DSR follow on – final presentation

A presentation to DECC

Andrew Nind, Oliver Pearce, Kostas Theodoropoulos

4 April 2011

Agenda

1. Objectives
2. Scenario assumptions
3. Scenario results
4. Next steps

Objectives

- To provide DECC with an understanding of the role played by pumped storage and interconnection in futures with and without DSR
- To provide output metrics as requested in the ToR:
  - Displaced capacity
  - CO_2 emissions
  - Curtailment costs
  - Load factors and GWh provided by plant and flexibility type
  - Wholesale price cost
  - Trends for use of interconnection and storage
  - Implications for low carbon generation
  - Plant IRRs

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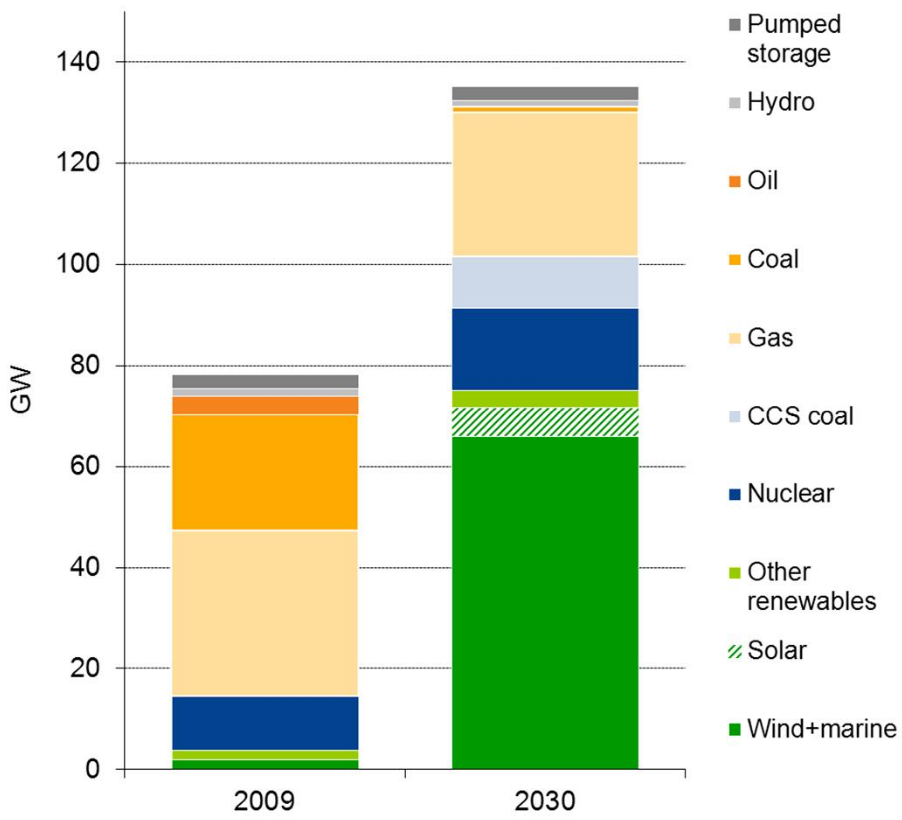
Common scenario assumptions (included in Baseline and scenario variants)

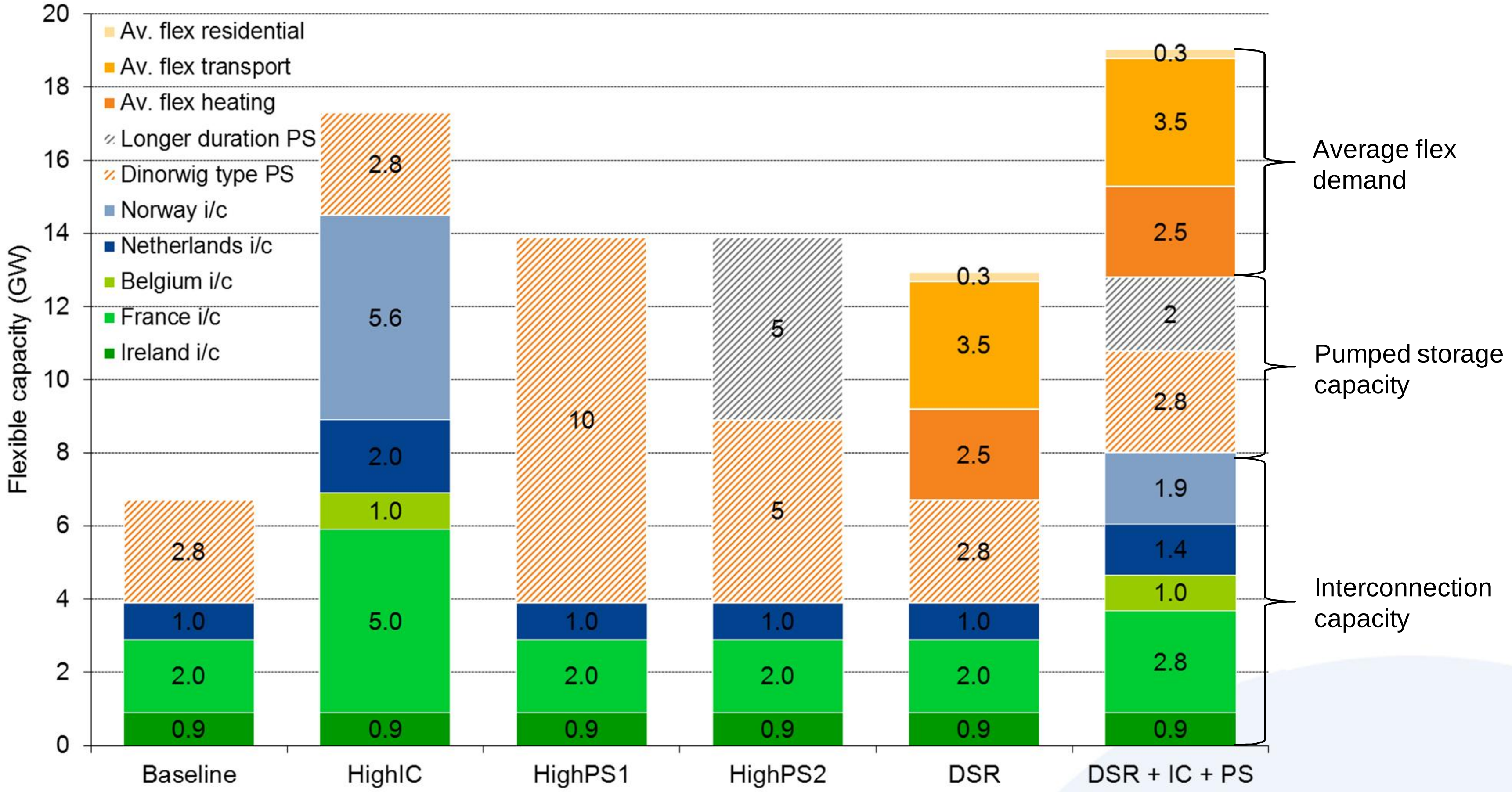


1. "Other renewables" primarily consists of geothermal plant

Details

- Common assumptions are consistent with the previous study
- Baseline generation mix (apart from some OCGT and CCGT capacity) taken from DECC 2050 Pathways – Pathway Alpha
  - Split between OCGT and CCGT varied between scenarios
- Baseline demand is 505TWh from DECC Pathway alpha
- Apart from interconnection and storage, only extra gas capacity (CCGT and OCGT) is altered between scenarios
- Other common assumptions are in the Appendix

Five variant scenarios investigate the impact of interconnection and storage on the market with and without DSR in 2030



- Longer duration storage refers to storage with a capacity to storage ratio of 1GW = 50GWh
- Dinorwig type storage refers to storage with a capacity to storage ratio of 1GW = 5GWh
- Flexible heating demand is 25% of total; flexible EV demand is 50% of total; there is also a small amount of flexible residential demand (see Appendix for details)

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Key messages

- Deploying flexible capacity increases revenue to generators – especially baseload plant – by raising average wholesale prices and hence the average capture price. However:
  - Pumped storage providers do not receive this benefit as the deployment of flexible plant effectively reduces the difference between pumping and generating prices
  - This could be a missed benefit for consumers as it is unclear how these increased revenues for baseload generators will be passed through to the consumer
- Although adding flexibility increases wholesale prices (as periods of negative or zero prices are reduced), this is compensated by a reduction in the subsidy required for low carbon generation (both intermittent renewables and nuclear / CCS plant) due to the higher average capture price and a reduction in shedding of low cost carbon generation. The subsidy is calculated as additional revenue required for plant to make a 10% IRR
- Interconnection works at different times to storage as it is based on price differentials between markets (not just at times of peak demand, but at any time when the plant at the margin in the two markets set prices at a sufficient difference to drive interconnector flows). Because of this, the benefits of interconnection are not easily captured by a simple time-weighted-average or demand-weighted-average price. Other metrics (such as displaced gas capacity or emissions) illustrate the benefits gained by deploying interconnection
- Interconnection, especially to Norway, displaces CCGT plant. This relationship holds even when DSR is deployed as interconnection has less impact on demand peaks. Therefore interconnection can be seen as complementary to both DSR and storage.

Key messages

- Interconnector benefits may accrue unequally to parties on either side of the interconnector (i.e. any benefit of Norwegian interconnection on the GB market may not be seen by Norwegian consumers)

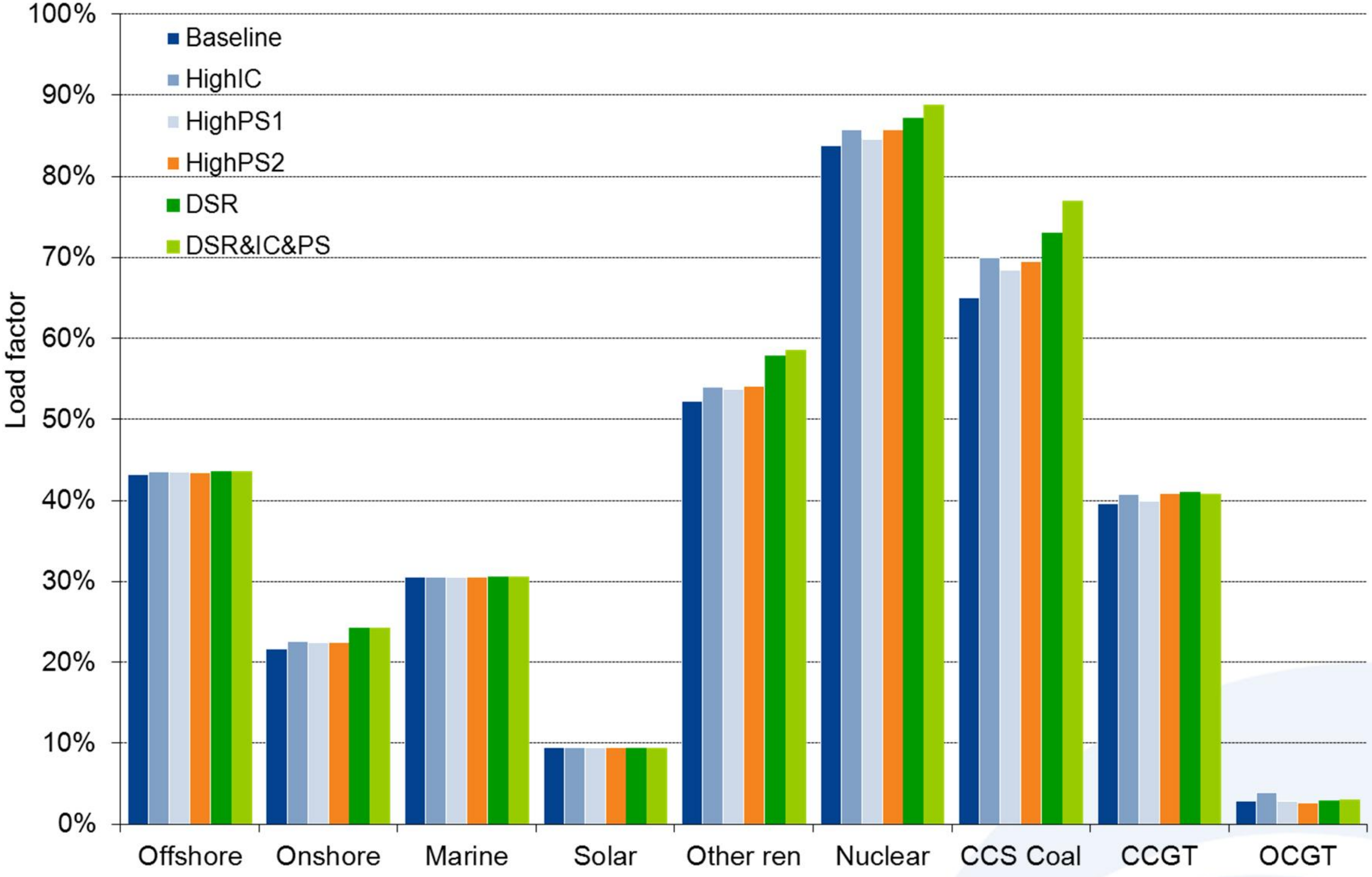
- The two different types of pumped storage we investigated were found to have different impacts on the market:
  - Short term pumped storage displaces OCGT plant – this is due to the relatively short period over which the plant can generate
  - Longer duration storage displaces both OCGT and CCGT plant as it generates for longer periods of time due to a larger storage capacity

- DSR has a significant impact on storage – it drives down the load factors and the arbitrage value of storage and as a result the IRRs decrease
  - However, this conclusion depends on how DSR is used – at the moment DSR has been modelled as optimal and;
  - We have not investigated other ways for pumped storage to make revenue, such as through the reserve market or grid scale storage connected to the transmission network
  - We have also not assessed the benefits associated with storage connected to the distribution network (e.g. to help DSO's manage price signals from TSO's or suppliers to avoid additional network investment costs)

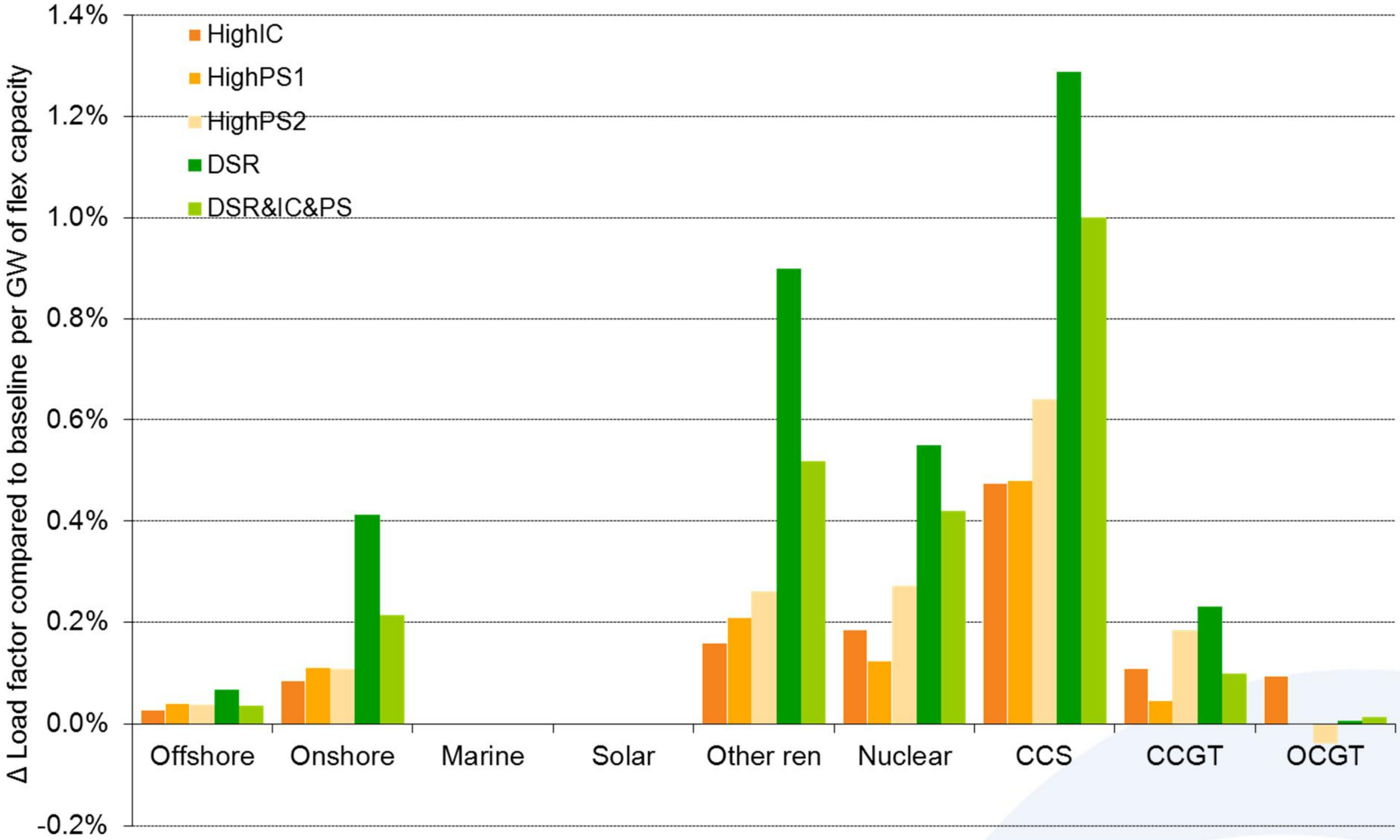
Key assumptions - DSR

- DSR has been modelled as performing in an optimal manner
- Therefore DSR acts to minimise the overall cost to the system of meeting demand
- It does not take into account any behavioral or other constraints that may limit the effectiveness of DSR dispatch such as the ability to move EV demand
- If these constraints were identified and implemented in the modelling of DSR, the benefits derived from DSR could be different

Plant load factors increase with additional flexibility

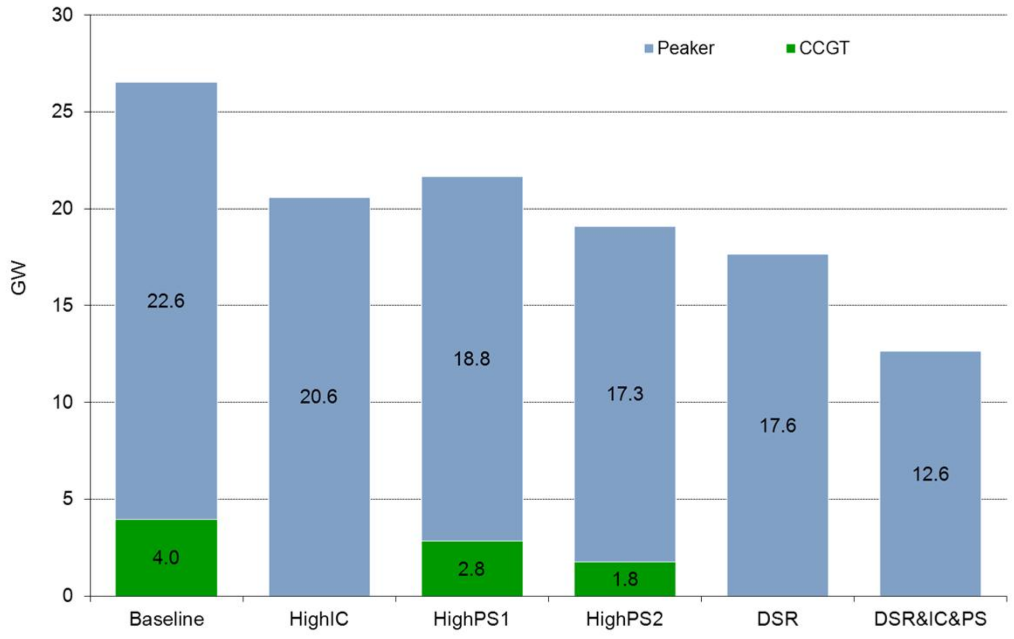


Plant load factors increase with additional flexibility



	Offshore	Onshore	Marine	Solar	Other Ren	Nuclear	CCS	CCGT	Peaker
Baseline load factor	43.2%	21.6%	32.2%	9.4%	52.3%	83.8%	65.0%	39.6%	2.9%

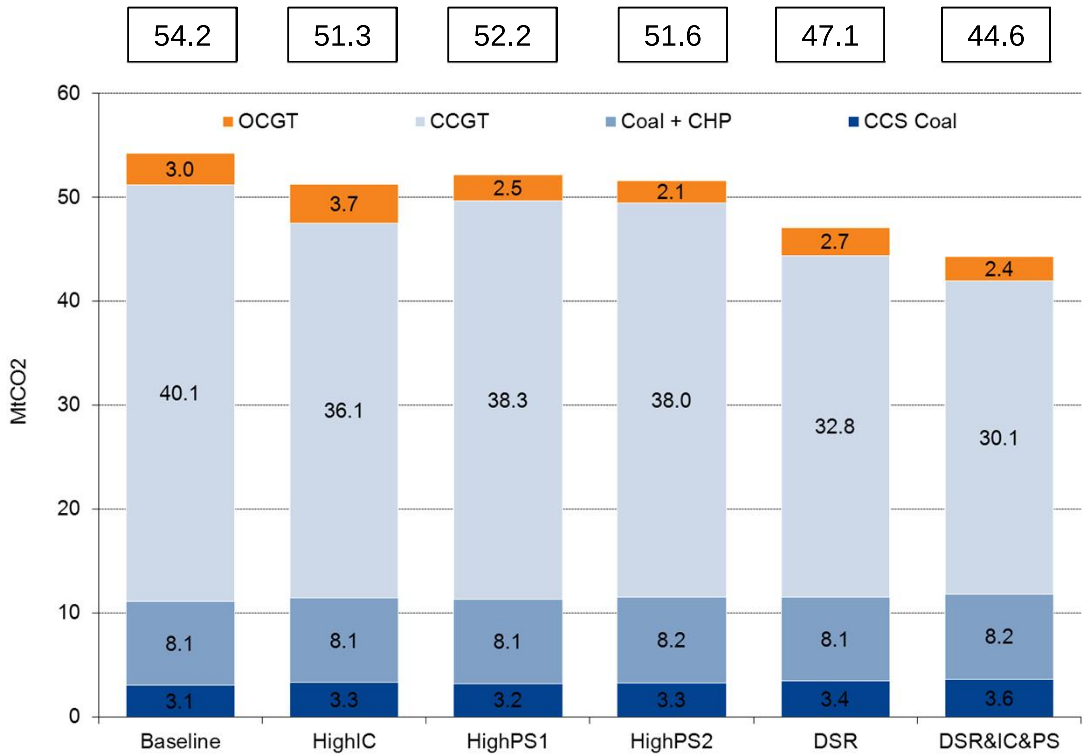
In general adding flexibility displaces CCGT and OCGT capacity



Δ GW to baseline	CCGT	OCGT
Baseline	-	-
High IC	-4.0	-2.0
HighPS1	-1.1	-3.8
HighPS2	-2.2	-5.3
DSR	-4.0	-4.9
DSR & IC & PS	-4.0	-9.9

- High interconnection is less effective at eliminating the need for peakers than PS (this has an effect on high price periods
- Norwegian interconnection in particular reduces the need CCGTs
- Longer duration pumped storage displaces both types of gas capacity (CCGT and OCGT)
- DSR reduces the need for both types of capacity

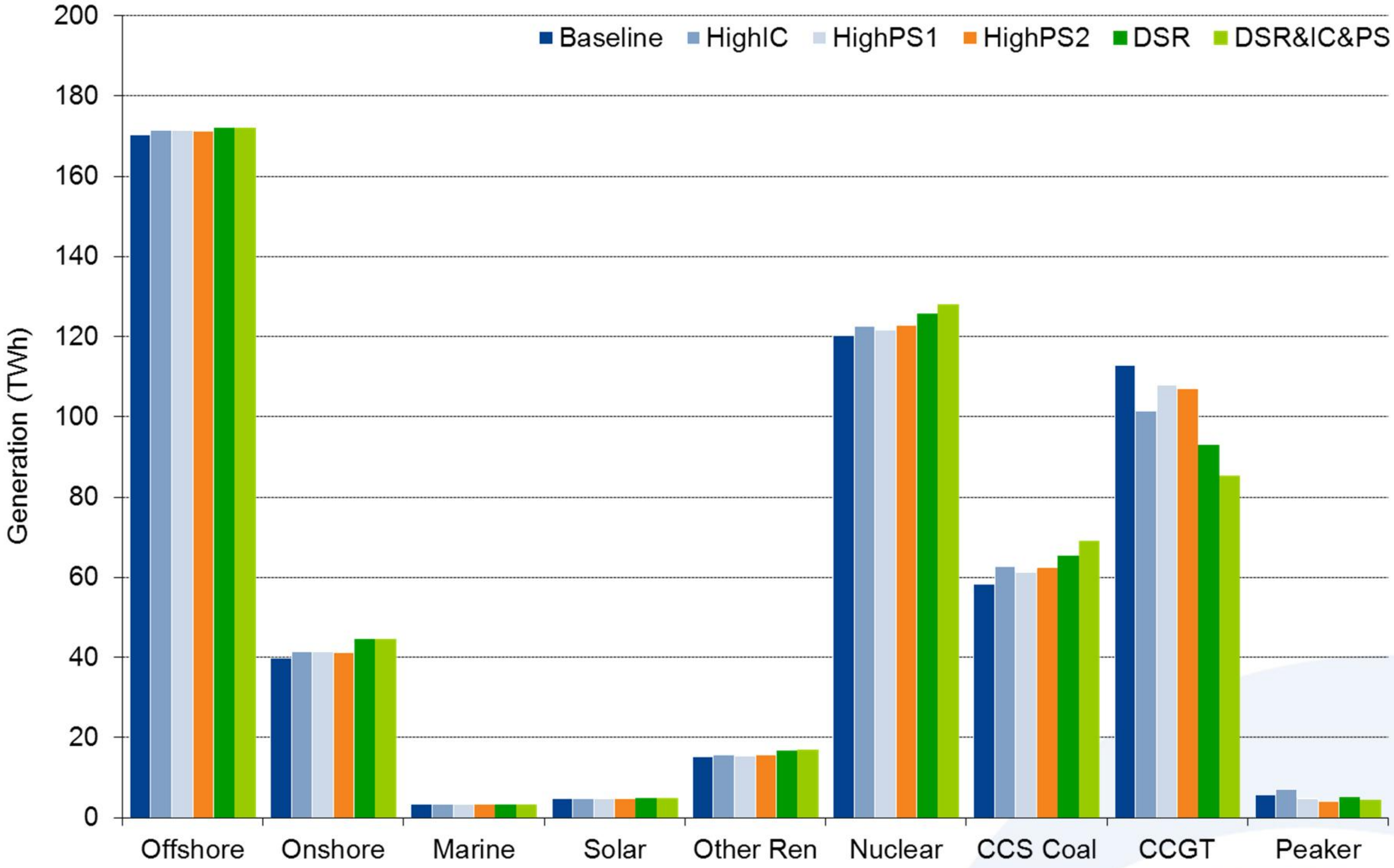
Emissions reduce due to displaced gas capacity…



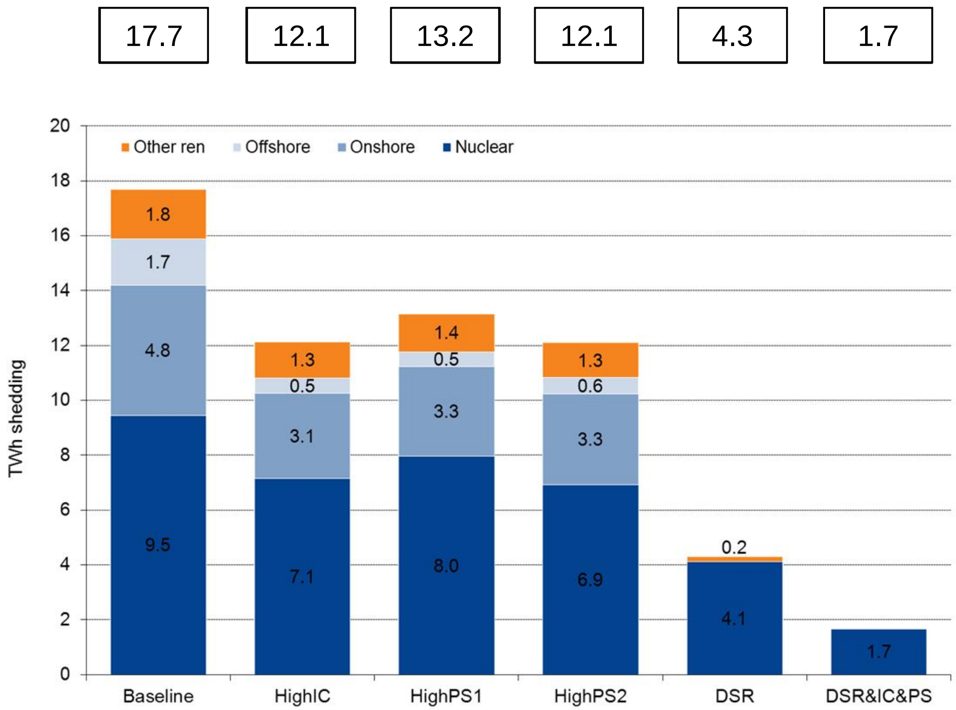
Δ $MtCO_2$ to baseline	OCGT	CCGT	Coal + CHP	CCS Coal
Baseline	-	-	-	-
High IC	0.7	-4.0	0.1	0.2
HighPS1	-0.5	-1.8	0.1	0.2
HighPS2	-0.9	-2.1	0.2	0.2
DSR	-0.3	-7.3	0.1	0.4
DSR & IC & PS	-0.6	-10.0	0.3	0.6

- DSR, interconnection and storage reduce emissions but:
- Emissions reduce most in the High IC case because CCGT plant with high load factors are taken off the system
- PS reduces OCGT on the system but emissions saving is less because the average load factor is lower
- Emissions fall significantly when DSR is included

..and also reduce because low carbon generation generates more while CCGT and OCGT plant generate less



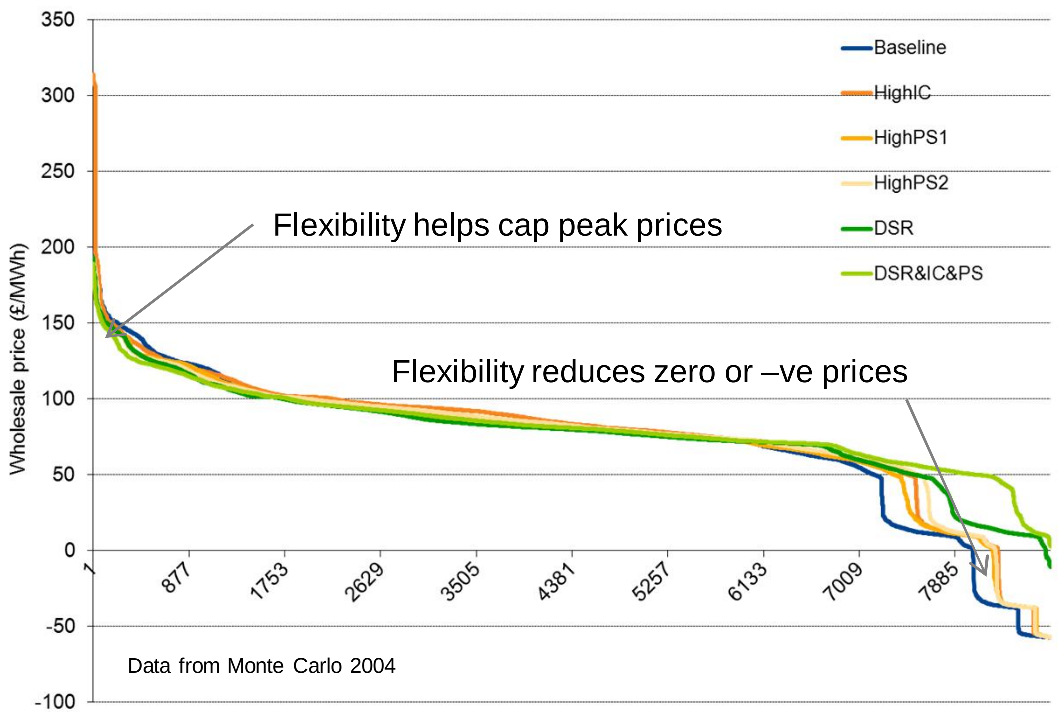
Increasing flexibility decreases shedding



Δ TWh to baseline	Nuclear	Onshore wind	Offshore wind	Other ren
Baseline	-	-	-	-
High IC	-2.3	-1.6	-1.1	-0.5
HighPS1	-1.5	-1.5	-1.1	-0.4
HighPS2	-2.5	-1.4	-1.1	-0.5
DSR	-5.3	-4.8	-1.7	-1.6
DSR&IC&PS	-7.8	-4.8	-1.7	-1.8

- All measures reduce shedding with high interconnection and the longer duration storage providing the most benefit
- This is because both PS and I/C enable low carbon generation to run more (e.g. export excess wind in the case of interconnection or pump when wind generation is high)

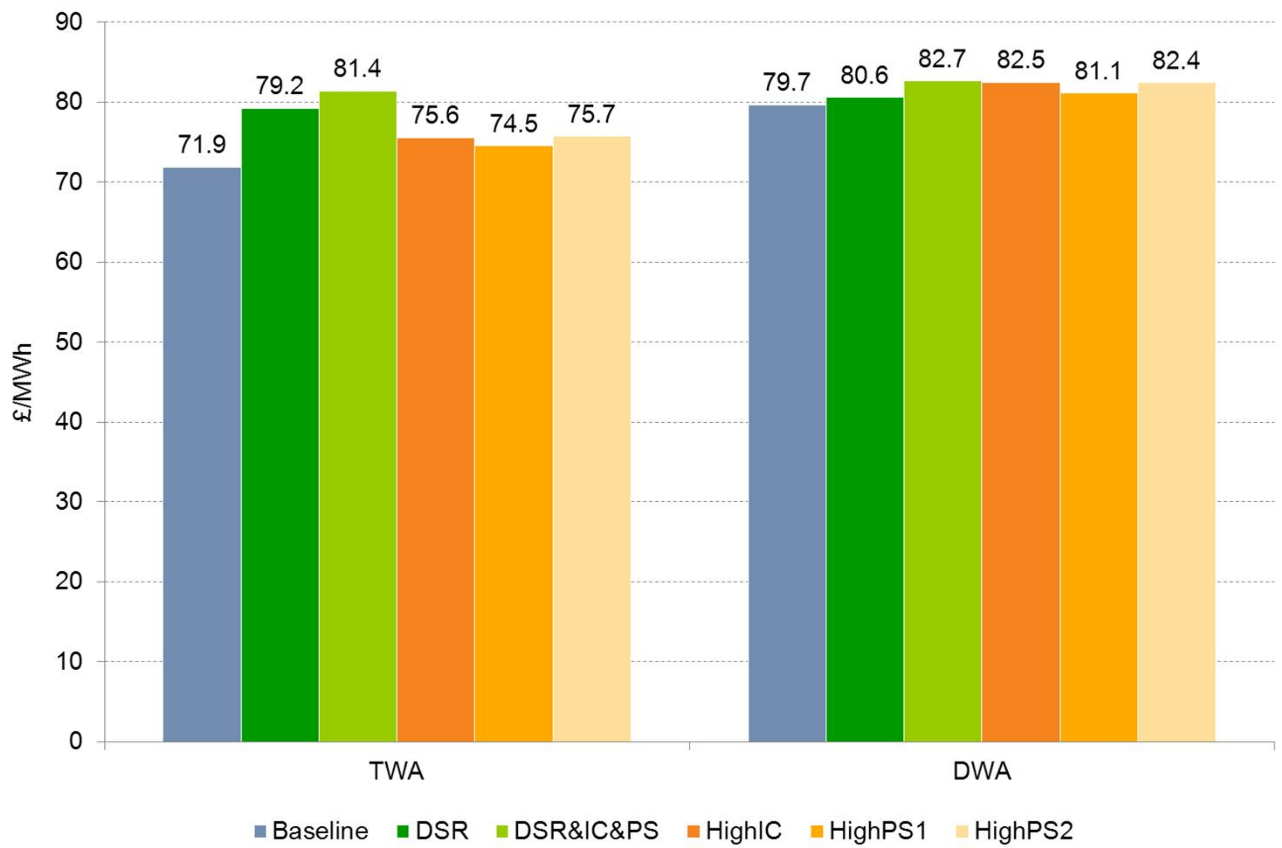
Increasing flexibility raises time weighted average wholesale prices



Av. Wholesale price	£/MWh
Baseline	71.9
High IC	75.6
HighPS1	74.5
HighPS2	75.7
DSR	79.2
DSR+IC+PS	81.4

- Average wholesale price increases because frequency of zero or negative prices reduces (due to interconnectors exporting, storage pumping and DSR shifting demand)
- Storage pumps when prices are low
- Utilisation increases because a certain level is required at the start of each week

Demand weighted average prices are raised less than time weighted average prices



- Weighting the prices by demand brings them closer together as storage, interconnection and DSR raise demand in periods of low prices when demand is low and allow the system to better cope with periods of high prices when demand is high (by providing flexible capacity or by reducing demand)

Some forms of flexibility have more of an impact on “total costs” than others

Δ £bn/a to baseline	£bn/a
Baseline	-
HighPS2	-0.03
HighPS1	-0.10
High IC	-0.36
DSR	-2.36
DSR & IC & PS	-2.44

- As we have not balanced the generation mix, we assume IRR’s are capped at 10% - higher revenues are netted off the total costs – but ideally one would rebalance the capacity mix
- Due to cost uncertainty, subsidy for DSR, PS and I/C has not been taken into account
- WP = Wholesale price * demand
- Subsidy is calculated as the additional revenue required to achieve a 10% IRR

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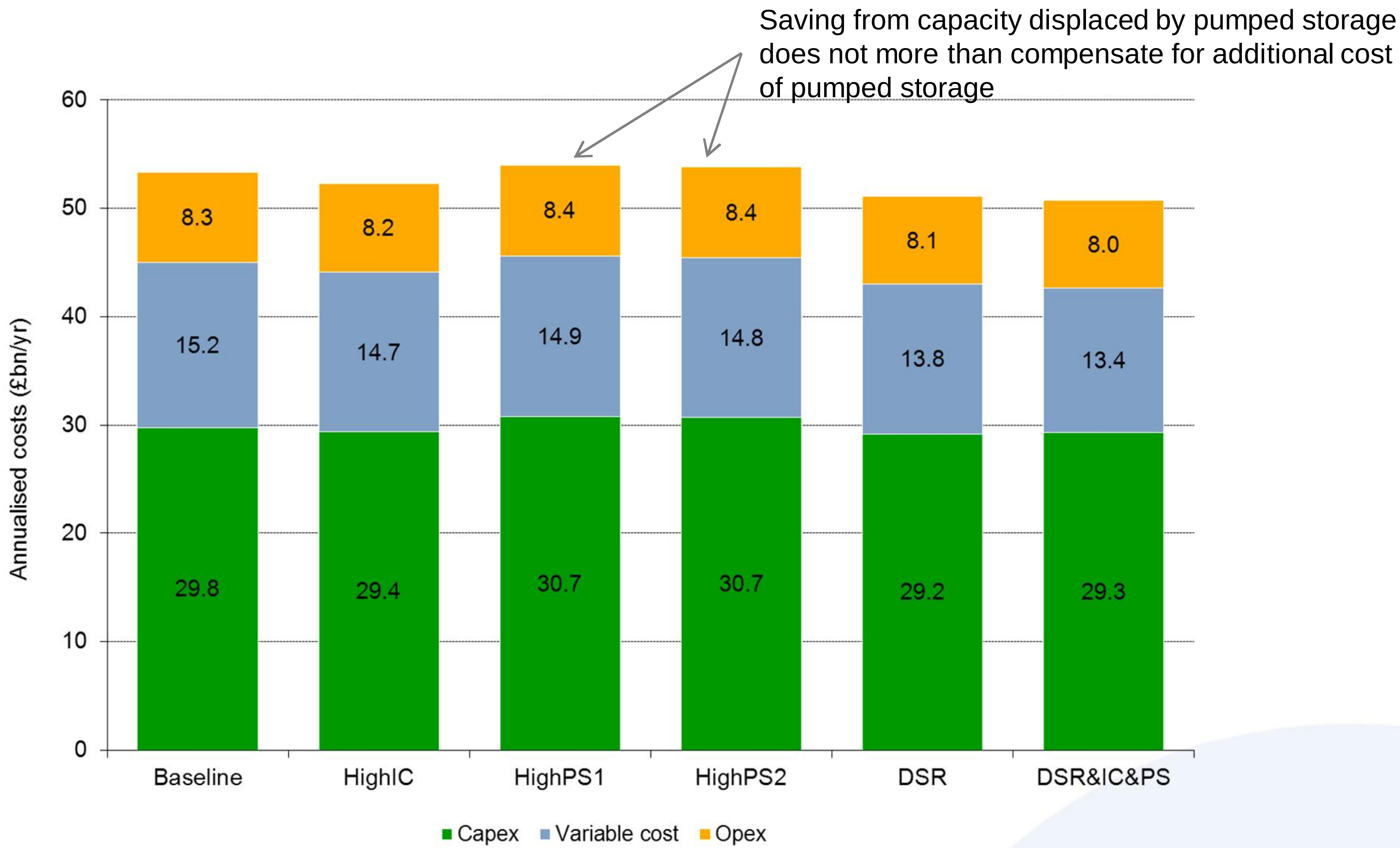
Total generation costs decrease under high interconnection and DSR scenarios



- Opex is fixed operational costs
- Variable cost contains fuel costs, CO_2 costs, VOWC and SUNL
- Capex of pumped storage is taken into account

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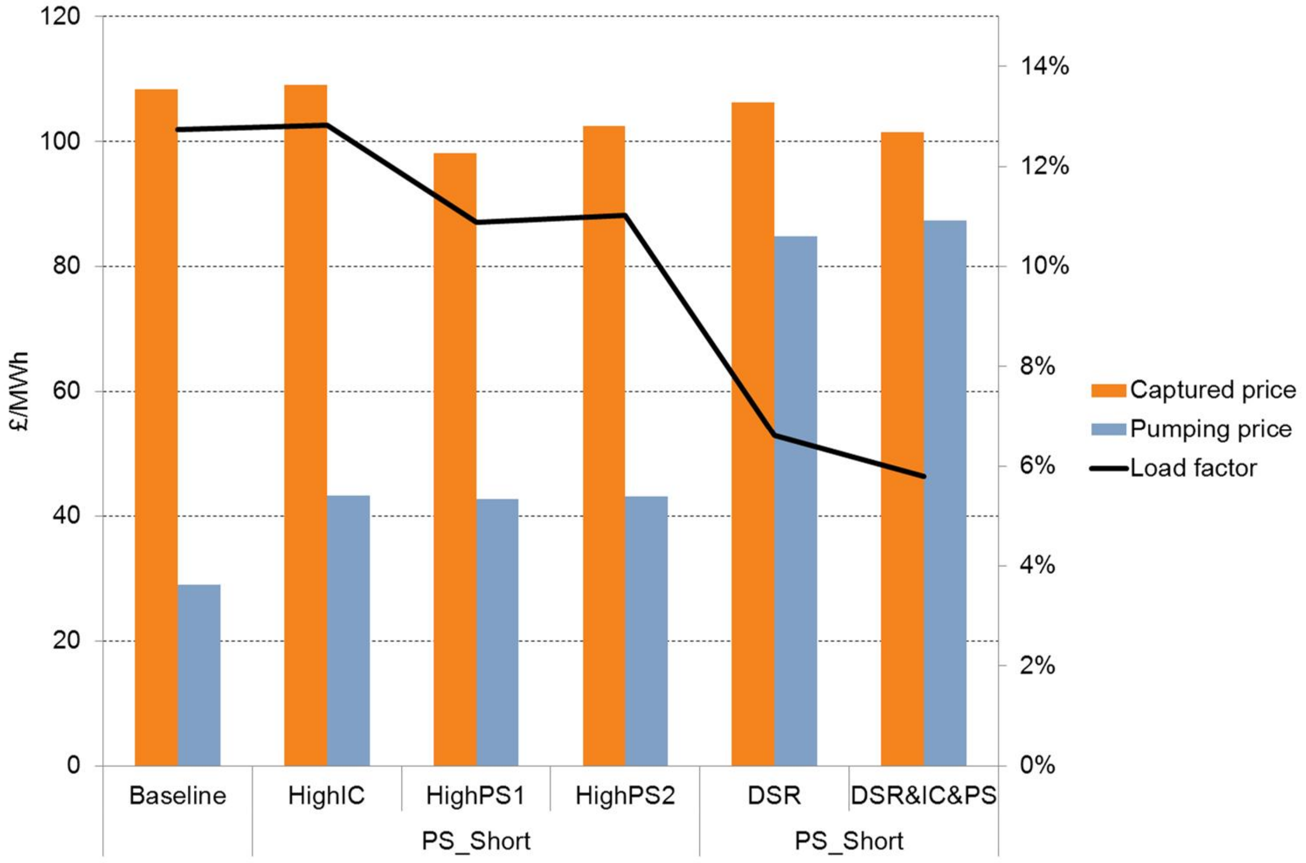
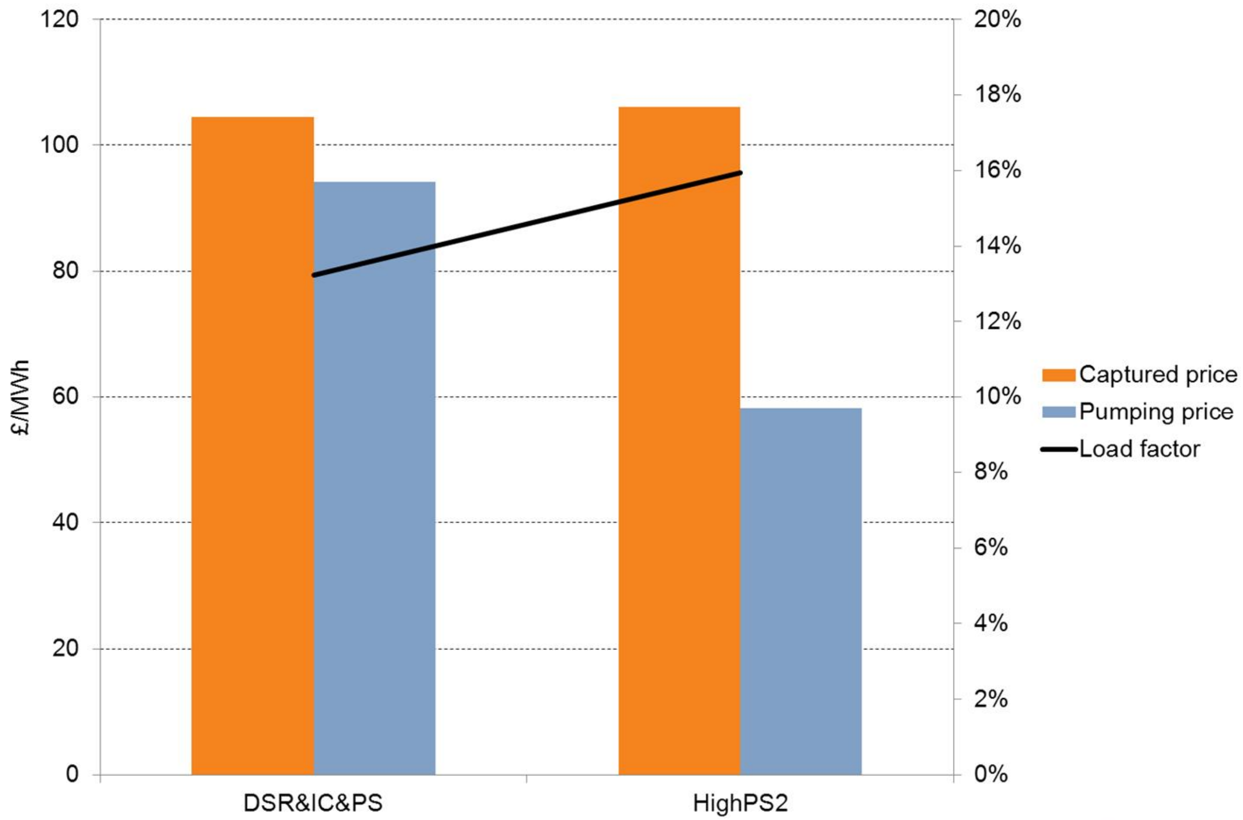
Pumped storage operational profile (without longer duration storage)



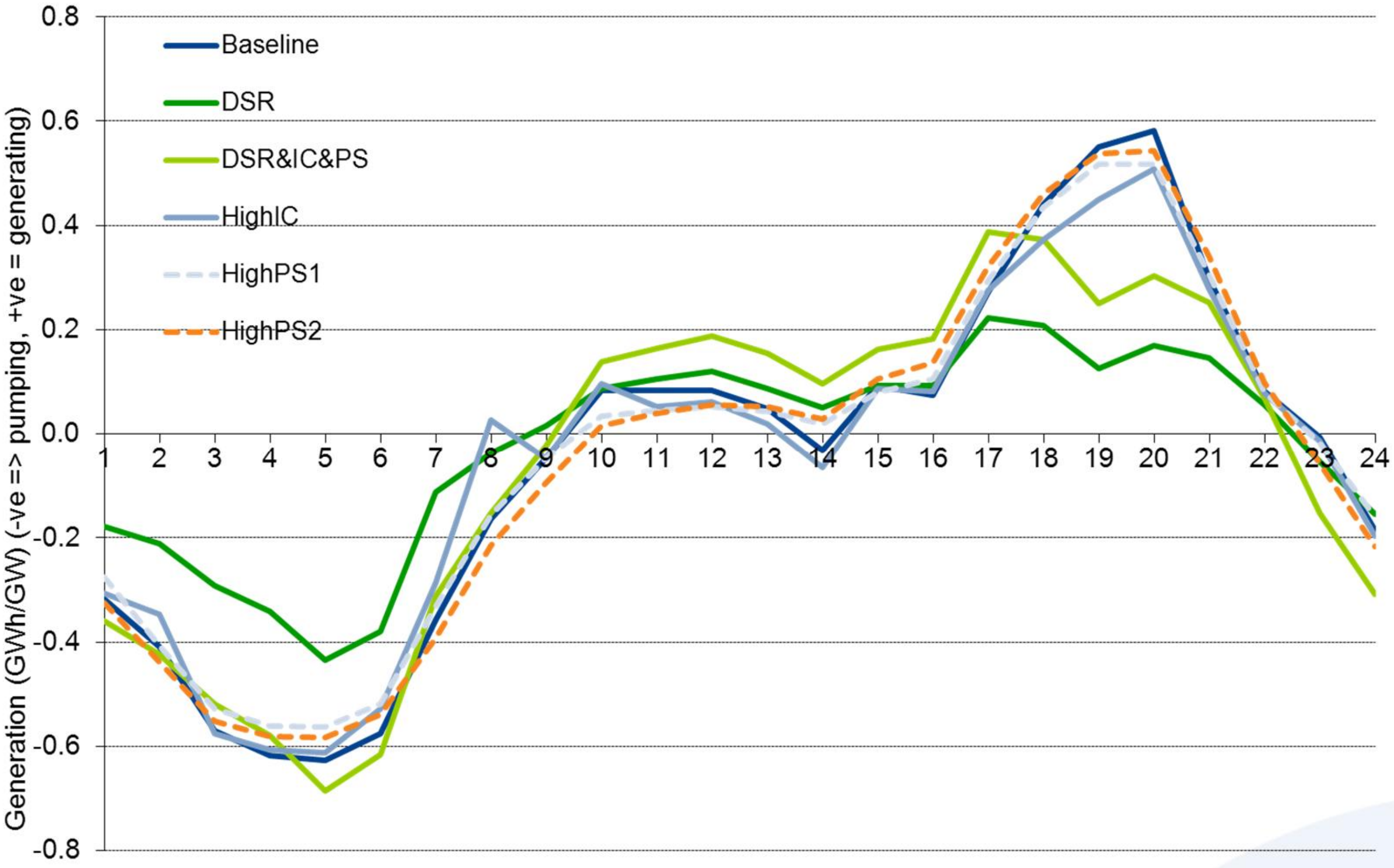
- DSR reduces load factors of pumped storage and also reduces the difference between the captured price and pumping price which will reduce the IRR of pumped storage

Pumped storage operational profile (with longer duration storage)



- DSR reduces load factors of pumped storage and also reduces the difference between the captured price and pumping price which will reduce the IRR of pumped storage

Operational profiles of pumped storage (average hourly generation)



- General pattern of pumped storage is to pump at night and generate in the evening hours
- DSR radically flattens the pumped storage profile

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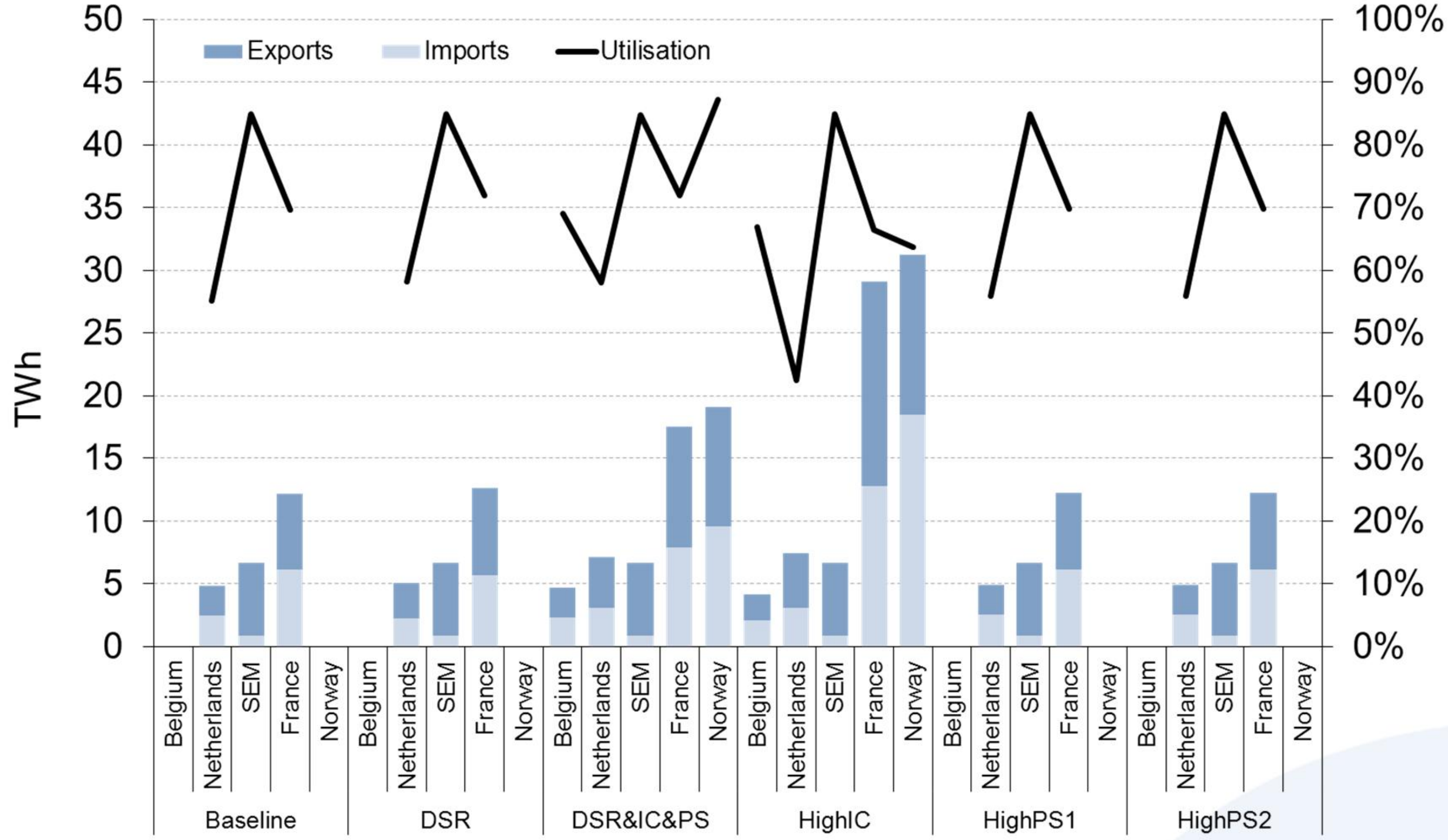
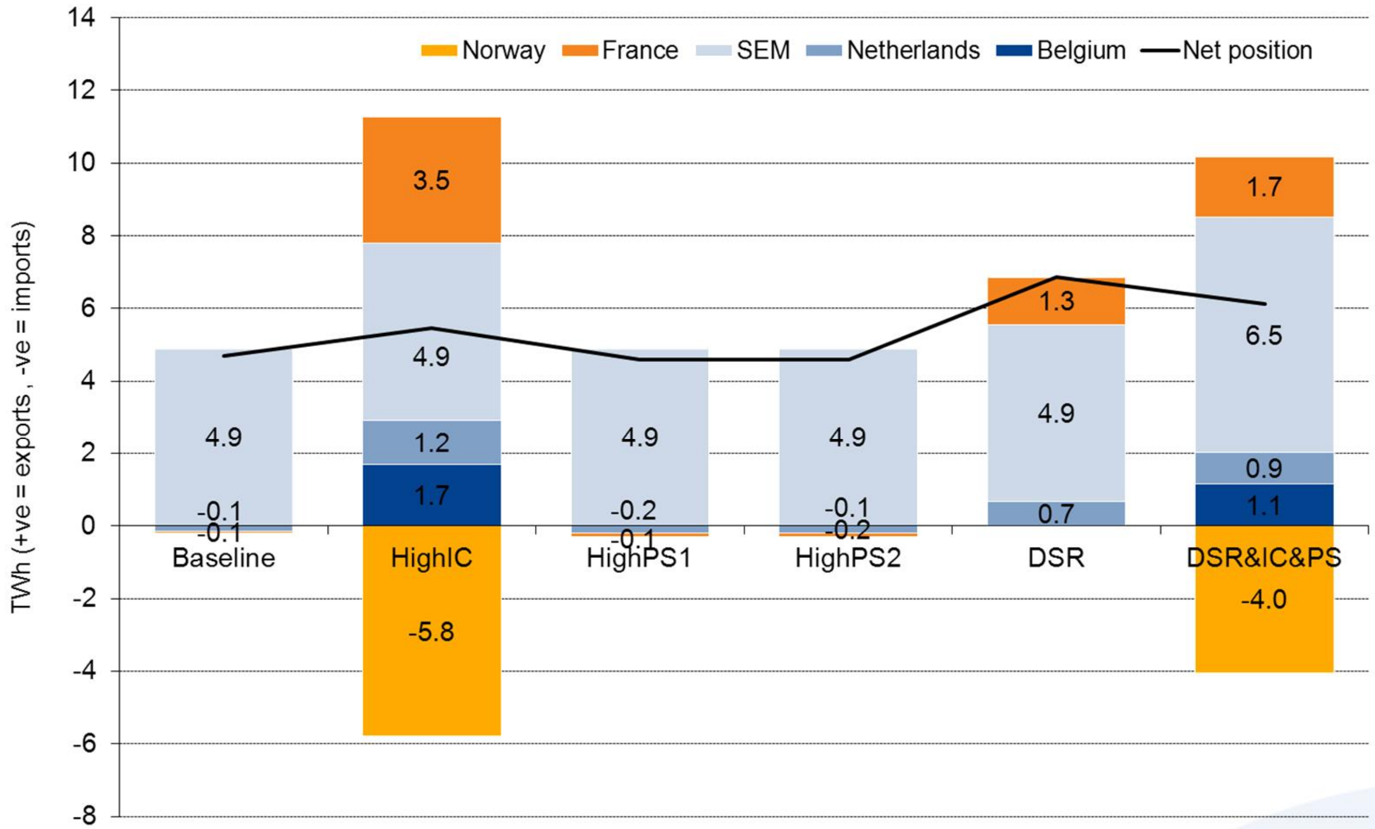
Operational profiles of interconnection



- Load factors decreases in High I/C case as the additional I/C capacity is not utilised

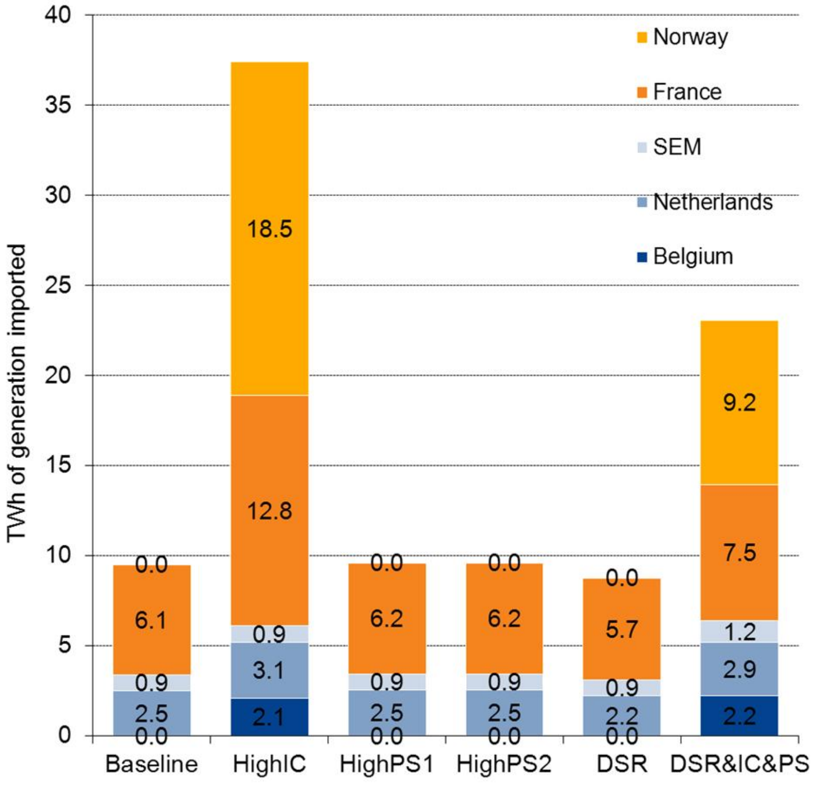
Operational profiles of interconnection



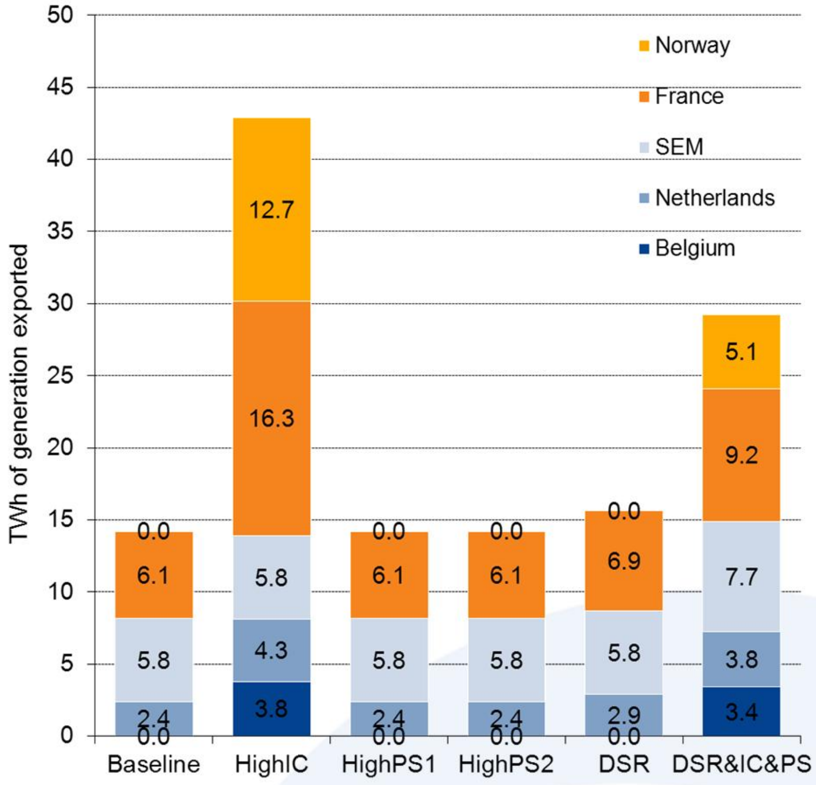
- GB is a net exporter in all scenarios
- Norwegian interconnection provides valuable capacity to GB when available

Operational profiles of interconnection

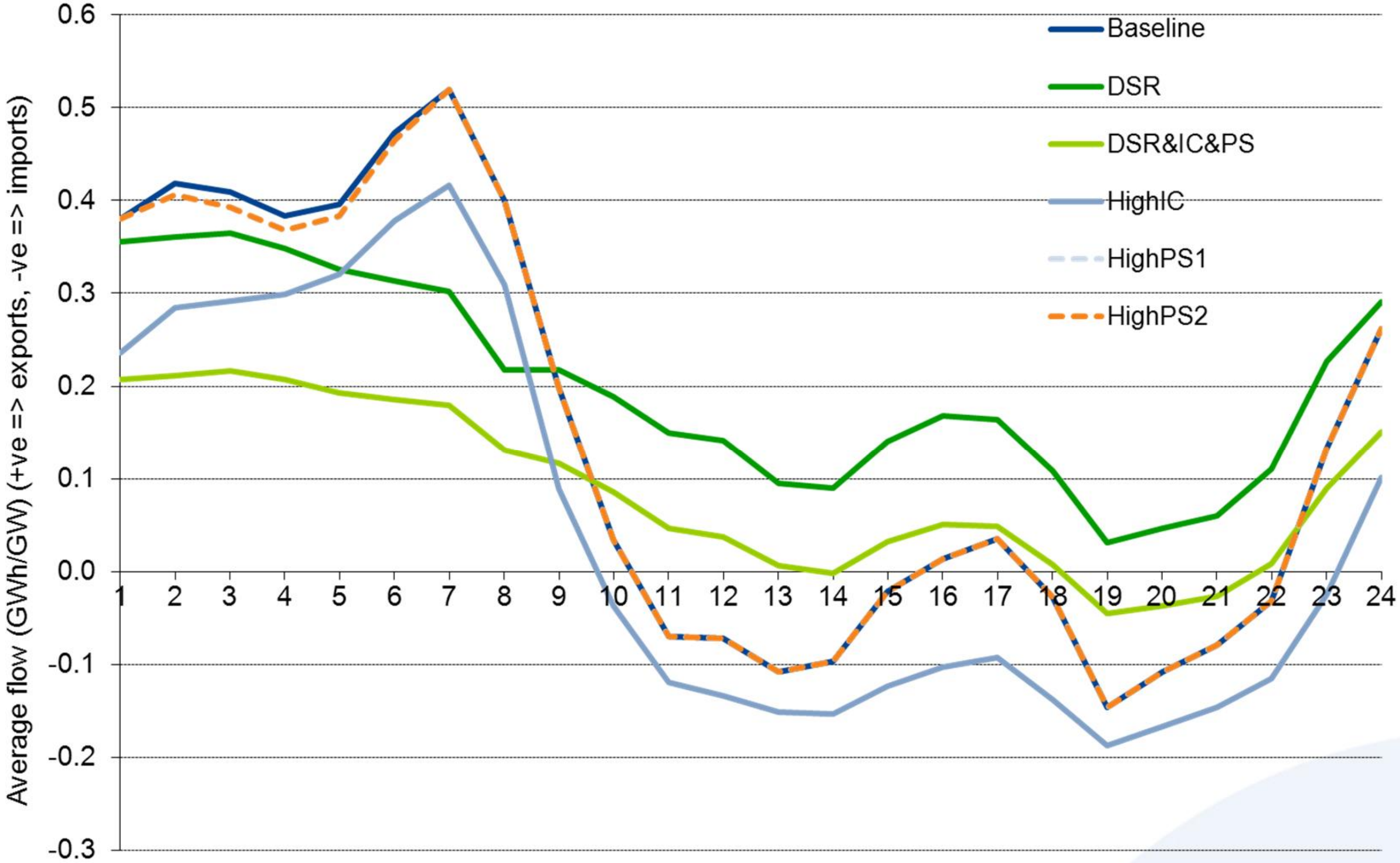
TWh of imports



TWh of exports



Operational profiles of interconnection (average hourly flows)



- DSR flattens the interconnector flow profile

Internal rates of return for thermal plant

Internal rate of return

IRR, %	Nuclear	CCS Coal	CCGT	OCGT
Baseline	10.7%	5.0%	10.1%	9.9%
High IC	11.2%	5.1%	10.0%	9.9%
High PS1	11.1%	5.5%	10.0%	9.9%
High PS2	11.3%	5.5%	10.0%	10.2%
DSR	11.7%	6.3%	10.1%	9.8%
DSR & IC & PS	12.1%	6.4%	9.8%	9.9%

- Costs for thermal plant are taken from Mott MacDonald assumptions as per the previous DSR study
- Nuclear and CCS run more when flexible capacity is added
- IRRs suggest that in practice less CCS capacity and more nuclear capacity would be deployed

Internal rates of return for pumped storage

Internal rate of return for PS

IRR, %	Short duration PS	Longer duration PS
Baseline	6.9%	
High IC	6.3%	-
High PS1	5.0%	-
High PS2	5.2%	5.6%
DSR	2.2%	-
DSR & IC & PS	1.1%	2.4%

- *Pöyry engineers require site information to provide estimates as geology and topography are important
- Therefore for the purposes of these calculations, we have assumed long duration PS costs are 10% higher than short duration storage
- We have not investigated the PS costs in detail

Assumptions*:

IRR, %	Short duration PS	Longer duration PS
Capex (£/kW)	1593.8	1753.1
Opex (£/kW)	25.5	28.1
Econ life (yrs)	50	50

Key messages from IRRs

- The plant mix in all scenarios should be readjusted to remove CCS coal (and replace with nuclear)
- PS does not make a sufficient IRR in any scenario, based on these costs assumptions
- When DSR is also on the system, PS IRR drops significantly because of:
  - A smaller difference between pumping price and capture price (due to DSR flattening prices)
  - Lower load factor (due to DSR redistributing demand)
- Interconnection does play a complementary role to DSR, especially the Norwegian interconnector*

*Full runs of the Northern Europe model would be required to verify this statement

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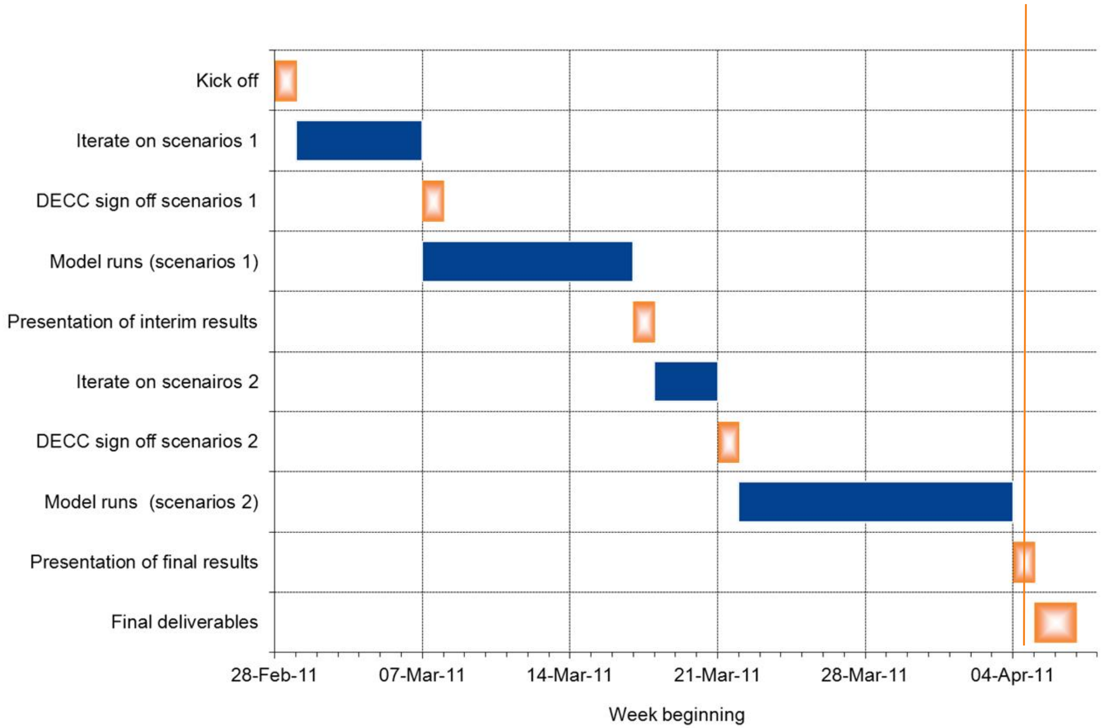
Next steps

Project timeline



- Handover of hourly results
- Invoice

Appendix: Assumptions

Common assumptions

Energy and generation

Assumption	Source
Baseline generation mix*	DECC assumptions / Pathways Alpha
Interconnection	
Exchange rate	
Carbon price	
Fuel price	
Demand Profiles	Work done by Pöyry for the CCC
Heat pump profiles	
Residential profiles	
Asset costs	Work done for DECC (Mott MacDonald)

Scenario specific assumptions

- Interconnection – see slide 8
- Storage – see slide 8

*See slide 4 for baseline generation mix

Flex demand assumptions

Flexible demand in 2030, TWh	Flexible heat	Flexible EV's	Flexible residential demand
No DSR	0.0	0.0	0.0
Network build incl DSR	21.0	24.2	6.0
Network build excl DSR	21.0	24.2	6.0

'Caveats'

- Not sought to rebalance generation mix i.e. re-optimisation
- Sought to minimise changes between scenarios in order to understand drivers of differences in results
- The value of 1 ROC is assumed to be £39.5/MWh, and banding for relevant technologies is as per current Ofgem guidelines
- Not undertake a full cost benefit analysis of interconnection or storage

Appendix: Overview of modelling methodology

- With agreement from DECC, interconnector modelling methodology has changed from the DSR previous study to take into account results from the Northern Europe Intermittency Study which were unavailable in the previous study

- We now base flows and capacities on a comparable scenario from our Northern Europe Intermittency study, specifically our 2035 “High Interconnection scenario”

- The High Interconnection scenario was chosen as a reference because
  - Levels of intermittent RES are of the same order of magnitude (64GW v 72GW)

- Given the new flows, we have reassessed the balance of OCGT and CCGT plants and the level of capacity payments to incentivise peaking plant

- As a result, baseline results are not identical to those derived in the November DSR project

Appendix: Implications of new modelling methodology

Wholesale price

£/MWh	Wholesale price
DSR study baseline	75.7
New baseline	71.9

Interconnector flows

TWh	Net flows
DSR study baseline	0.3
New baseline	4.7

- Average wholesale prices decrease in the new baseline compared to the DSR study, because of rebalanced CCGT / OCGT mix (which alters the marginal plant) and a slight difference in capacity support for peaking plants

Appendix: Overview of modelling methodology

- There are a number of reasons why the baseline has changed:
  - Total OCGT and CCGT capacity has reduced (due to interconnector flows)
  - OCGT and CCGT mix has changed – there are now more CCGT plants in the mix
  - Running hours CCGT plants have increased

- As a result, OCGT plant is setting the price in fewer periods, and CCGT plant is setting the price in more periods compared to the baseline

- When flexibility is introduced in the new baseline, CCGT plants are displaced more often which means that the difference in the time weighted average price is not as marked

Appendix: demand weighted v time weighted average prices

- Time weighted average prices are equal to the sum of wholesale price in each hour of the year divided by the number of hours in the year

- Demand weighted average prices are equal to the sum of (hourly wholesale price * hourly demand) divided by total annual demand

- Weighting the prices by demand brings them closer together as storage, interconnection and DSR raise demand in periods of low prices when demand is low and allow the system to better cope with periods of high prices when demand is high (by providing flexible capacity or by reducing demand)
  - The impact of this trend can be seen when looking at the difference between time weighted average price and demand weighted average price across scenarios. The difference reduces with increasing flexibility implying that TWA price and DWA price converge with increasing flexibility

- The relationship between different DWA prices can move in the opposite direction to the TWA price because of the correlation of demand and prices and periods of zero demand (see high IC case v high PS2 case in slide 18)

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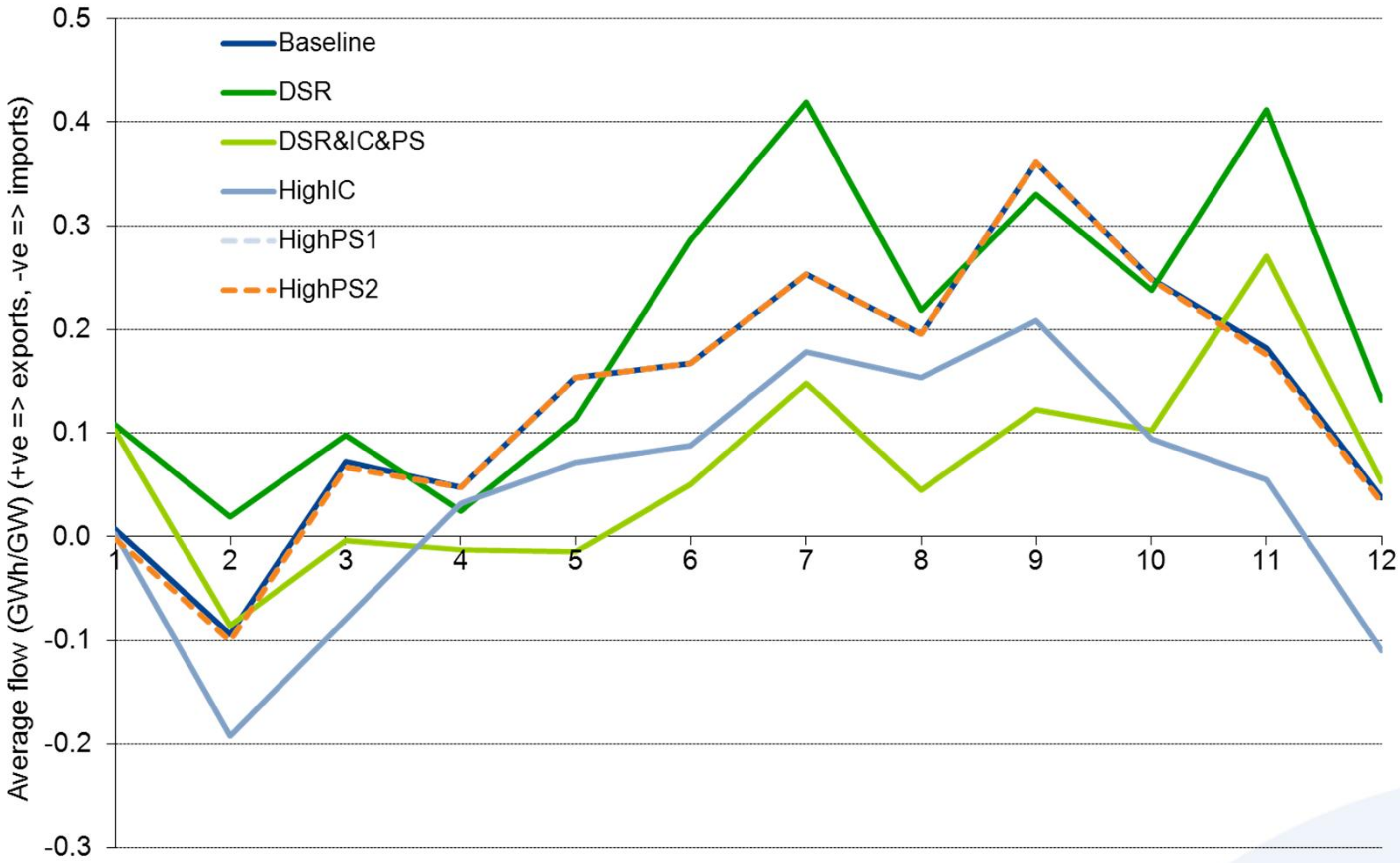
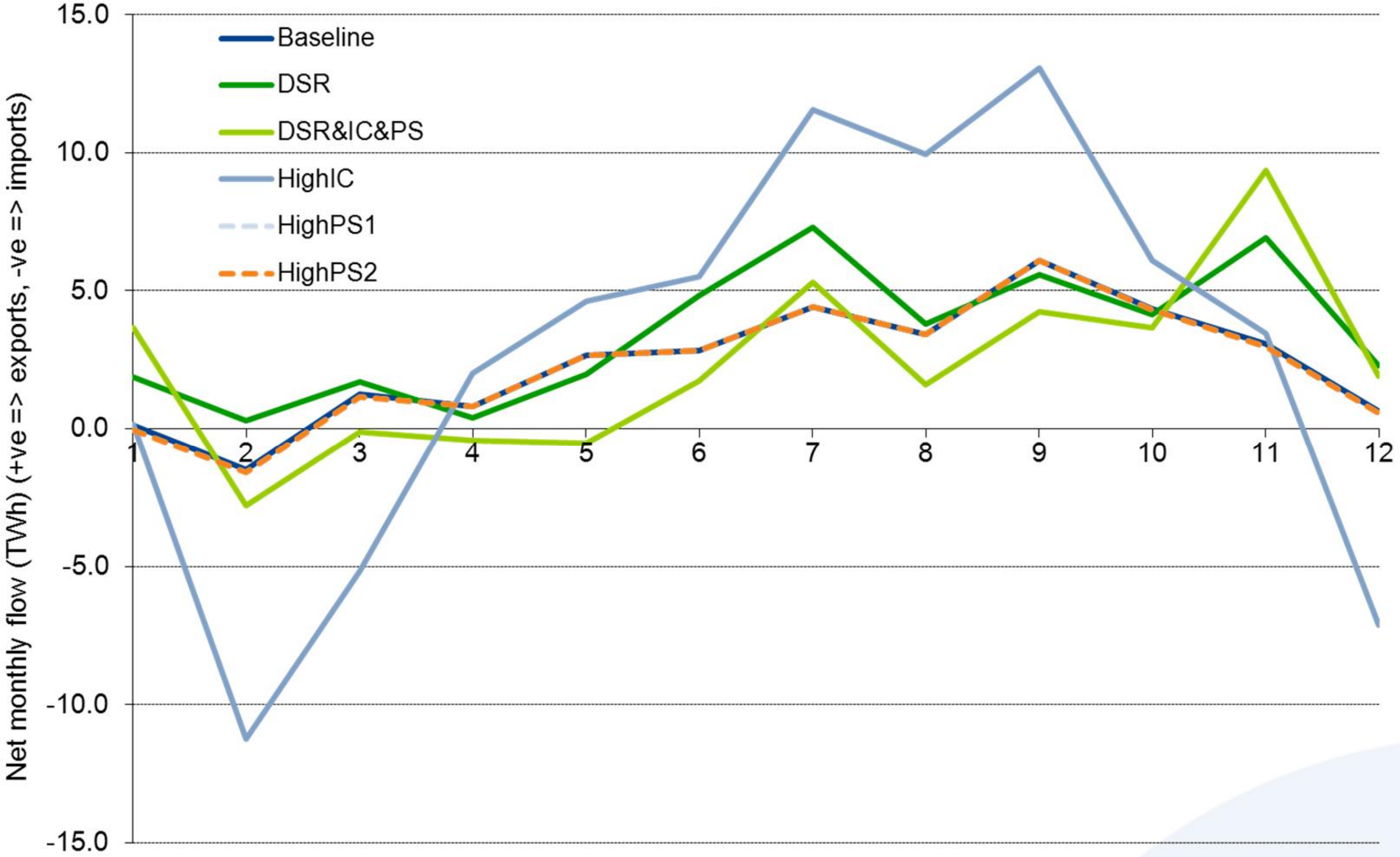
Operational profiles of interconnection (average monthly flows)



- Winter months tend to be periods of import in GB using the Norwegian interconnector
- DSR tends to increase exports

Operational profiles of interconnection (net monthly flows)



- Net import months tend to be in the Winter with imports most pronounced when the Norwegian interconnector is available
- DSR tends to increase exports

Andrew Nind
Andrew.nind@poyry.com

Oliver Pearce
Oliver.pearce@poyry.com

Kostas Theodoropoulos
Kostas.theodoropoulos@poyry.com

Pöyry Management Consulting (UK) Ltd
King Charles House
Park End Street
Oxford, UK
OX1 1JD

+44 (0)1865 722660
www.poyry.com
www.ilexenergy.com