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Policy Masterclass

Role and value of energy storage in supporting cost effective transition to resilient low carbon energy future

Goran Strbac

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21 March 2023

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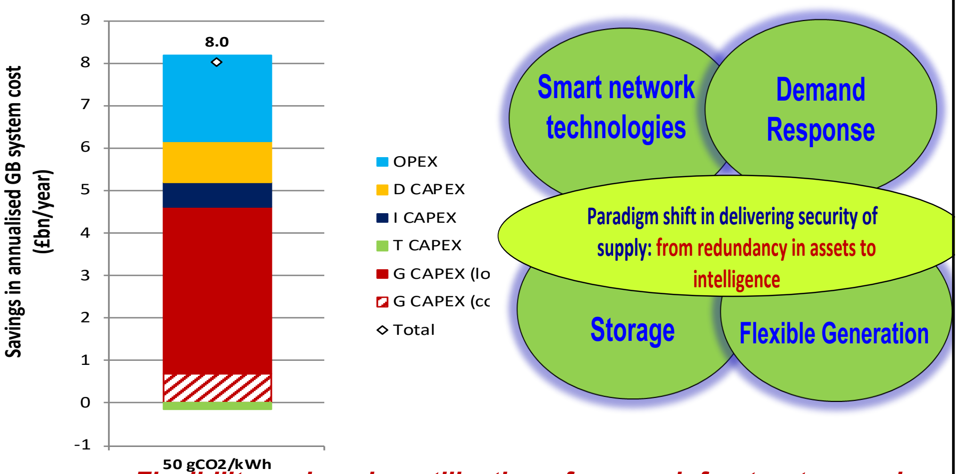
Volume of the market for flexible technologies & smart control post 2030 in UK > £8bn/y



Flexibility: enhancing utilisation of energy infrastructure and supporting cost effective integration of low carbon generation

Multi-service provision by storage

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- **Arbitrage**
  - ✓ Participate in day-ahead energy market
- **Balancing services**
  - ✓ Participate in real-time balancing market
- **Frequency regulation services**
  - ✓ Providing primary/secondary / tertiary frequency regulation services
- **Contribution to meeting peak demand**
  - ✓ Reducing need for peaking plant
- **Network Support**
  - ✓ Reducing need for network reinforcement
- **Low carbon generation mix**
  - ✓ Meeting carbon targets with minimum LC generation
- **Option value**
  - ✓ Providing flexibility to deal with uncertainty

Whole-system modelling critical for capturing Time and Location interactions in low carbon systems

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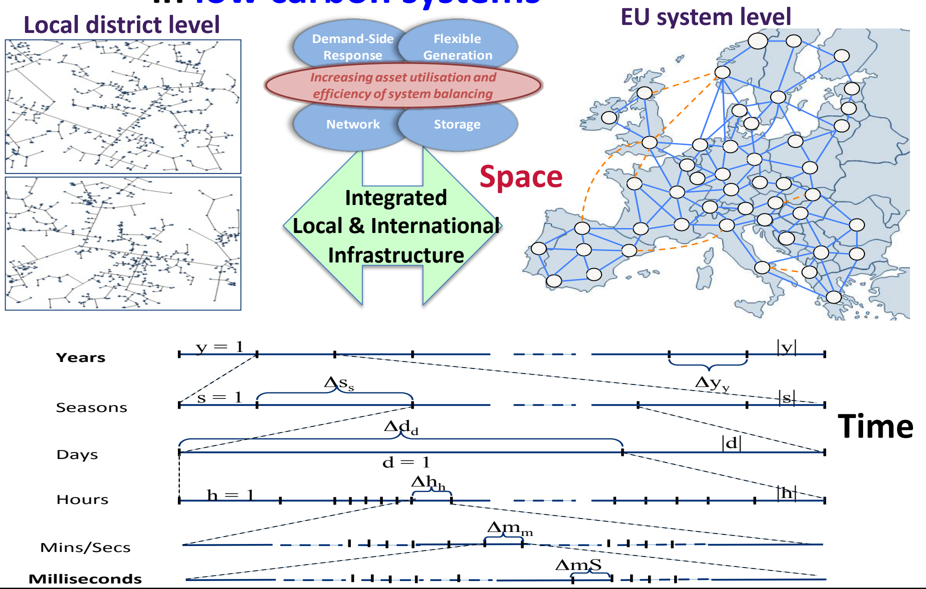

Value of storage over time

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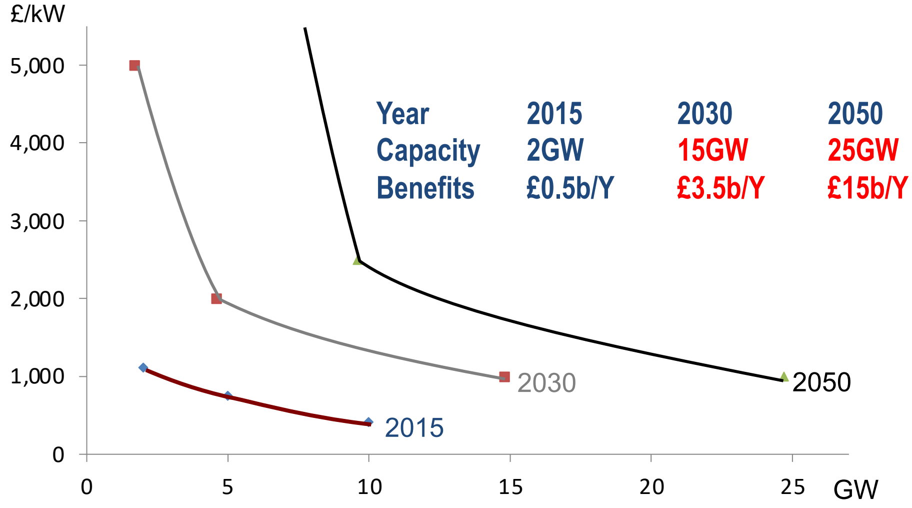

Year	2015	2030	2050
Capacity	2GW	15GW	25GW
Benefits	£0.5b/Y	£3.5b/Y	£15b/Y

Growing need for frequency regulation related ancillary services

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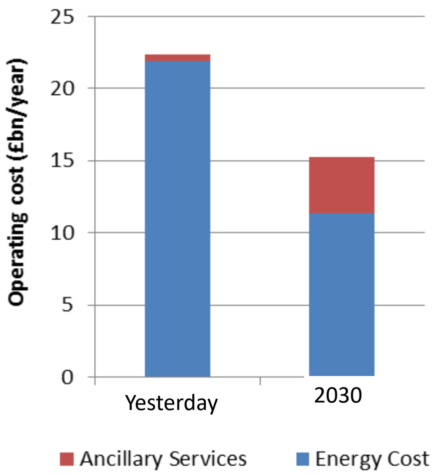
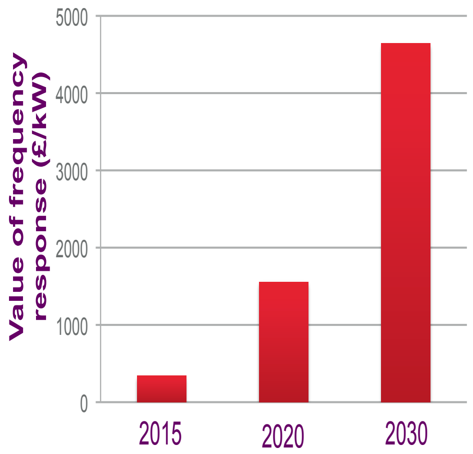
Share of Ancillary Services From 1.5% to 25%



Value of Frequency Response



Making more money by doing less!

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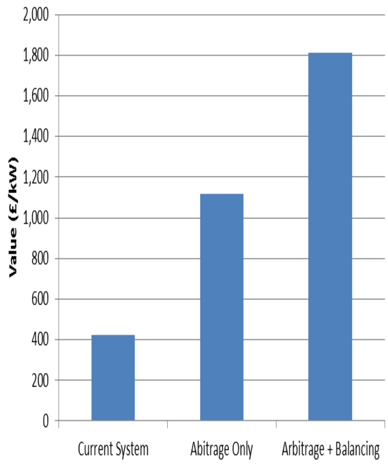

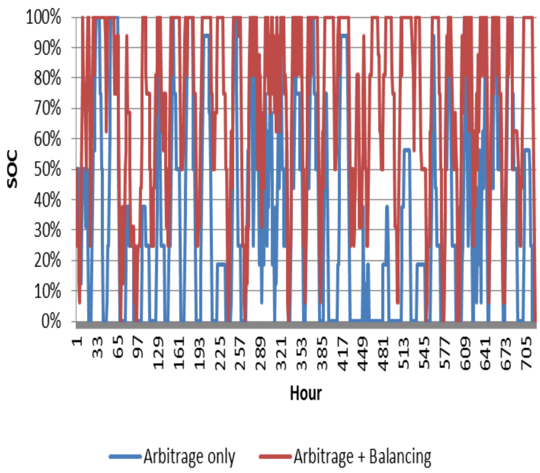

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Carbon benefits of storage

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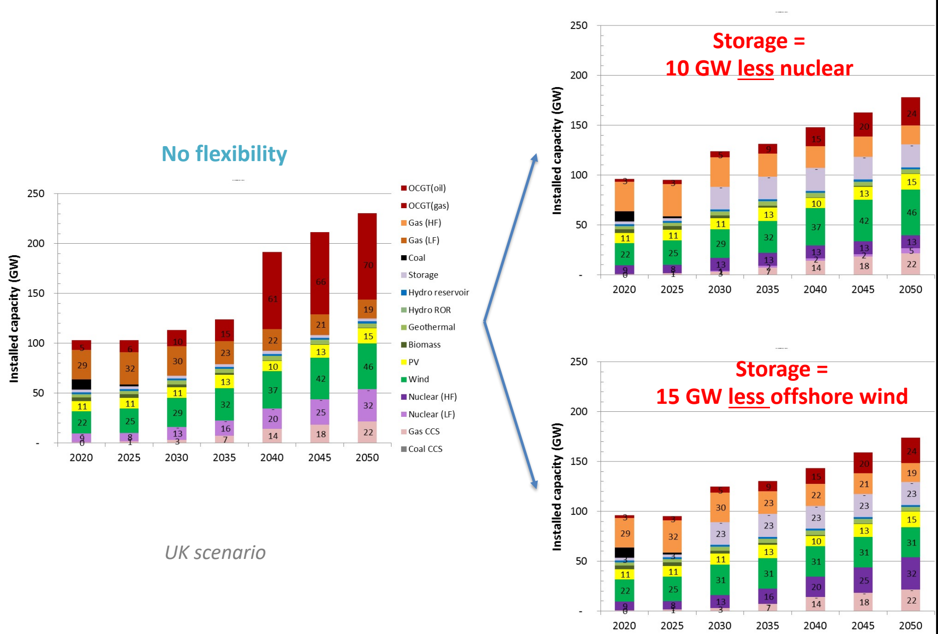

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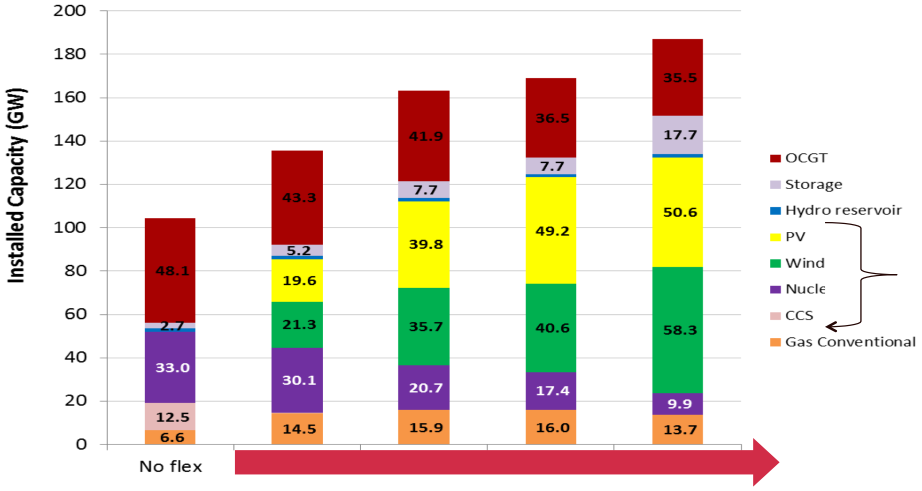
Flexibility – key driver for cost effective evolution to low carbon energy system



Flexibility –Storage and flexible demand

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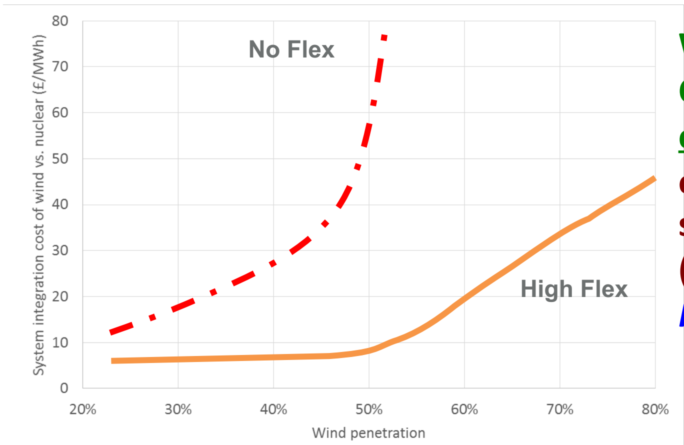
Storage increases the ability of the system to integrate intermittent RES

$WSC_{RES} = LCOE_{RES}$ ± System Integration Cost



Whole-System Costs and competitiveness of RES driven by system flexibility (storage)

Market design?

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Equivalent Generation Capacity (EGC) of energy storage

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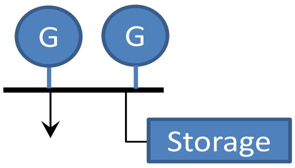
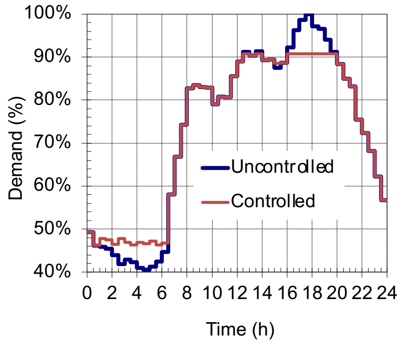


- Demand represented by a peak day profile with peak demand of 7035 kW
- Storage
  - Rated power is 20% of peak demand, 1,407 kW
  - Storage capacity is 1h, 1,407 kWh
  - Storage efficiency is 90%
- How much of conventional generation capacity could be displaced by storage?



- Storage could reduce peak demand by 649 kW (9.2%) resulting in contribution of 649/1407 = 46%

Can storage replace grid infrastructure?

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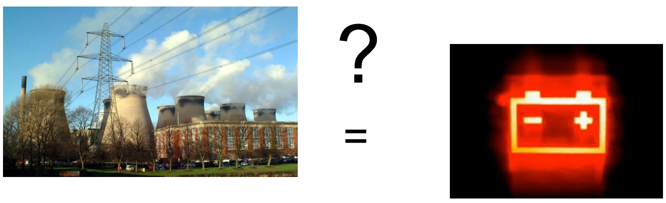

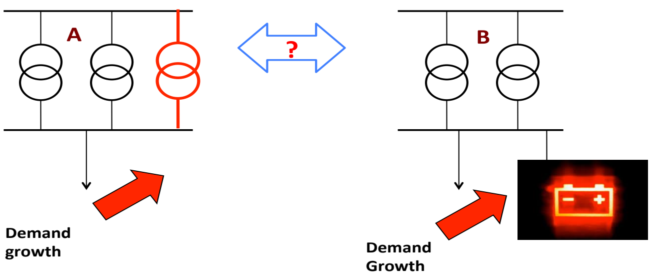

Fundamental review of network security standards: Establishing level playing field is critical

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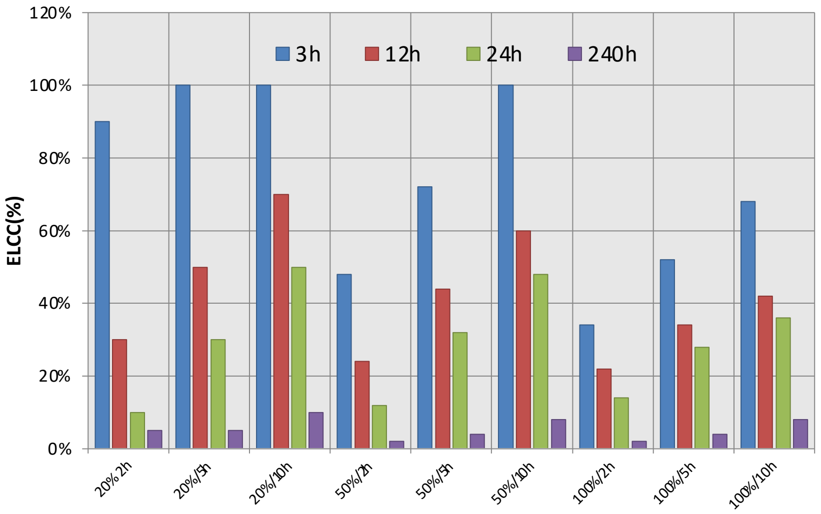
Impact of outage duration



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Competition between energy storage and other flexible solutions

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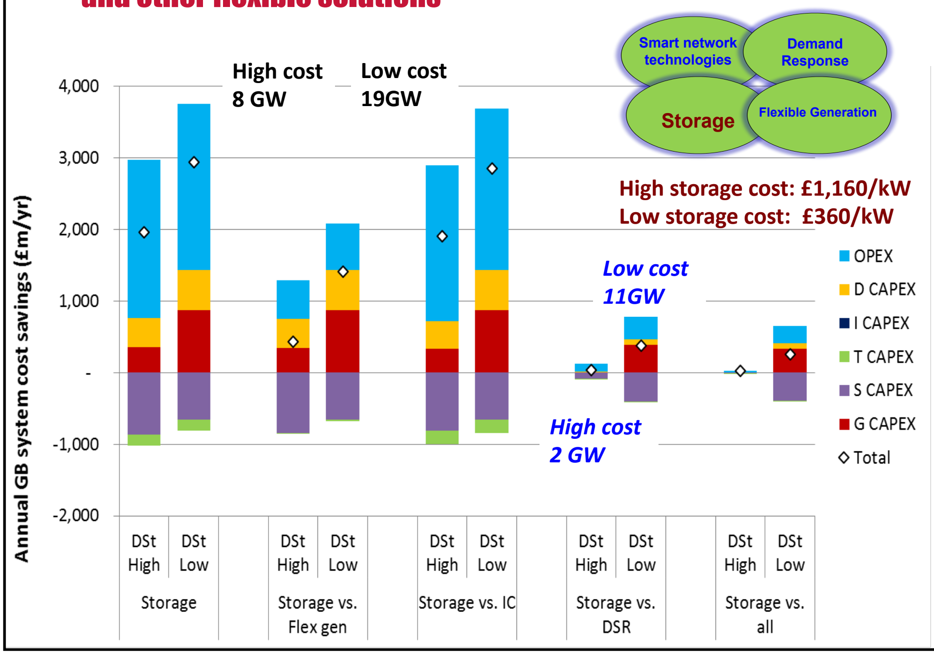

How much energy storage will be needed in the net-zero system?

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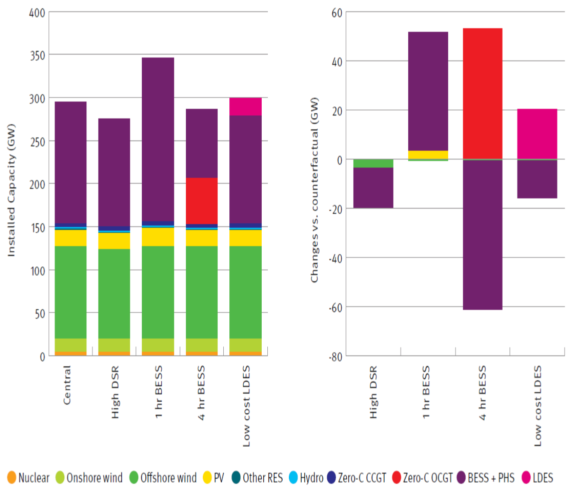
A substantial increase in the volume of energy storage is needed to support a system dominated by RES.



- Volume of battery storage that may need to be built is over 140 GW (100x increase on today)
- Battery storage balances demand and supply, assists with security of supply and mitigates reinforcement of electricity grids
- High uptake of Demand-Side Response (DSR) results in a modest reduction in storage capacity
- Varying storage durations indicate that power capacity is more valuable to the system than energy capacity
- Long-Duration Energy Storage (LDES) with 120-hr duration was found to be attractive only at low cost

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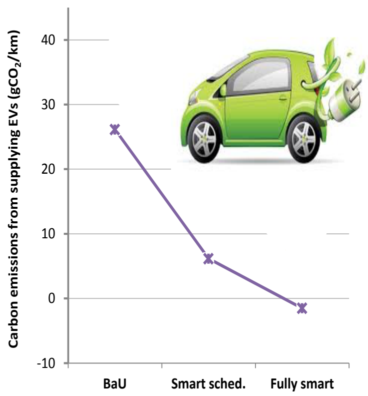
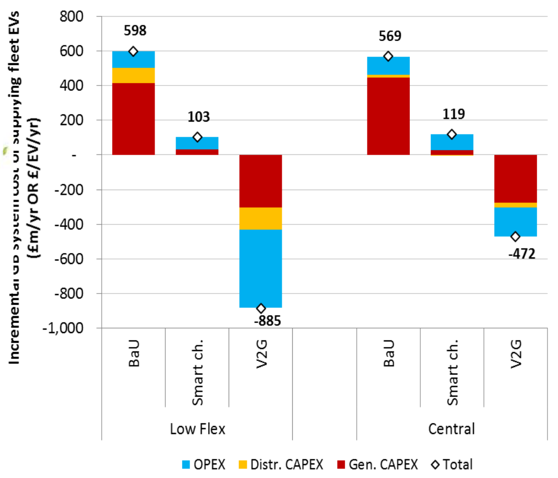
Benefits of integration of transport sector





Long-Duration energy storage: system benefits

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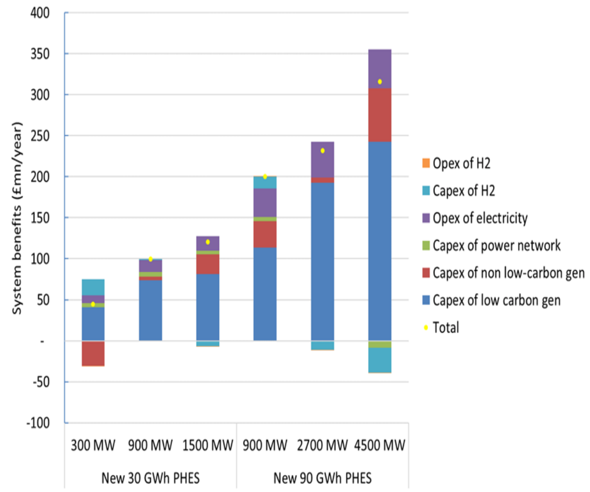

20h to 100h duration

- Total cost savings: £44m - £316m/year
- Value is system specific
  - 30 – 90 GWh of energy storage
  - 300 MW – 4500 MW installed capacity
  - 77 GW of wind
- 75% of the savings are from the avoided capital cost in low-carbon electricity generation

Value of LD-ES

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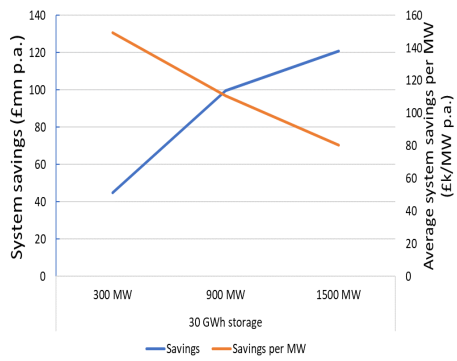
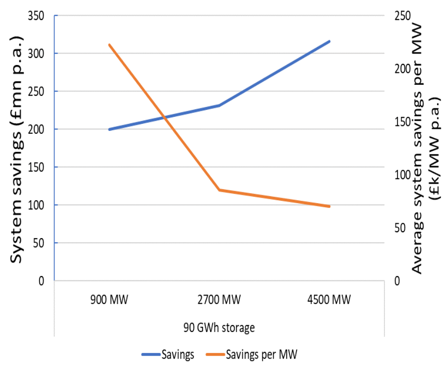
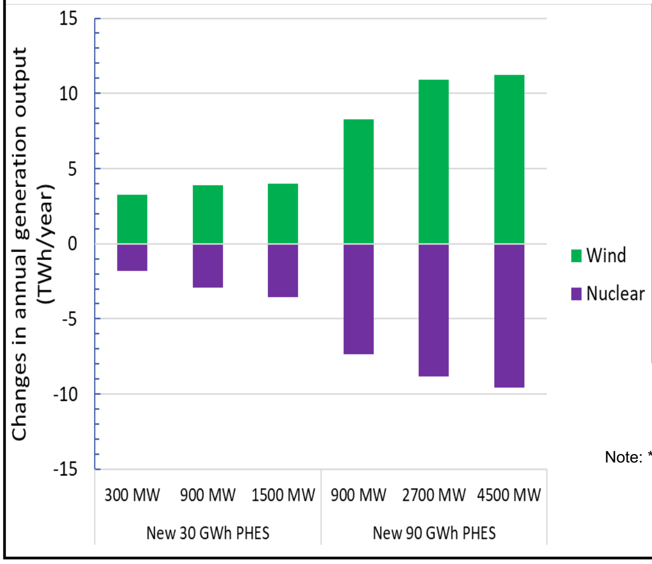




- Higher value for longer-duration energy storage
- The incremental benefit of increasing power capacity (savings per MW) decreases

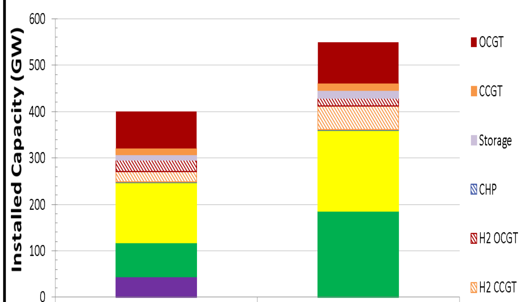
Impact on electricity production from nuclear and wind



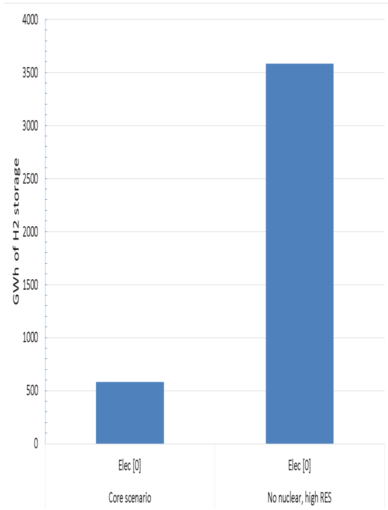
- LD-ES reduces the integration cost of wind
- Higher volume of wind can be integrated*
- Less nuclear power needed

Note: * within the range of studies

Firm Low Carbon Generation: Renewables + Long term storage



	E: HP+RH [MF] [0] Base case	E: HP+RH [MF] No nuclear
OCGT	79	88
CCGT	13	14
Storage	12	18
CHP	0	0
H2 OCGT	24	16
H2 CCGT	23	51
CCS	0	0
Hydro	1	1
PV	129	175
Wind	74	185
Nuclear	43	0



Value of storage with different durations

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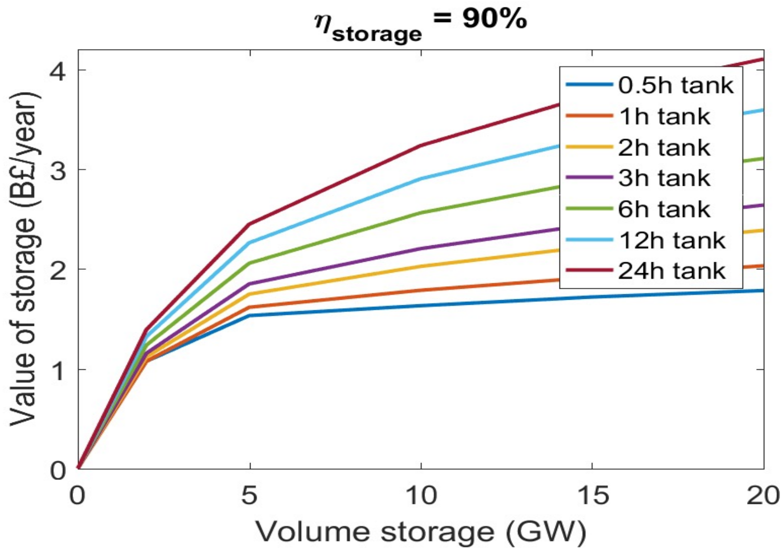

Size of the storage tank may have a significant impact for large volumes of deployed storage capacity

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Additional H2 storage to deal with prolonged low/no wind periods

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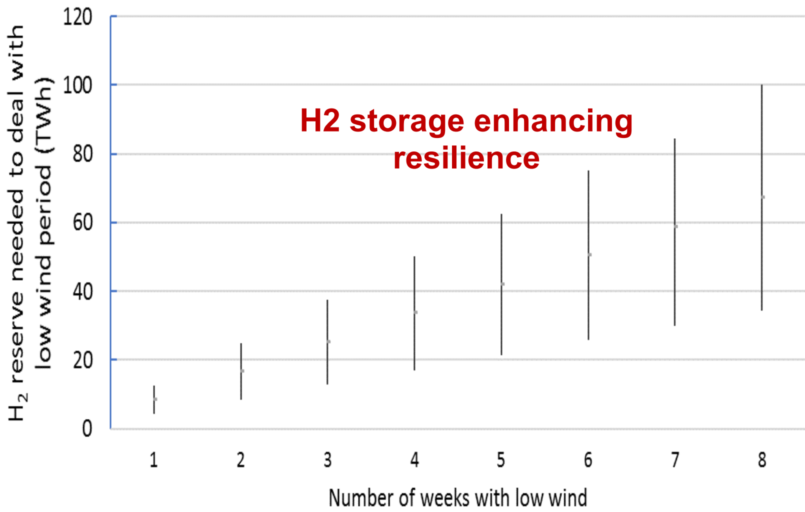

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Cost assessment

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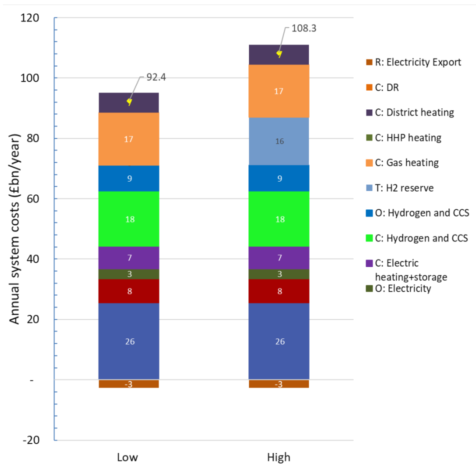
- **Production cost of hydrogen, including investment energy infrastructure:**
  - **Blue H2 (natural gas via ATR+CCS) £185m/year**
  - **Green H2 (offshore wind) £200m/year**
- **The main cost is associated with H2 storage**
  - Capex and opex cost of H2 storage **£15.7 billion/year**
- **<u>Total cost: £15.9bn/year</u>**



System integration cost of wind?

System benefits of r-SOC

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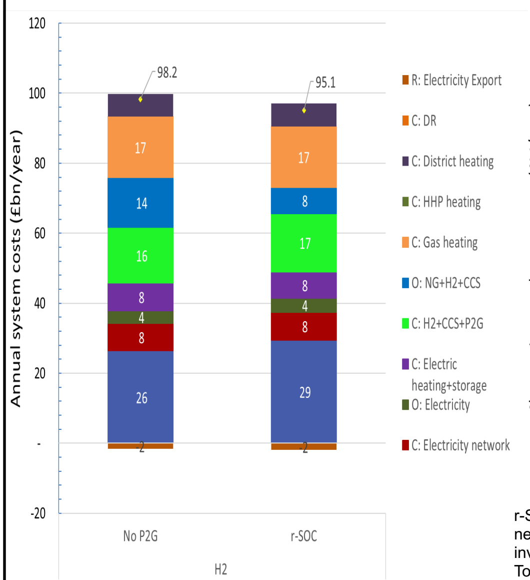
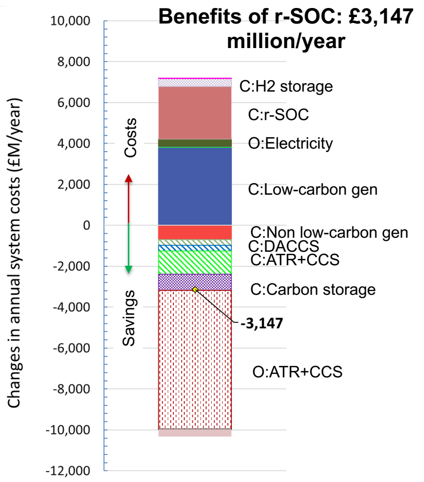
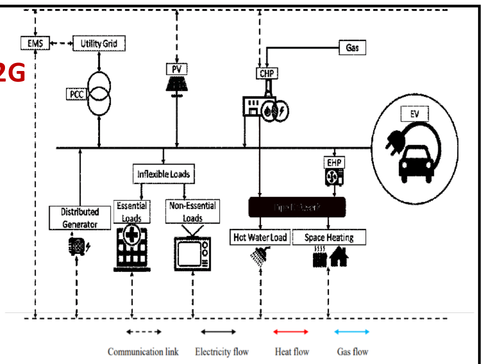


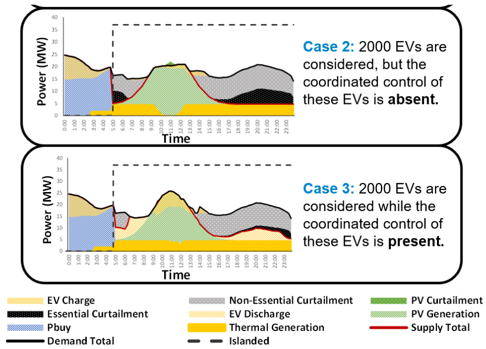


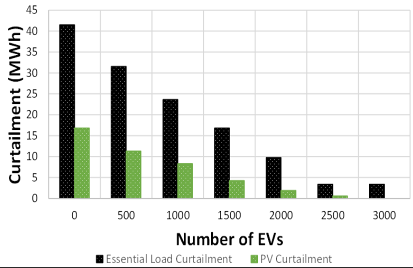
r-SOC allows more investment in low-carbon generation but needs to be supported with H2 storage. r-SOC reduces investment in DACCS, peaking plant, carbon storage, and Totex of ATR+CCS

Enhancing system **Resilience** via coordinated control of **Storage and V2G**

- The presence of **uncoordinated EVs burdens the system**, resulting in 3.8% more non-essential load curtailment during islanding, compared to when they are absent.
- On the other hand, the presence of **coordinated V2G control helps the system**, resulting in a significant 73.5% reduction in essential load curtailment, and a moderate 7.8% reduction in non-essential load curtailment.







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Dealing with uncertainty in future development: where, when and how much to invest? – into what?

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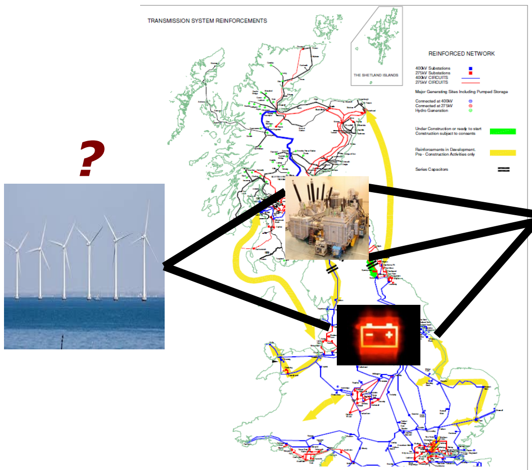

Deterministic planning would lead to investment strategies that may ignore energy storage and favour conventional investments

Significant value in investing in flexibility to deal with uncertainty

Significant Option Value of energy storage

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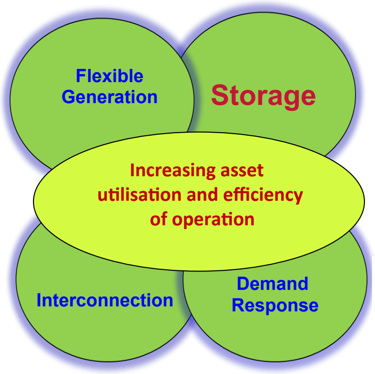
What about competition to storage?

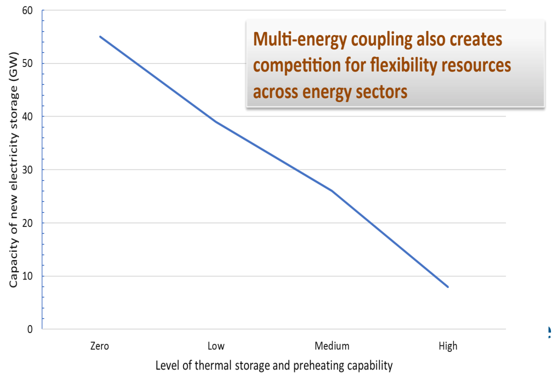


Key questions:

(1) What are the performance and cost targets for alternative technologies?

(2) Understand the competitiveness and synergies between alternative technologies

Cost effectiveness of alternative technology options will be system specific



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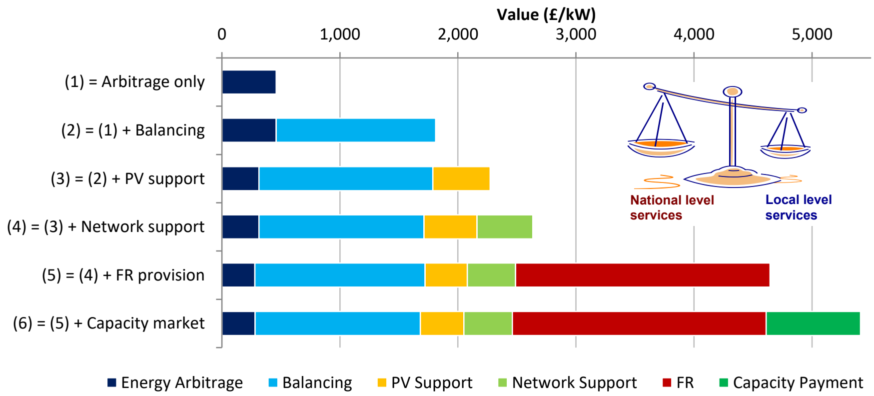
Business case for energy storage:
access to both local and national level benefits is critical



Flexibility- market design, business model?

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Challenges and opportunities

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- **Technology**
  - Reducing costs, improving performance, . . .
  - System requirements informed technology development . . .
- **Strategies for control & management**
  - Multi service provision, uncertainty, degradation management . . .
  - Hybrid technologies . . .
- **Standards, Markets & Policy**
  - Network planning standards, option value of flexibility
  - Market design, regulation, business models . .
  - Role of storage in low carbon energy future including revenues
  - Whole-system approach, Interaction between different energy vectors . . .
  - Delivering resilient low carbon energy future….
- **Turning the problem into opportunity**
  - Need for storage based flexibility and resilience

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