

Modelling of UK Offshore Wind Farms for Cost- effective Decarbonisation

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Science & Innovation for Climate & Energy (SICE)

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Why we model?

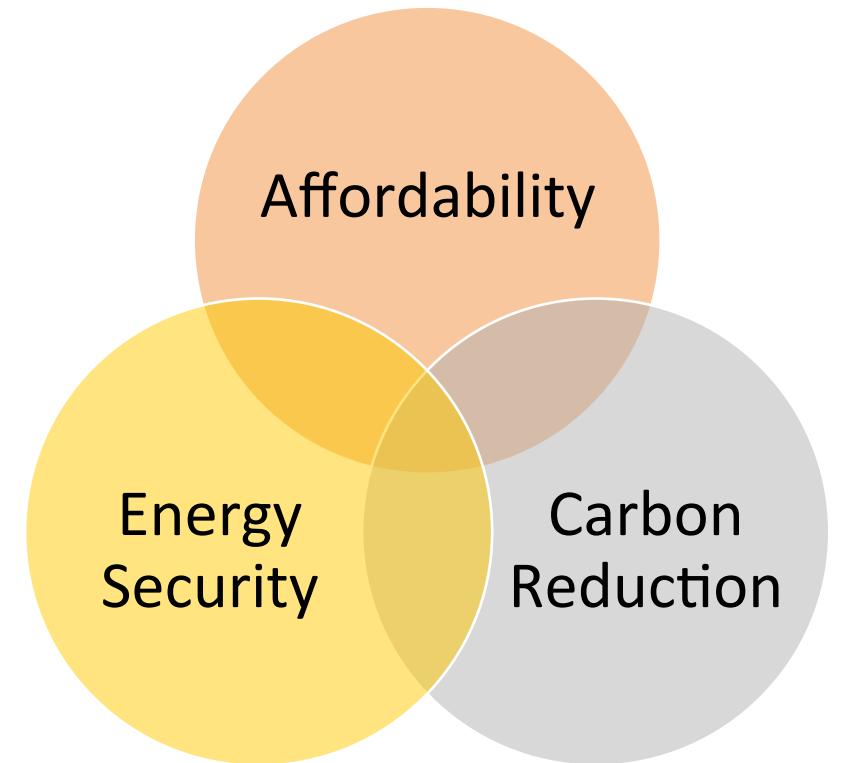
Support for Low Carbon Technologies

Low carbon technology innovation funding

- Renewables
- Built environment
- Smart energy systems
- Industry & CCS
- Energy Entrepreneurs Fund

Low-carbon electricity generation support

- Renewables Obligation (RO)
- Feed in Tariffs (FiT)
- Contracts for Difference (CfD)



Levy Control Framework (LCF)

- LCF was introduced in 2011 to regulate the costs of supporting low carbon electricity paid for through consumers' energy bills
- Aim to achieve 30% renewable electricity by 2020

Renewable Obligations (RO)

- Obligation on suppliers to buy a proportion of their electricity from renewable sources.
- BEIS publishes the Renewable Obligation Certificates (ROCs)

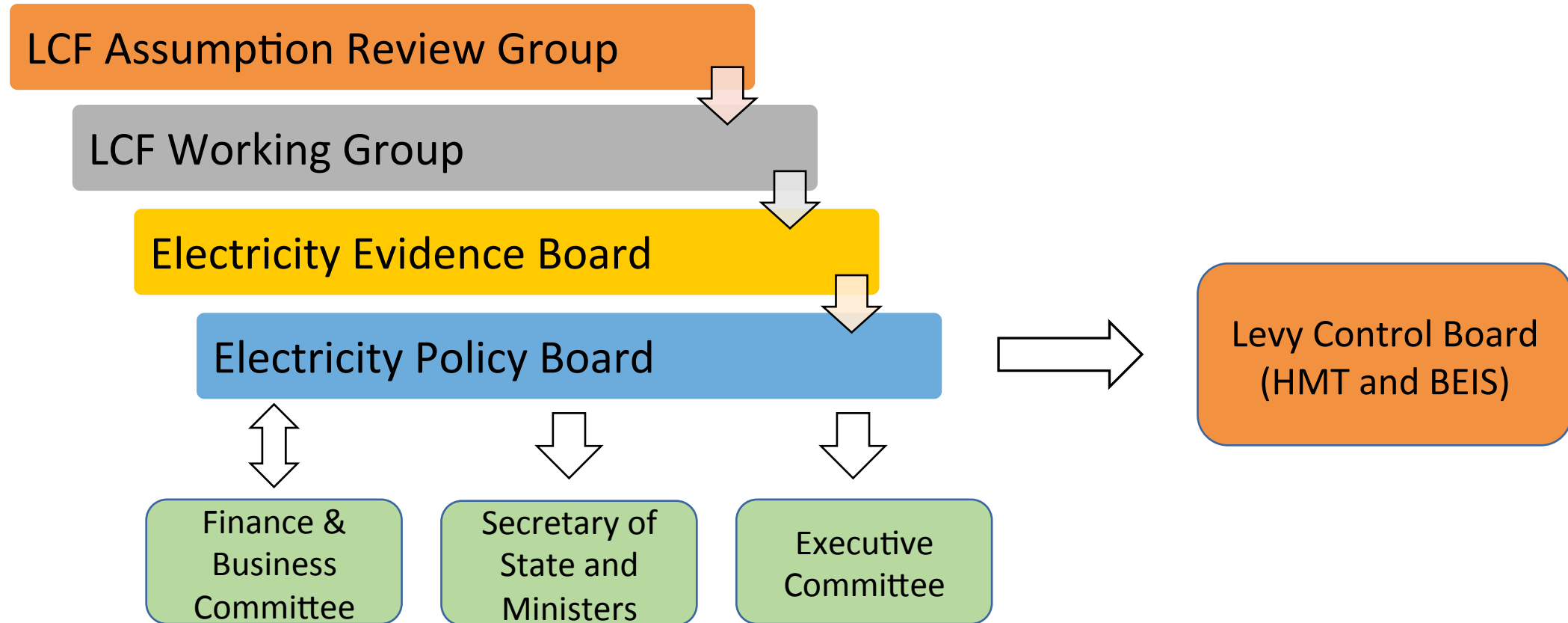
Contracts for Difference (CfD)

- Mechanism by which the government buys power from renewable technologies at a guaranteed strike price.
- BEIS sets the Admin Strike Price. If wholesale price is below Admin Strike Price, the price difference is passed onto consumer bills.

Feed-in Tariffs (FiT)

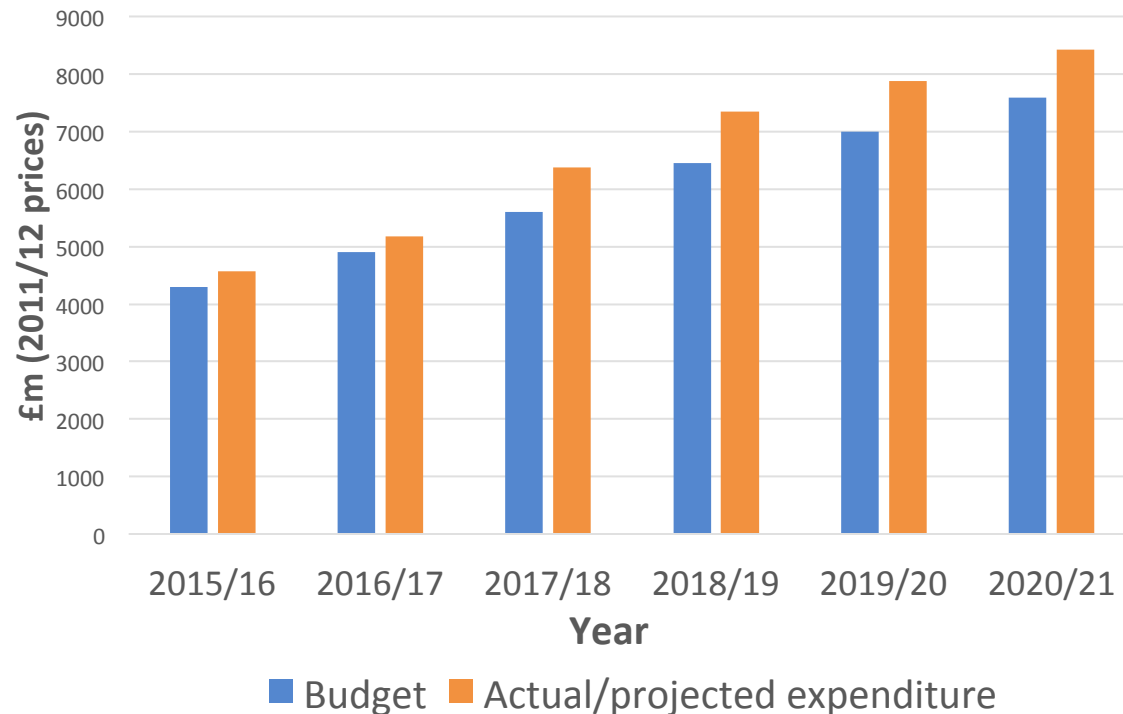
- Payments to ordinary energy users for the renewable electricity they generate

LCF Governance Process



LCF Budget Caps

LCF Budget and Expenditure



Key Drivers of Spend Projections:

1. Deployment
 - Commissioning dates
 - Capacity
2. Load factors
 - The ratio of the amount of electricity produced to its total potential, based on nameplate capacity, over one year
3. Wholesale Price
4. Policy changes

Cost Control Measures

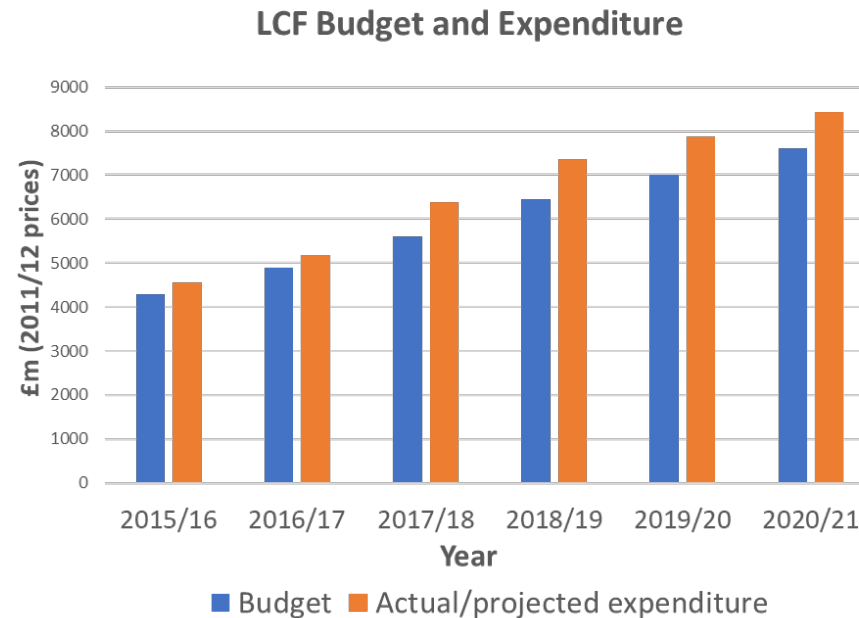
- Closure of FiTs
- Closure of RO scheme
 - Removal of grandfathering for biomass projects
 - Early closure of small scale solar PV
 - Early closure of onshore wind
- Removal of solar PV on CfD scheme

Why we model?

Offshore
wind is
36% of RO
budget

£££ = Windiness x Load Factor

Offshore
wind is
25% of CfD
budget



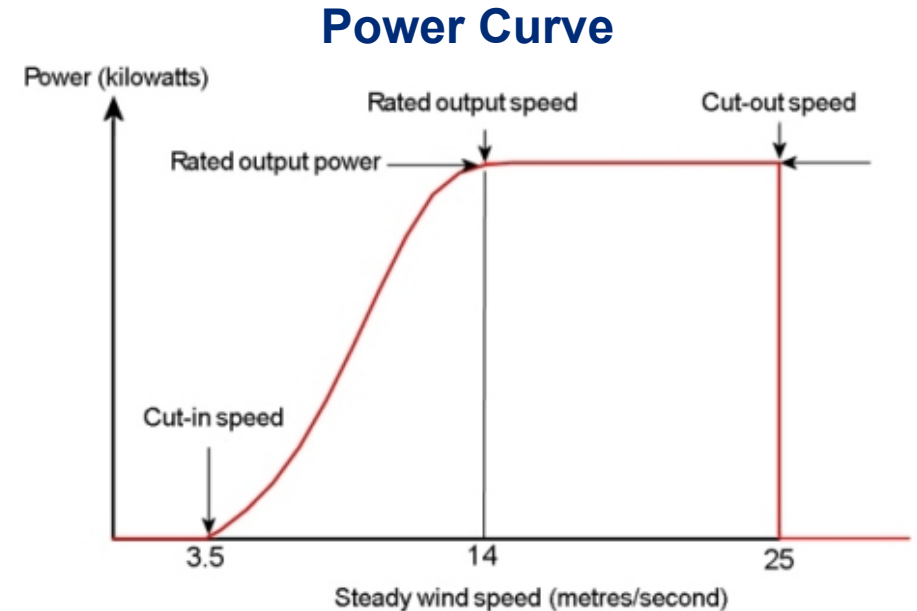
What we model?

Previously in BEIS...

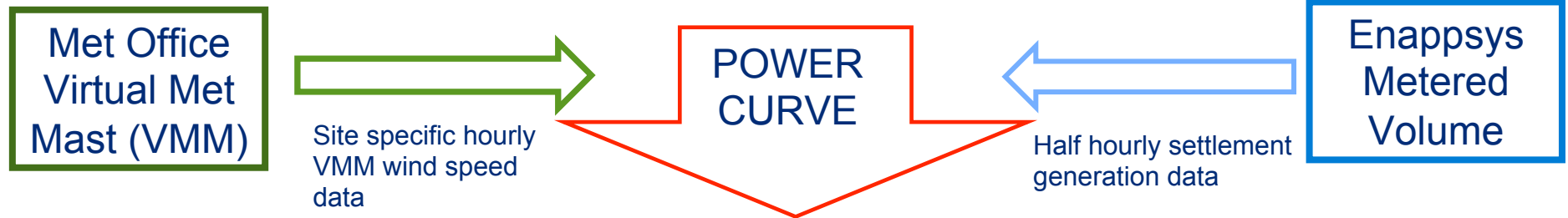
- Load factors were based on average wind speed and historic data
- But, wind energy depends on swept area of the turbine and wind speed:

$$P = \frac{1}{2} C_p \rho A v^3$$

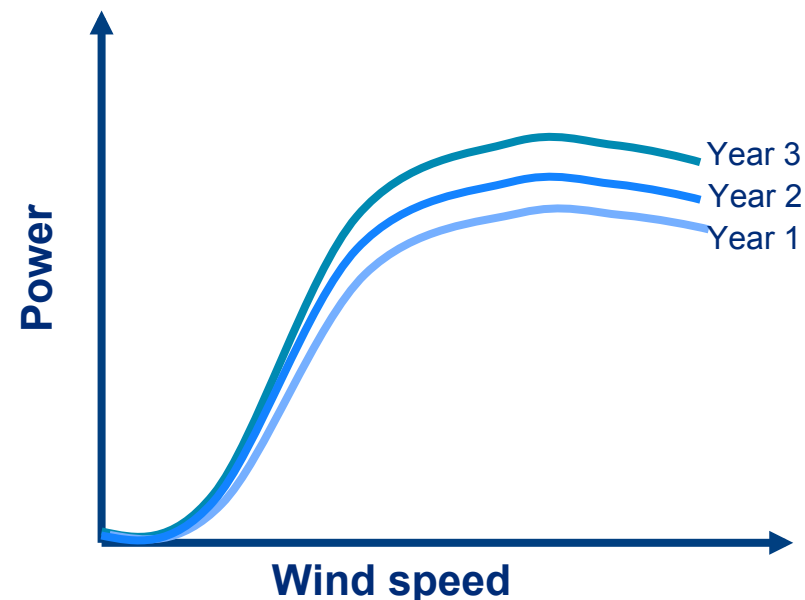
- Power curve – relationship between wind speed and power output of a turbine:
 - Cut-in speed
 - Rated output speed
 - Cut-out speed



Power Curve - Existing Farms

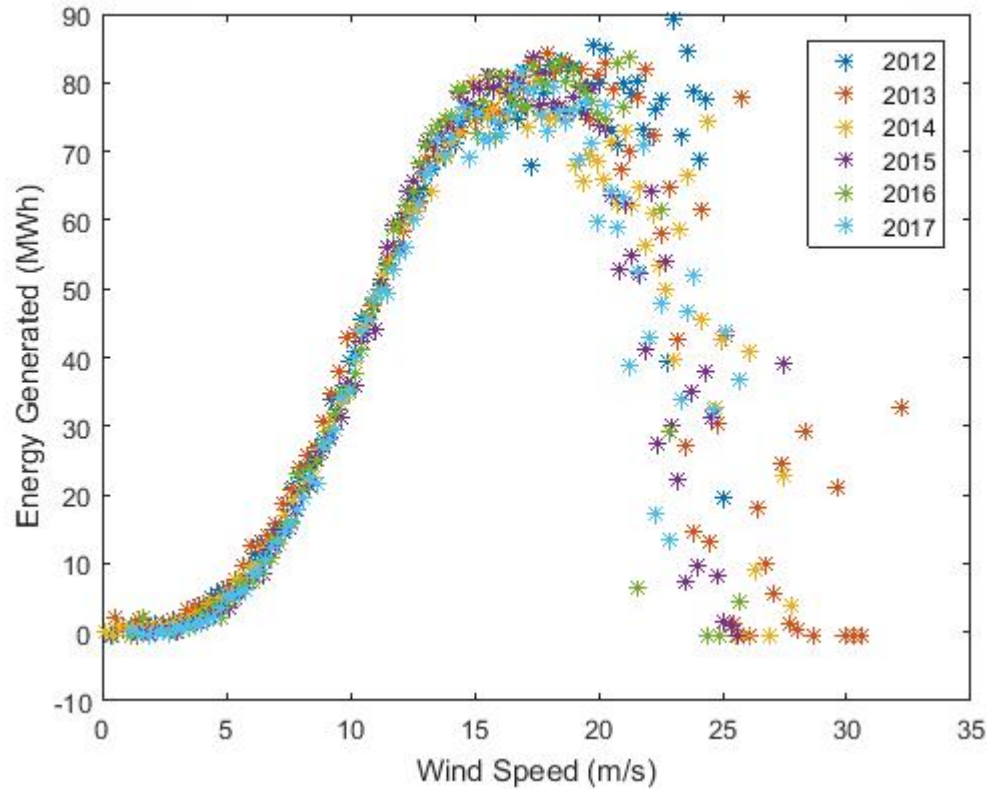


- The power generation data is obtained commercially from Enappsys and is based on metered volume of power generation connected to the National Grid
- The wind speed data is provided by the Met Office Virtual Met Mast (VMM) which is a site-specific hub height wind speed modelled data which has been extensively verified and compared against historical data.
- For each year of operation, a power curve is plotted by time matching the power generation to VMM wind speed for that year so that the relative magnitude of power generation to wind speed for each farm is known

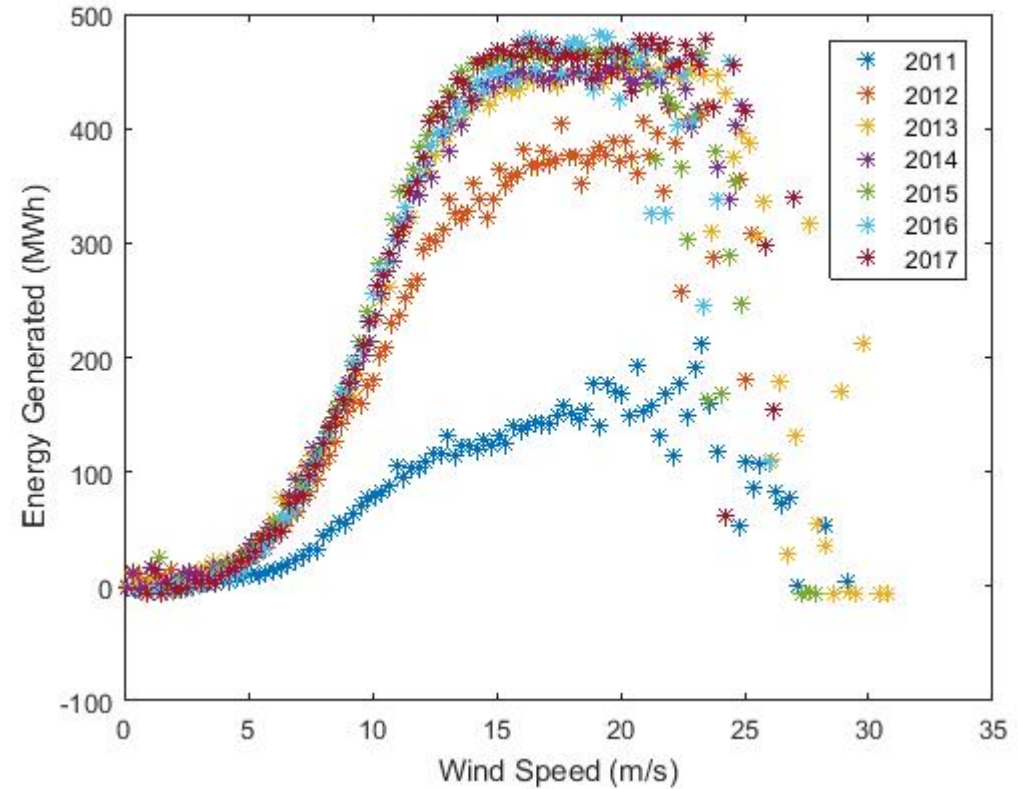


Power Curve – Existing Farms

Barrow Offshore Wind Farm



Greater Gabbard Offshore Wind Farm

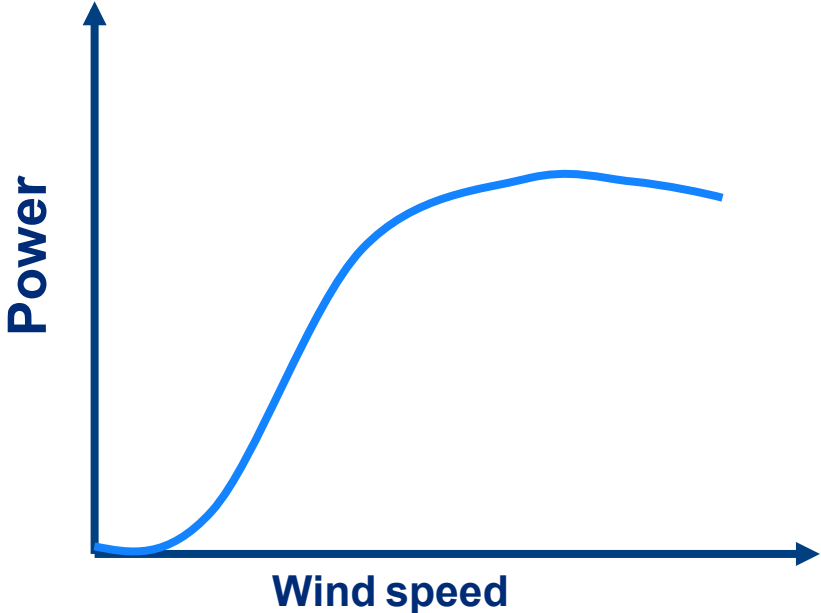


Power Curve - New Build

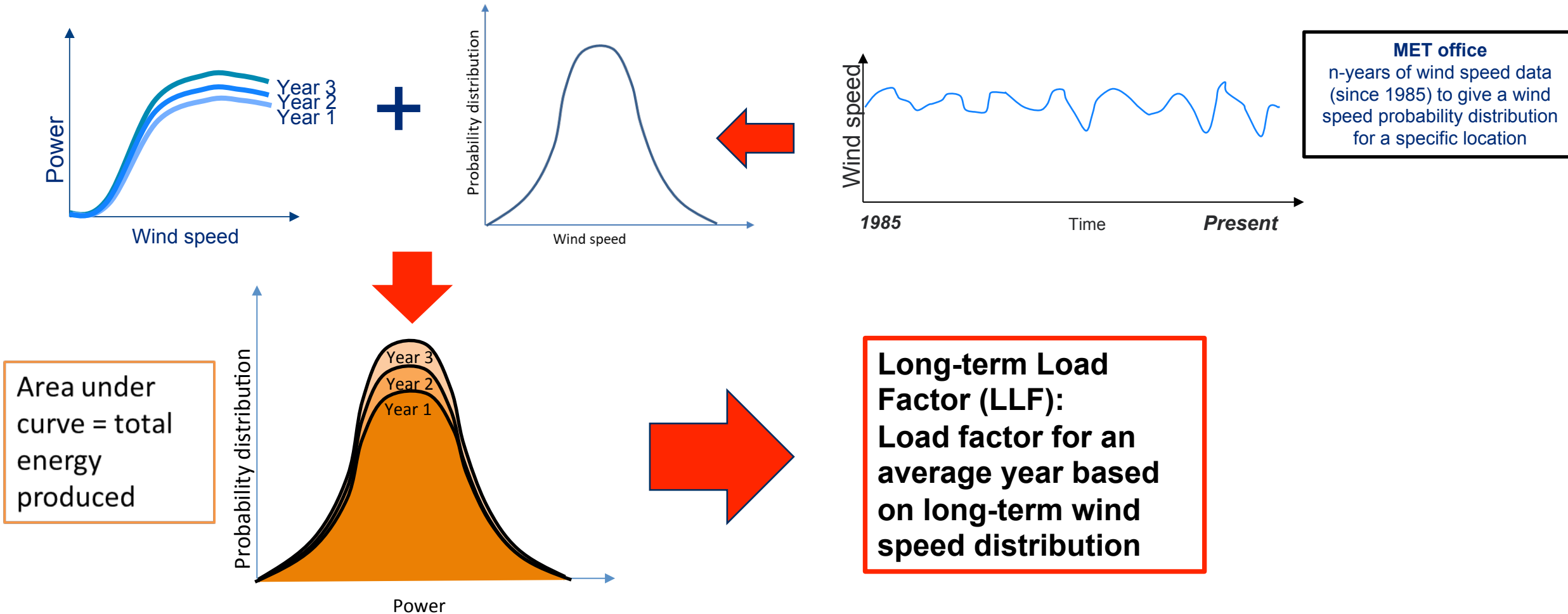


- *Capacity*
- *Turbine size*
- *Hub Height*

$$\text{Power} = \frac{1}{2} C_p \rho A v^3$$



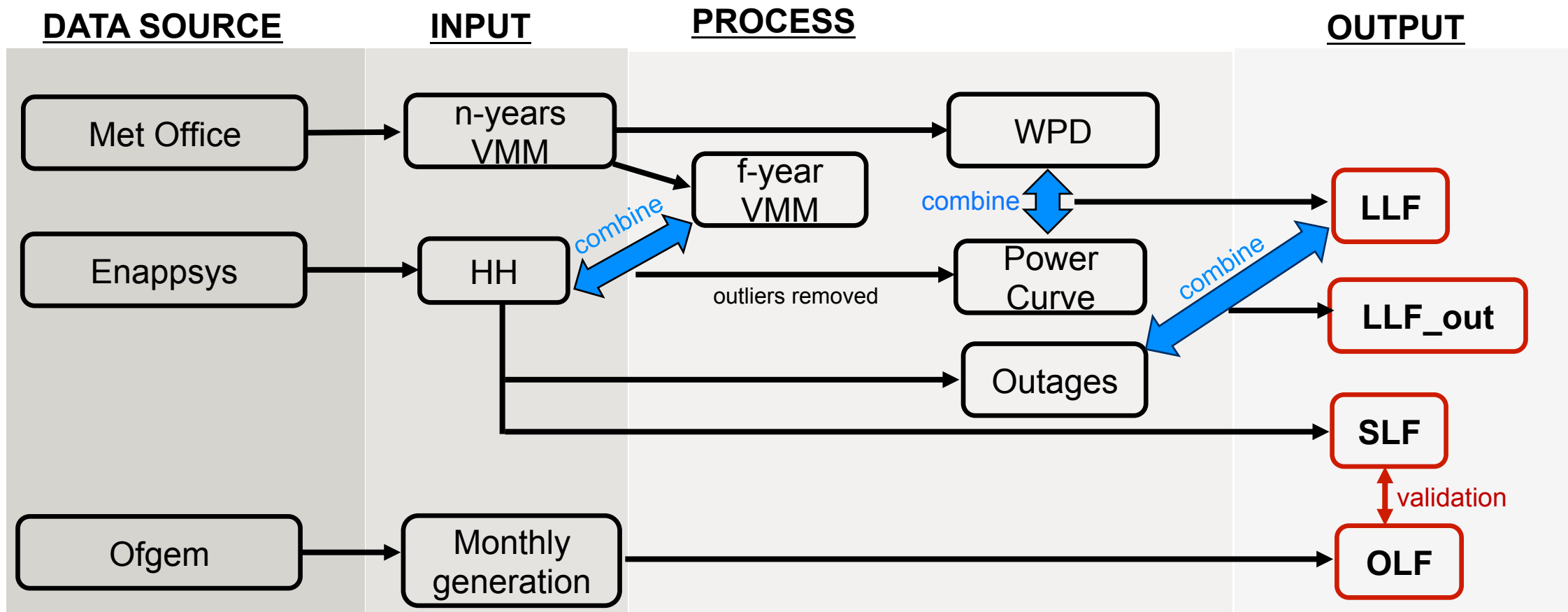
Long-term Offshore Wind Farm Load Factor



Outages Consideration

- Existing farm
 - Outages calculated from the proportion of power below 0 between cut-in and cut-out speeds relative to total power
- New build
 - Average outages from existing farms *or*
 - Differences between load factor from generation data and load factor from modelled power curve

Data Flow - Summary



HH – Half-hourly generation
VMM – Virtual Met Mast wind speed
n-years – all available VMM data (since 1985)
f-year – financial year
WPD – Wind speed probability distribution

LLF – long-term load factor
LLF_out – long-term load factor corrected for outages
SLF – specific load factor
OLF – load factor from Ofgem data

Summary

- Load factors are important in Levy Control Framework spend forecast
- The model uses over 30 years of wind speed data to generate a site-specific power curve and takes into account technological learning to estimate load factor
- The model is currently being extended into battery storage
- Future work: develop models for other technologies. Solar PV model is currently in development

Questions?

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