Options for addressing the balancing challenges:

Integrated gas and electricity perspectives

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EPSRC
Pioneering research and skills

Balancing challenges

- Large increase in wind generation capacity in GB
- Balancing challenges due to wind variability
- A number of *technically*-feasible options:
  - Generation flexibility
  - Electricity storage
  - Power-to-Gas
  - Demand flexibility
- Efficacy of these options?
- What is the impacts on the operation of gas network (linepack changes)?
- What is the role of gas network?

Type	Capacity (GW)
Gas	44
Coal	10
Nuclear	12
Wind	45
Hydro	1.1
Interconnector	7.6
Pumped storage	2.7

Generation capacity mix in 2030,
Source: National Grid ETYS, 2012

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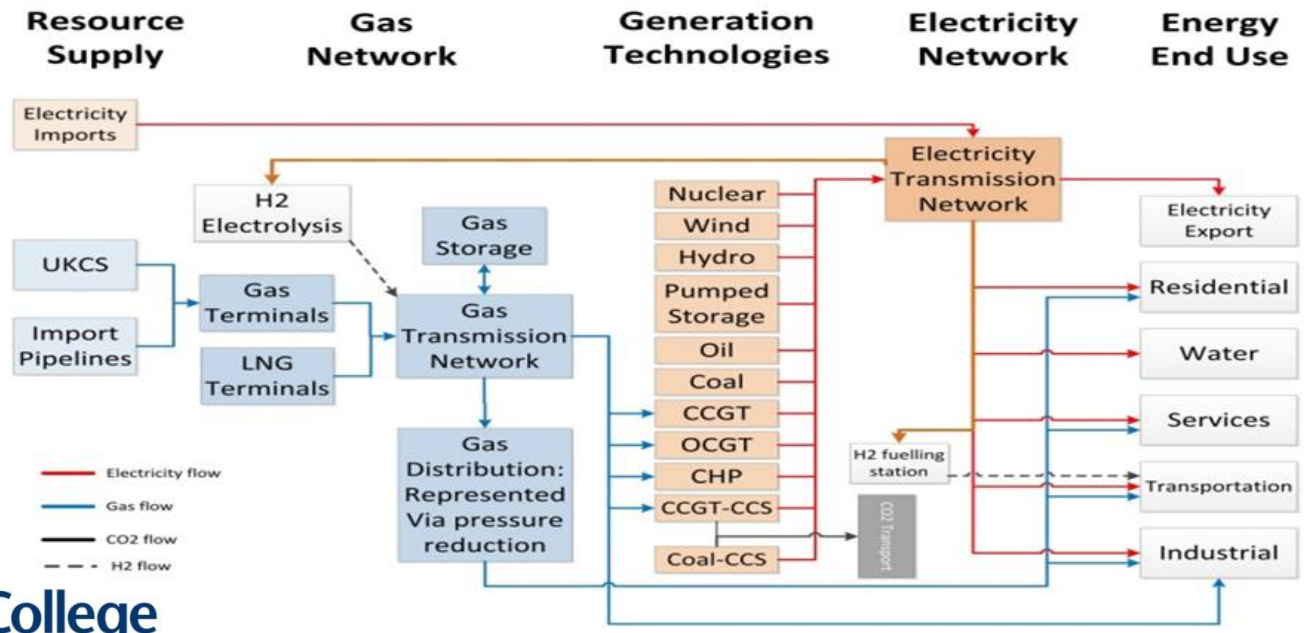
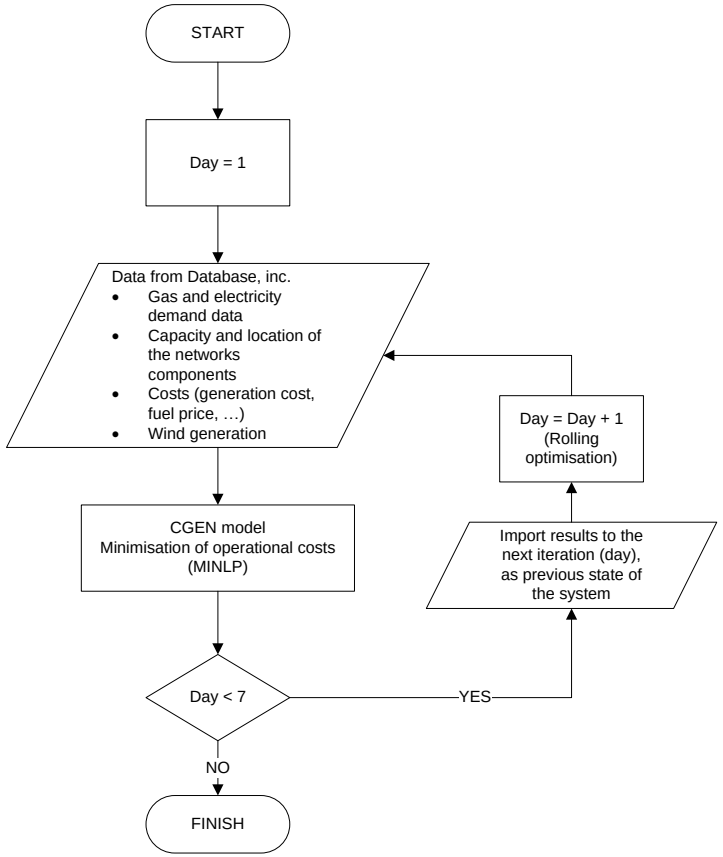
Combined Gas and Electricity Network model (CGEN)

- CGEN is an optimisation model for integrated gas and electricity network
- Rolling optimisation approach





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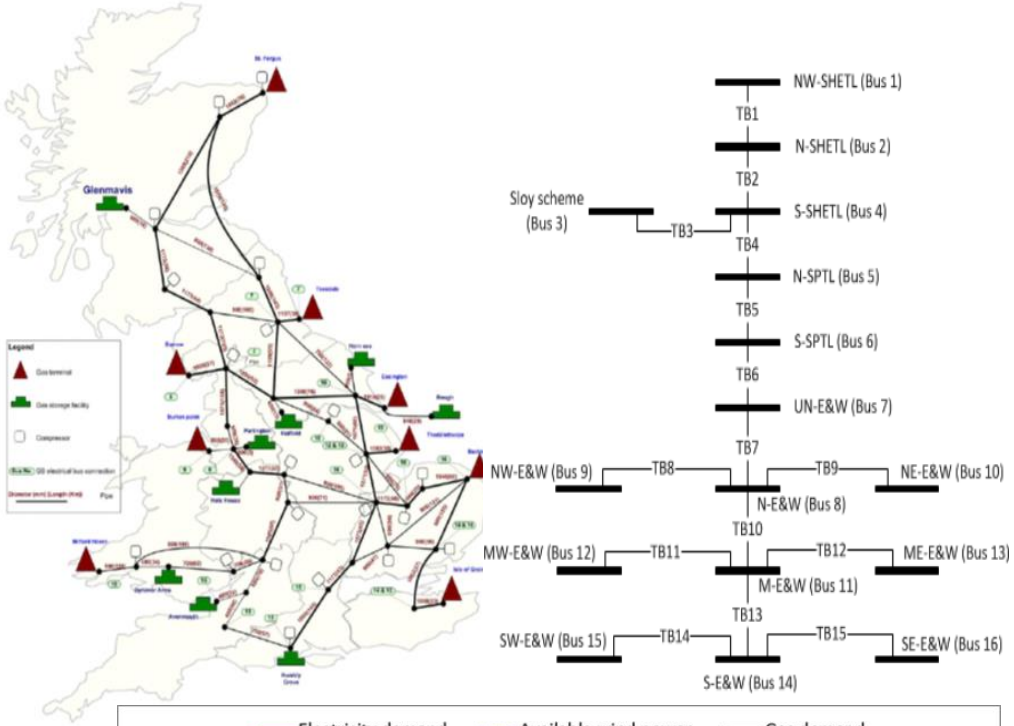
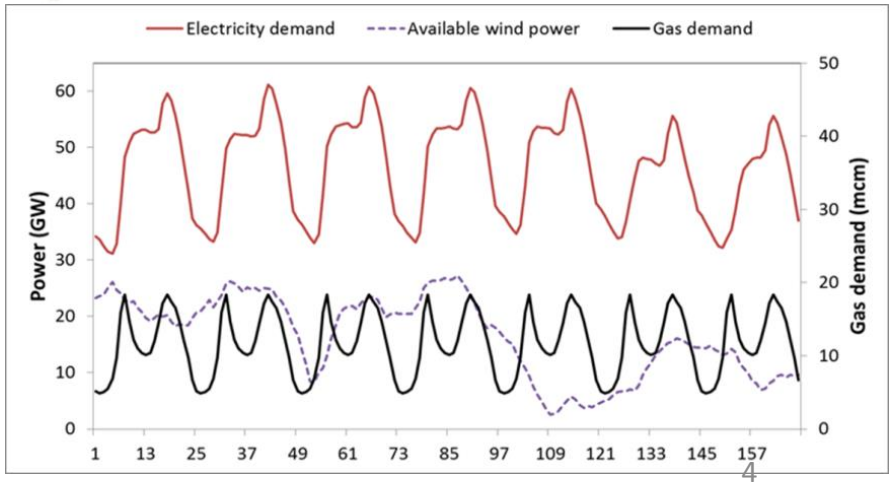
Case studies

- Options for addressing balancing challenges:
  - Reference
  - Flexible CCGTs
  - Electricity storage
  - Power-to-Gas
- Simplified electricity and gas networks were used to represent the GB system in 2030
- A typical winter week in 2030 was modelled (with hourly time steps)
- No constraint on power transmission capacity was assumed





Data from: National Grid, Elexon and ITRC

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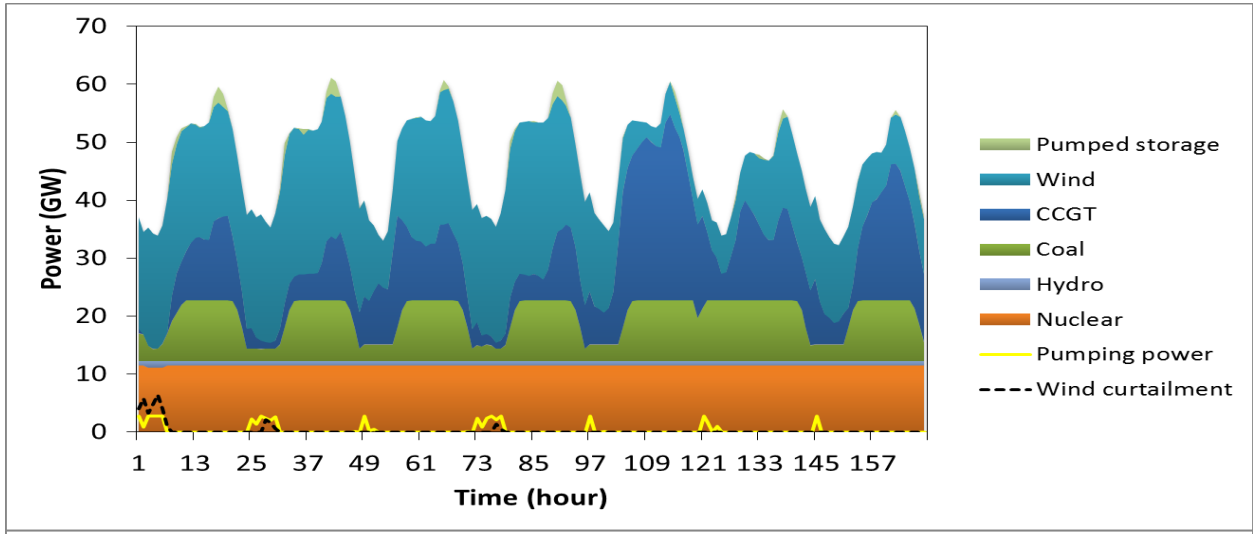
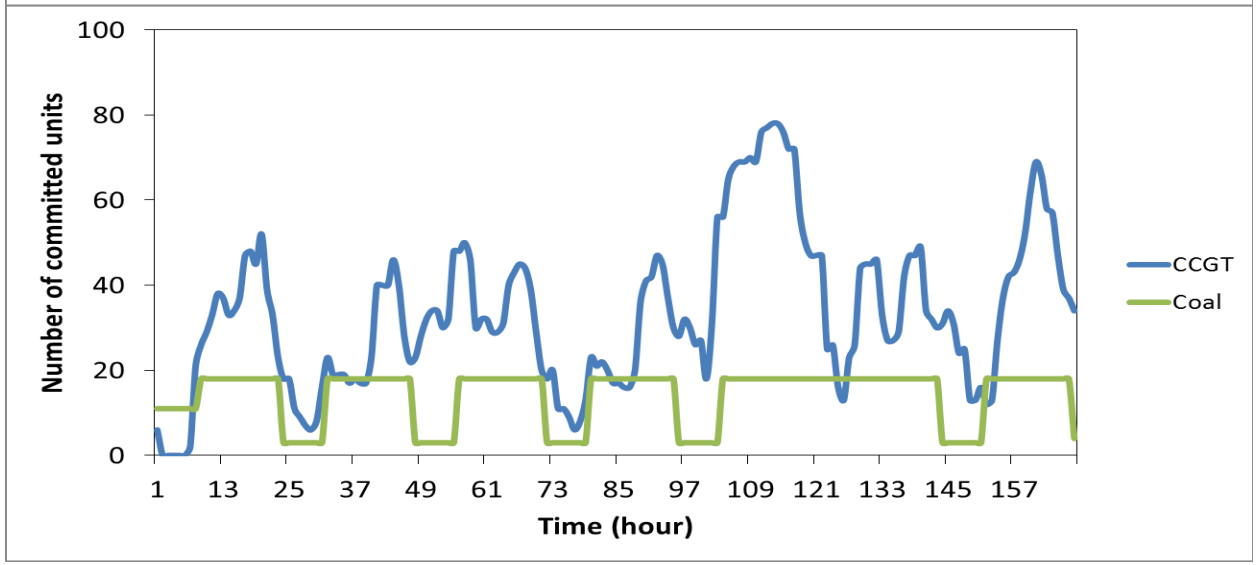
Impacts on power system \ 1

In the Reference case:

- Wind curtailment occurs during low demand-high wind periods.
- CCGTs ramp up/down to compensate for variability of net load.
- Frequent on/off cycles for CCGTs





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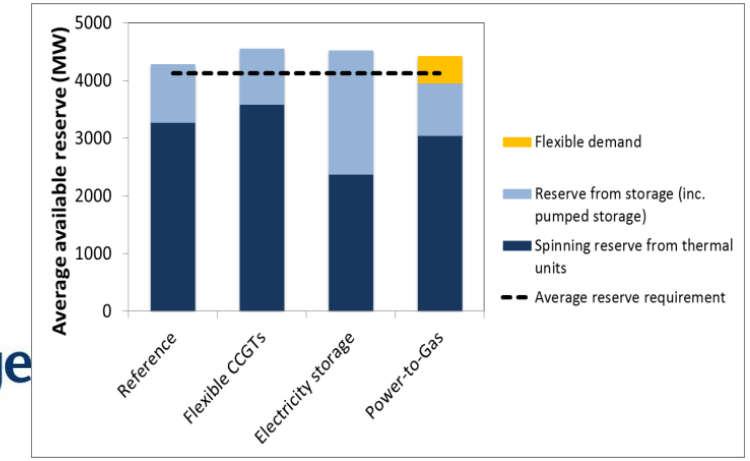
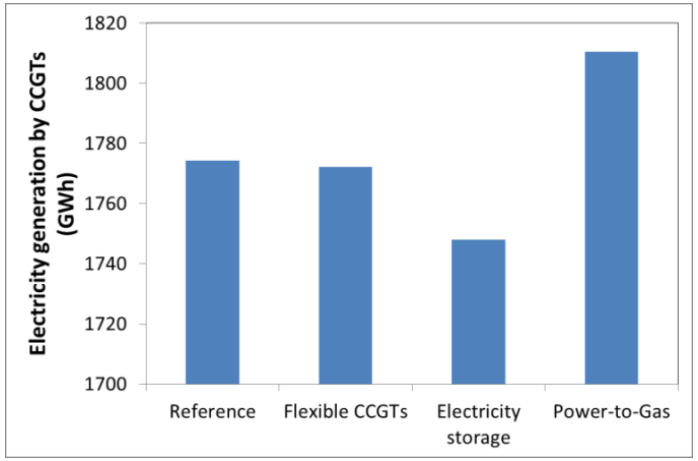
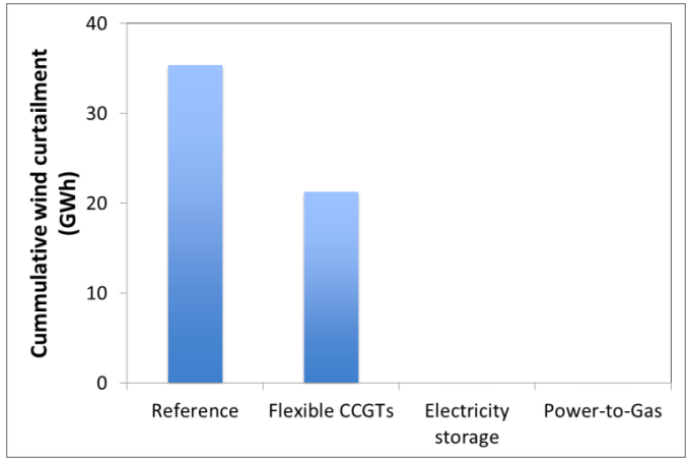
Impacts on power system \ 2

- Introduction of flexibility options reduced wind curtailment.
- More flexible CCGTs provided:
  - Slightly lower power output
  - Higher spinning reserve
- Power-to-Gas provided reserve through flexible demand for H_2 electrolysers







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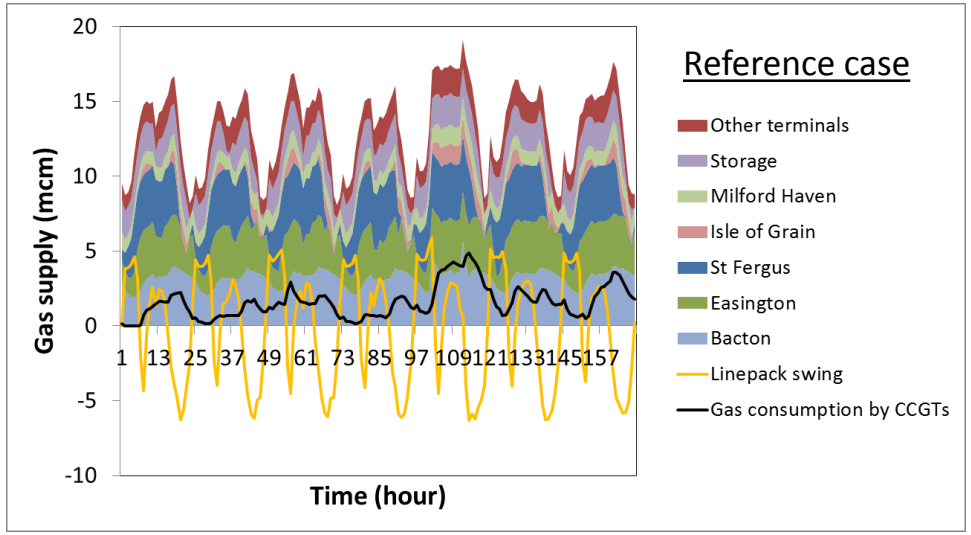
Impacts on the gas network \ 1

In all the case studies:

- Higher gas supply and compressor power during low wind-high demand periods
- The volume of gas within pipes (linepack) was used to meet abrupt increase in gas demand.
- Despite higher compressor power consumption, roughly 40 mcm drop in the linepack occurred during low wind – high demand period (peak hours – Day 5)



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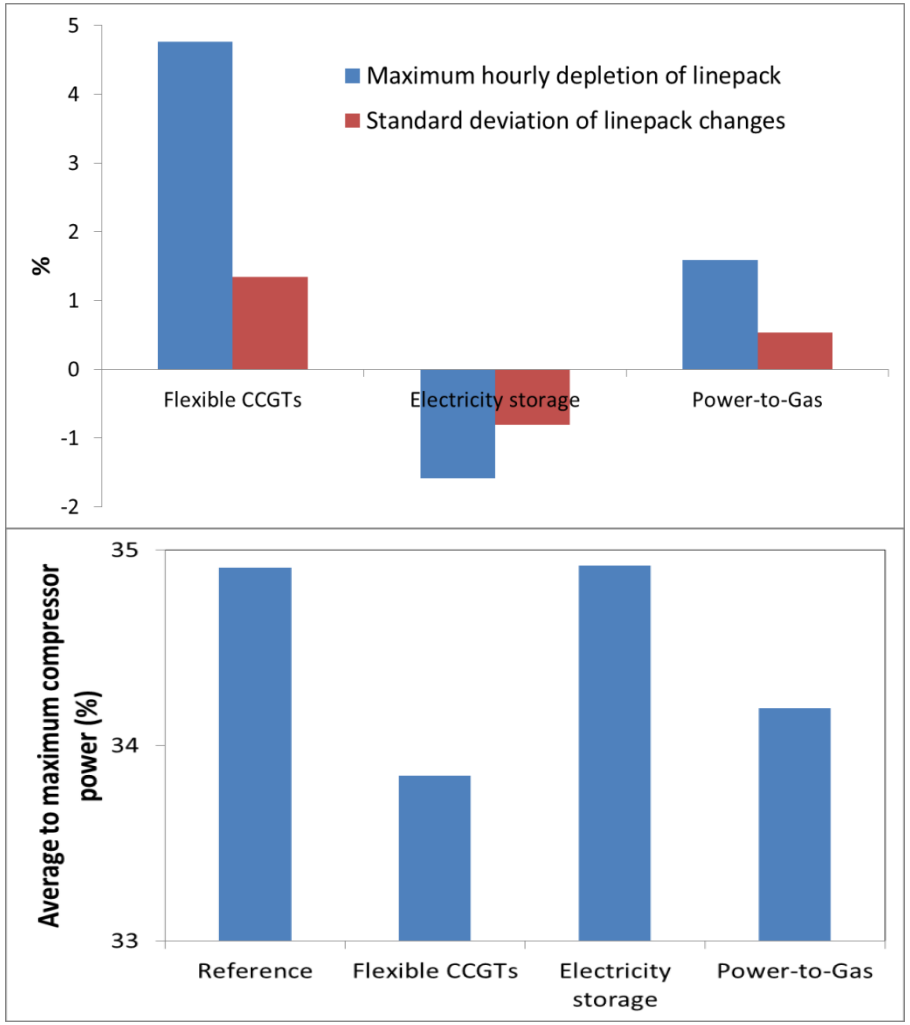
Impacts on the gas network \ 2

- Using more flexible CCGTs increased (in respect to the reference case):
  - Maximum hourly depletion of linepack
  - Linepack fluctuation
- Employing electricity storage resulted in less variable power output from gas plants and consequently less fluctuation in linepack.
- Average/Max compressor power ratio is the lowest for the case with flexible CCGTs:
  - i.e. higher maximum flow but lower level of utilisation (lower capacity factor)
  - Could lead to higher connection (to the gas network) fee



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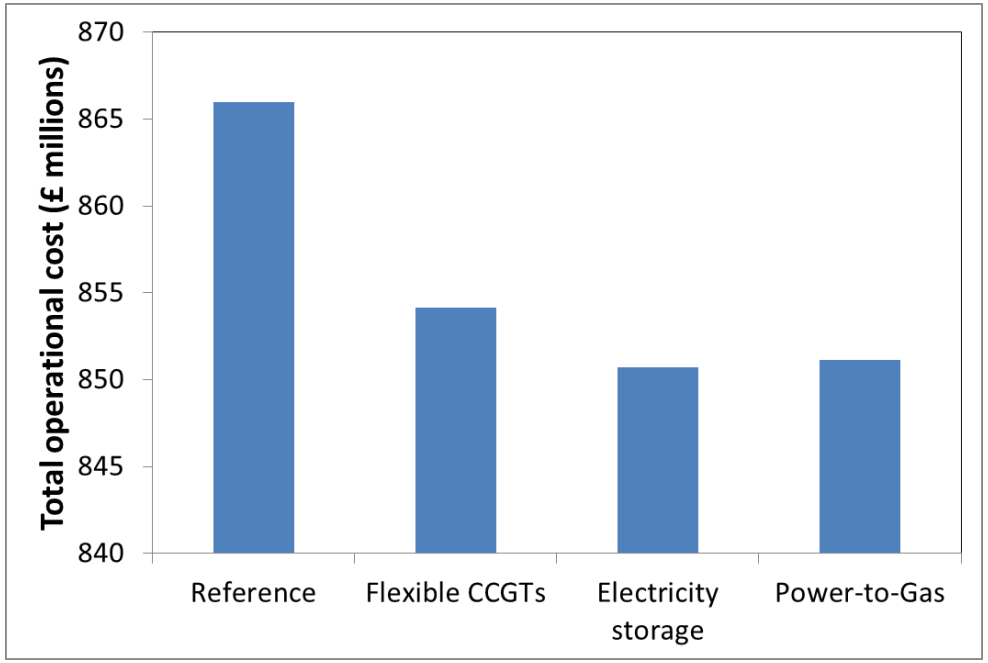
Operational costs

- Up to 1.7% reduction in the total operational cost of gas and electricity networks over a week
  - Flexible CCGTs: lower start up/shut down costs, provision of higher spinning reserve
  - Electricity storage: avoiding wind curtailment and providing reserve
  - Power-to-Gas: avoiding wind curtailment, providing reserve (flexible demand)
- Capital costs of the flexibility options need to be taken into account.



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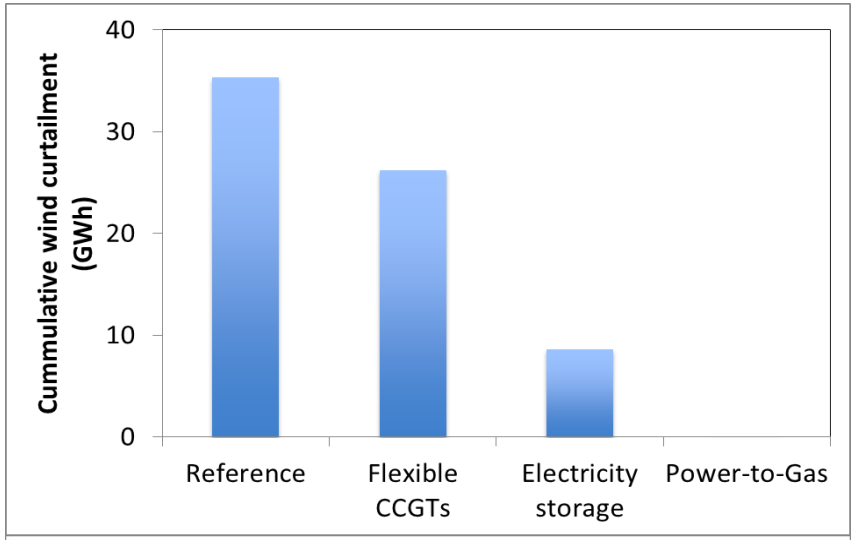
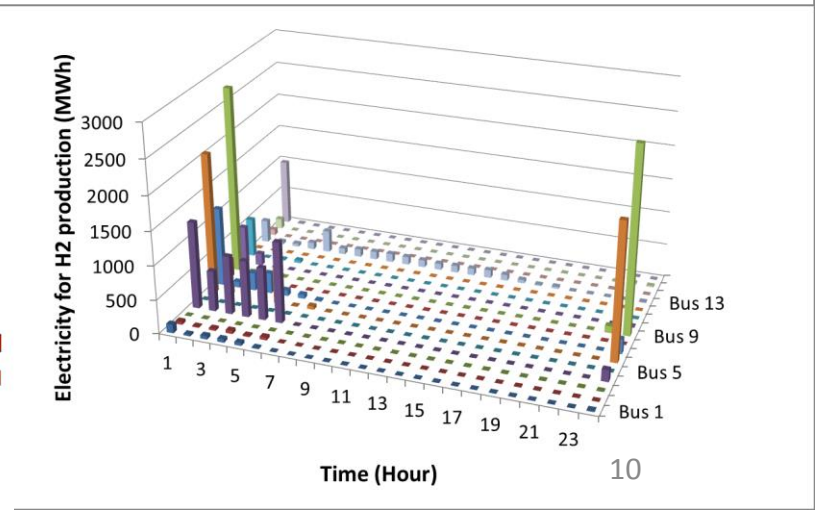
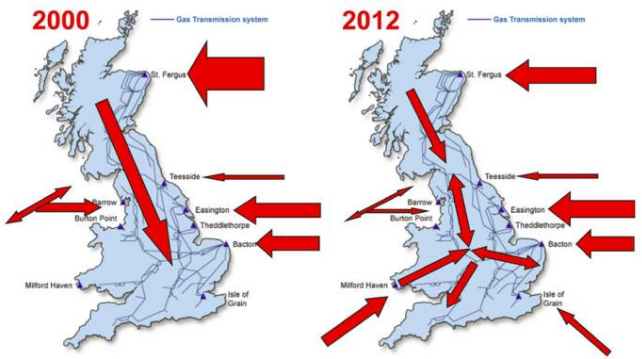
Electricity storage vs. Power-to-Gas

- Taking into account the power transmission constraints resulted in better performance of Power-to-Gas:
  - Employing electrolysers in congested area (mostly Scotland and North England) to absorb wind power
  - Bypassing power transmission congestion through employing the gas network storage/transport capacity







Source: National Grid, GTYS 2012

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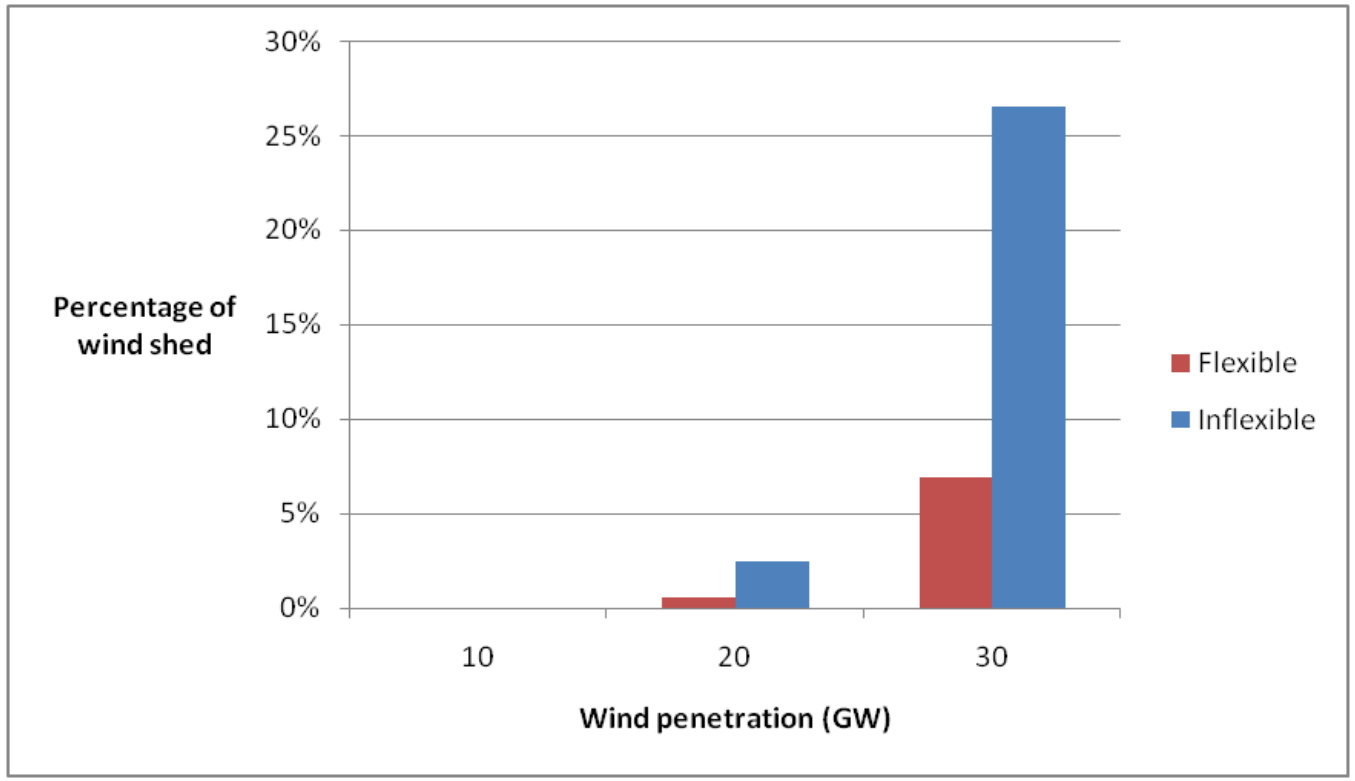
Integration of low carbon generation technologies:

Value of gas plant flexibility and impact on gas plant operation

Balancing and need for flexibility



Zero or negative energy prices for >15% of time

Value of energy frequently lower than value of flexibility

Unprecedented price volatility….

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

...while providing significant opportunities for flexible generation, demand side response, storage, interconnection, H2

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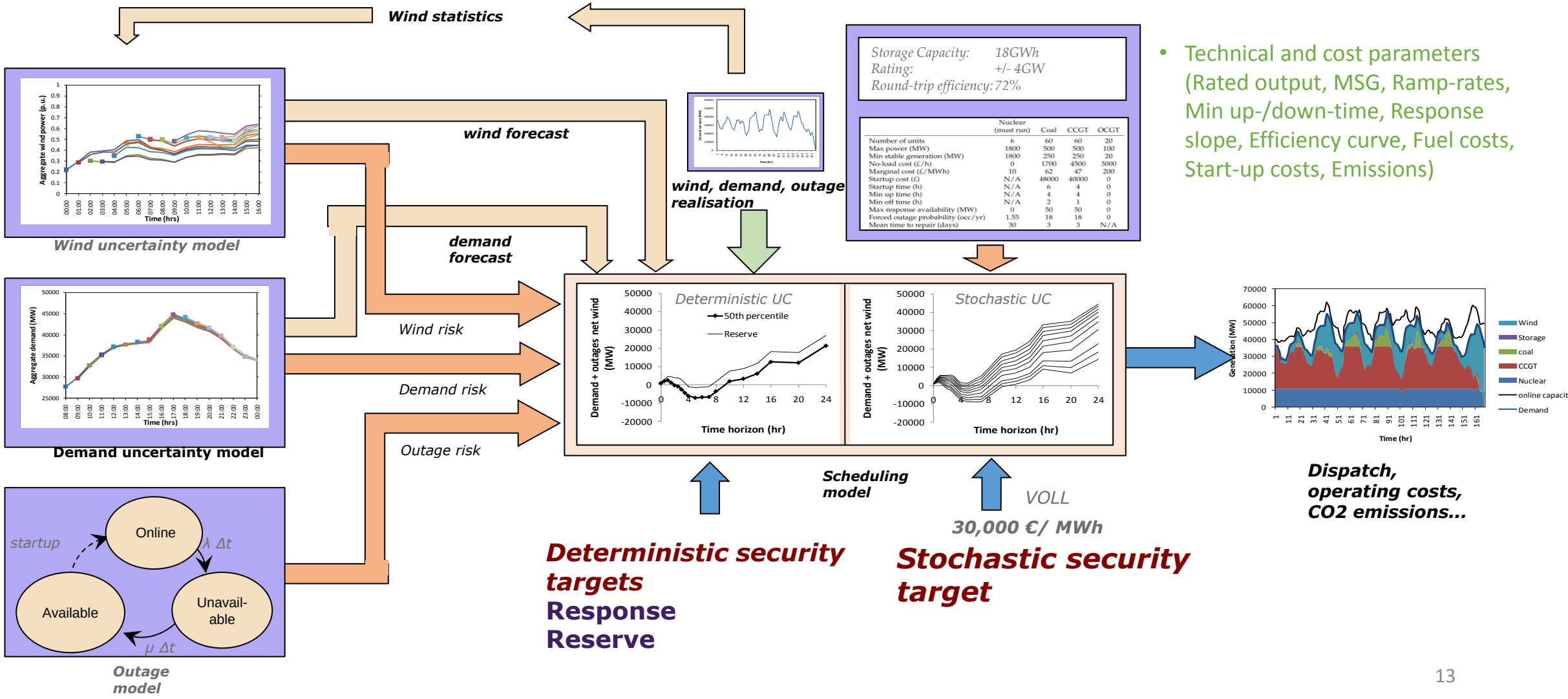
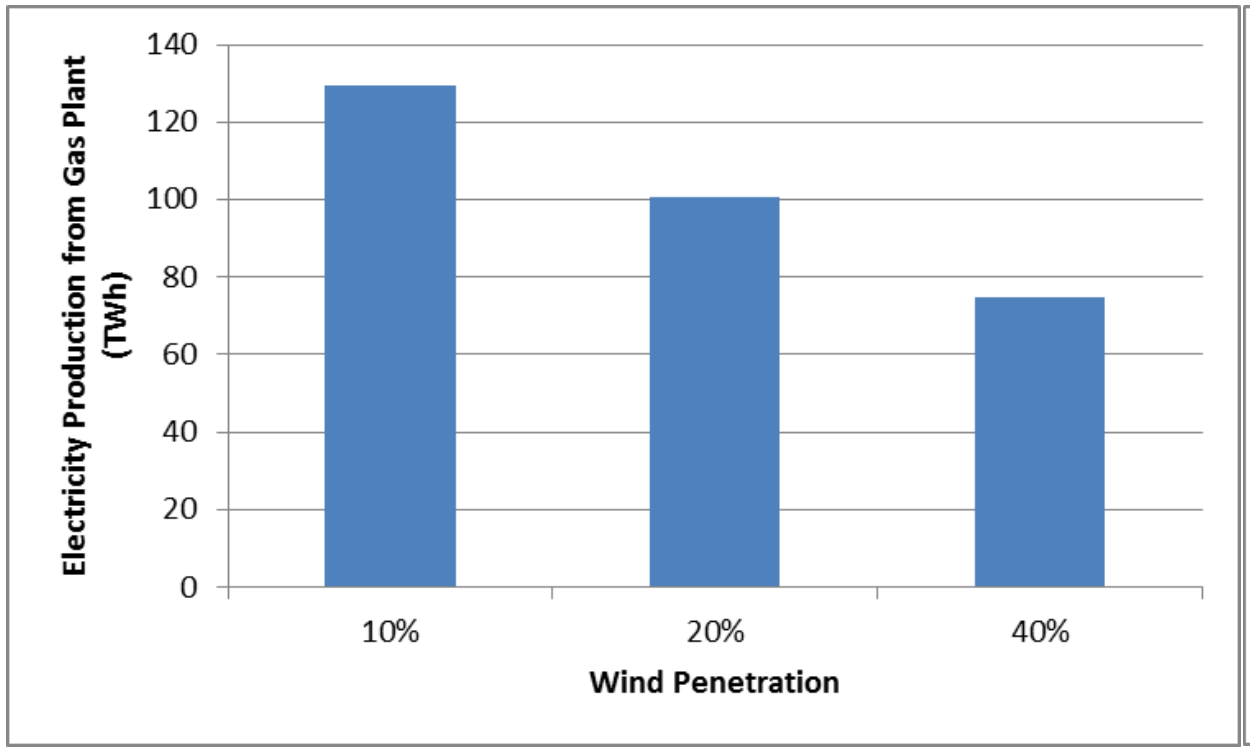
Enhanced time-domain stochastic scheduling:

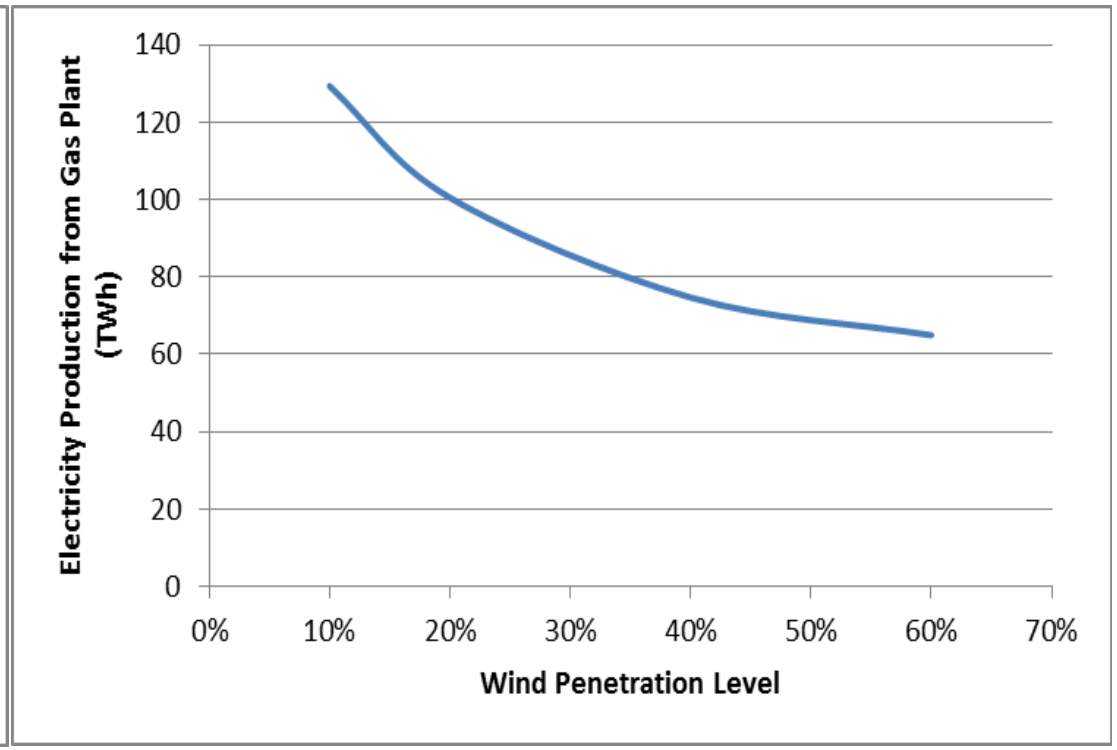
simulation of wind-integrated power systems



- Technical and cost parameters (Rated output, MSG, Ramp-rates, Min up-/down-time, Response slope, Efficiency curve, Fuel costs, Start-up costs, Emissions)

Energy production by gas plant at different wind penetration levels





Reduction in volumes of gas non-linear

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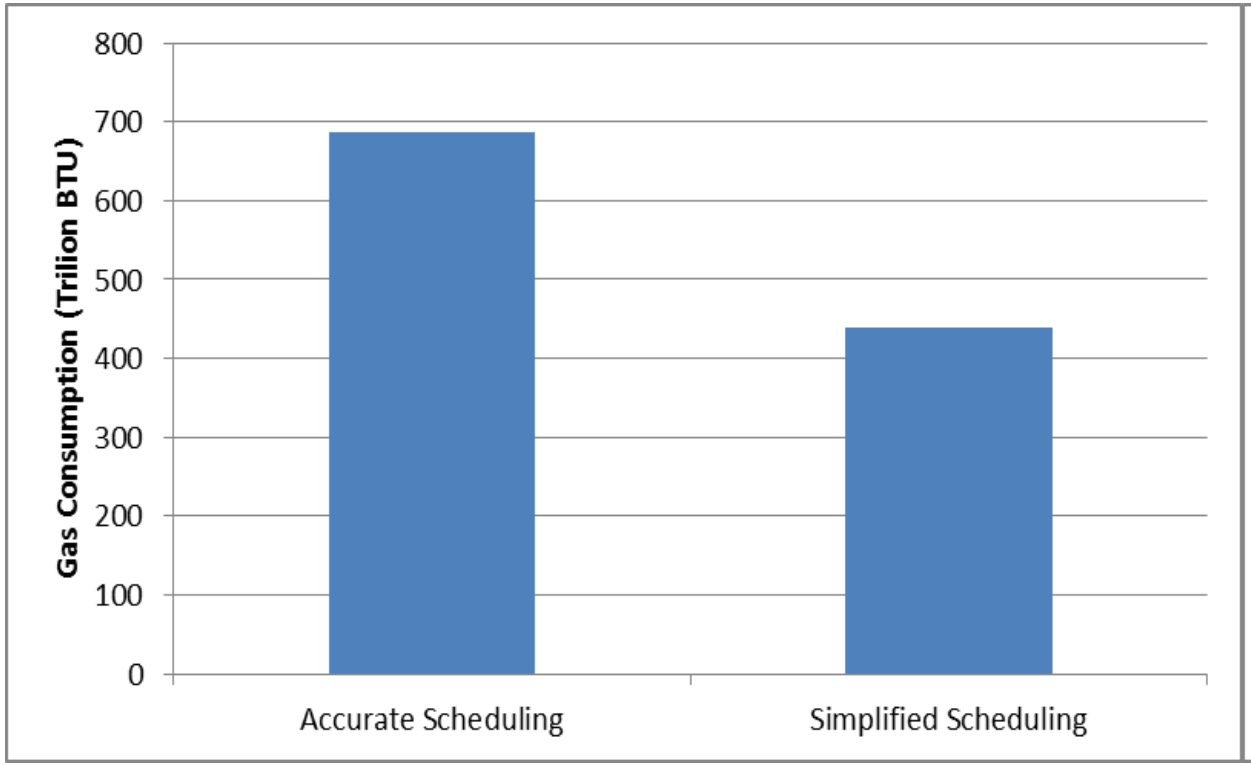
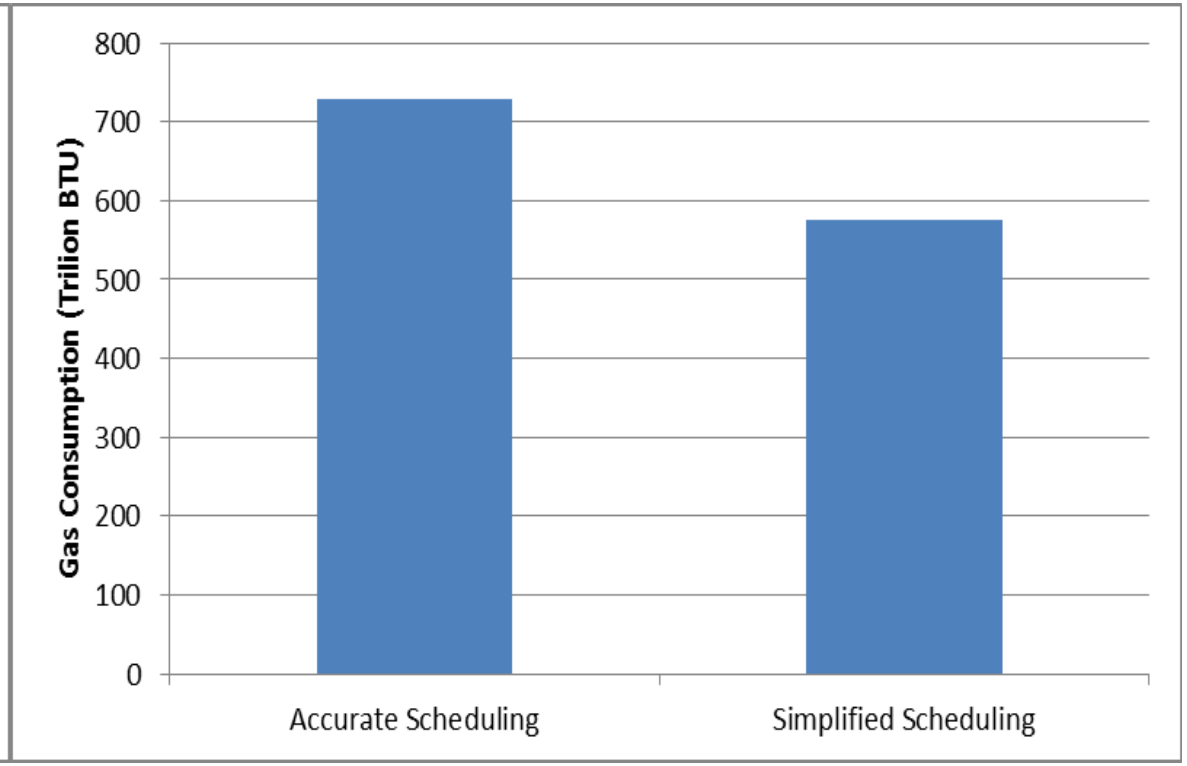
Predicting gas consumption – alternative models /1

Base Case



Plant maintenance



Granular time resolution needed

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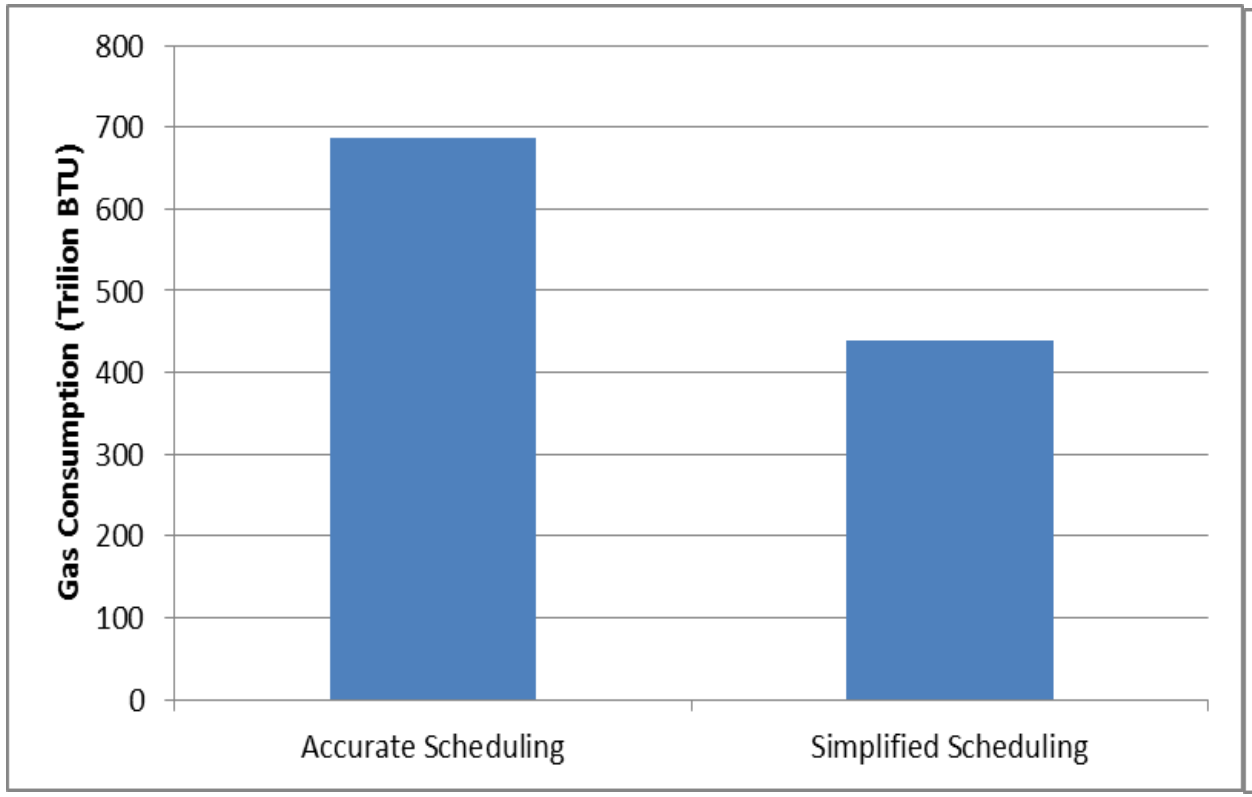
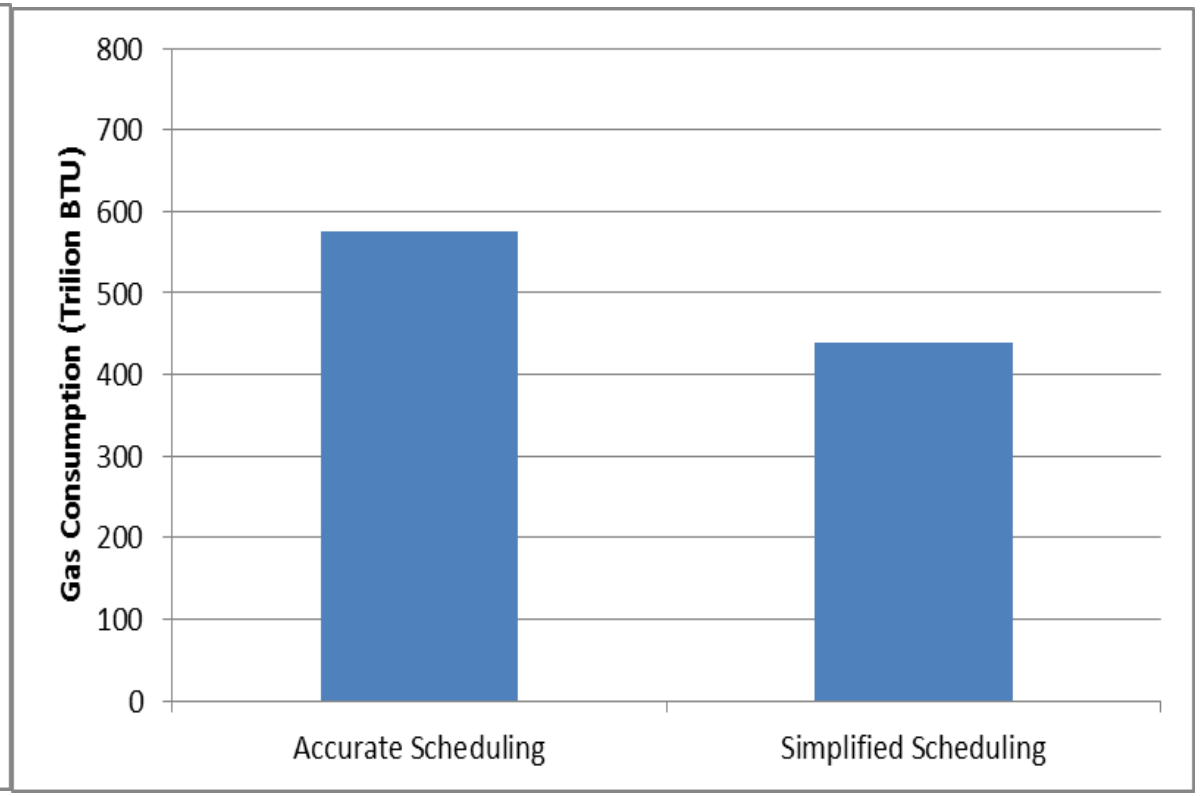
Predicting gas consumption – alternative models /2

Base Case



Additional 5GW Storage



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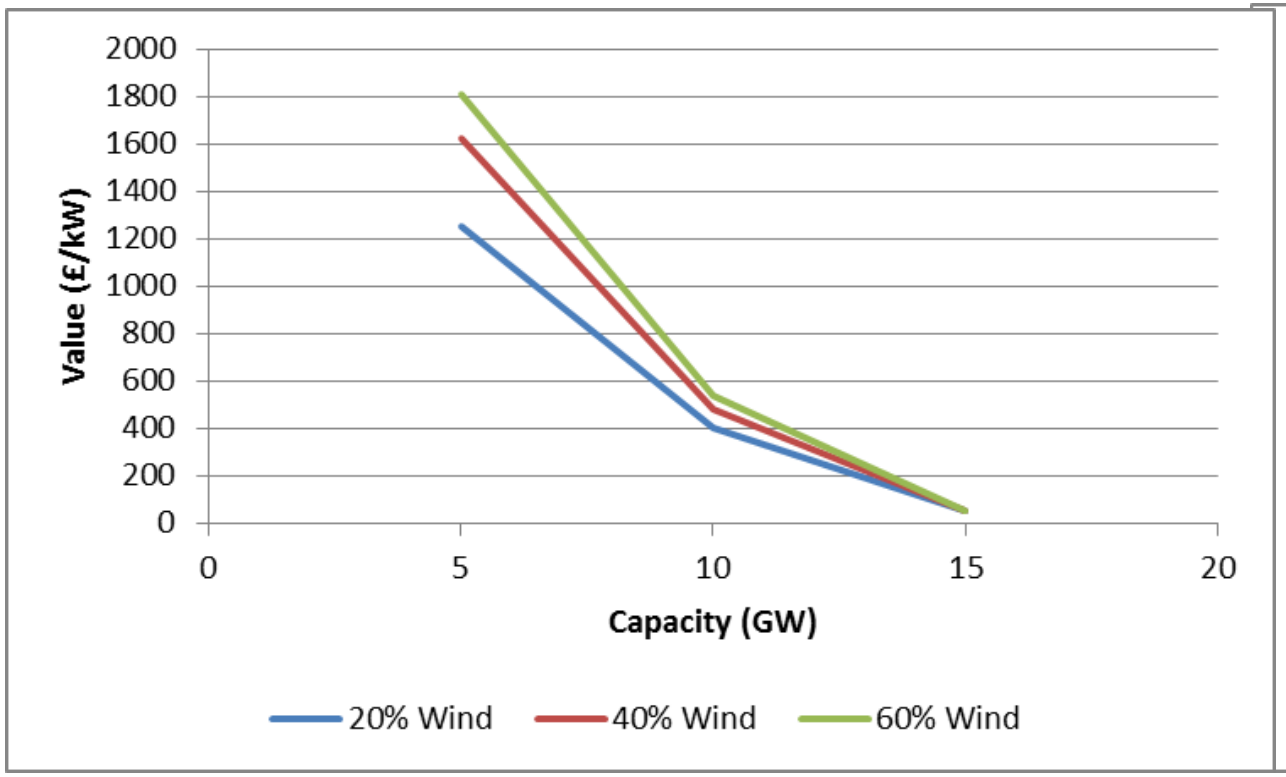
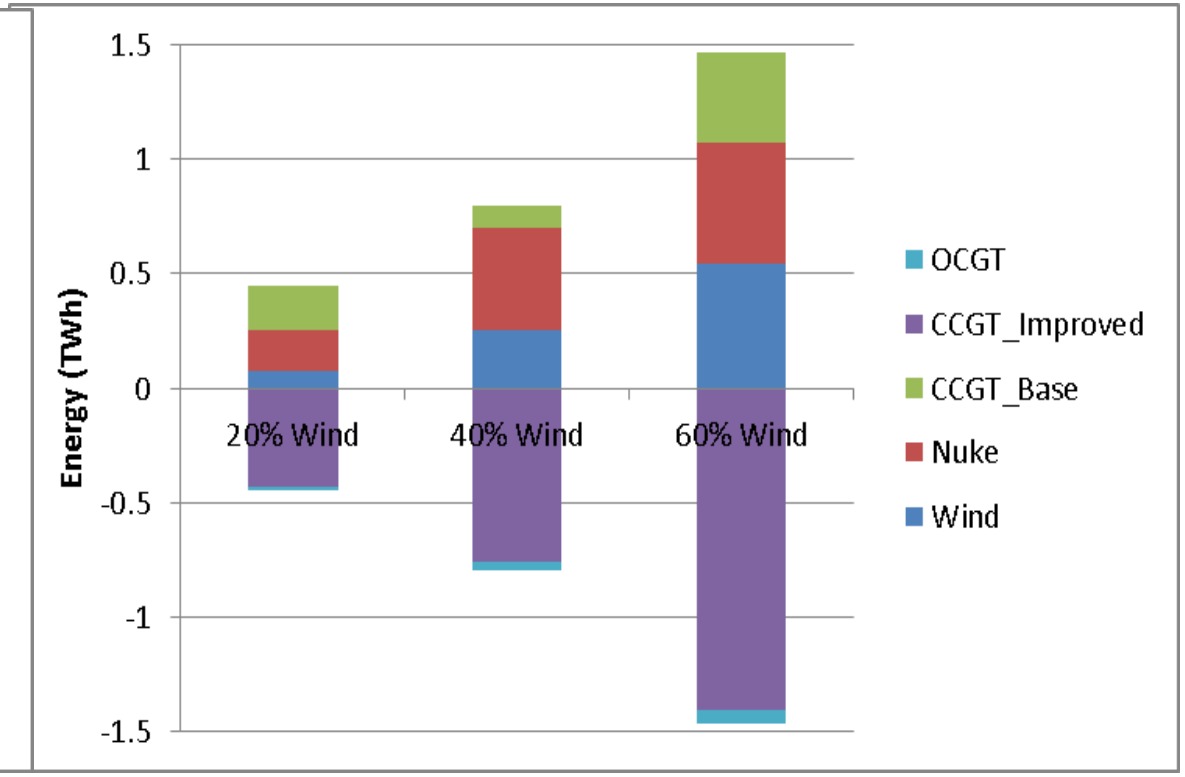
Investment in flexibility?





System value of enhanced flexibility of CCGTs will be significant

How about the value to investors?

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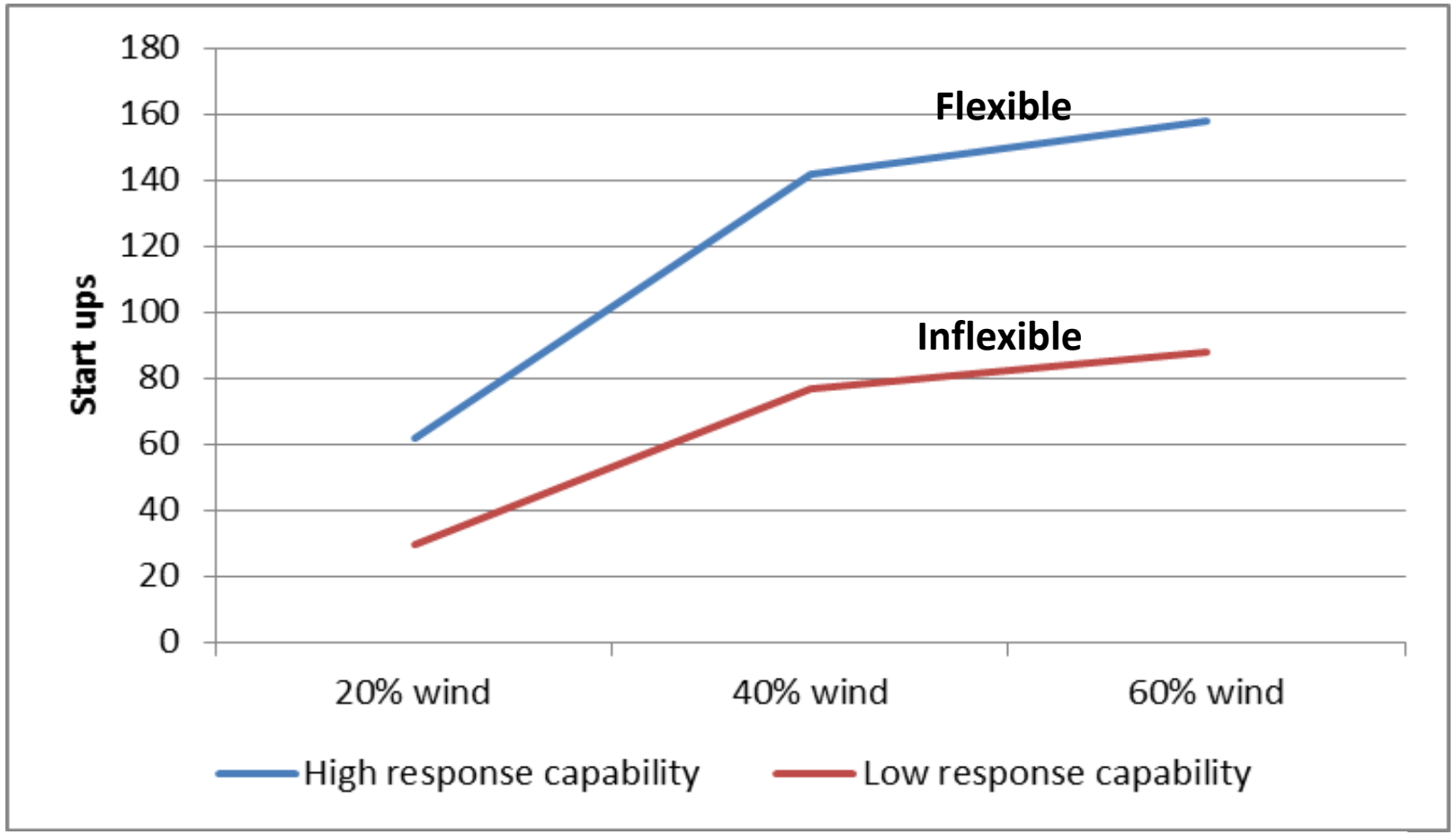
Enhancing flexibility will lead to increase in number of start ups



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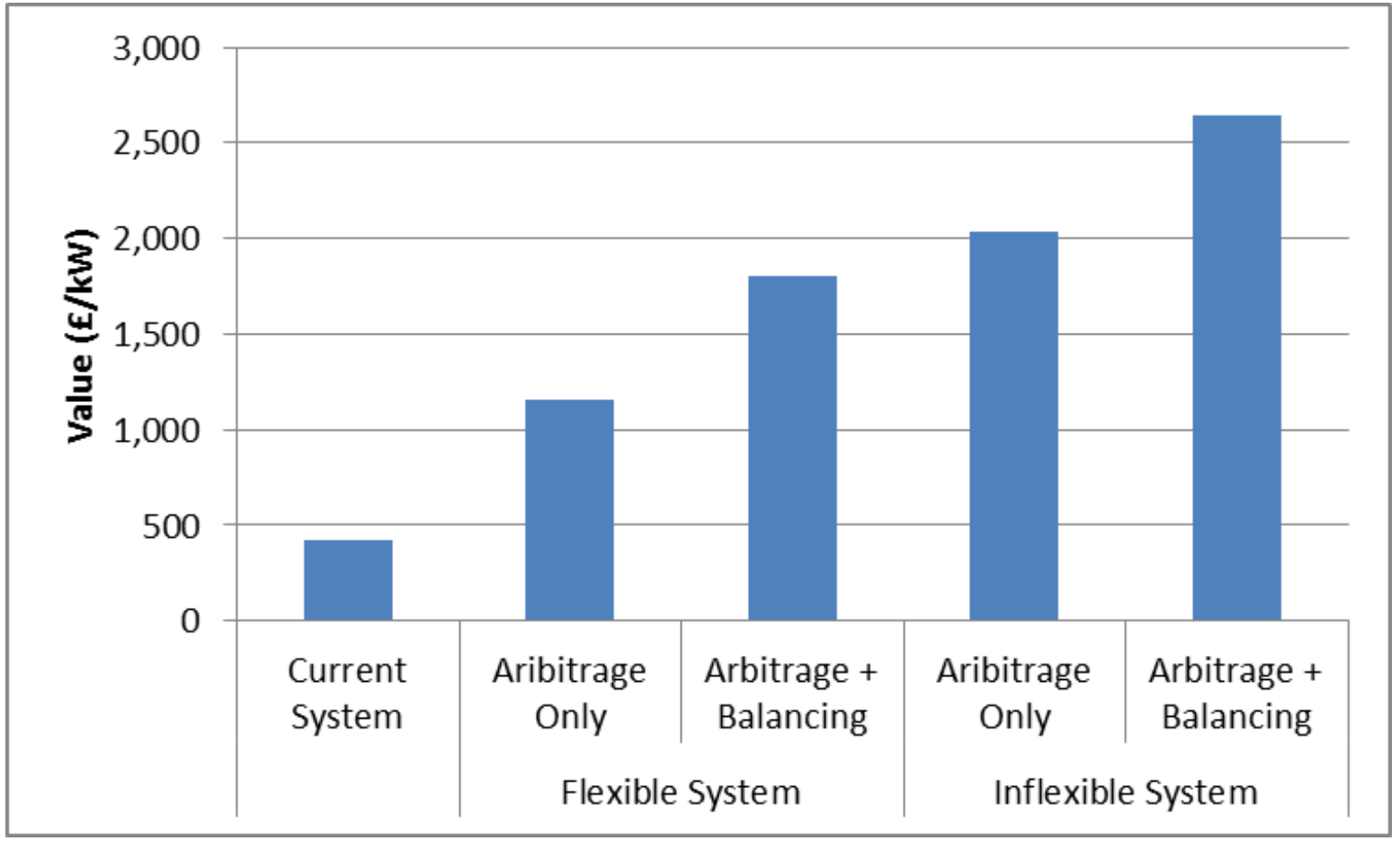
Participation of storage in balancing market



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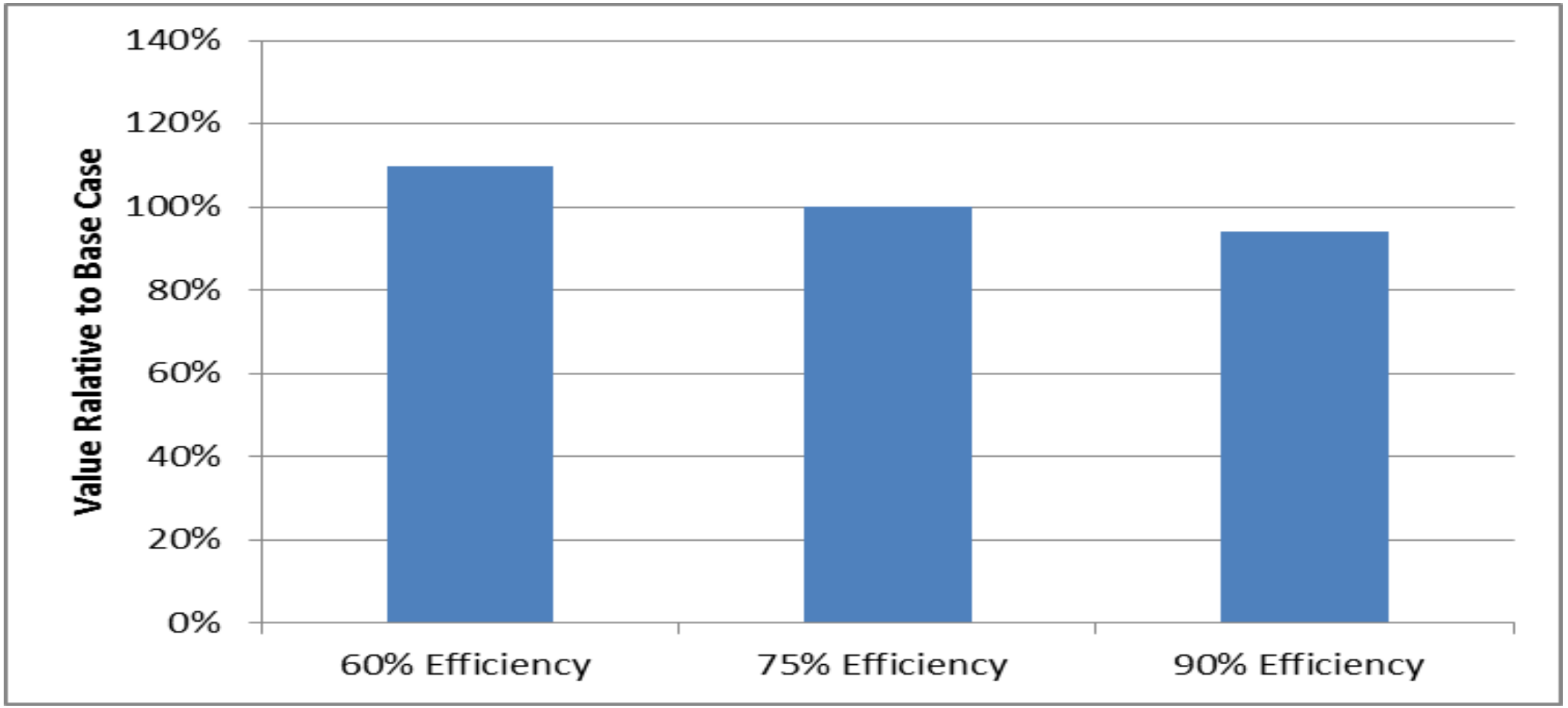
How important is efficiency?



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Summary

- Opportunities/challenges of employing different flexibility options were investigated with respect to electricity and gas networks.
- Large capacity of gas-fired generators, compensating for wind variability, will increase fluctuations in the gas network linepack.
- Within-day linepack management will be required to maintain within-day gas storage capability of the NTS.
- A number of options for dealing with balancing challenge identified, including Power to Gas - decarbonising of the gas network
- Potential conflicts between national and investor objectives