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Wind Energy: Intro lecture

Rafael Palacios

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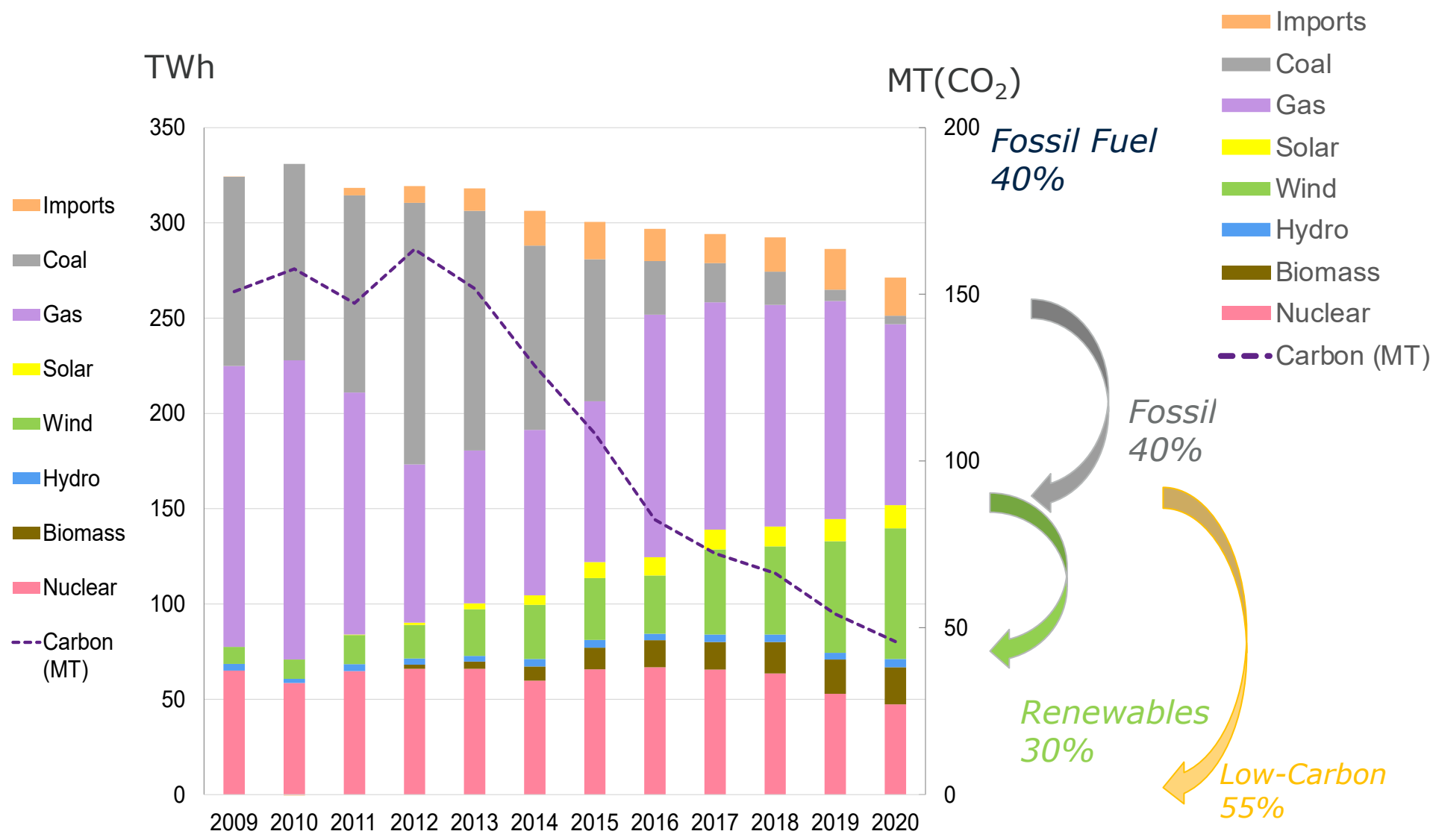
UK Annual Electricity Production



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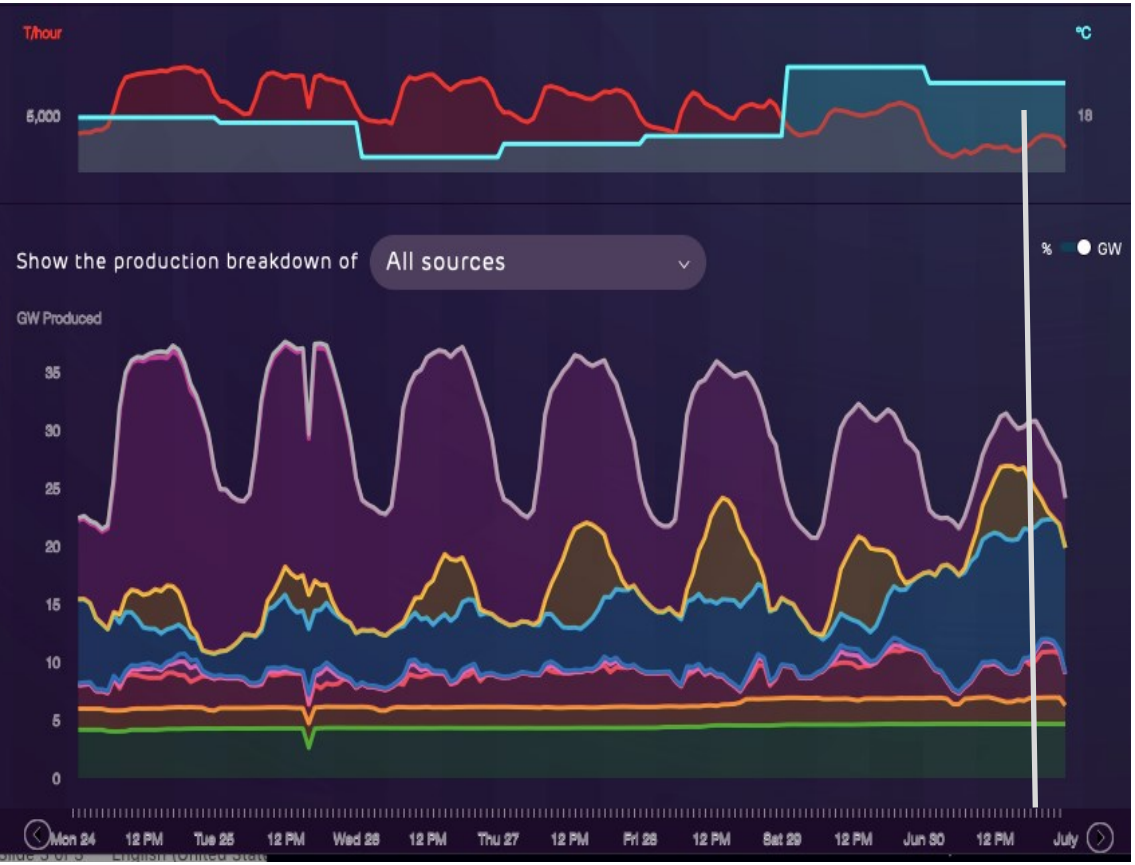
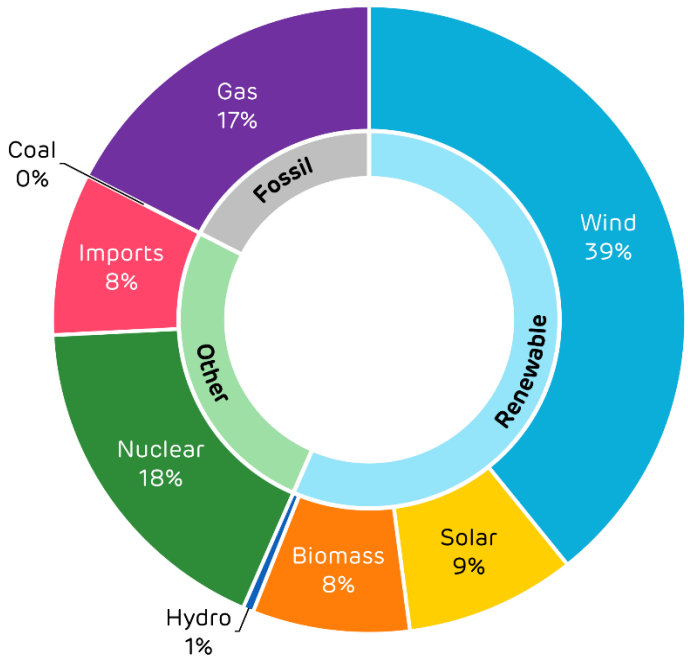
16:00 30th June 2019: 71 g(CO_2e)/kWh
Less than 100 g/kWh for the whole day

electricinsights.co.uk





Demand 29.4 GW

Coal 0.0 GW (0%)
Gas 3.52 GW (11.7%)
Solar 5.99 GW (19.9%)
Wind 11.31 GW (37.6%)
Imports 2.44 GW (8.1%)
Biomass 2.06 GW (6.85%)
Nuclear 4.67 GW (15.5%)

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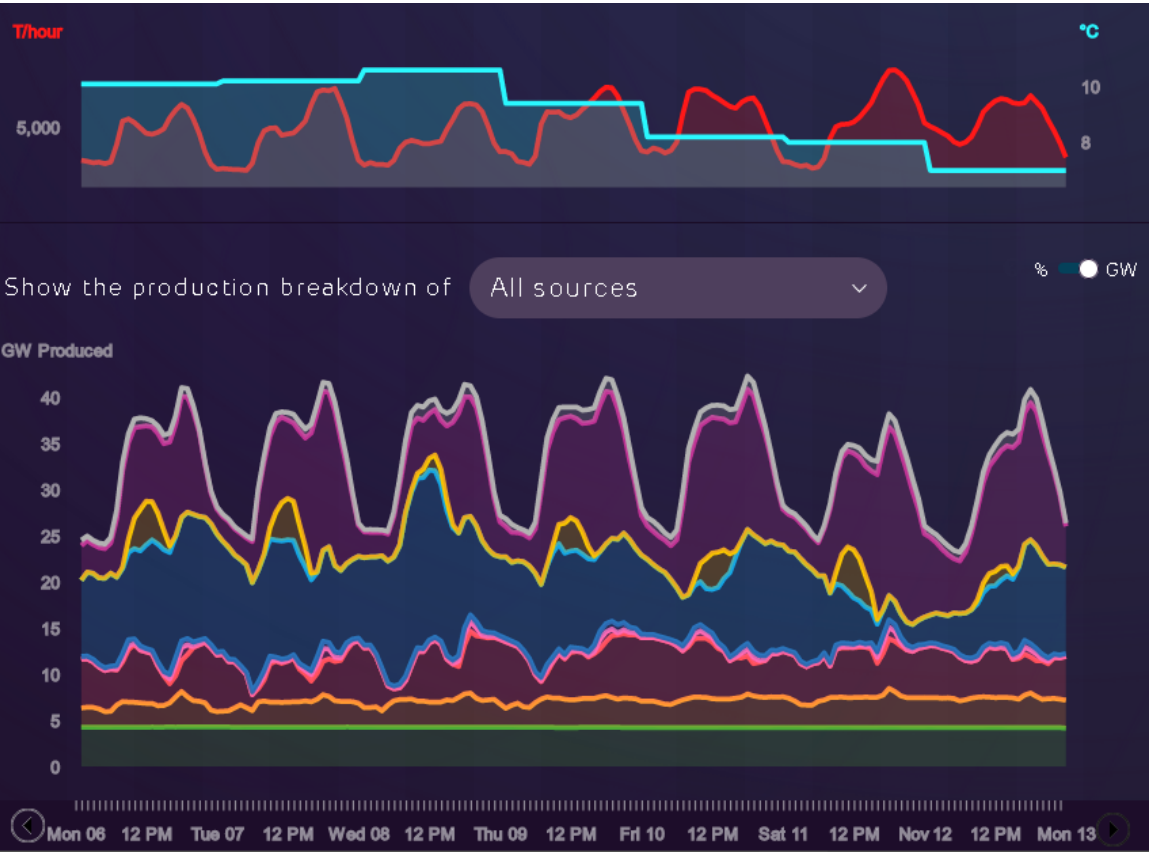
Week from 6th Nov 2023

- Coal is back (marginally)
- Very little solar in winter
- Much more wind
- Some more imports

electricinsights.co.uk



Coal	0.93GW	2.75%
Gas	9.25GW	26.78%
Solar	0.75GW	2.01%
Wind	9.53GW	29.14%
Hydro	0.44GW	1.30%
Pumped Storage	0.21GW	0.55%
Imports & Exports	4.91GW	15.35%
Biomass	2.92GW	8.93%
Nuclear	4.23GW	13.19%

World's largest offshore windfarm project starts powering UK grid

First of 277 turbines goes into operation at site that will produce enough energy for 6m homes

The project will produce 3.6GW of power, enough for 6m homes, when it is completed in 2026. Photograph: Dogger Bank

The first turbine to be completed in a project to build the world's largest offshore windfarm, in the North Sea, has begun powering British homes and businesses.

Developers confirmed on Monday that Dogger Bank, which sits 70 nautical miles off the coast of Yorkshire, started producing power over the weekend as the first of 277 turbines was connected to the electricity grid.

The Guardian
Newspaper of the year

Alex Lawson

Mon 9 Oct 2023 22.30 BST

Dogger Bank will be 3.6 GW composed of three 1.2 GW sections.

Joint venture between SSE and Equinor

Around £9B cost in total

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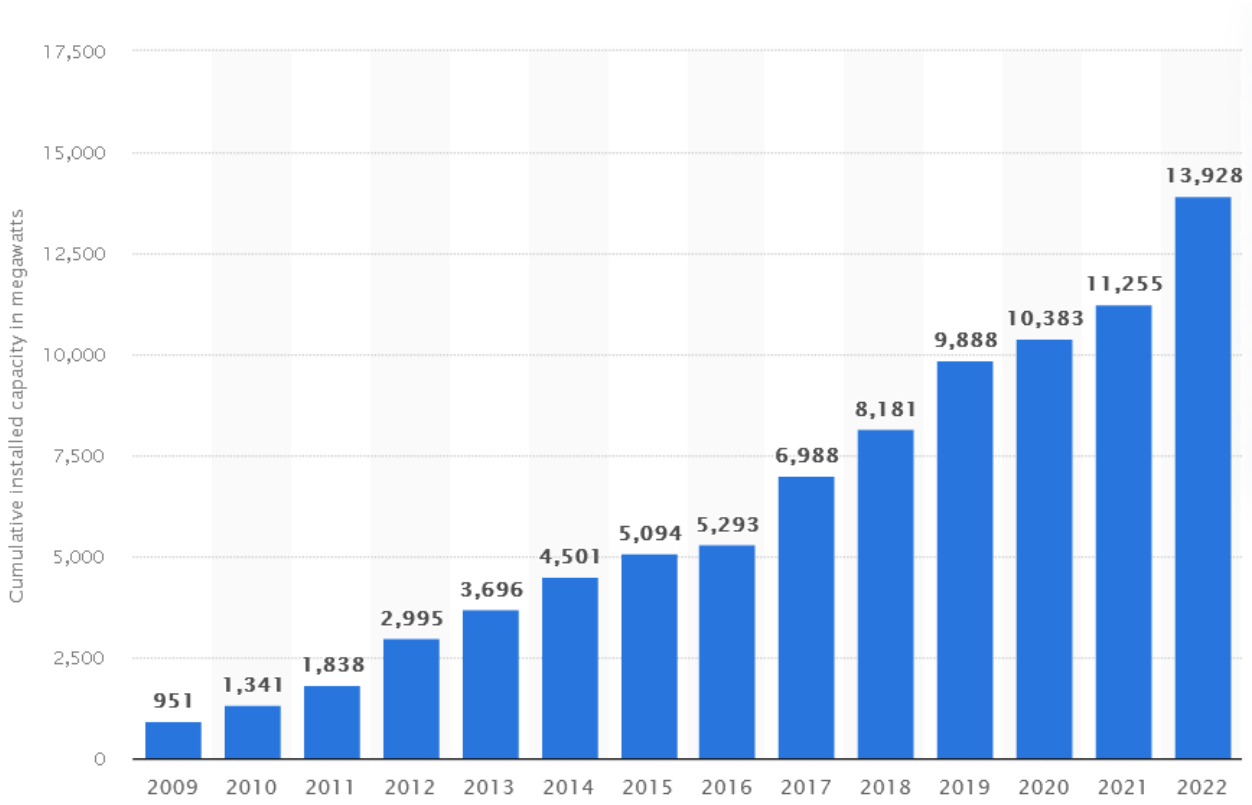
Offshore wind power capacity



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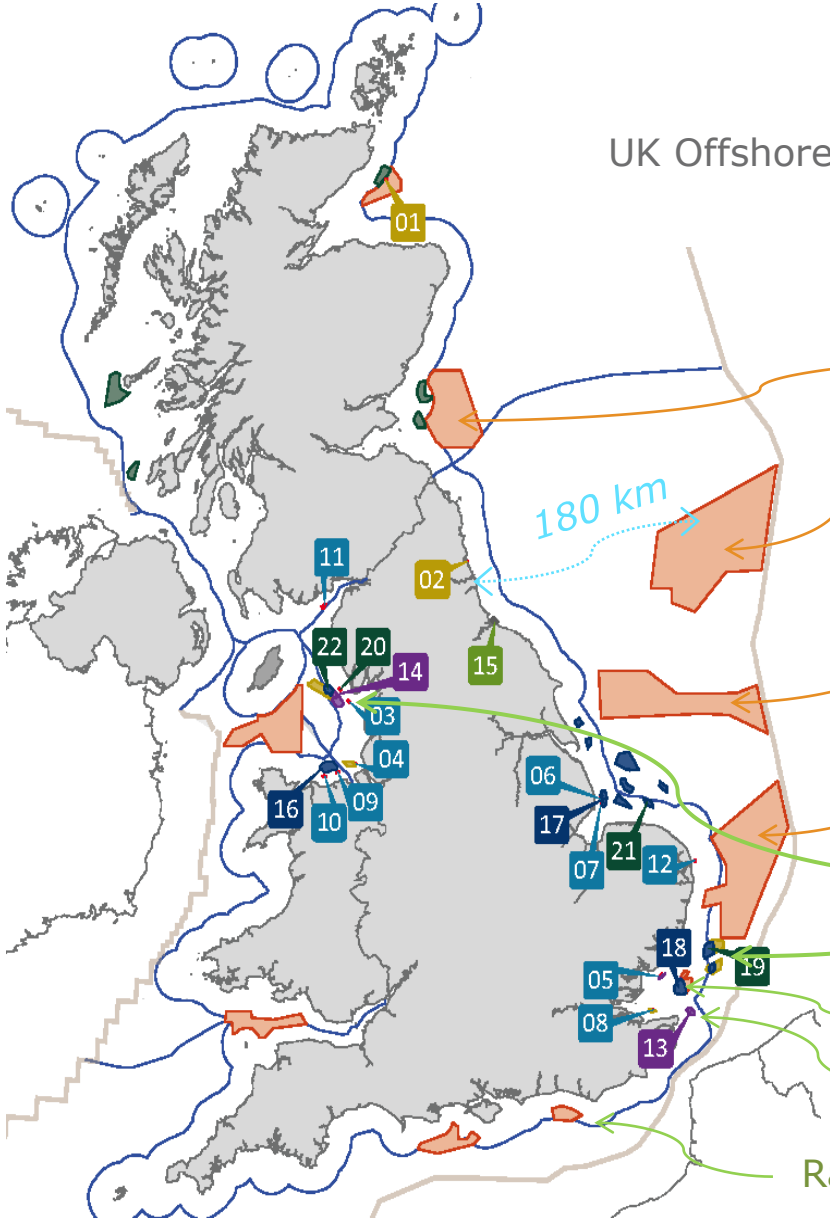
Offshore Wind Power Projects



UK Peak demand: 60,000 MW
UK Offshore installed wind capacity: 14,000 MW
UK Offshore wind under construction or approved: 11,000 MW
UK Onshore installed wind capacity: 15,000 MW

Firth of Forth – 1,075 MW – Construction

Dogger Bank – 4,800 MW – Construction

Hornsea 1– 1,200 MW – Operational
Hornsea 2– 1,800 MW – Submitted

East Anglia 1– 700 MW – Construction
East Anglia 2 and 3 -2,100 MW - Approved

Walney Extension – 660 MW - Operational

Greater Gabbard – 504 MW - Operational

London Array – 640 MW - Operational

Thanet – 300 MW - Operational

Rampion – 400 MW - Operational

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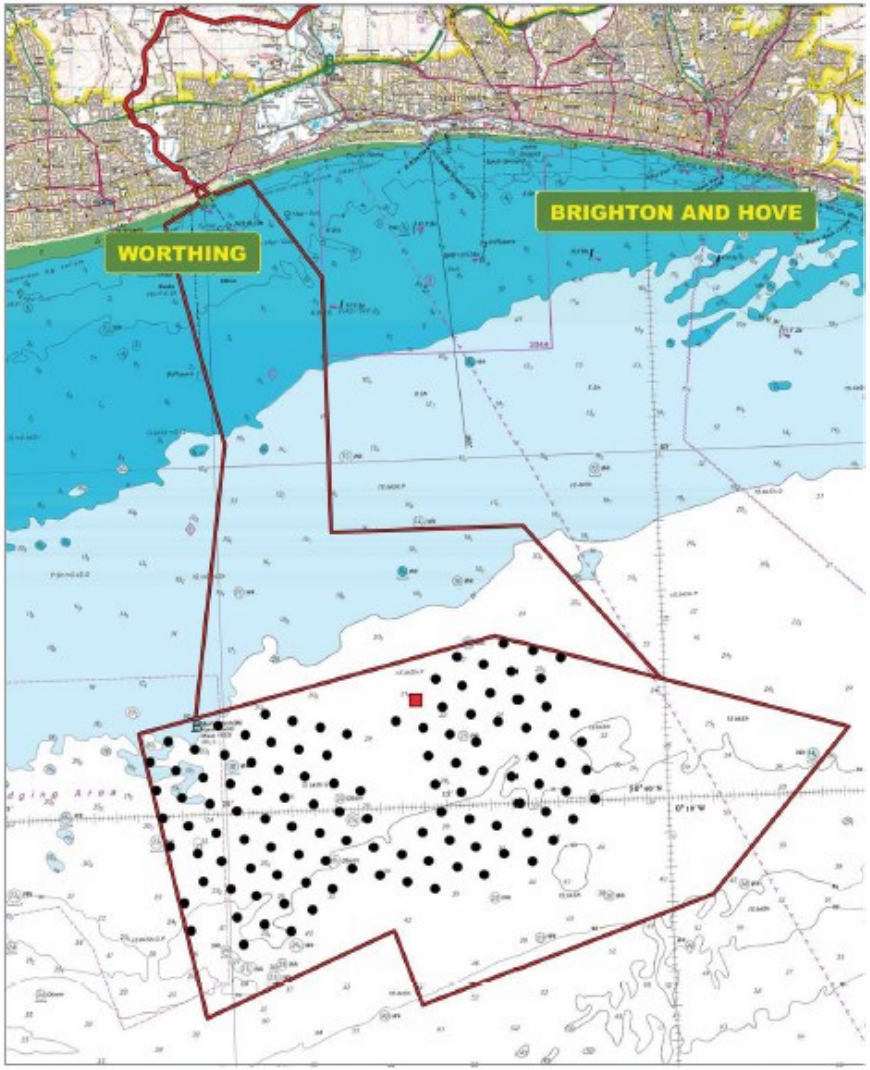
Rampion Offshore Wind Farm Completed 2018



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116 × 3.45 MW turbines
Hub height of 80 m
Blade diameter of 112 m
Total capacity of 400 MW

12 × 33kV array cables
9 or 10 turbines per array

A 3,000 ton offshore substation to raise voltage for 150 kV cables to shore

Typical energy yield is 1.4 TWh per year which implies load factor of 40%.

https://www.rampionoffshore.com

BRIGHTONDIVER.COM

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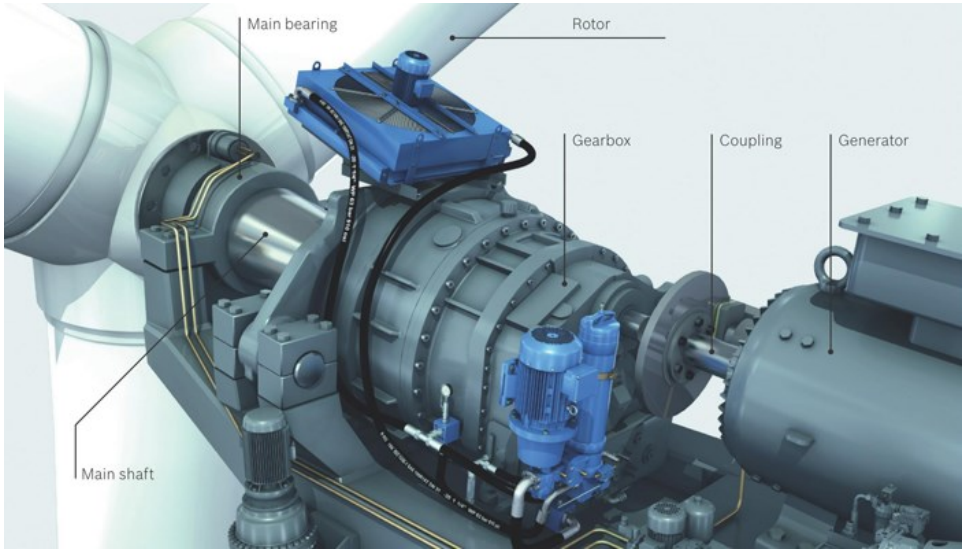
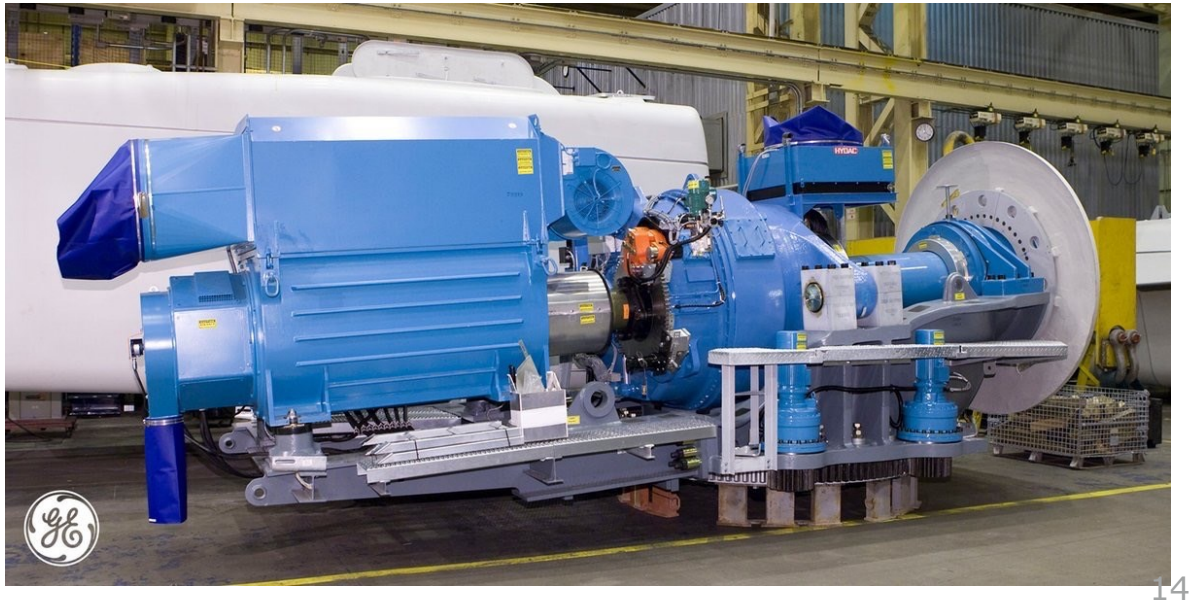
Internal view of a Nacelle





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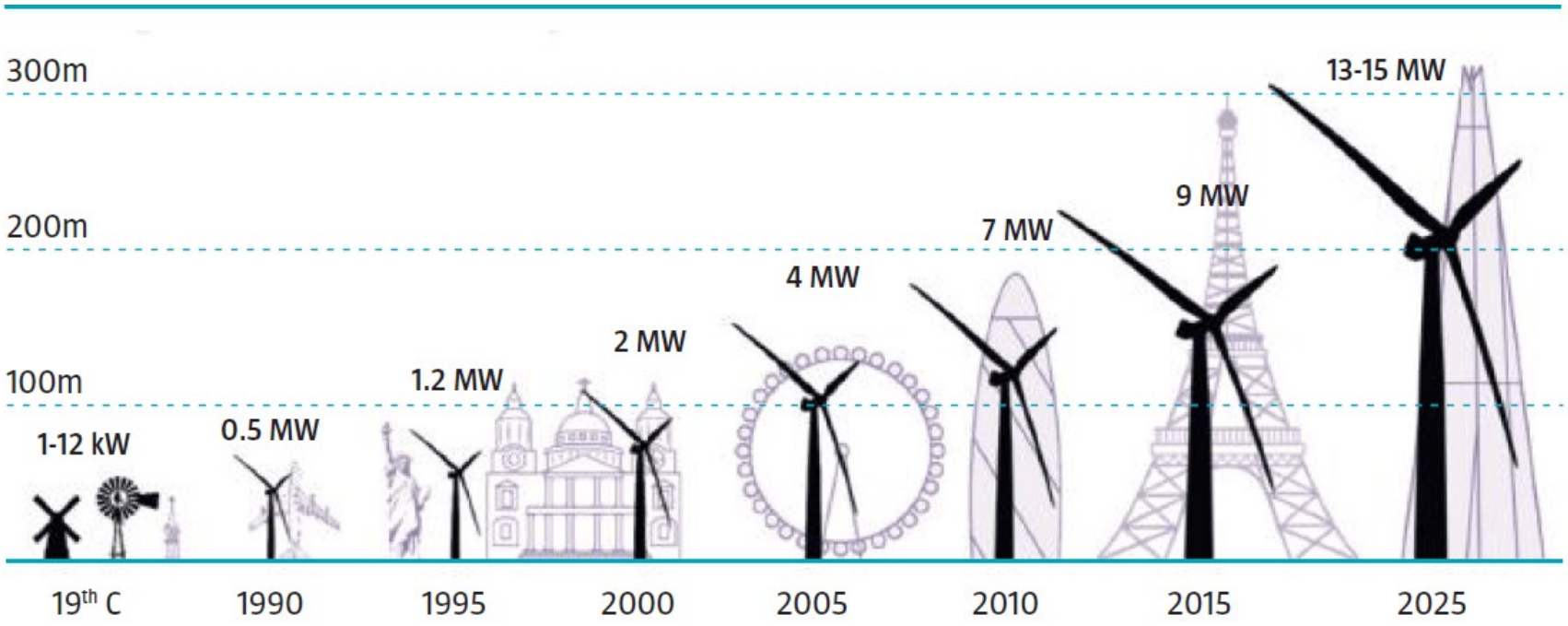
Trend in Wind Turbine Size

Firth of Forth will use 10 MW turbines
Dogger Bank will use 12 MW turbines



https://northsearegion.eu/northsee/e-energy/future-energy-industry-trends/

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Lots of R&T behind the wind energy revolution

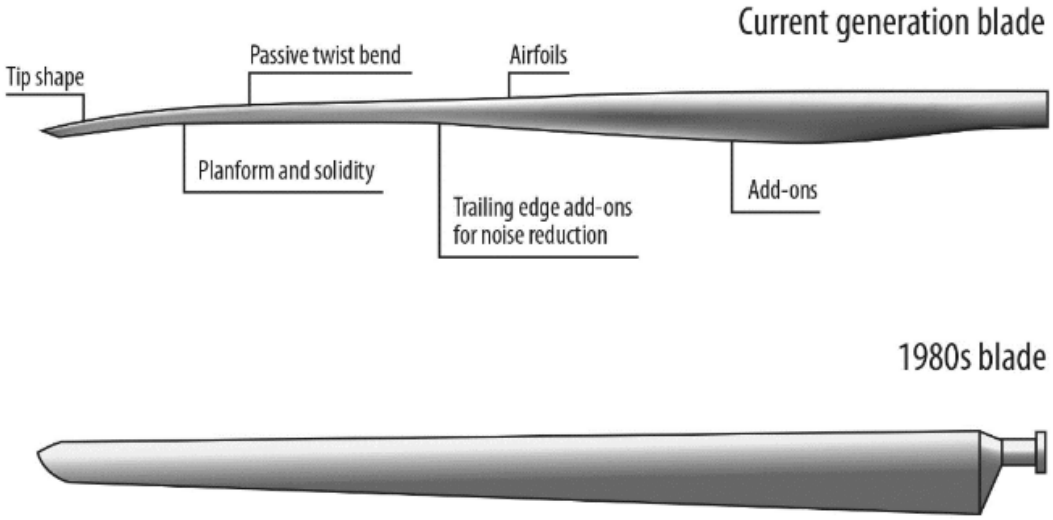

Fig. 2. Wind turbine blade innovation comparing a modern commercial blade (top) and a commercial blade from the mid-1980s (bottom) scaled to the same length. The modern blade is 90% lighter than the scaled 1980s technology. Source: National Renewable Energy Laboratory (NREL) based on a concept by Kenneth Thomsen (Siemens Gamesa).

Veers et al., Science (2019)

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Lecture Plan

Heading	Topics	Duration	Lecture
Intro to wind	Growth of wind and some pictures	20 mins	1
Energy Yield	Power curve; Wind Histogram; Load Factor	30 mins	1
Blade Aerodynamics	Airflow Components; Drag and lift; Rotation and Bending,	40 mins	1
Betz Limit	Stream tubes; Derivation	20 mins	1
Coursework	Describe task and show maps	10 mins	1
Outline of Turbine Control	Cp curves and tip-speed ratio; two control regions; optimal torque equation	30 mins	2
Electrical Generators	Full-converter and DFIG options; Drive train efficiency and control	30 mins	2
Wakes and Farm Layout	Wake examples; wind rose; turbine spacing; collector network	20 mins	2
Offshore Wind	UK examples; cable characteristics; HVDC	20 mins	2