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Role and value of flexibility in supporting cost-effective transition to an integrated low-carbon energy system

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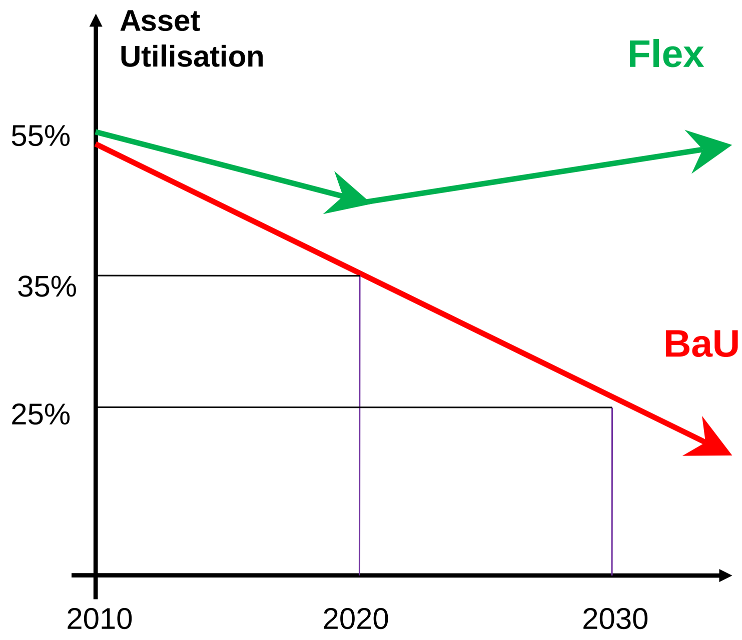
Background

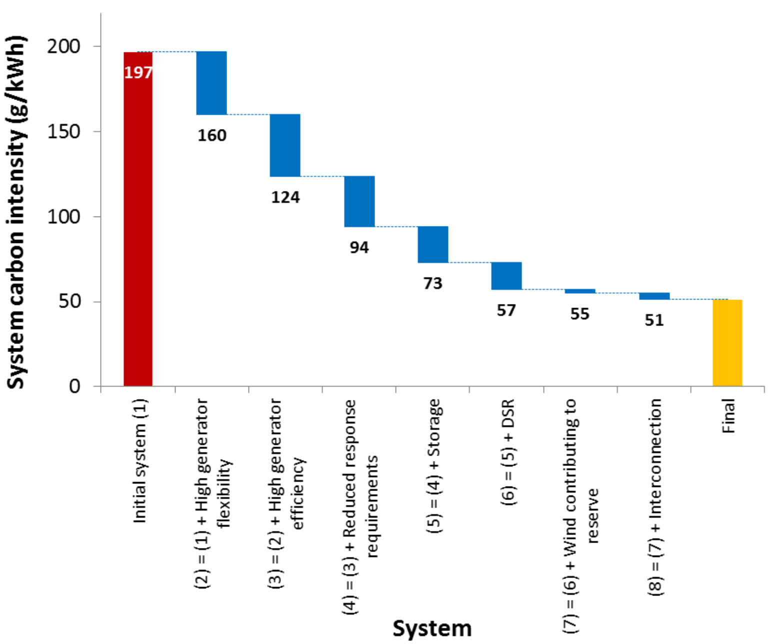
- Ambitious decarbonisation targets in the UK in 2030-2050 horizon
  - Rapid expansion of RES and less flexible low-carbon generation
  - Electrification of heat and transport demand
  - Reduction of capacity and output of conventional (coal and gas) units
- Potentially negative impact on asset utilisation, increasing system costs

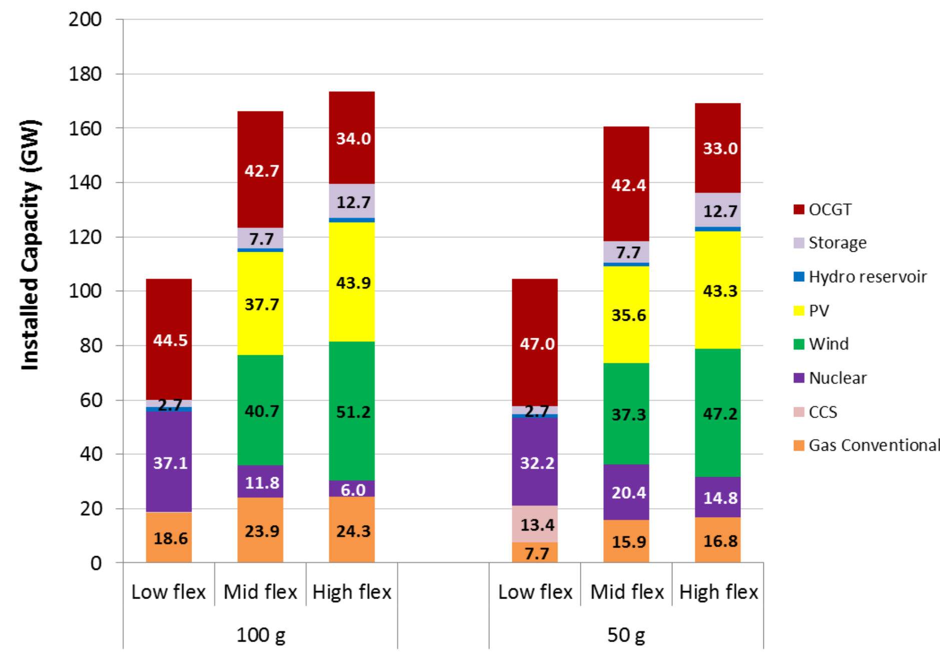
→ ***Need for additional flexibility***

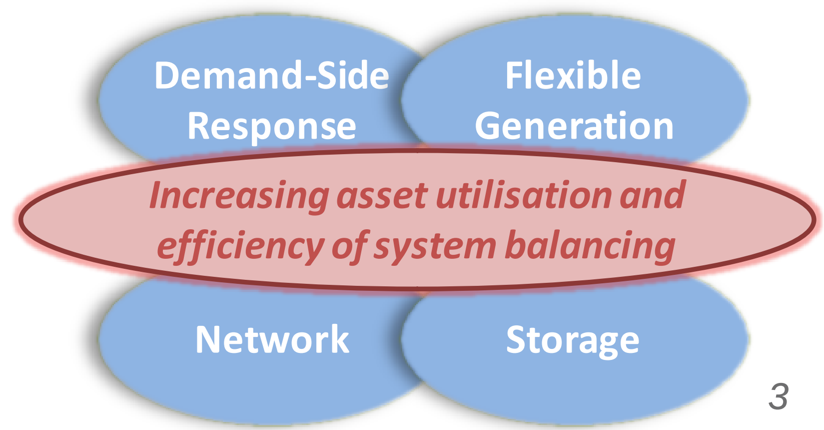


Why we need flexibility

- Previous analysis shows significantly more investment is needed in absence of flexibility
- Flexibility can support a cheaper low-carbon generation mix to meet a given carbon reduction target

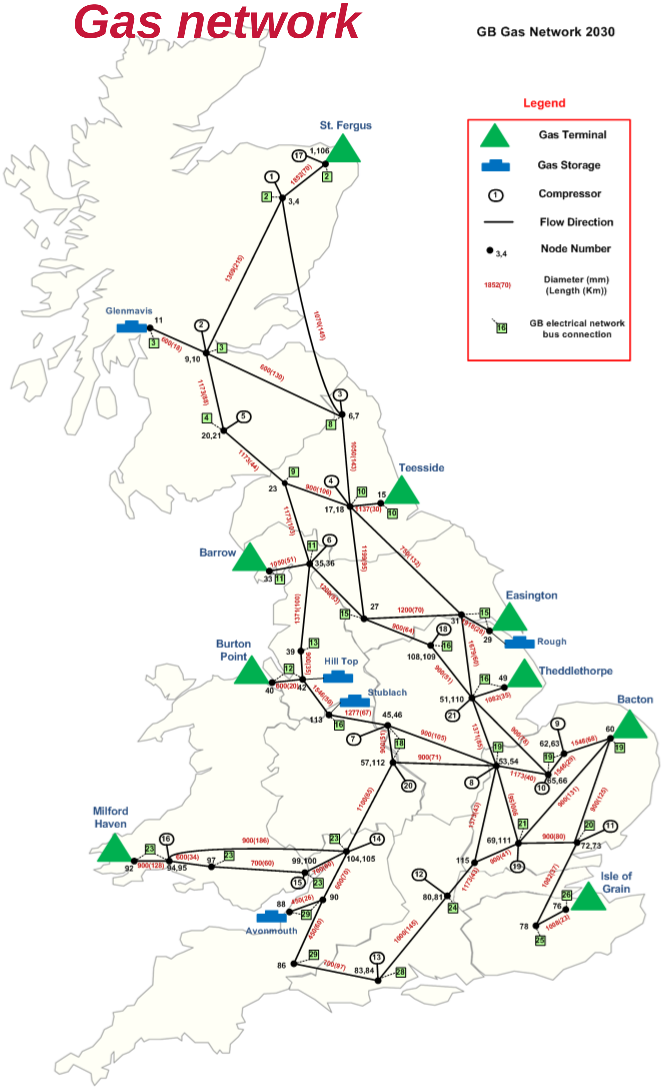




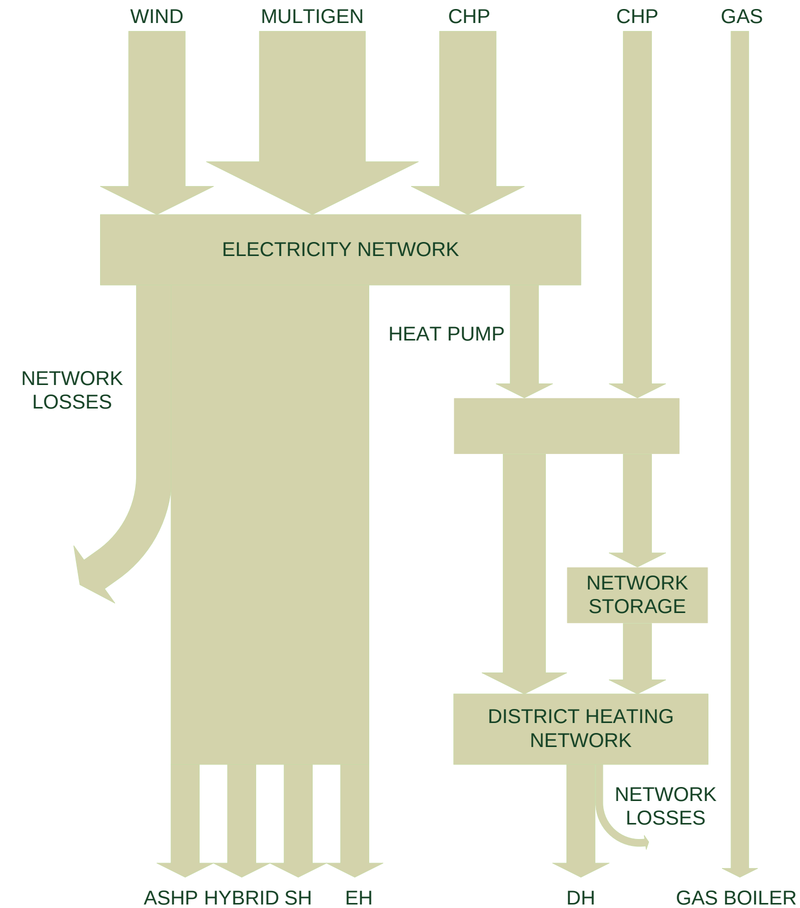


Flexibility extends beyond electricity system boundaries

Gas network



Integrated electricity and heat networks



Role of flexibility under uncertainty

- Understanding the role of flexibility is very complex and associated with a number of uncertainties
  - Evolution of future energy system
  - Projected cost and availability of different flexibility options
- Despite uncertainties, key investment decisions need to be made in the short-term but will have a lasting impact due to long lead times
- This creates the possibility for ***regret*** i.e. additional cost due to suboptimal decisions
- Flexibility can provide ***option value*** – postponing decisions on larger investments until there is better information, hence reducing the need to make potentially high regret decisions
- ***'Least-worst regret'*** approach is about quantifying the worst possible outcomes for a set of strategic choices, and then identifying the choice with the 'least-worst' outcome

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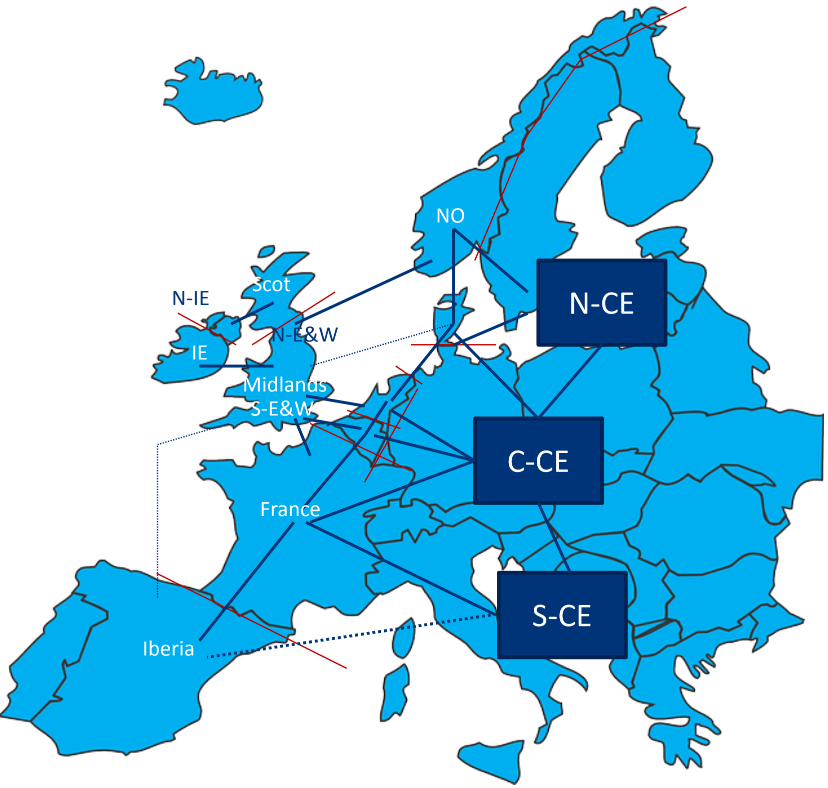
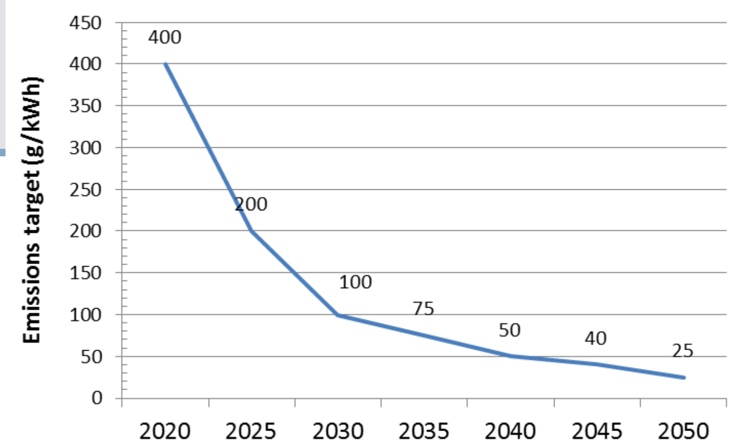
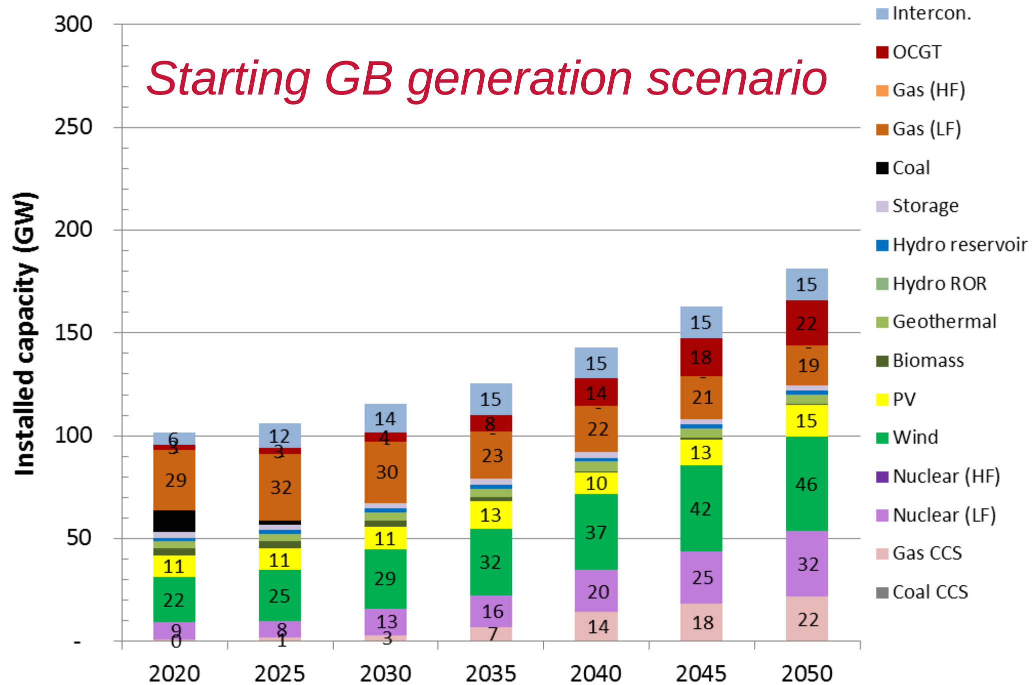
System configuration



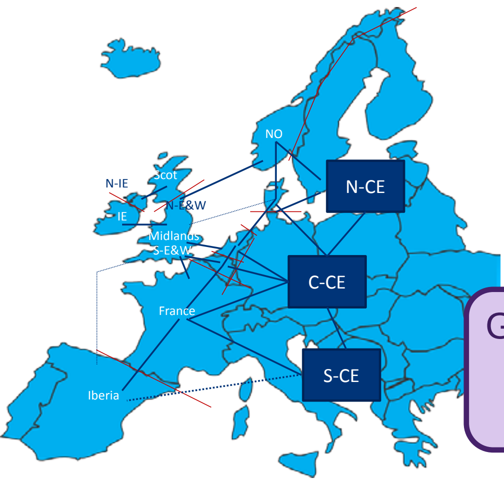
GB emission target

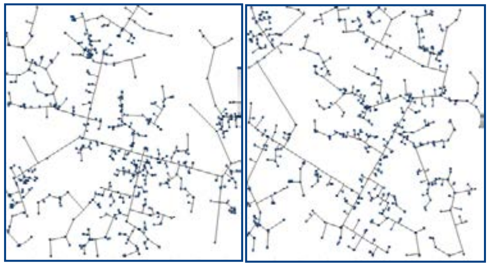




Multi-year Whole electricity System Model (WeSIM)

Interconnected GB system





~10 representative DNs

Future development scenarios (GB & EU):
- Generation mix evolution (RES etc.)
- Demand (electrification etc.)

GB + EU Grid Model: Transmission + Distribution

WeSIM: Generation, Transmission and Distribution Investment and Operation Model

CO_2 constraints

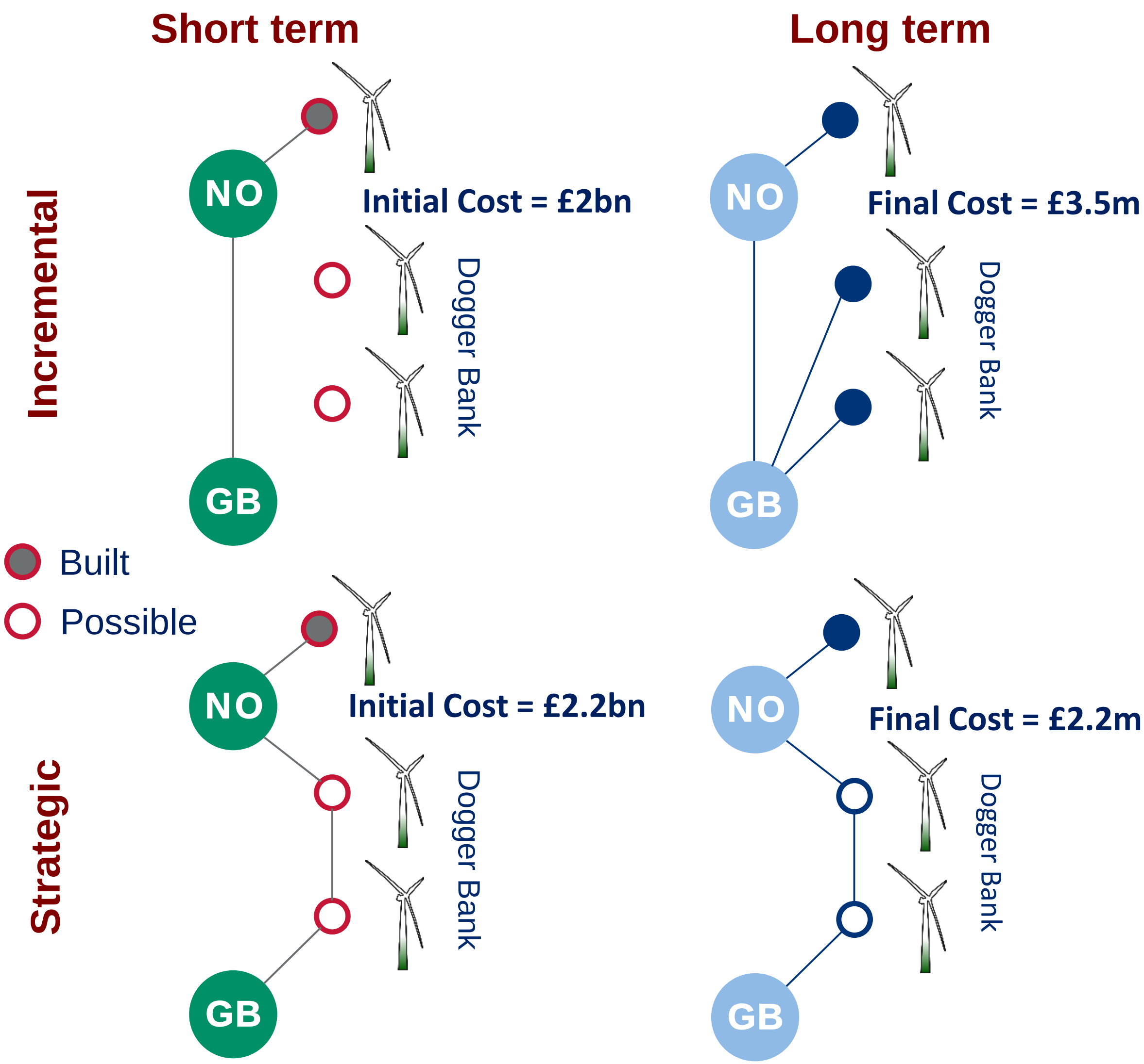
- Investment in G/T/D & storage infrastructure
- Generation & storage output, RES curtailment & CO2 emissions
- Overall investment and operation cost

Key results

Outturn carbon intensity

System value of flexibility

Example of least-worst regret analysis: investment in offshore grids



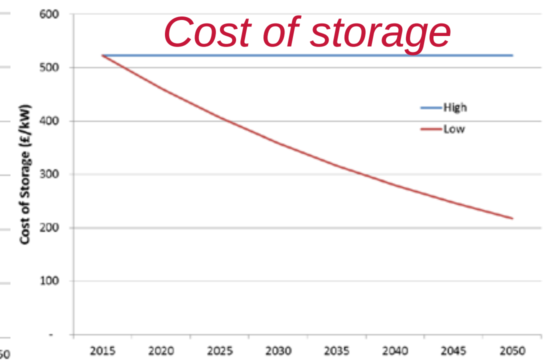
Should we strategically connect GB and NO via Dogger Bank (with uncertain but possible development of offshore wind), or connect offshore wind farms incrementally if/when the need arises?

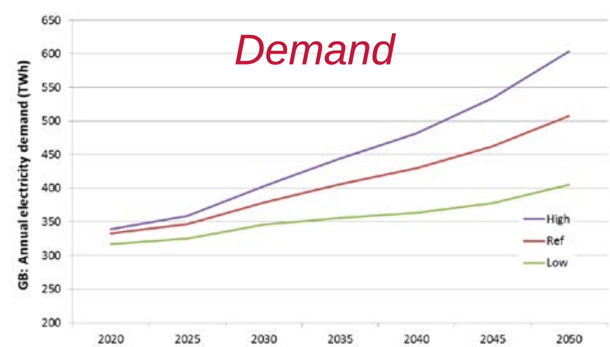
- Max regret:
  - Incremental: £1,500m
  - **Strategic: £200m**

Least – Worst Regret Option

Uncertainties/scenarios considered in the analysis

- Cost of DSR: High/Low
- Cost of storage: High/Low
- System demand/generation background: High/Low
- Deployment of new interconnection capacity between 2025 and 2030: as planned (14 GW by 2030) or none
- Challenge: keep the number of combinations low while covering extremes

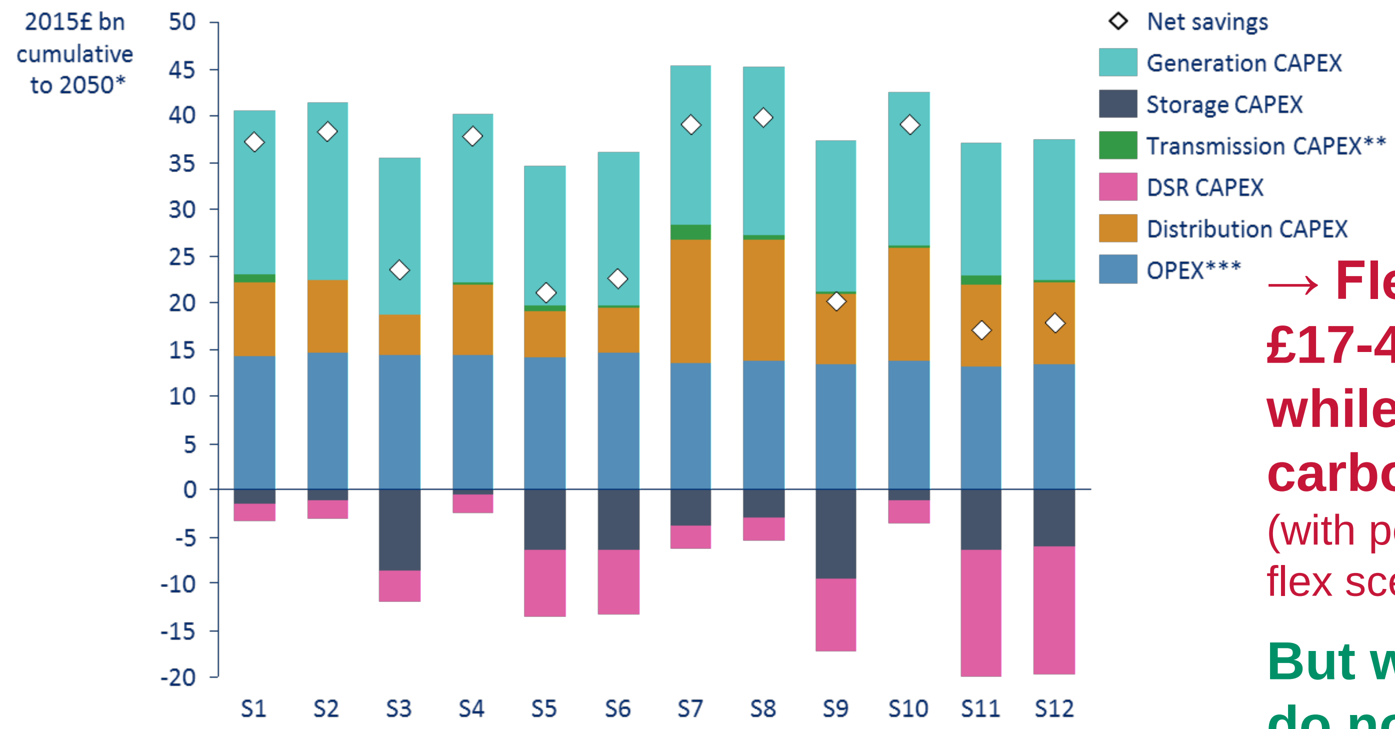




Scenario	De	St	Ds	In	System demand	Cost of storage	Cost of DSR	Interconnector deployment
S1	● light	● light	● light	● light	Low	Low	Low	Delayed
S2	● light	● light	● light	● dark	Low	Low	Low	Full
S3	● light	● light	● dark	● dark	Low	Low	High	Full
S4	● light	● dark	● light	● dark	Low	High	Low	Full
S5	● light	● dark	● dark	● light	Low	High	High	Delayed
S6	● light	● dark	● dark	● dark	Low	High	High	Full
S7	● dark	● light	● light	● light	High	Low	Low	Delayed
S8	● dark	● light	● light	● dark	High	Low	Low	Full
S9	● dark	● light	● dark	● dark	High	Low	High	Full
S10	● dark	● dark	● light	● dark	High	High	Low	Full
S11	● dark	● dark	● dark	● light	High	High	High	Delayed
S12	● dark	● dark	● dark	● dark	High	High	High	Full

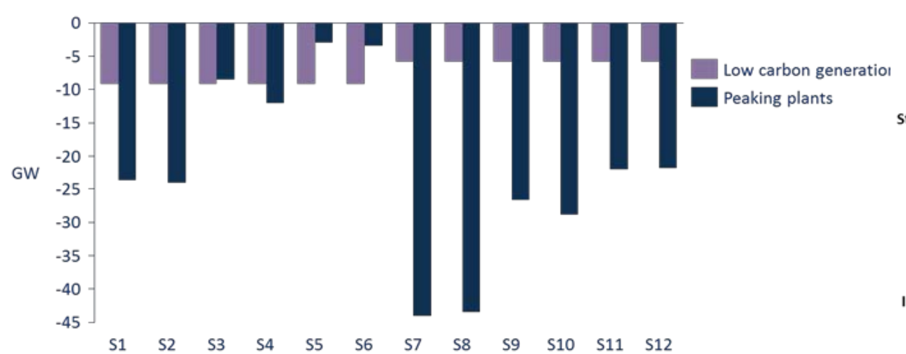
Imperial College London and Carbon Trust, “An analysis of electricity system flexibility for Great Britain”, report for DECC, July 2016

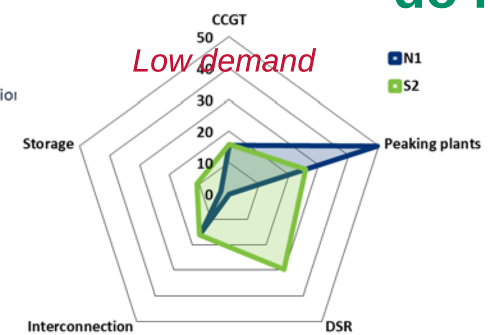
Value of flexibility across scenarios

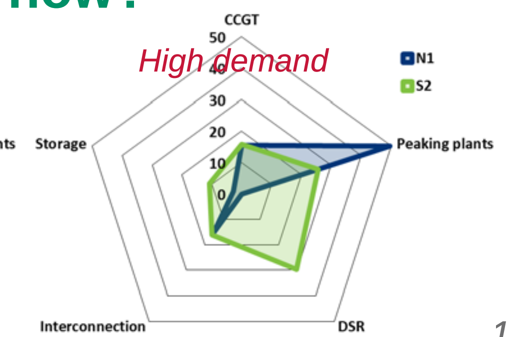


→ Flexibility can save £17-40bn until 2050 while meeting the same carbon targets
(with perfect foresight, vs. no-flex scenario)

But what do we need to do now?







Least-worst regret analysis

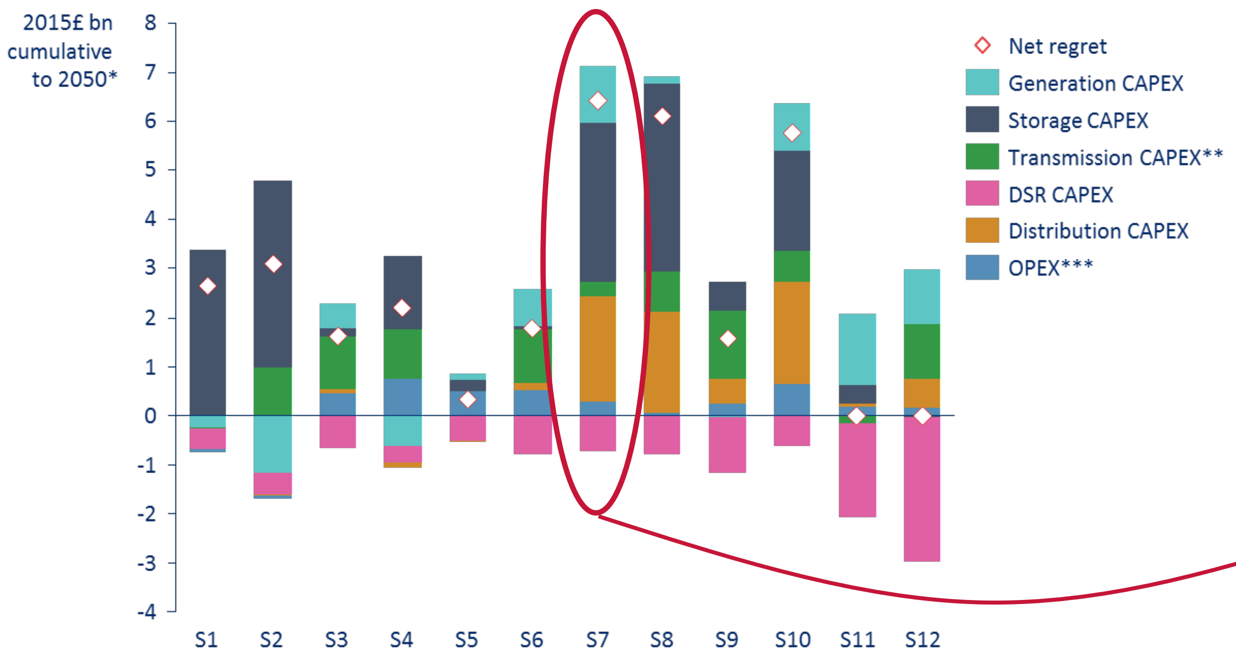
- Based on optimal deployment of flexibility across all 12 scenarios four key Pathways (short-term deployment strategies) are formulated
- These decisions are fixed across all scenarios and the model rerun to quantify the increase in cost i.e. regret for each scenario

Pathway	DSR in 2020	Storage in 2020	Flexible CCGT in 2020	Additional interconnection in 2025
Only DSR	2-5	-	-	-
Only Storage	-	1.2-3	-	-
Balanced	1-5	0.5-3	1	-
Do Nothing	-	-	-	-

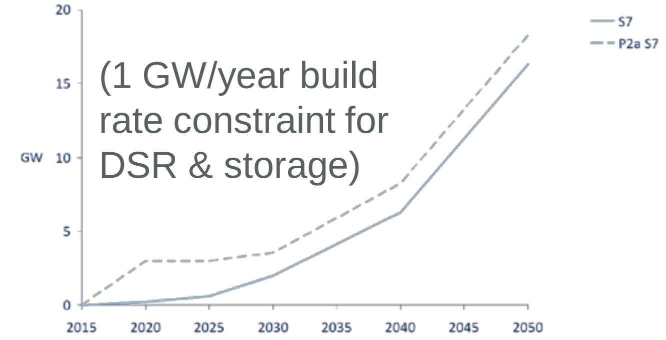
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	Worst regret
Only DSR	0.0	0.1	1.7	0.0	0.5	1.6	0.0	0.0	1.0	0.0	0.4	0.2	1.7
Only Storage	2.6	3.1	1.6	2.2	0.3	1.8	6.4	6.1	1.6	5.8	0.0	0.0	6.4
Balanced	0.0	0.2	1.4	0.1	0.2	1.3	0.1	0.0	0.7	0.1	0.0	0.0	1.4
Do Nothing	4.5	4.3	1.8	4.4	0.8	1.6	9.0	8.5	1.7	8.9	1.6	1.4	9.0

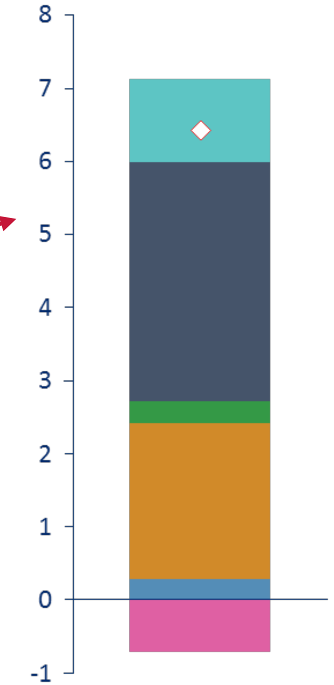
Example for the 'Only Storage' Pathway

Cost difference (regret) between the optimal deployment and 'Only Storage' Pathway across all scenarios



Deployment of storage





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Key findings

- The UK could save ***£17-40bn*** across the electricity system from now to 2050 by deploying flexibility technologies
- Not deploying any additional sources of flexibility ('Do Nothing') by 2020 is the Pathway that delivers the ***greatest regret*** (£9bn)
- ***'Balanced'*** strategy of deployment across different sources of flexibility represents the least-worst regret pathway
- ***DSR*** has a key role in providing flexibility but also has the greatest uncertainty in terms of cost and uptake (non-technical barriers)
- ***Energy storage*** represents a critical ingredient in the future flexibility portfolio, particularly if cost reductions in other flexibility technologies are slow
- ***Interconnectors*** are a key source of flexibility for the UK; any delays to the expected pipeline would increase costs
- ***Gas power plants*** have a long-term role by providing both flexibility and peaking capacity, although with reducing utilisation over time
- Further demonstration, trials etc. are needed + more streamlined regulatory and market framework
- **Action is required now to have an efficient flexibility portfolio in place by ~2020**

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