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Low-hanging Fruit for Reducing the Cost of Energy
Optimising the Electrical Export Capacity

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Summary

Some of the more immediate and direct ways of reducing the Cost of Electricity from offshore wind are to focus on the offshore windfarm design, with one such design approach being to optimise the ratio between the windturbine generating capacity and the electrical infrastructure export capacity. This optimisation of the physical wind-farm provides several good cost reduction possibilities and can be considered 'low-hanging-fruit'.

The traditional approach, appropriate for smaller sites, has been to size the wind-farm, consent and connection, at name-plate rating. This no longer leads to the optimal design.

Since the electrical infrastructure is a considerable part of the overall CapEx and since windspeed and hence energy production varies in time, windturbines will be out of operation at times for scheduled maintenance and repairs, and electrical losses are more significant for larger wind farms, it makes good economic sense to build a small number of extra windturbines in the windfarm.

Through two independently developed approaches, this poster and accompanying paper explores how the ratio of electrical infrastructure capacity to the wind turbine capacity affects the project's cost of energy. Optimal windfarm sizing, for given sets of design criteria, are identified, along with the associated reduction in the cost of energy.

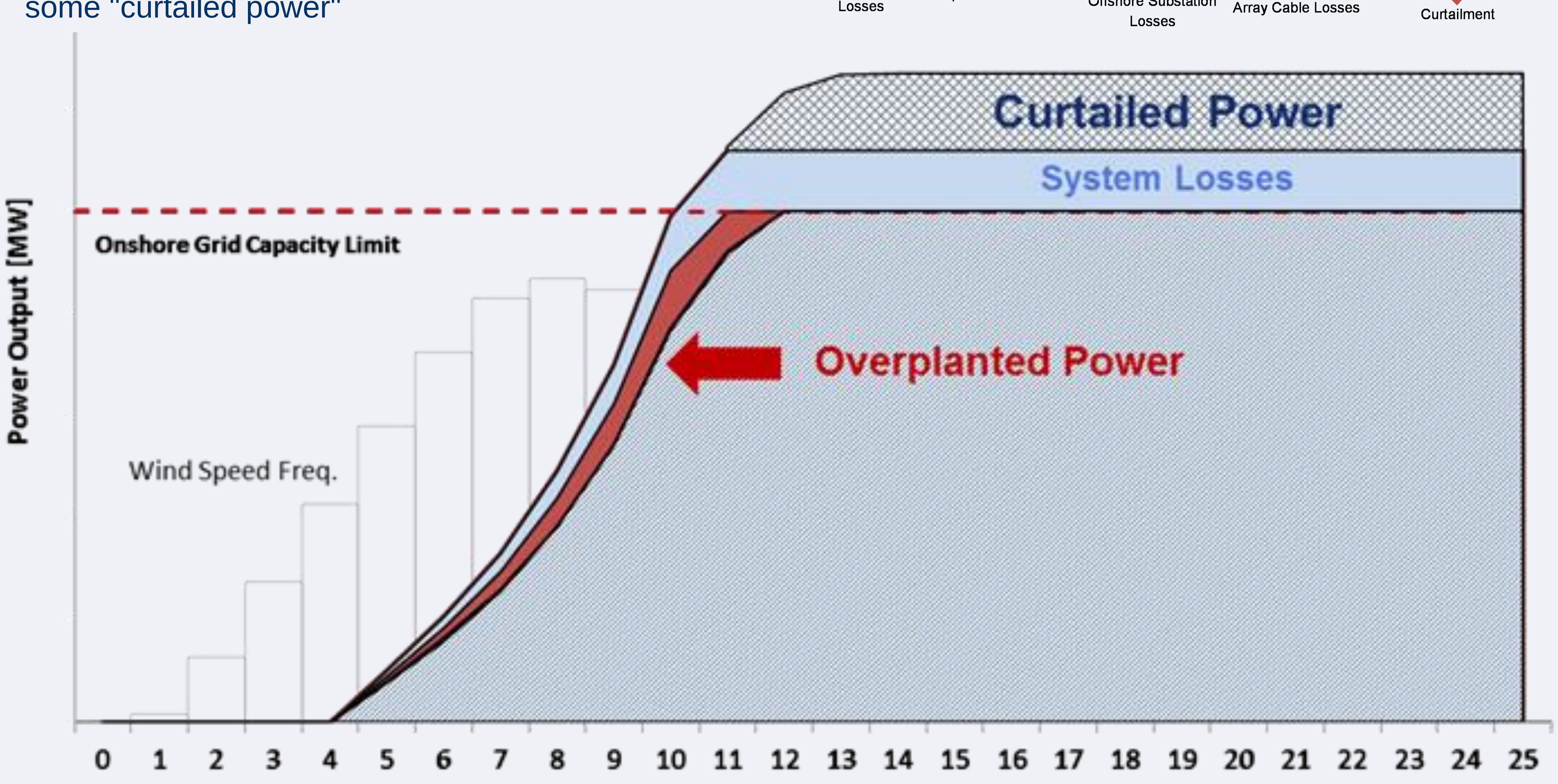
Design studies combining theory, detailed analysis and review of real operational records suggests that simply by finding the optimal windfarm design for this design aspect, the cost of energy for offshore wind can be reduced by something in the range of ½% to 1%.

Approach and Method

There are two aspects to optimising the capacity of the windturbines and the electrical infrastructure respectively at offshore windfarms relating to:

[i.] electrical losses, or "system losses"; designing each component to the calculated power flows at that particular point in the circuit

[ii.] the variability of energy production; avoiding rating the electrical infrastructure for the rare periods when all windturbines are operating and the windspeed is above rated; the consequence is some "curtailed power"



Principle of Capacity Optimisation or ("Overplanting")

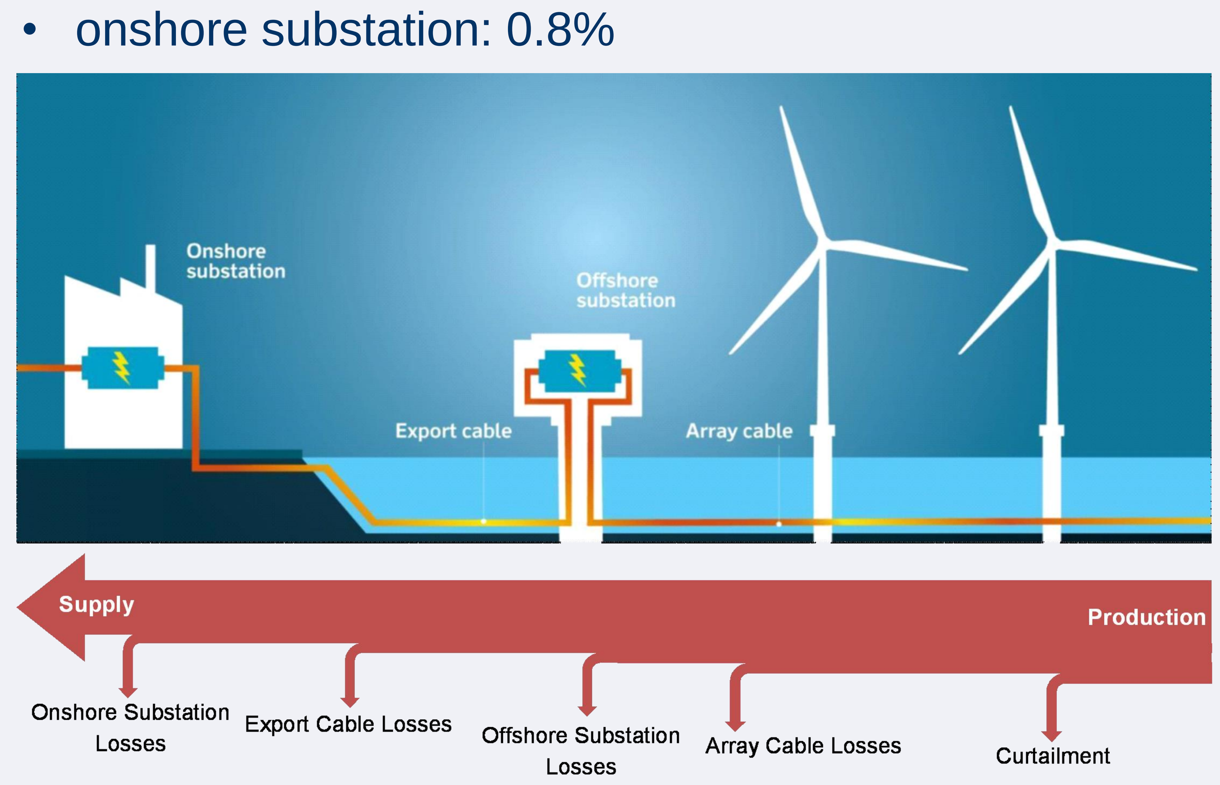
There are two primary reasons why it may be beneficial to design the windfarm with differing the windturbine generating and electrical infrastructure capacities:

- **as the power is exported through the electrical infrastructure, it will experience losses, hence the transmitted power will gradually reduce through the array cables, offshore substation, offshore and onshore export cables and onshore substation**
- **typically not all windturbines will be operating at full capacity, either due to windspeeds being below rated or one or more windturbines being offline for maintenance or repairs**
  - **hence the optimal design is the balance between**
    - **the cost of sizing the electrical infrastructure to transmit the full power (for the relatively infrequent occurrences that this is needed)**
    - **and the value of any lost production due to curtailing excess power instead**

Accounting for Electrical Losses

At each stage during the transmission of power to the grid onshore, inefficiencies of the system will generate small losses, hence the power being transmitted will reduce through to the onshore grid connection:

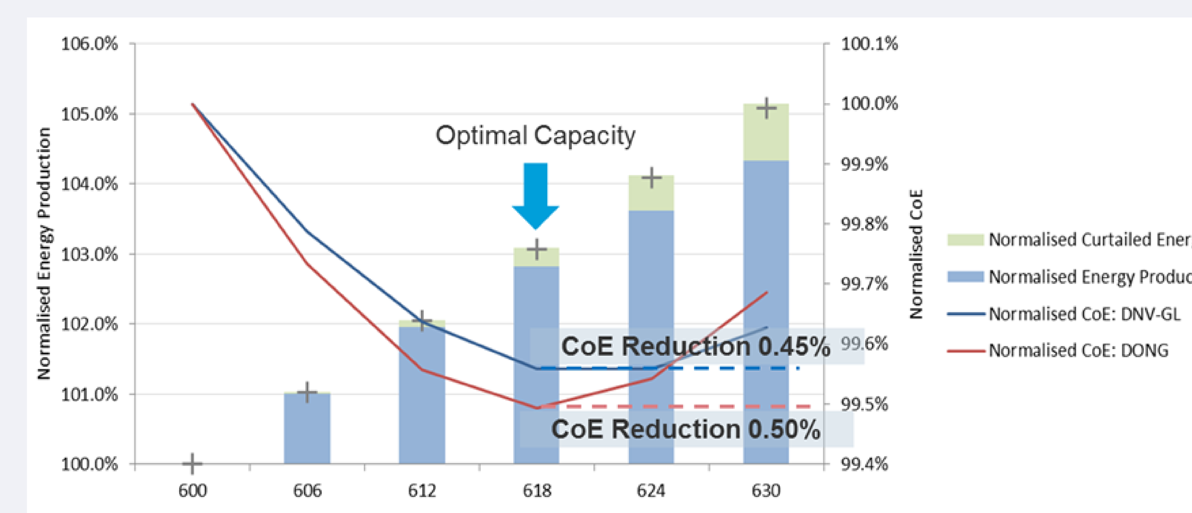
- array cables:1-2%
- offshore substation: 0.3-0.5%
- export cable: 1-6%
- onshore substation: 0.8%



Accounting for Windturbine Availability

Based on the assumptions characteristic of current offshore windfarms (see accompanying paper), the optimal capacity for the electrical infrastructure would be approximately 97% of the windturbine rated capacity, or 3 additional windturbines; this would reduce the cost of energy by around ½%. Hence by simply optimising the conceptual design and without any dependency on development of new technologies or contracting strategies, additional value in the order of £10m could be created for a typical windfarm.

(Note that the scaling to 97% is in addition to scaling due to electrical losses).



It is noted that there are small differences between the two sets of results. This is due to minor variations of how the DONG Energy and DNV.GL of technical and financial models have been set up. There is no impact on the overall conclusions.

Robustness and Sensitivities

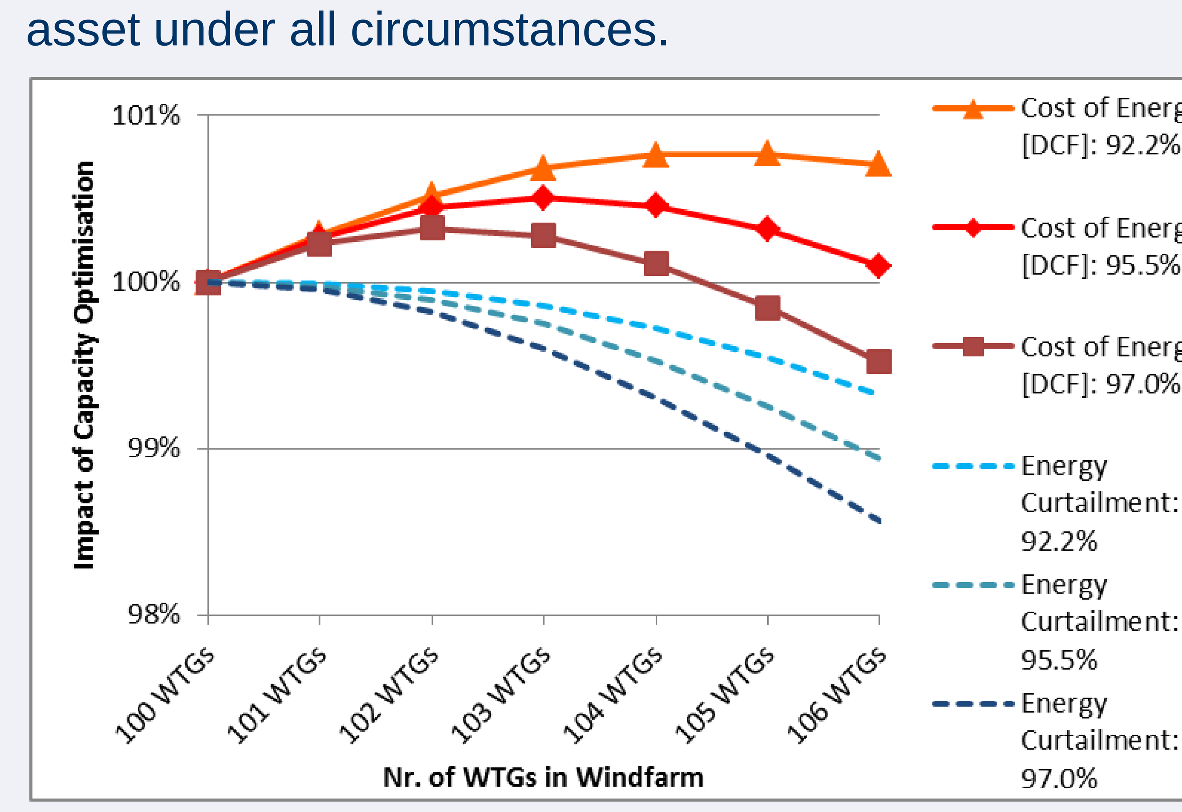
The purpose of sensitivity studies are to:

[1] identify which assumptions are important

[2] identify sensitivity of value created

[3] identify which near-optimal design (i.e. two or three additional windturbines) is most robust to changes in circumstances

For example, if the windturbines operate at a higher or lower availability, the exact number of additional windturbines that is optimal changes; however an additional 3 windturbines creates a more valuable asset under all circumstances.



Discussion

The analysis to determine the optimal design is detailed and somewhat involved and hence to provide some confidence in the conclusions, DONG Energy and DNV-GL, who have independently been examining this design challenge, jointly present their autonomously derived conclusions here and thus confirm the anticipated benefits and the importance of implementing this immediate and transparent lever contributing to reducing costs.

Finally Capacity Optimisation design can be affected by:

- dynamic cable design rating
- windturbine power-curves upgrades
- provision by the TSO of grid connection offshore, in which case the TSO may wish to apply this design principle
- Regulatory Requirements, including of the PPA

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