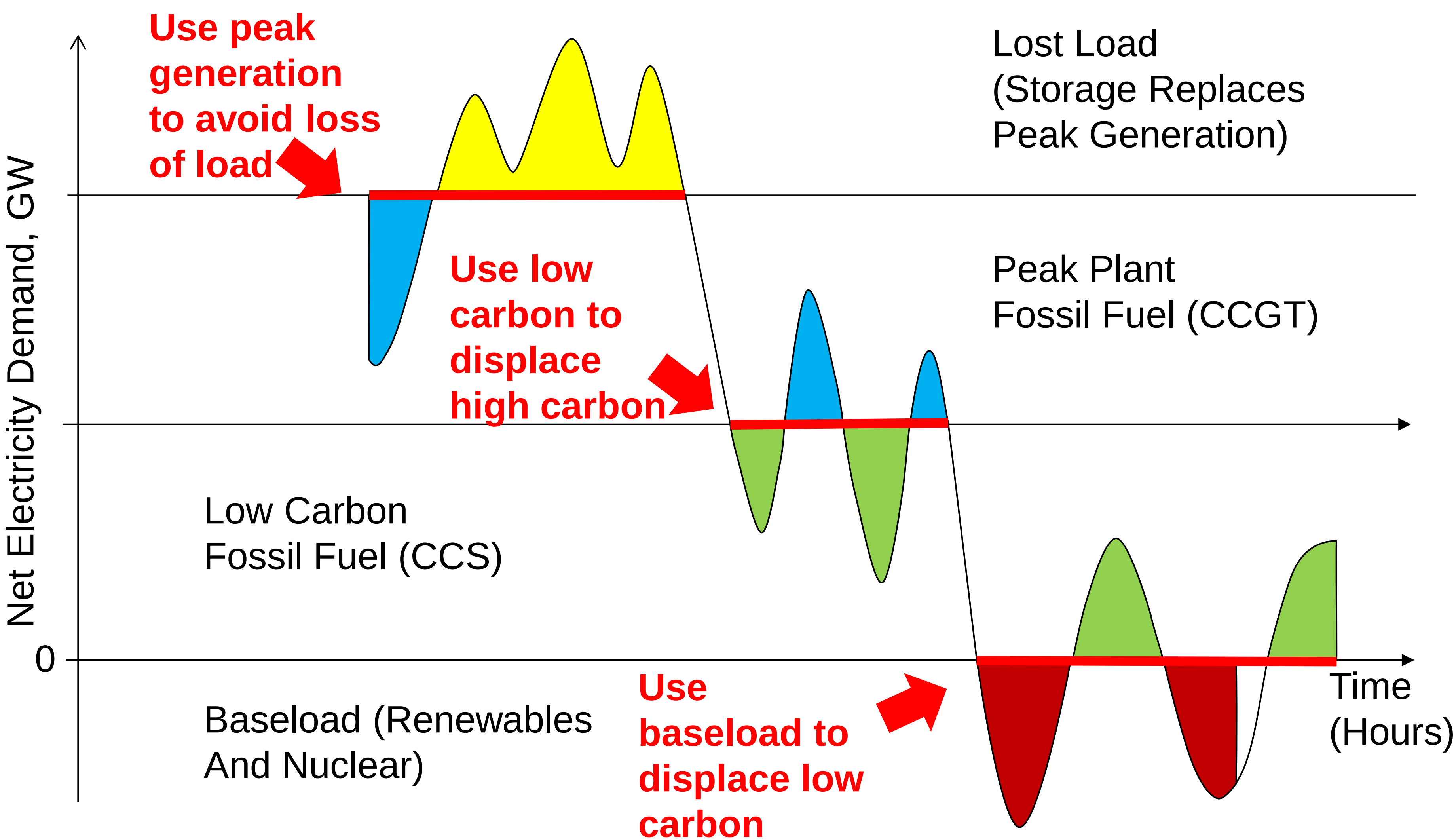
Marginal Costs of Generation (1)



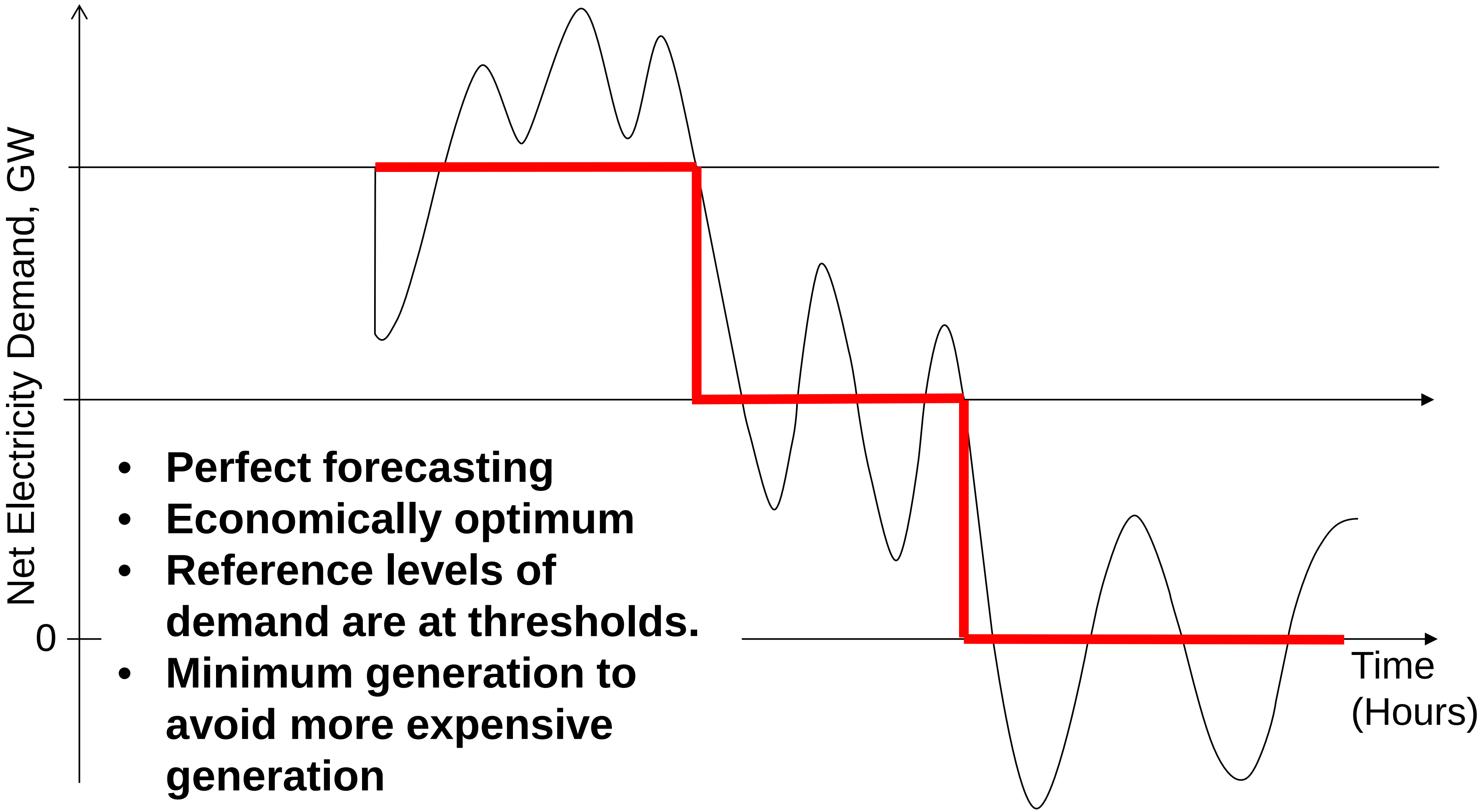
Marginal Costs of Generation (2)



3 Thresholds of Storage

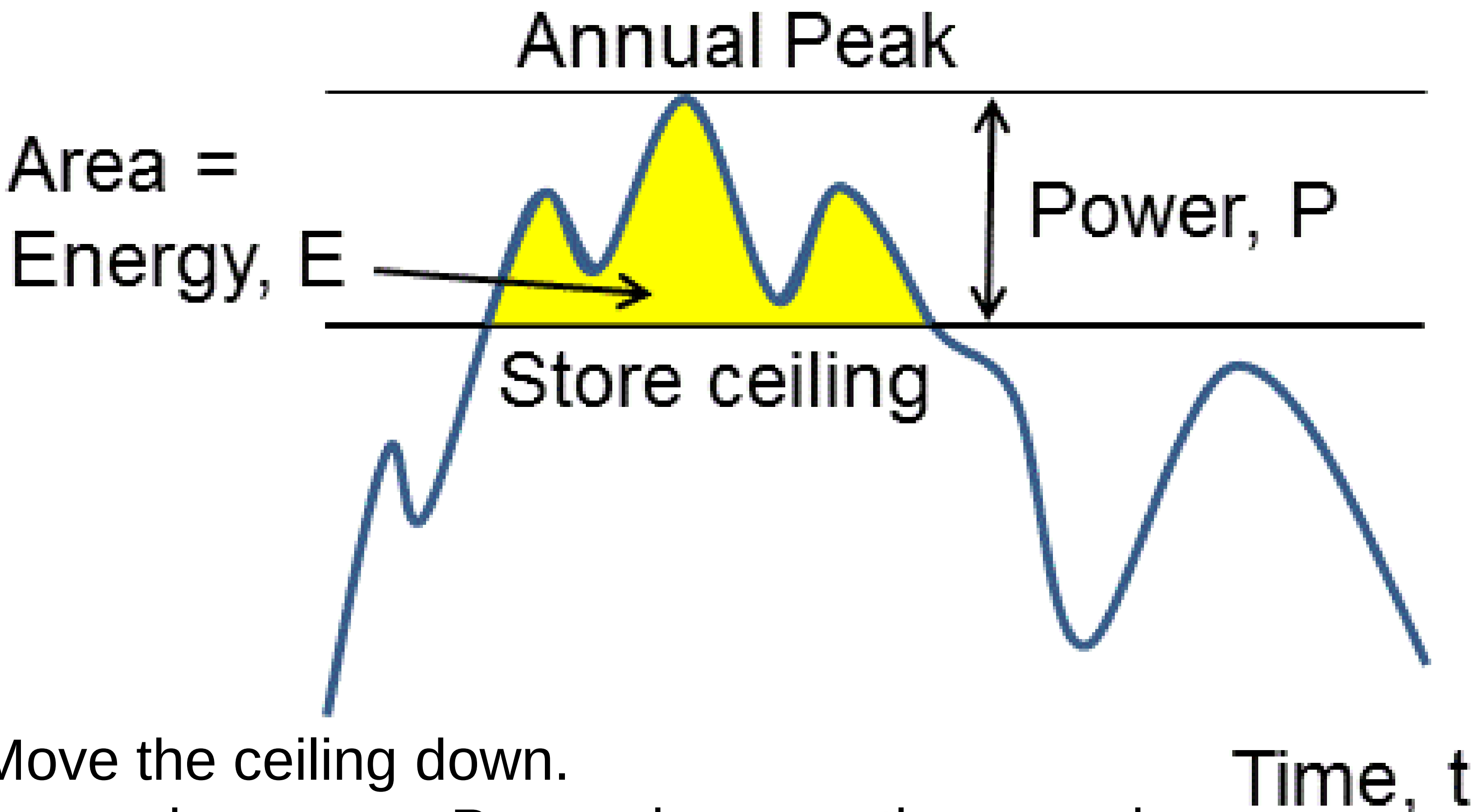


3 Thresholds of Storage



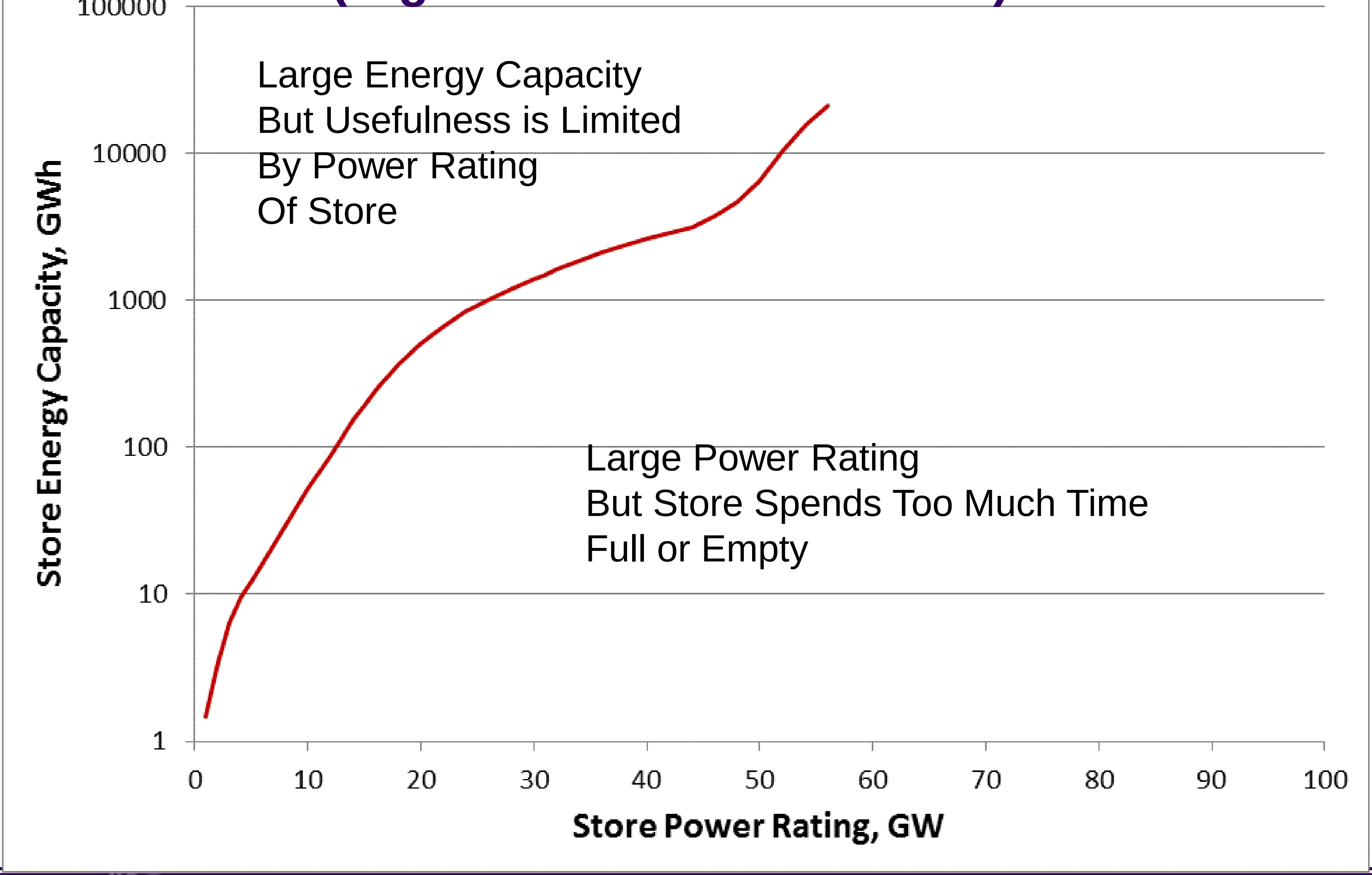
- **Perfect forecasting**
- **Economically optimum**
- **Reference levels of demand are at thresholds.**
- **Minimum generation to avoid more expensive generation**

Store Sizing with Real Demand Data



Move the ceiling down.
Increasing power, P = peak generation saved
Calculate the energy capacity, E = store capacity

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



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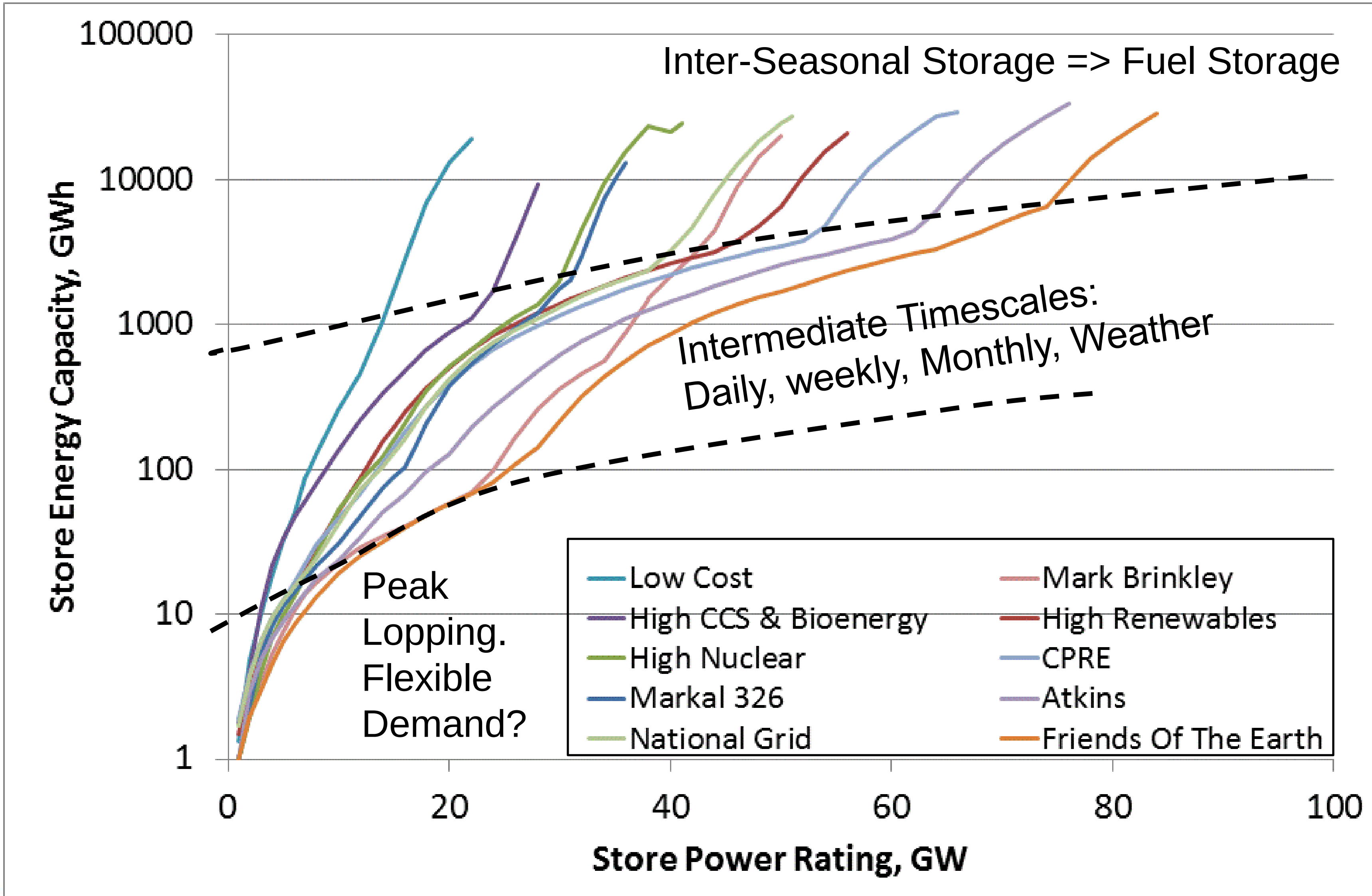
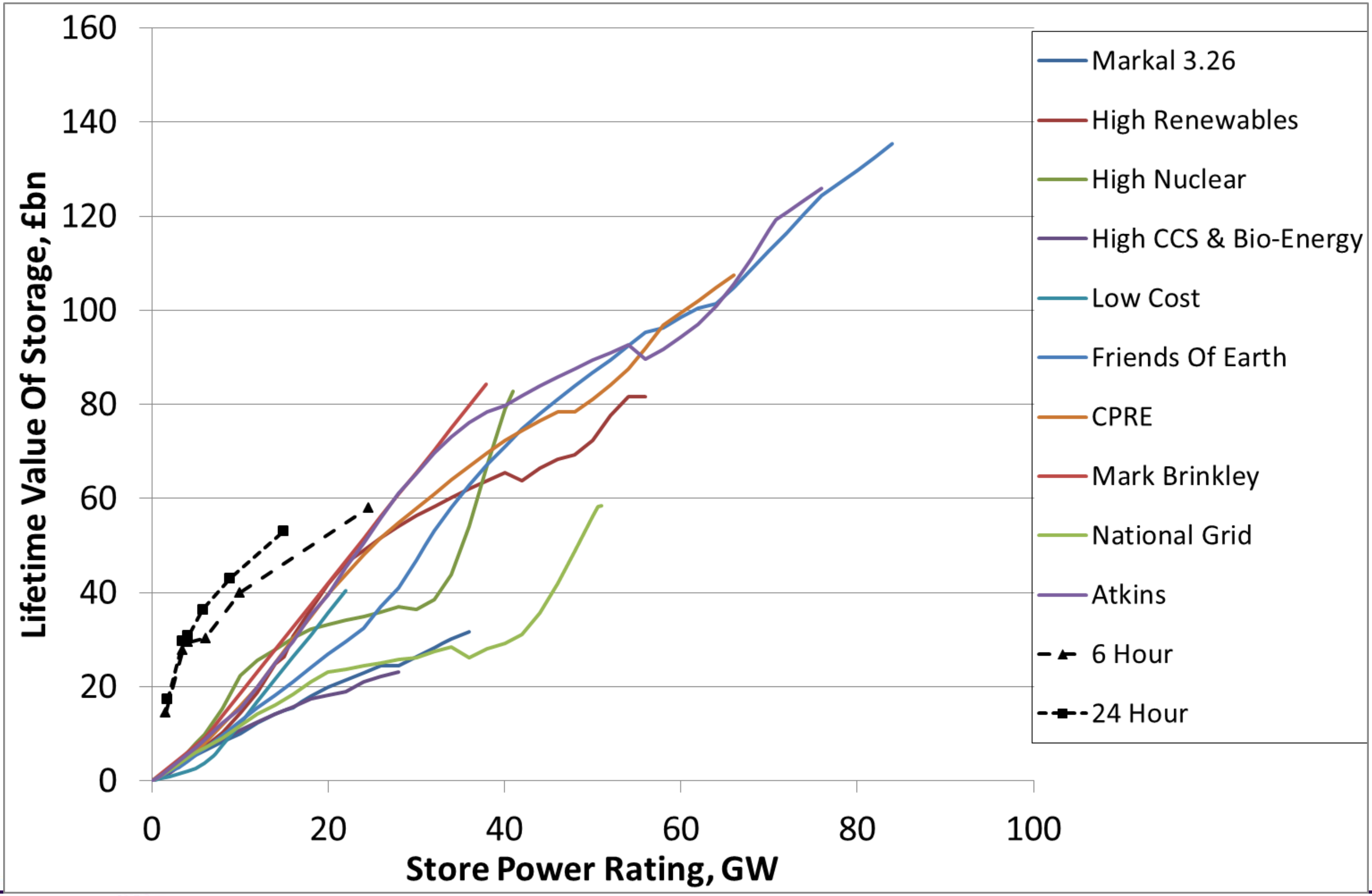
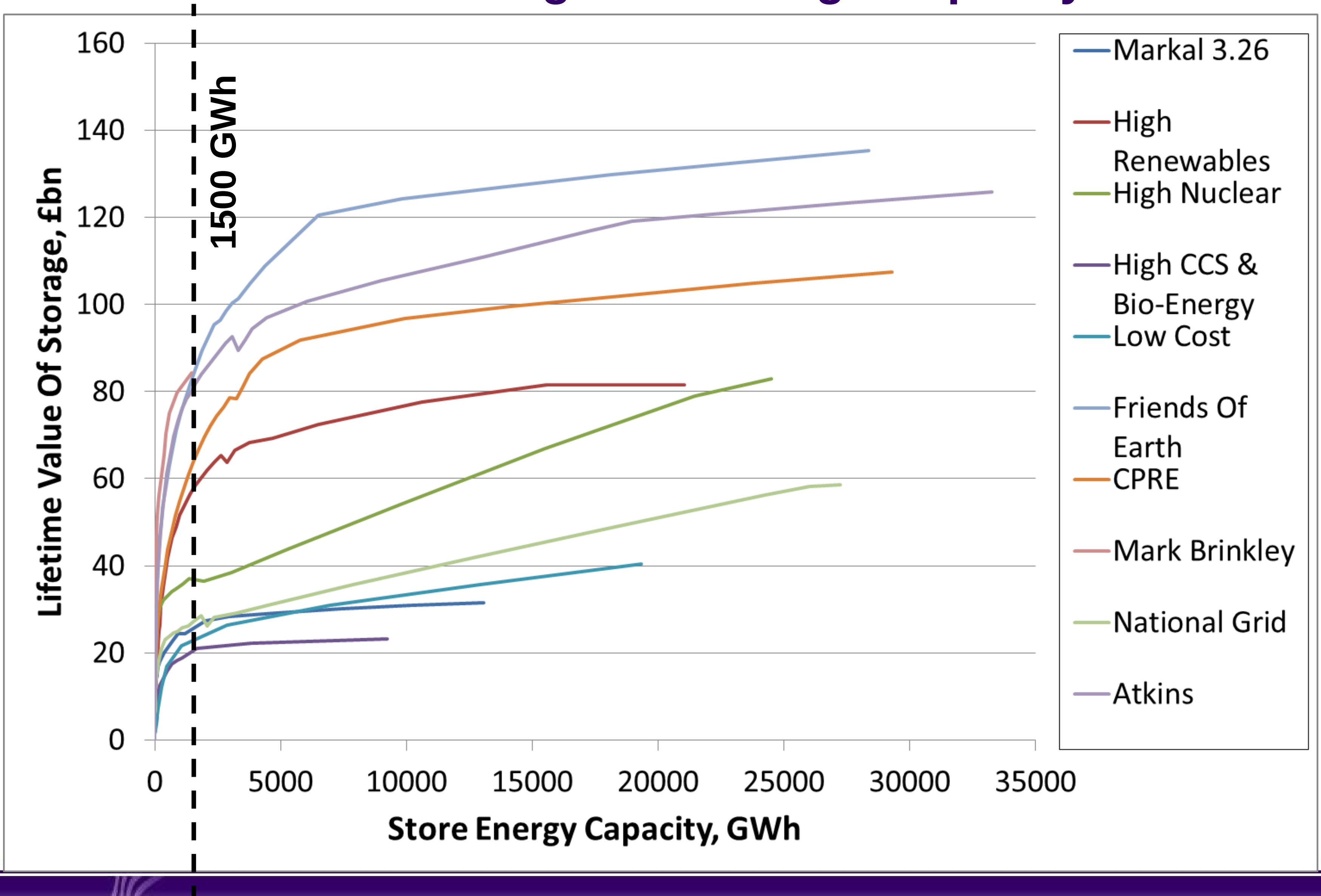
Optimum Ratio of energy Capacity to Power (GWh/GW)



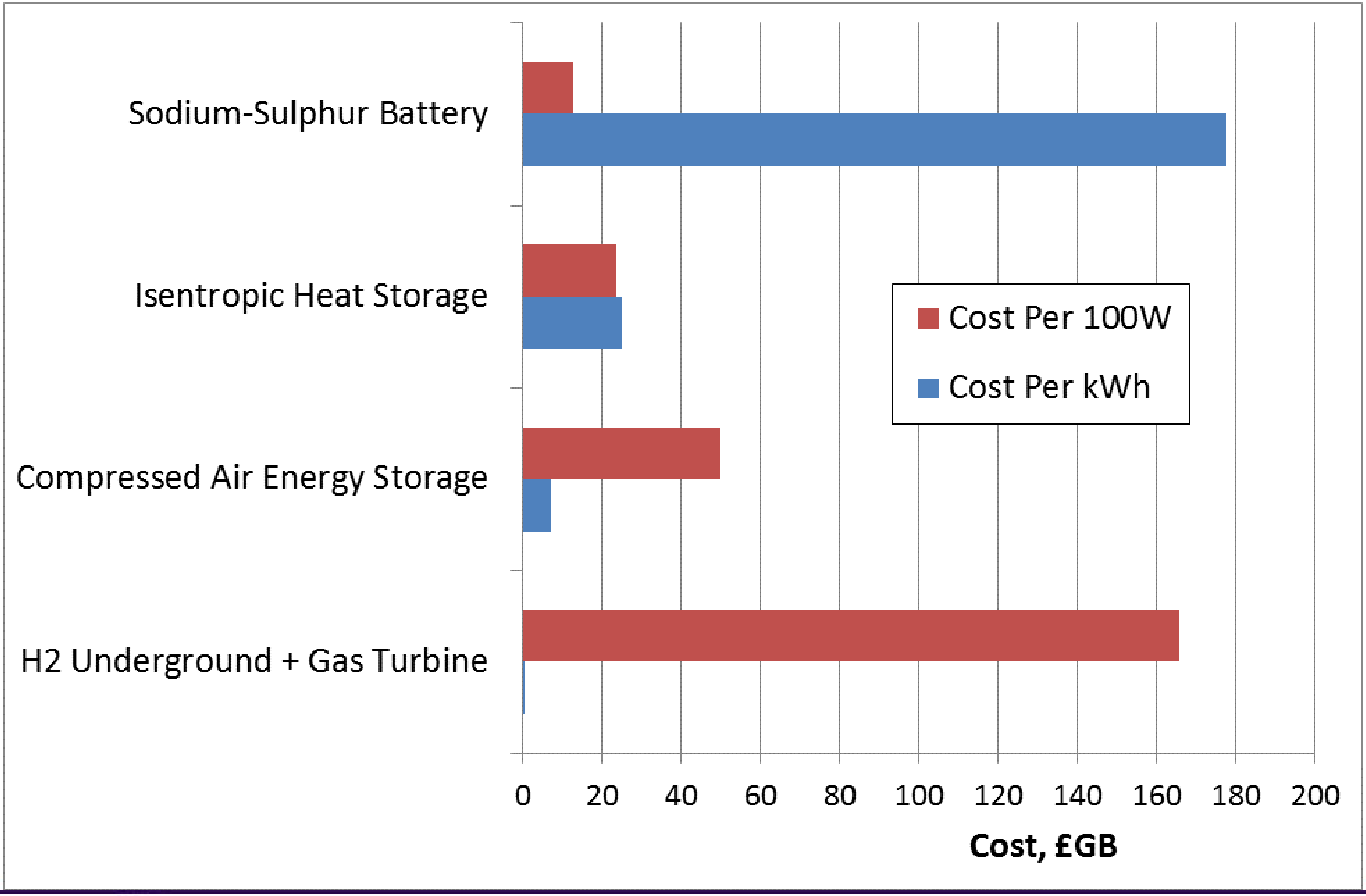
Value of Storage vs. Store Power



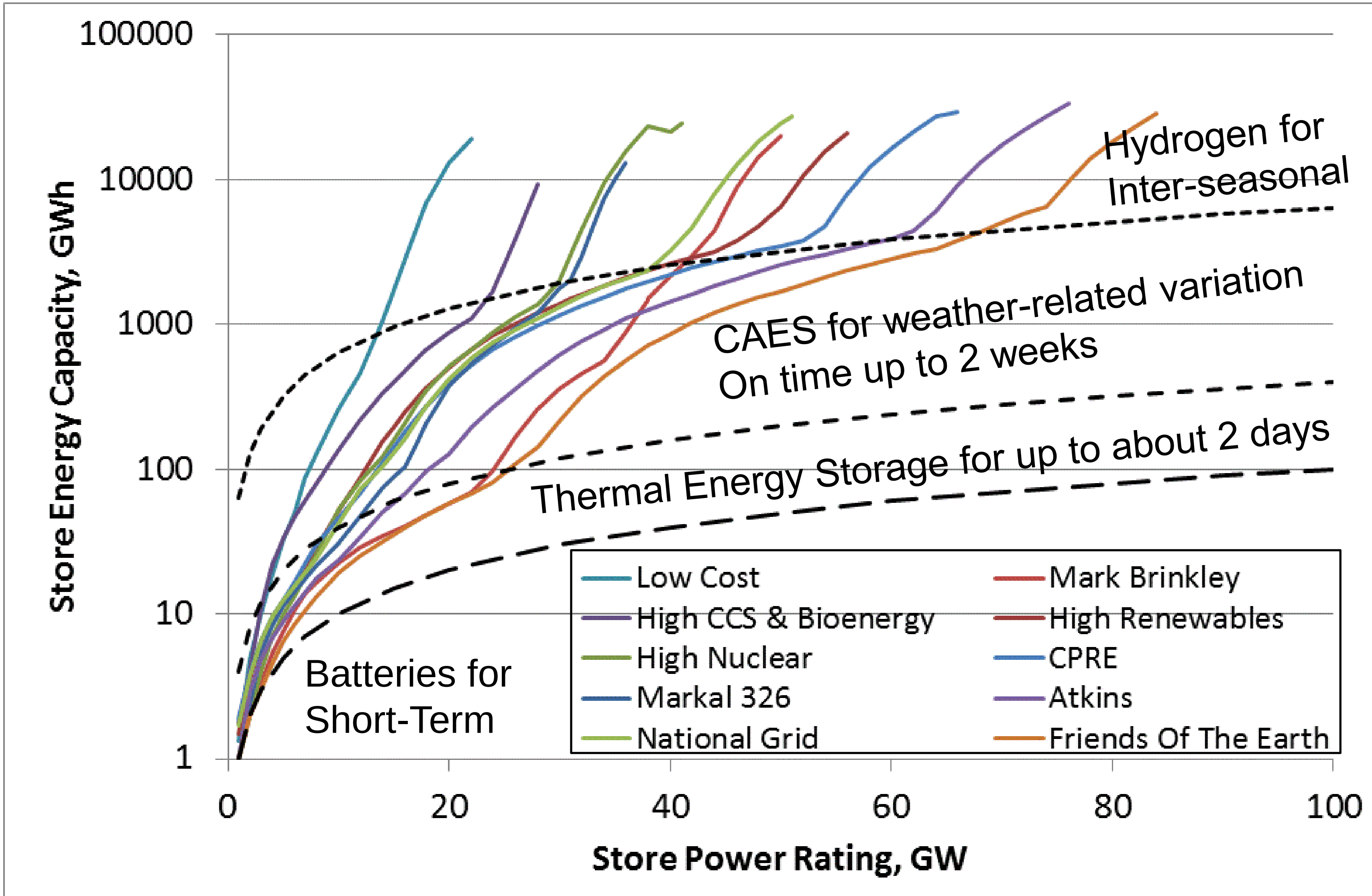
Value of Storage vs. Storage Capacity



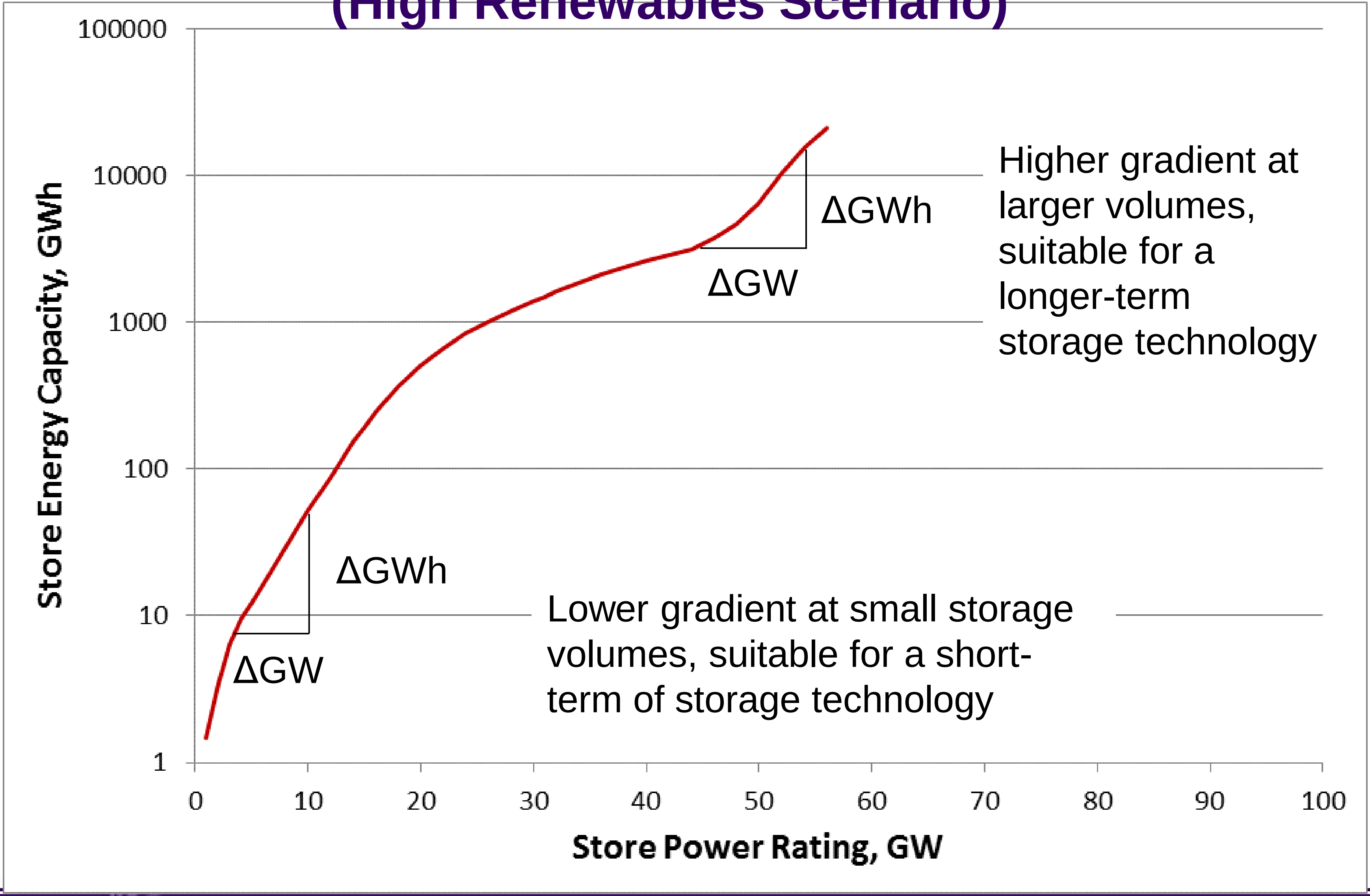
Capital Costs Per Power and Energy for Energy Storage



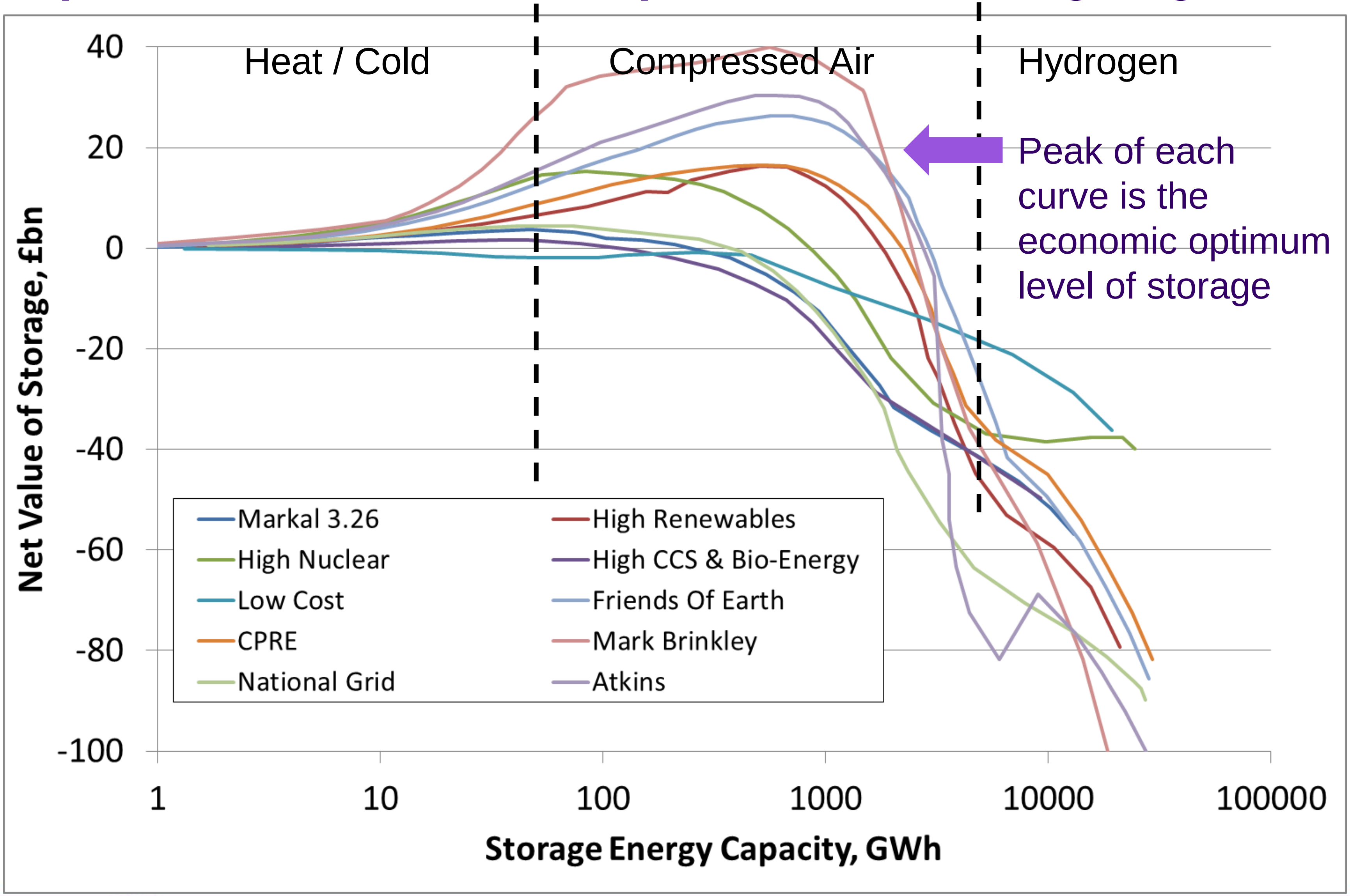
Size of Storage and Appropriate Technology by Application



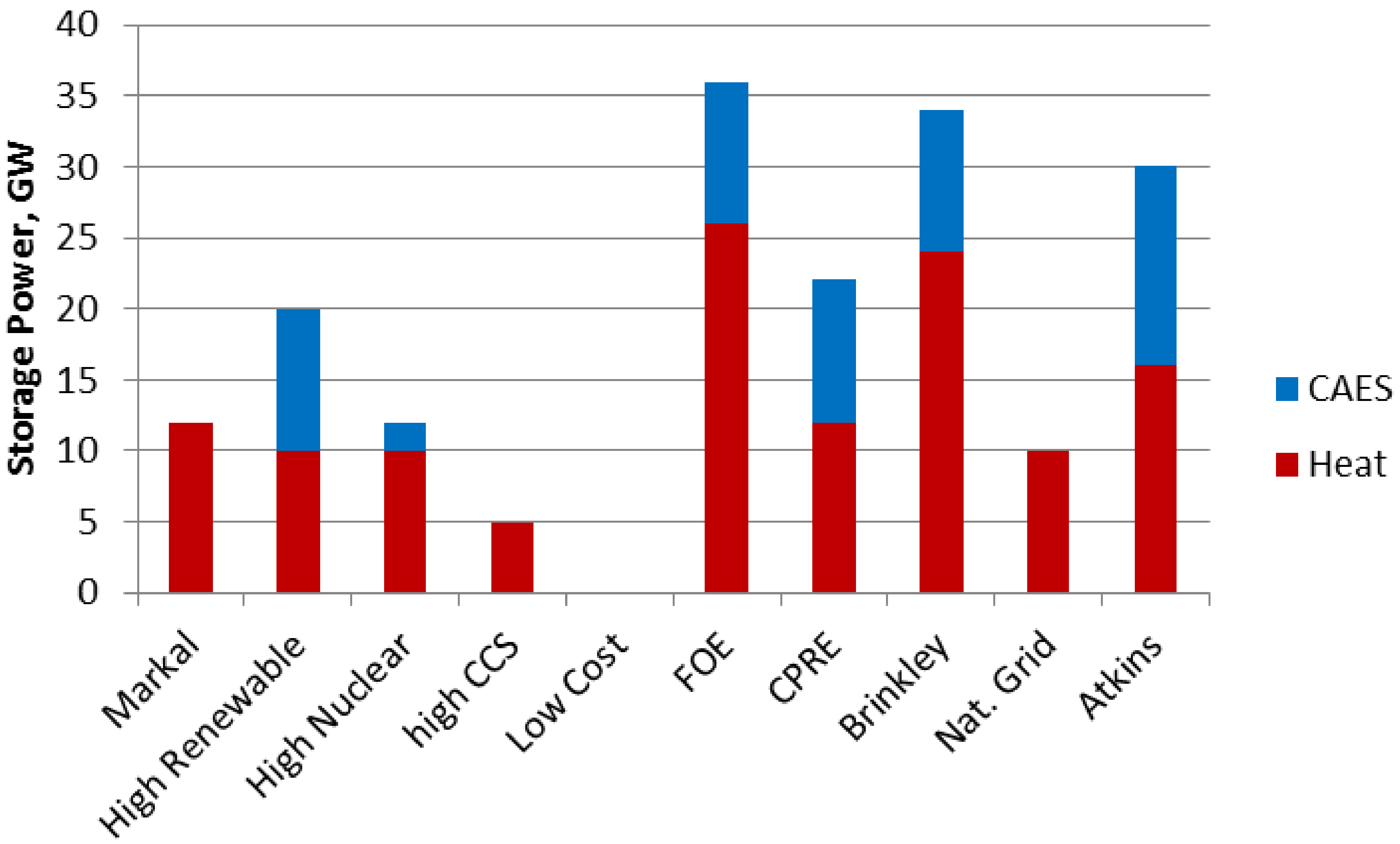
Optimum Ratio of energy Capacity to Power (GWh/GW) (High Renewables Scenario)



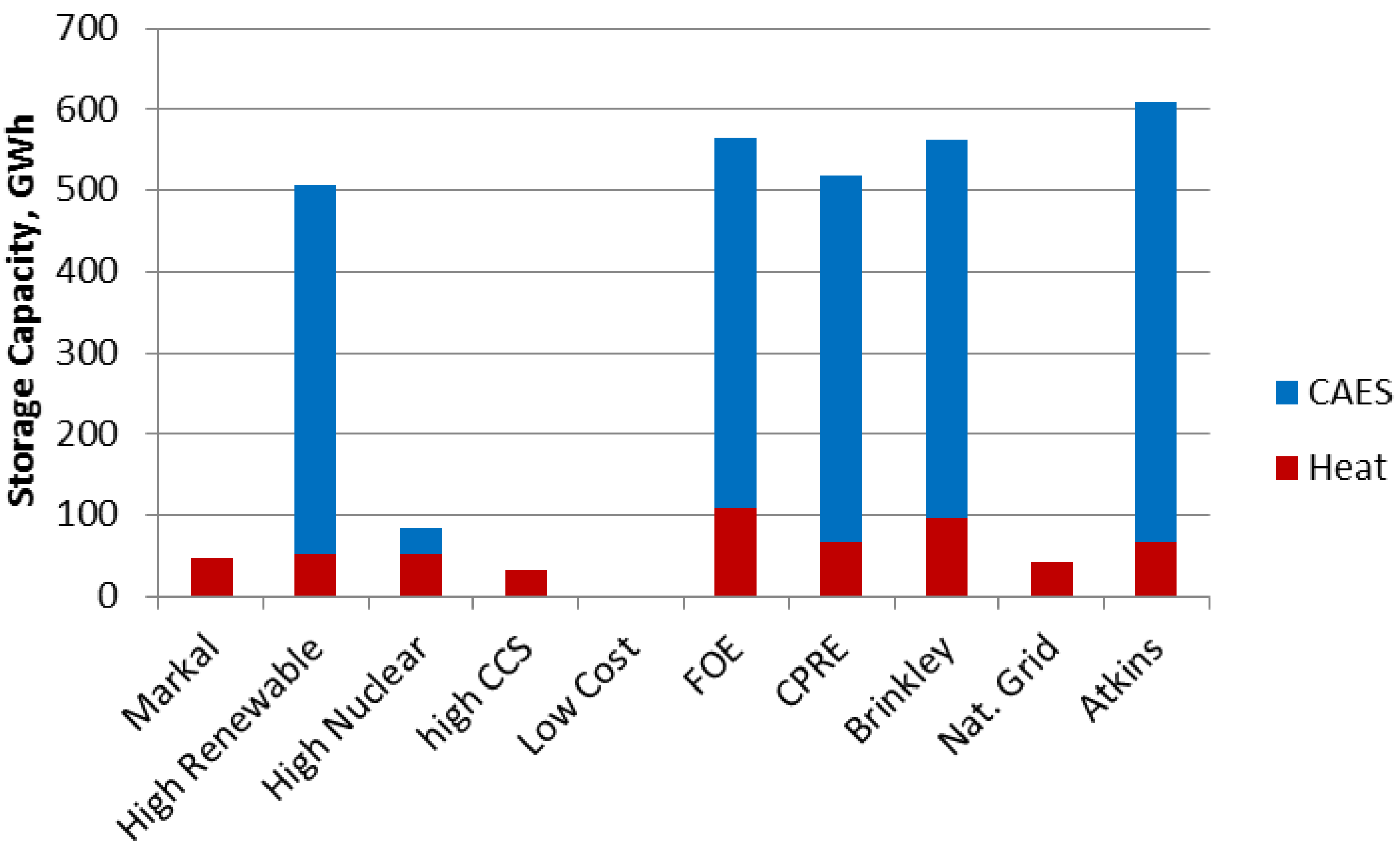
Optimum Solution is Multiple Stores Working Together



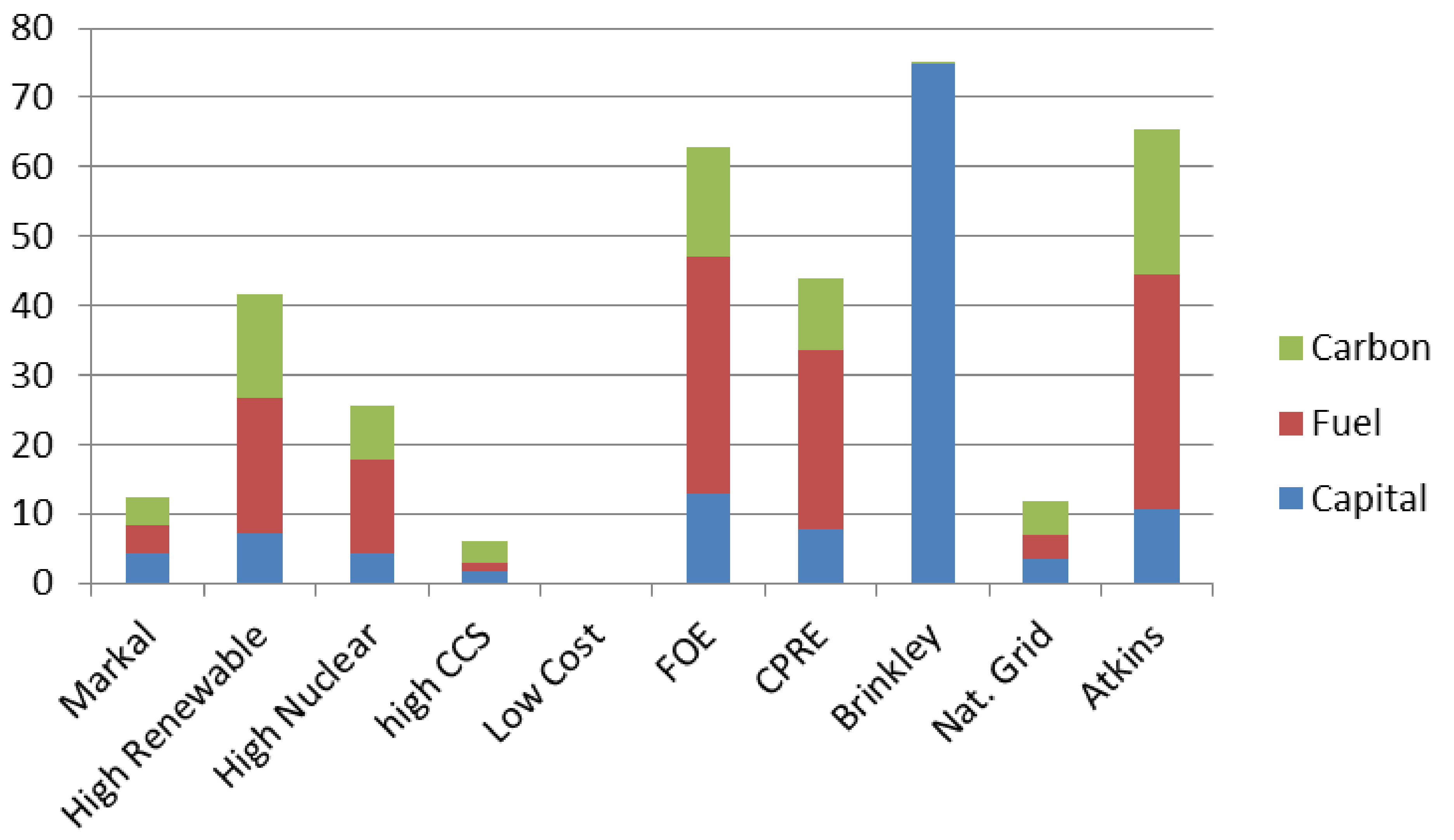
Optimum Storage Power



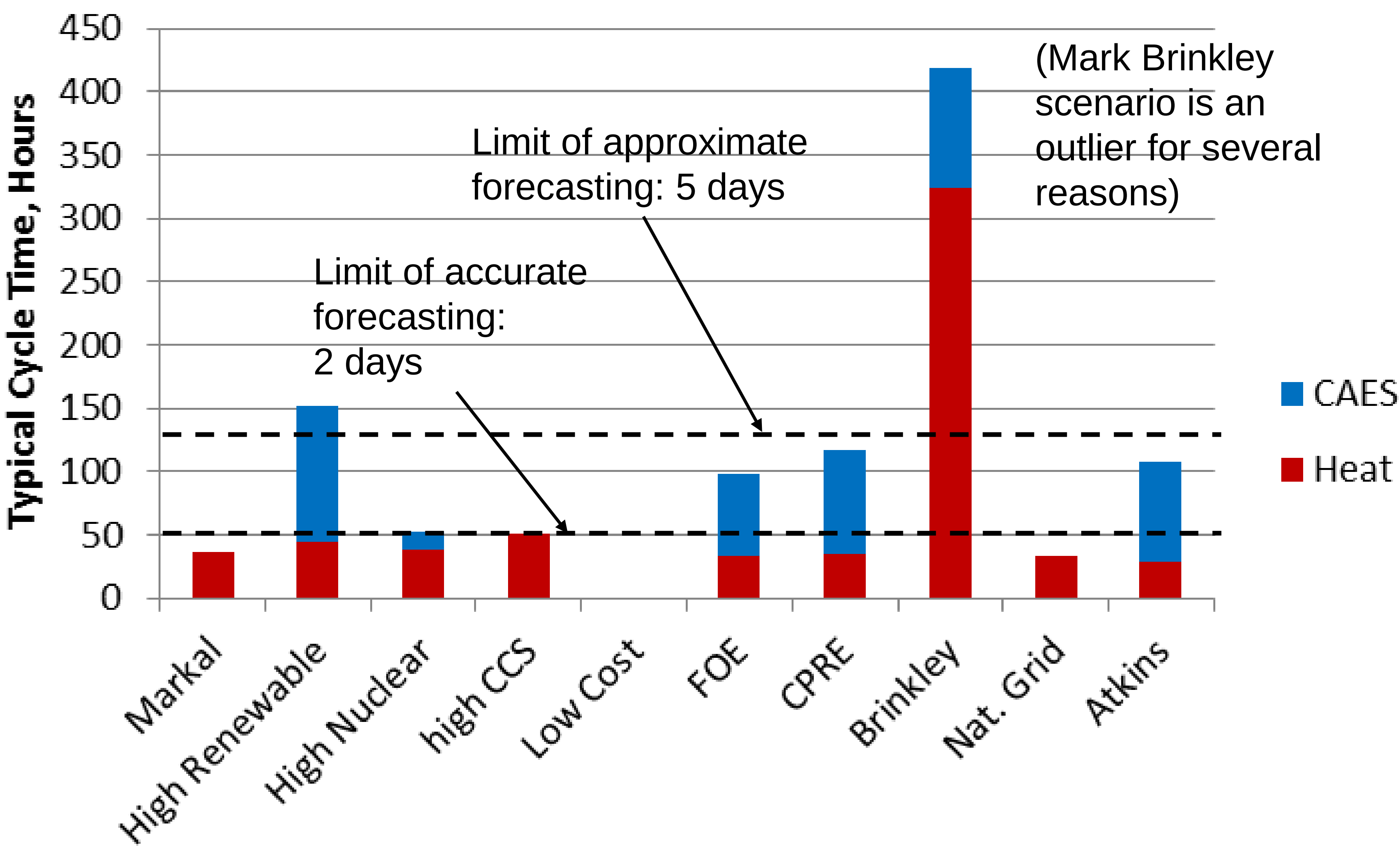
Optimum Storage Energy Capacity



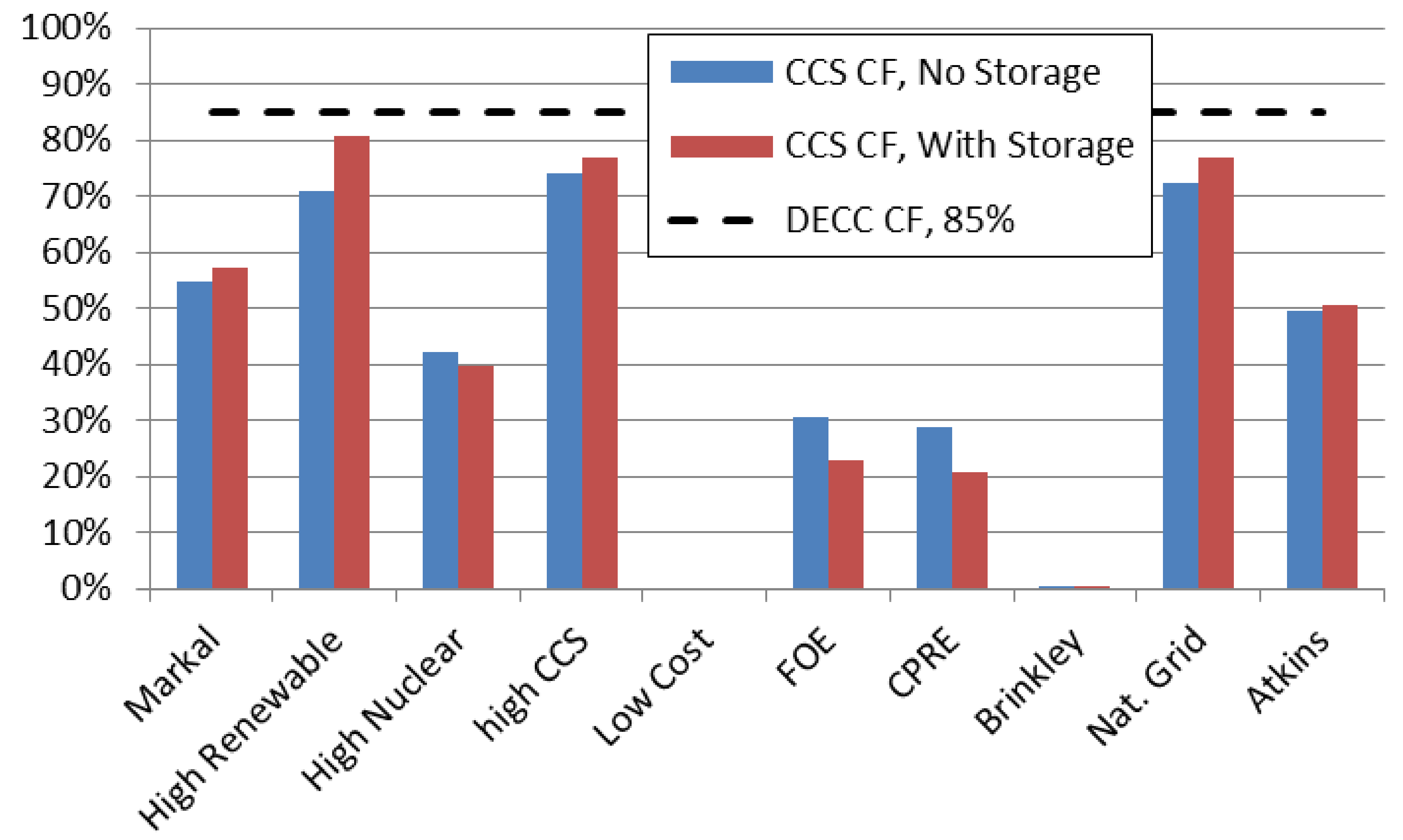
Components of Value of Energy Storage



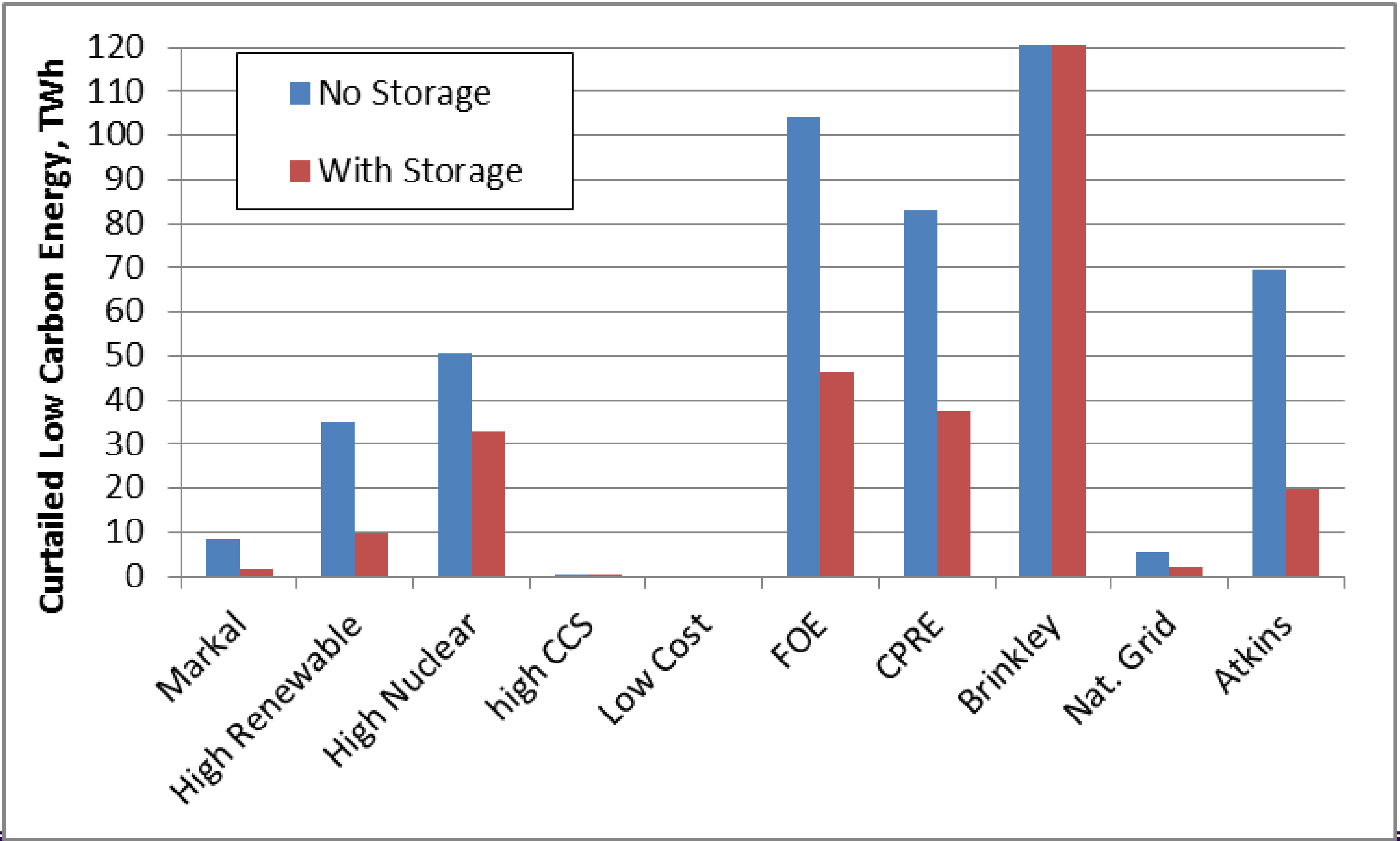
Energy Storage Cycle Time vs. Weather Predictability



Modest Improvement in Load Factor of CCS



Reduction in Curtailed Low Carbon Energy at Economically Optimum Level of Energy Storage



Conclusions – Part 1

- The need for energy storage is increasing
- The optimum ratio of GWh/GW (time constant) increases exponentially with power rating
- Strong law of diminishing returns with energy capacity, GWh
- The cost-effective technologies appear to be heat/cold storage and Compressed Air (CAES)
- Storage is cost-effective for cycle times of **approximately** 2 to 5 days but no more:
  - Poor Economics of storage technologies
  - Inadequate long-term weather forecasts

Conclusions – Part 2

- Energy storage can substantially reduce the following parameters but it is not economically feasible to build enough storage to eliminate them:
  - Curtailed low-carbon energy
  - High carbon peaking generating plant
- Energy storage can increase the utilisation factor of fossil-fuelled plant with CCS, but it is not economically feasible to use storage to bring it up to the levels anticipated in the DECC 2050 Calculator Model

Next Steps

- Forecasting Errors – How the optimum size, despatch algorithm and value of storage change with imperfect forecasting
- Extend FESA to a European model – the optimum role of storage alongside interconnectors
- Demand response – where (in timescale) does DR finish and storage begin?
- Alternative supply scenarios – more electricity generation mixes, e.g. from ETI, Shell, UKERC

Cost of Storage with Increasing Timescales