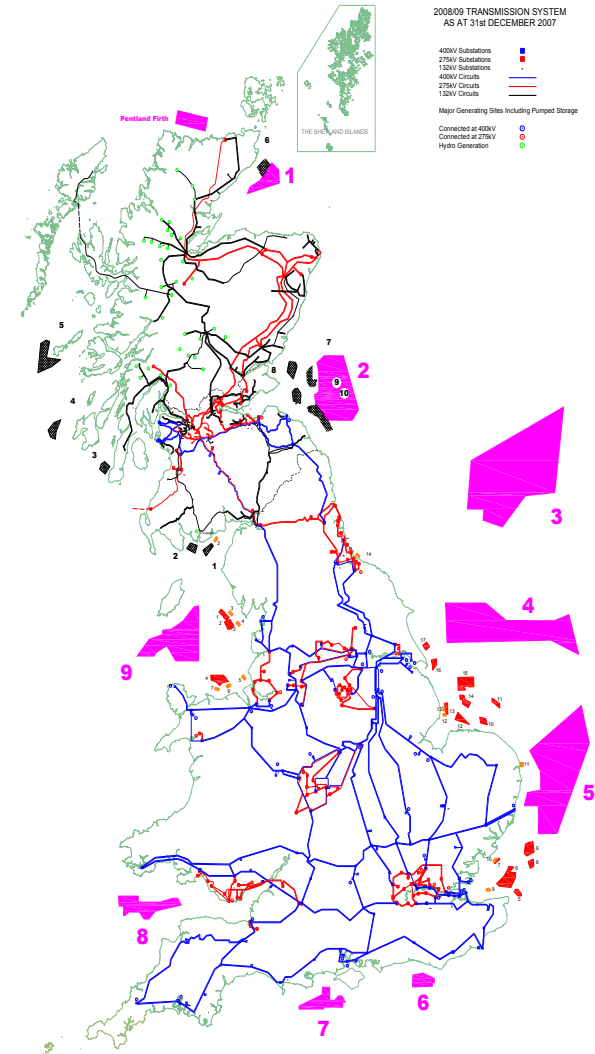


**Cost effective evolution to a
Low Carbon Future:
*Role and Value of
Demand Side Response***

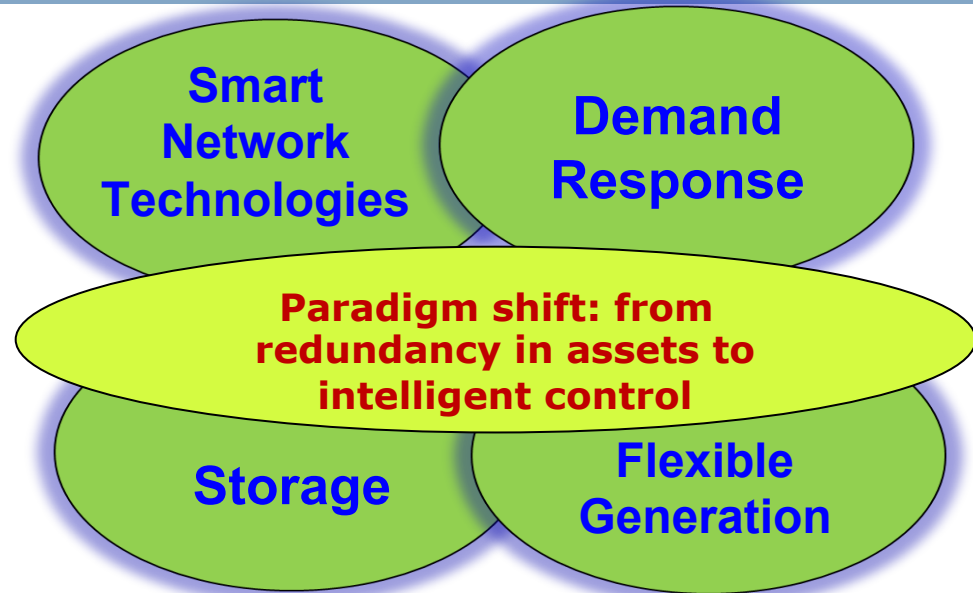
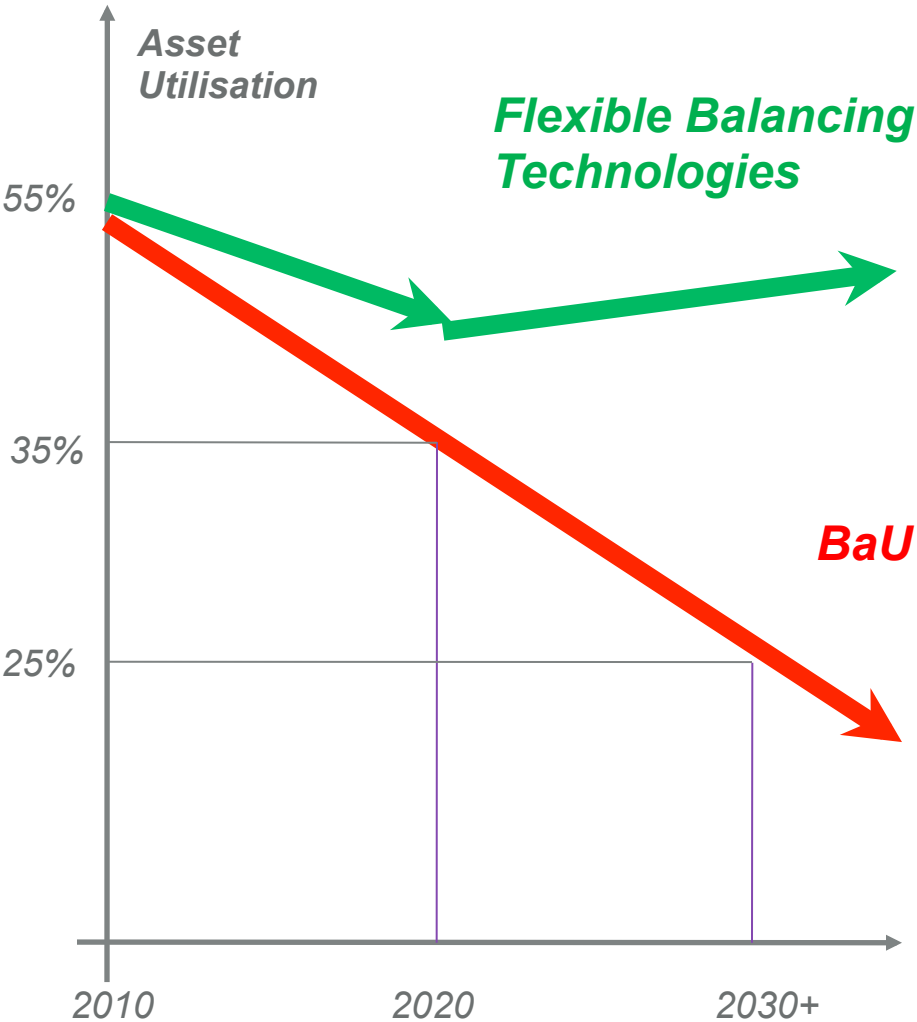
**Prof Goran Strbac
Imperial College London**

UK Response to Climate Change Challenge

- 2020: 25% of all electricity demand to be met by renewable generation
- 2030+ :
 - Decarbonise electricity generation, while.....
 - Electrifying (segments) of transport and heat sectors....
- ...in order to reduce CO2 emissions by 80% by 2050



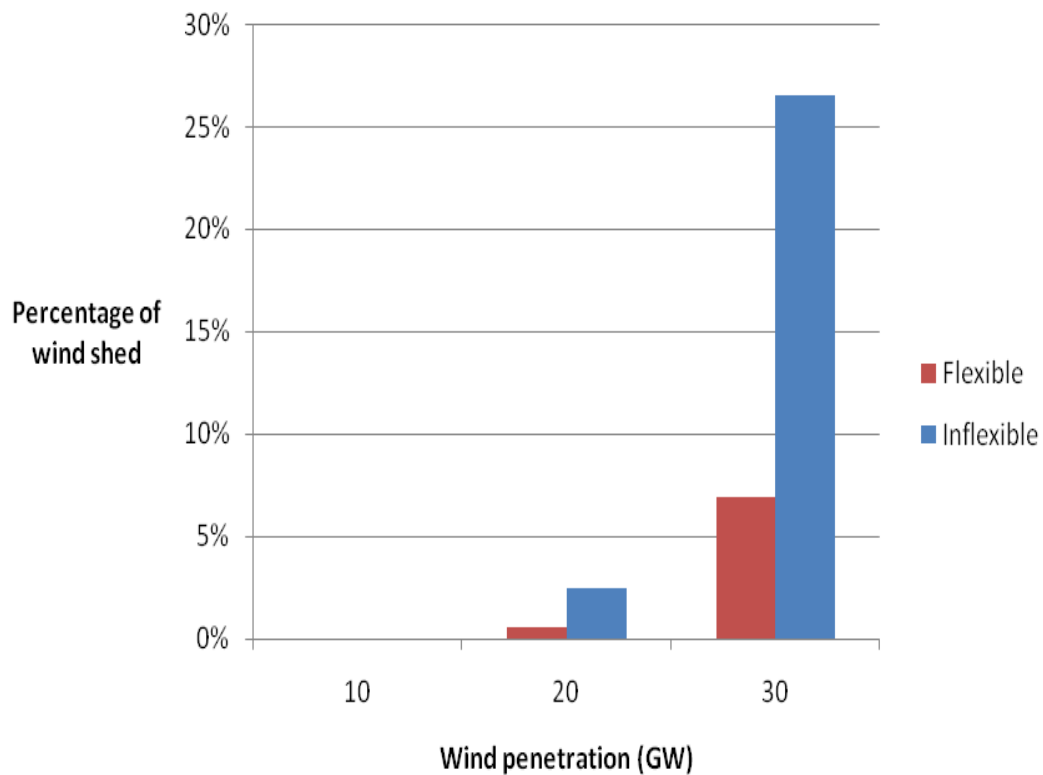
Low carbon system integration challenge: degradation in asset utilization



Volume of the market for flexible balancing technologies >£60b

System integration costs in low carbon European system may exceed €500b

Balancing and Need for Flexibility



Number of hours with zero or negative prices

High Generation Flexibility

Low Generation Flexibility

200

>1500

Unprecedented price volatility... value of energy frequently lower than value of flexibility

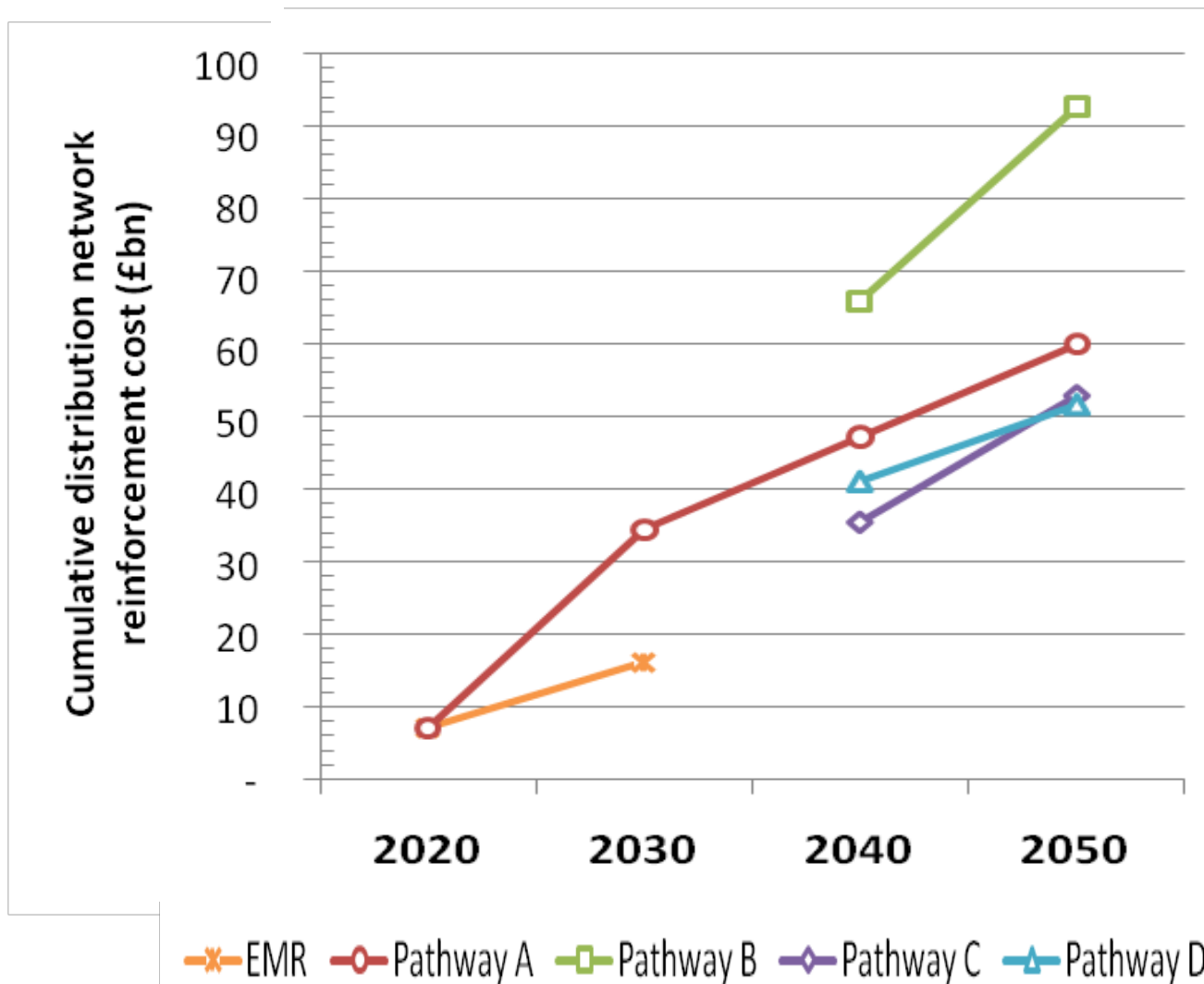
leading to increased base-load & peak generation investment risks...

...while providing massive opportunities for demand side response, storage, flexible (distributed) generation

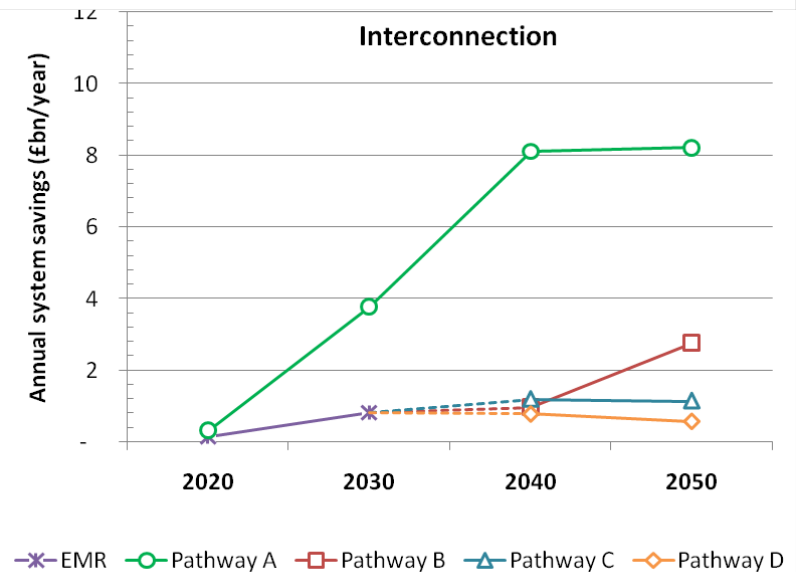
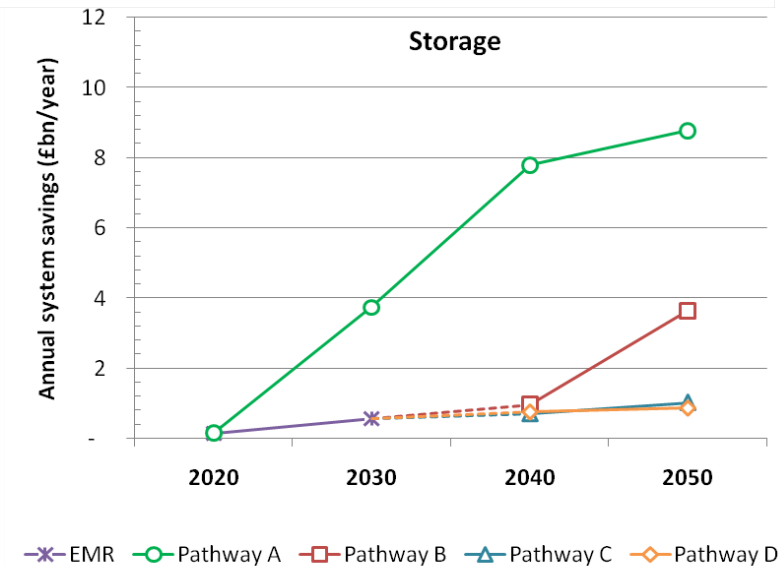
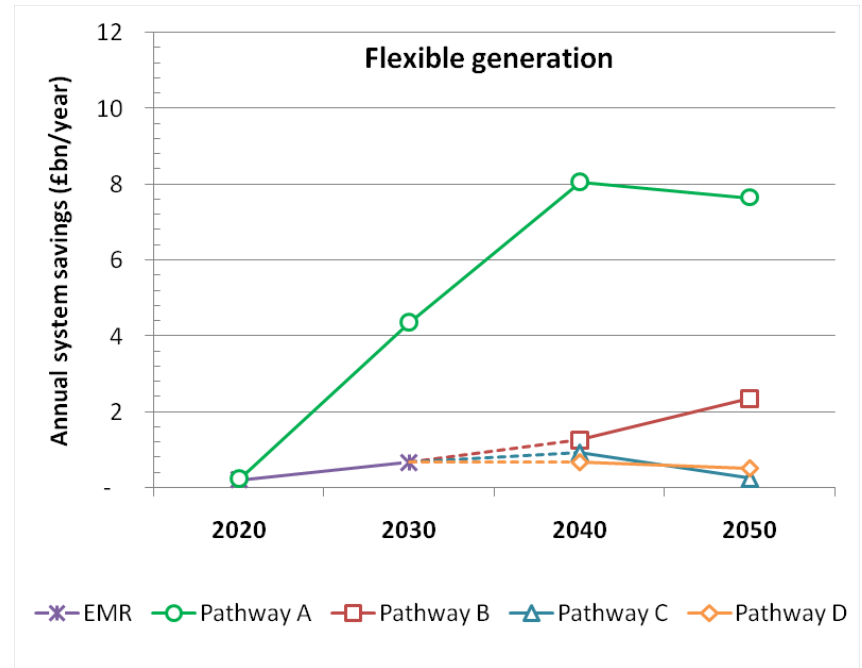
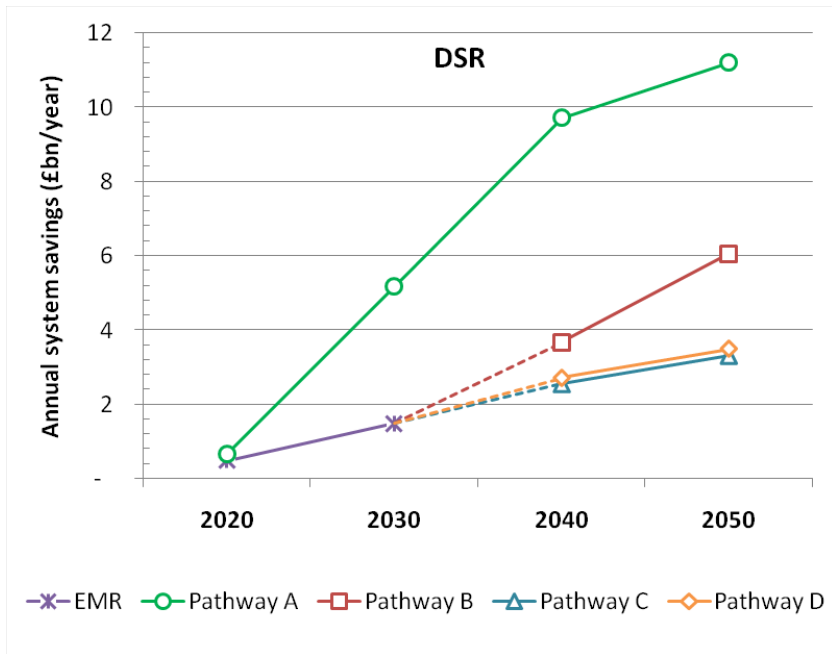
Understanding system integration challenge

- **UK Low Carbon Pathways:**
 - Pathway A (Renewables | High efficiency | High electrification)
 - Pathway B (Nuclear | Low efficiency | High electrification)
 - Pathway C (CCS | Medium efficiency | Low electrification)
 - Pathway D (Core Market)
 - **Objectives:** Given that pathways balance energy production and consumption on annual basis, analyse the merits of, and the interaction between, alternative balancing technologies
 - ***Flexible generation, Interconnection, Storage, Demand side response***
- in minimizing the costs of integration, in short and long-term (real time balancing & infrastructure investment)

Uptake of Low Carbon Technologies and Distribution Network Investment

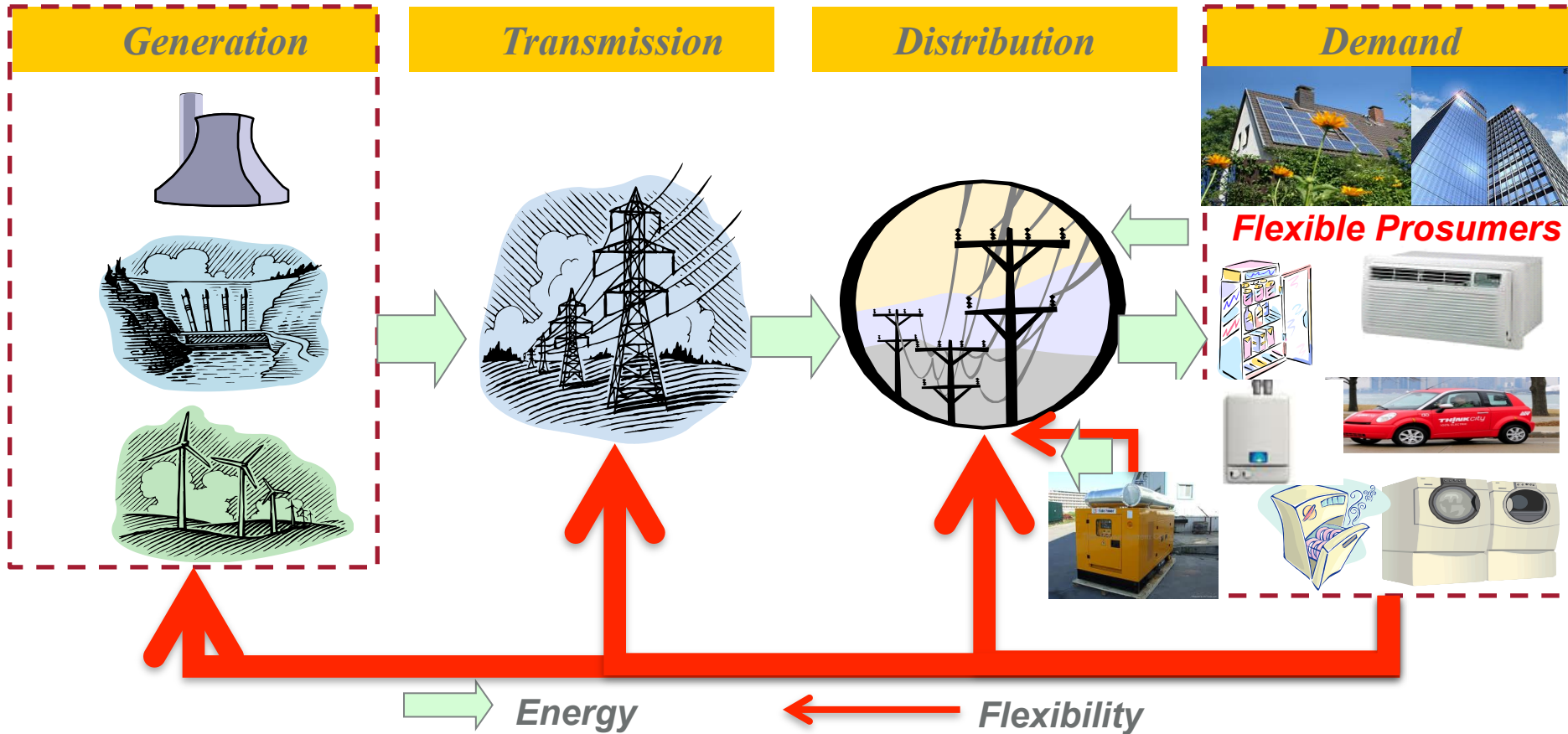


Benefits of alternative balancing technologies



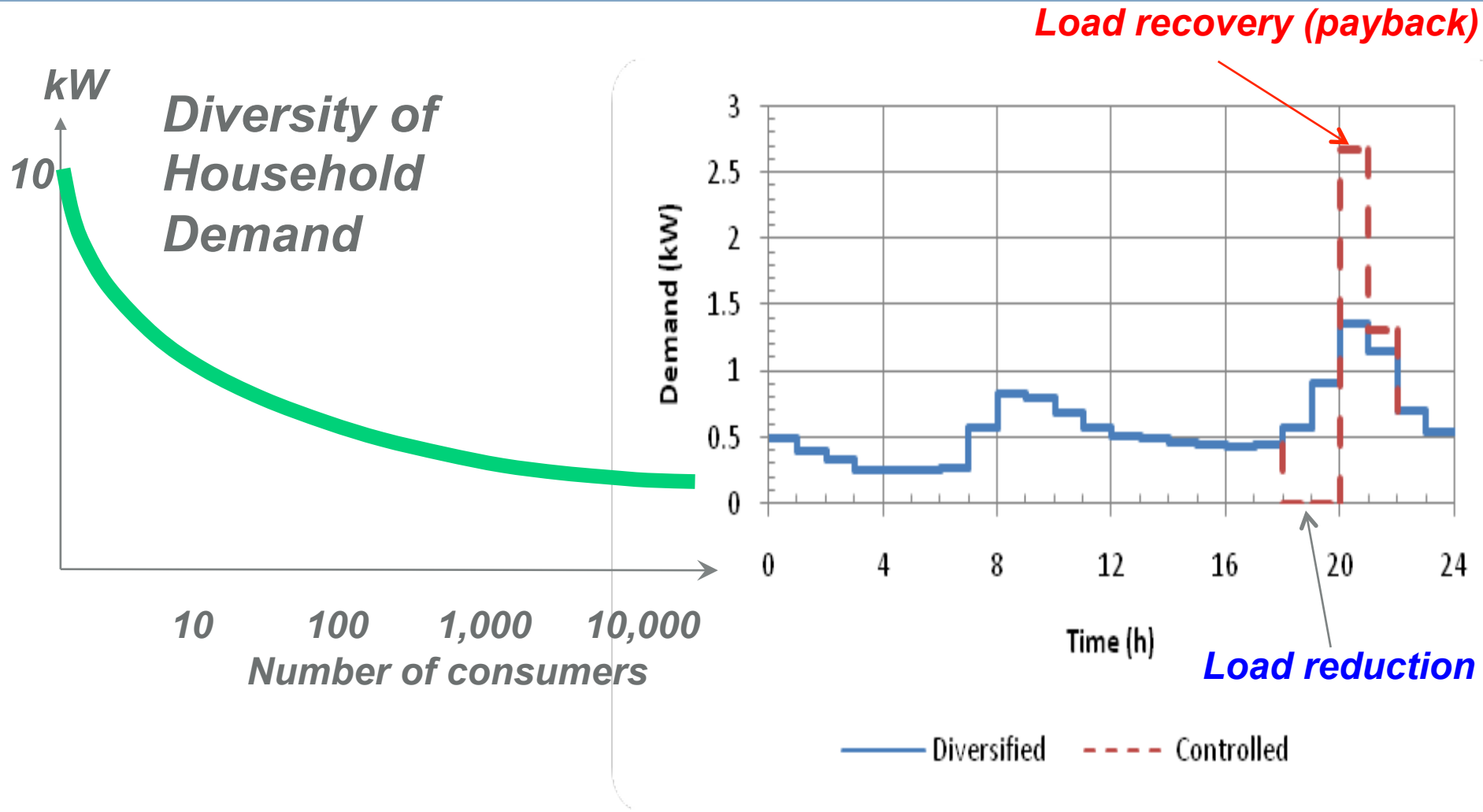
From the Grid to Consumers

Integrating distributed energy resources: From Consumers to the Grid

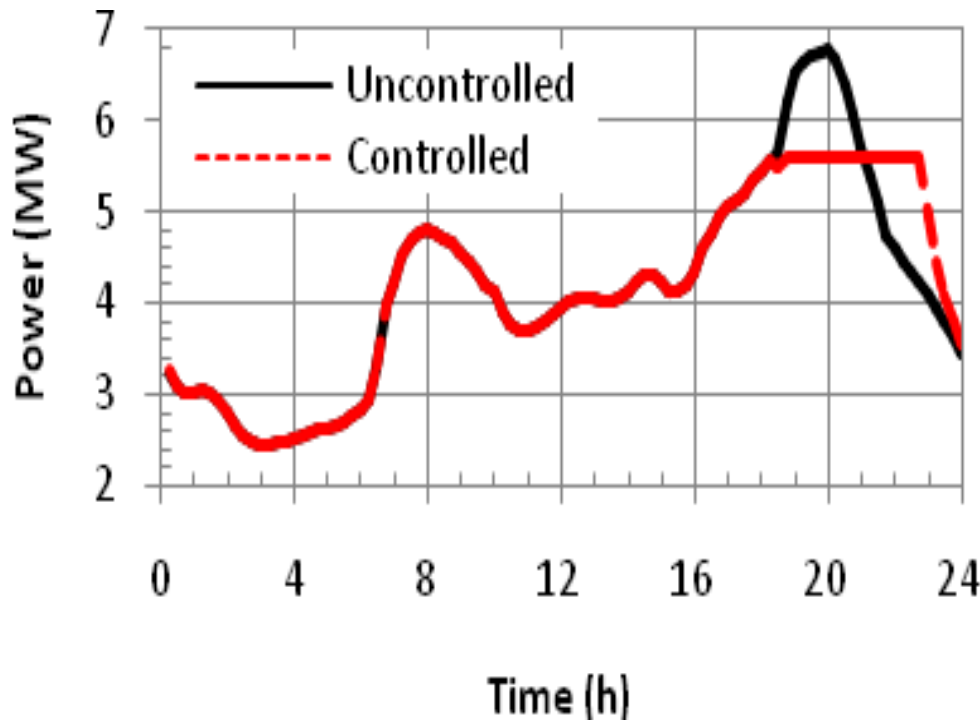


Where does the flexibility come from?
Critical role of LCNF

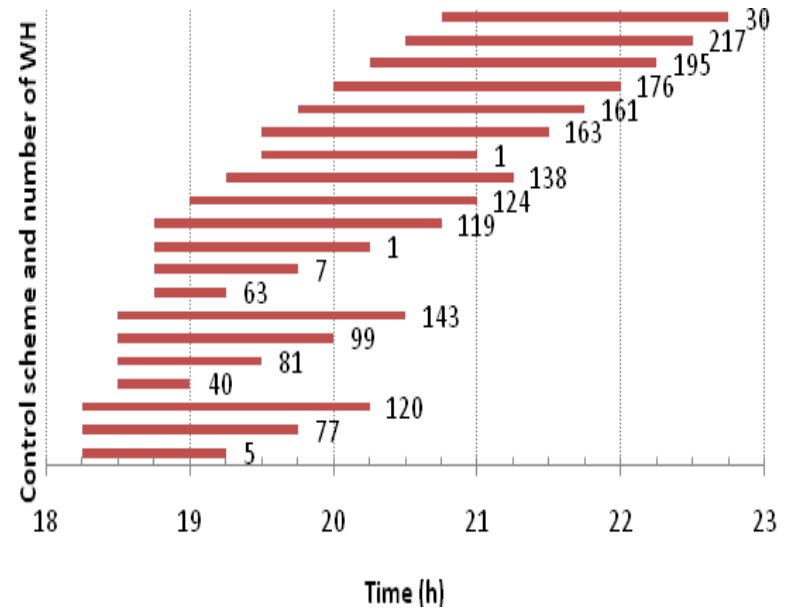
Anything to worry about with demand response?



Managing Response: you have to be smart!

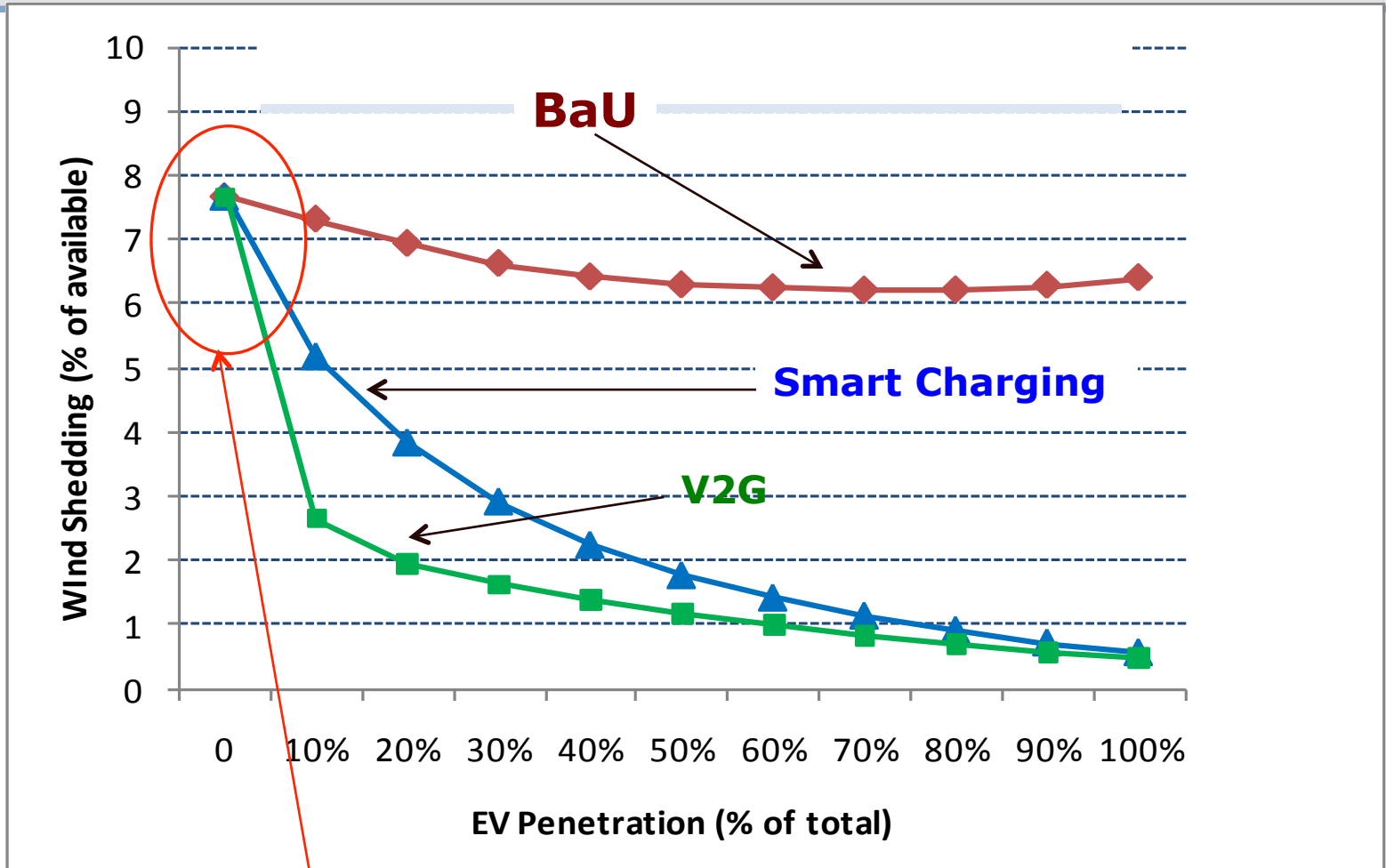


Aggregate Demand profile



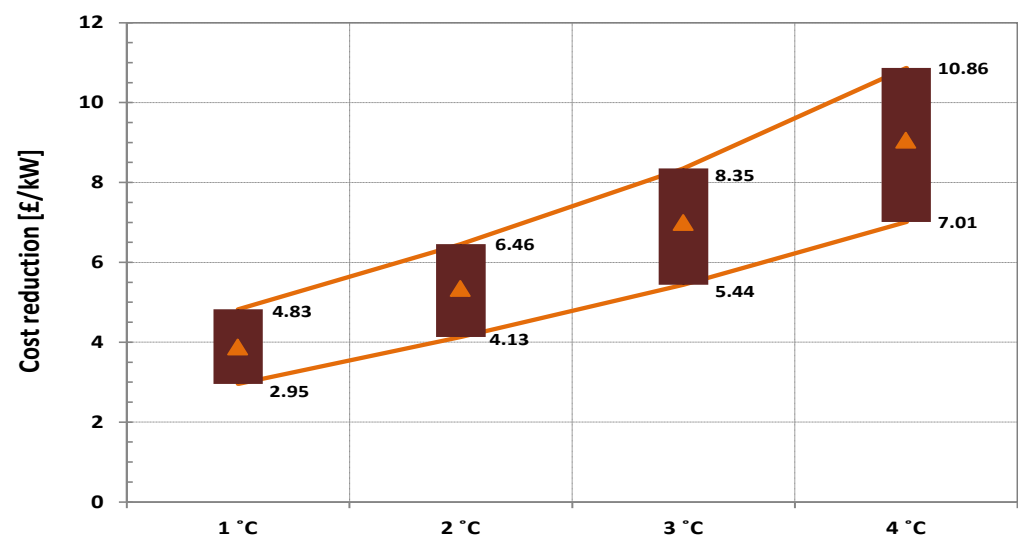
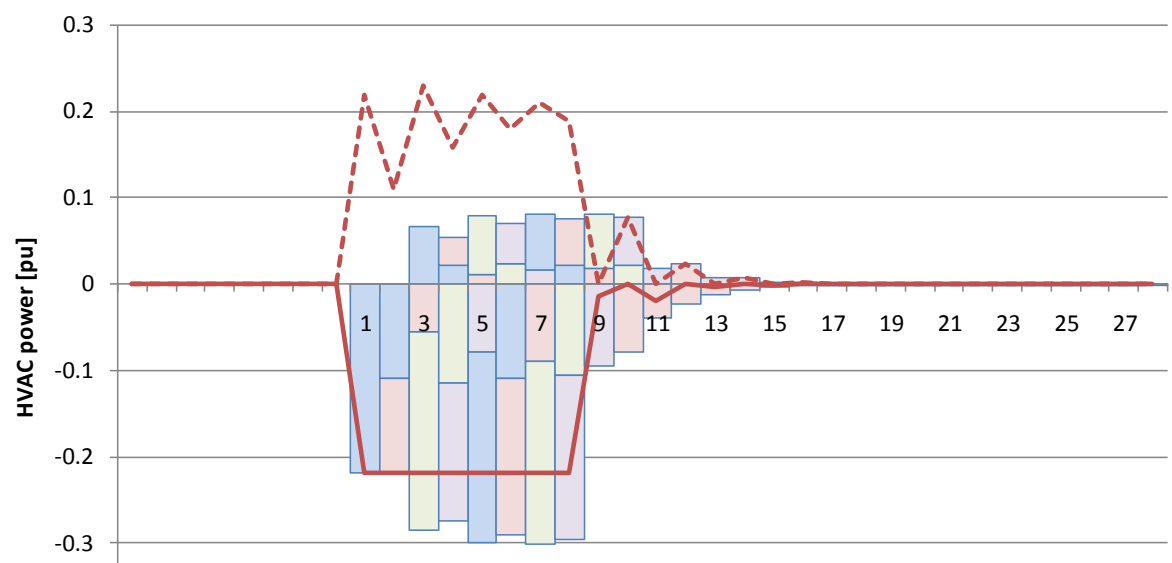
Control scheme

Examples: Smart Charging and V2G reduce emissions

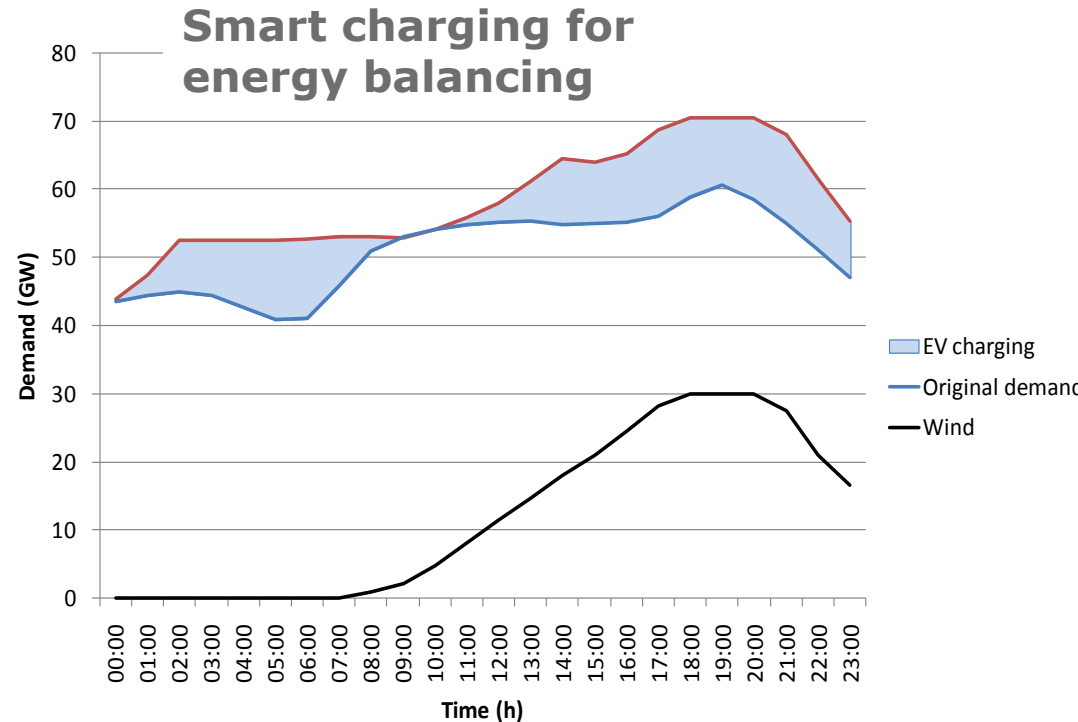
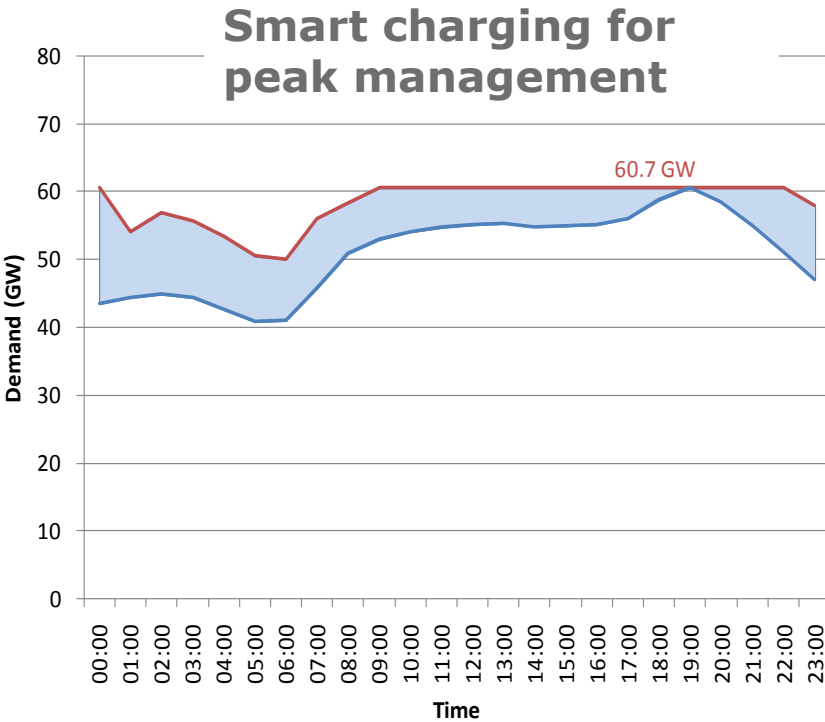


Amount of saved energy is greater than the energy consumed by EVs ~15% EV

DSR in commercial sector: opportunities to participate in the capacity mechanism may be significant

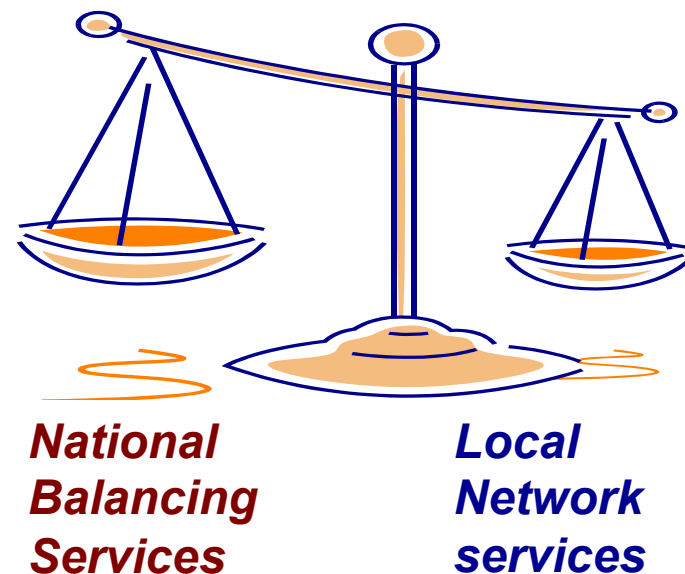
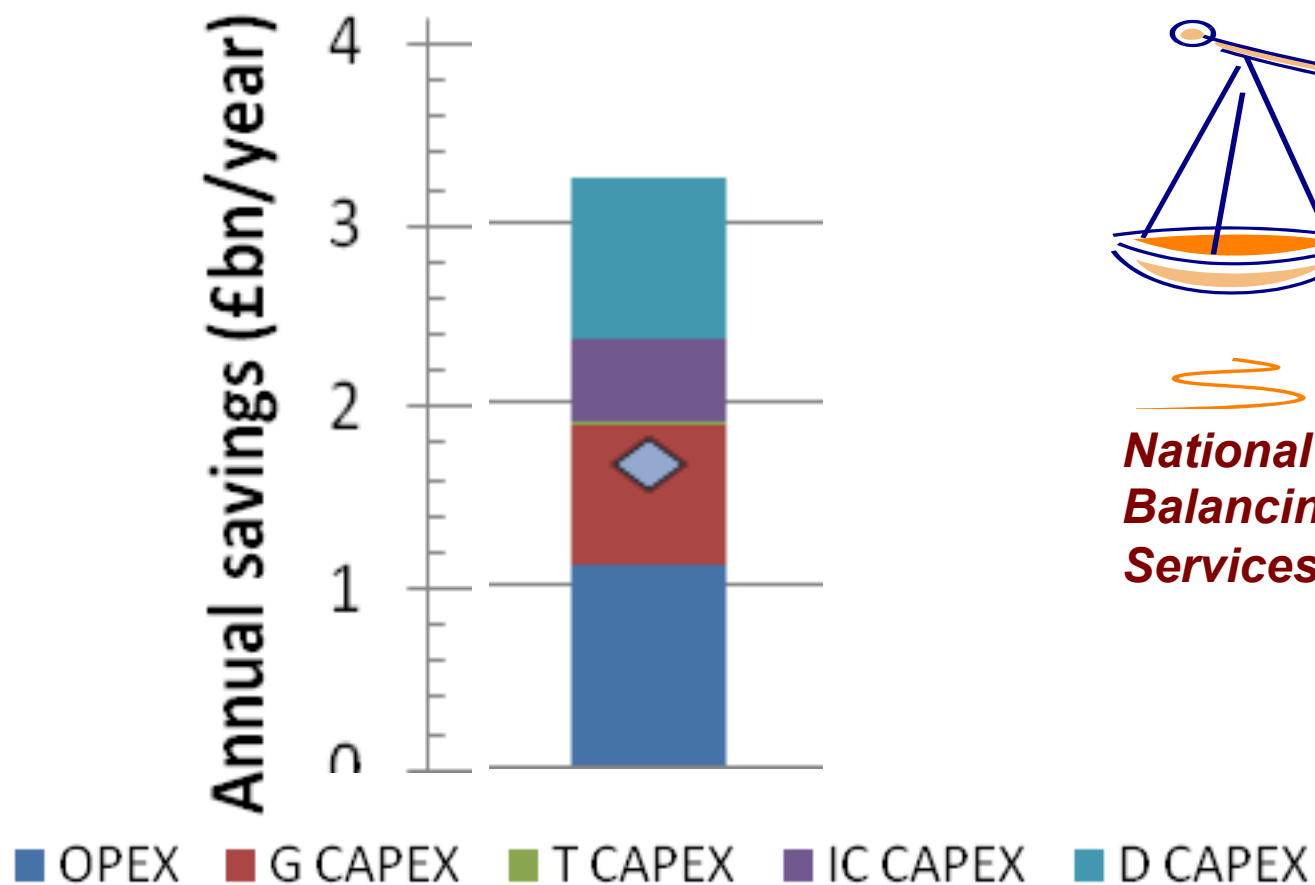


Conflicts between national energy market and local network objectives



Optimal EV response to electricity prices would increase peak demand and overload distribution networks

Complexity of DSR and Storage: Split benefits



Can the market facilitate this?

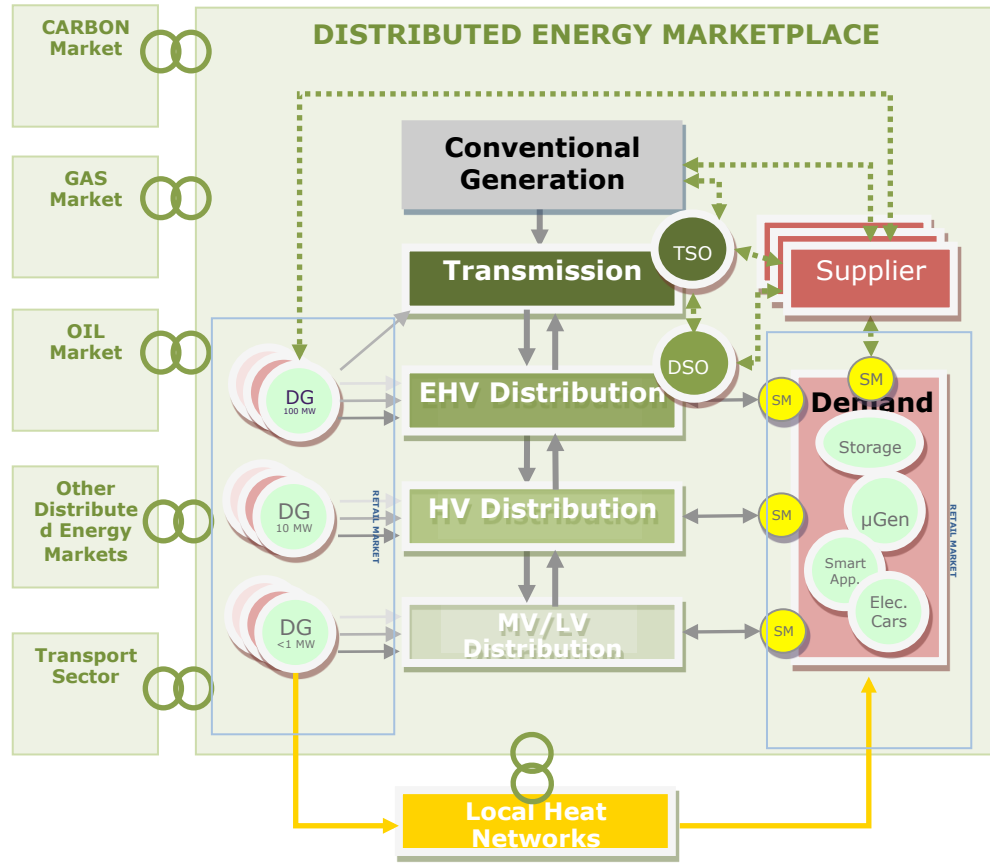
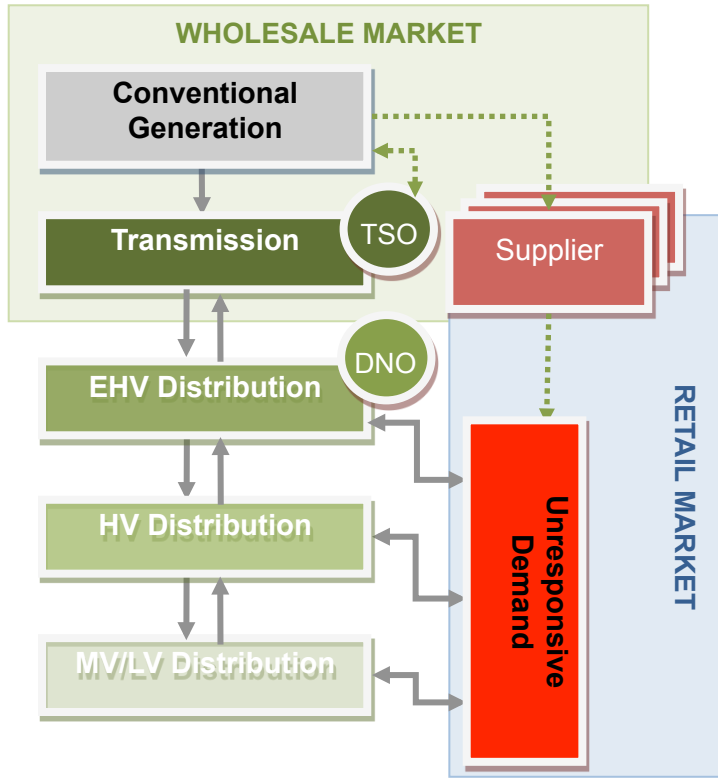
Developments in Market and Regulation

- **EMR & Capacity Mechanism**
 - Very significant international experience with DSR contributing to adequacy of supply (capacity)
 - Excluding DSR from capacity mechanism may undermine its value and its future development
- **Network design and regulation:**
 - Network problems solved by network solutions
 - Growing experience with DSR through LCNF
 - T & D Network Design Standards: updates (and fundamental reviews) are needed

Closer integration of wholesale and retail markets: Impact on Consumers

- Smart metering rollout => Consumers, by making choices could finally drive development of electricity industry
 - Growing value of flexibility in future => energy bills of flexible consumers may be only 30% of these for inflexible consumers
 - Reliability / security differentiated pricing will be possible (relevance to capacity market?)
 - Growing experience with dynamic time-of-use tariffs
 - Will the market facilitate this choice? Fairness?

Integrating Wholesale and Retail markets



Linking all market participants through an integrated real time marketplace

Enabling DSR: Role of future Policy, Market, Regulation, Technology, Consumers.....

Innovation, Policy, Market design

- Understanding and developing DSR flexibility (LCNF experiences)
- Enable competition between DSR and asset based solutions (generation and networks) for the provision of adequacy and balancing services through appropriate market design (DSO)

T and D network standards:

- Recognition of DSR and storage in network planning

Regulation:

- Incentivise application of flexible solutions against asset-based solutions
- Split Benefits and business model

Technology:

- Shift from centralised to distributed system management – ICT
- Virtual Power Plant

Consumers:

Choice, reliability differentiated pricing....

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