THE OXFORD INSTITUTE FOR ENERGY STUDIES

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UNIVERSITY OF OXFORD

Modelling Two Power Plants

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The Economics of Energy Corporations (2)

Revision

Change the WACC in the model

- Corporate borrowing rate – 6.5%
- Company Beta – 1.47
- Debt:Equity – 40:60

- What is the new WACC?

Change the model

Oil price 25% lower

Capex 50% higher

Production 25% higher

What are the results?

What is the breakeven oil price?

Outline of the course

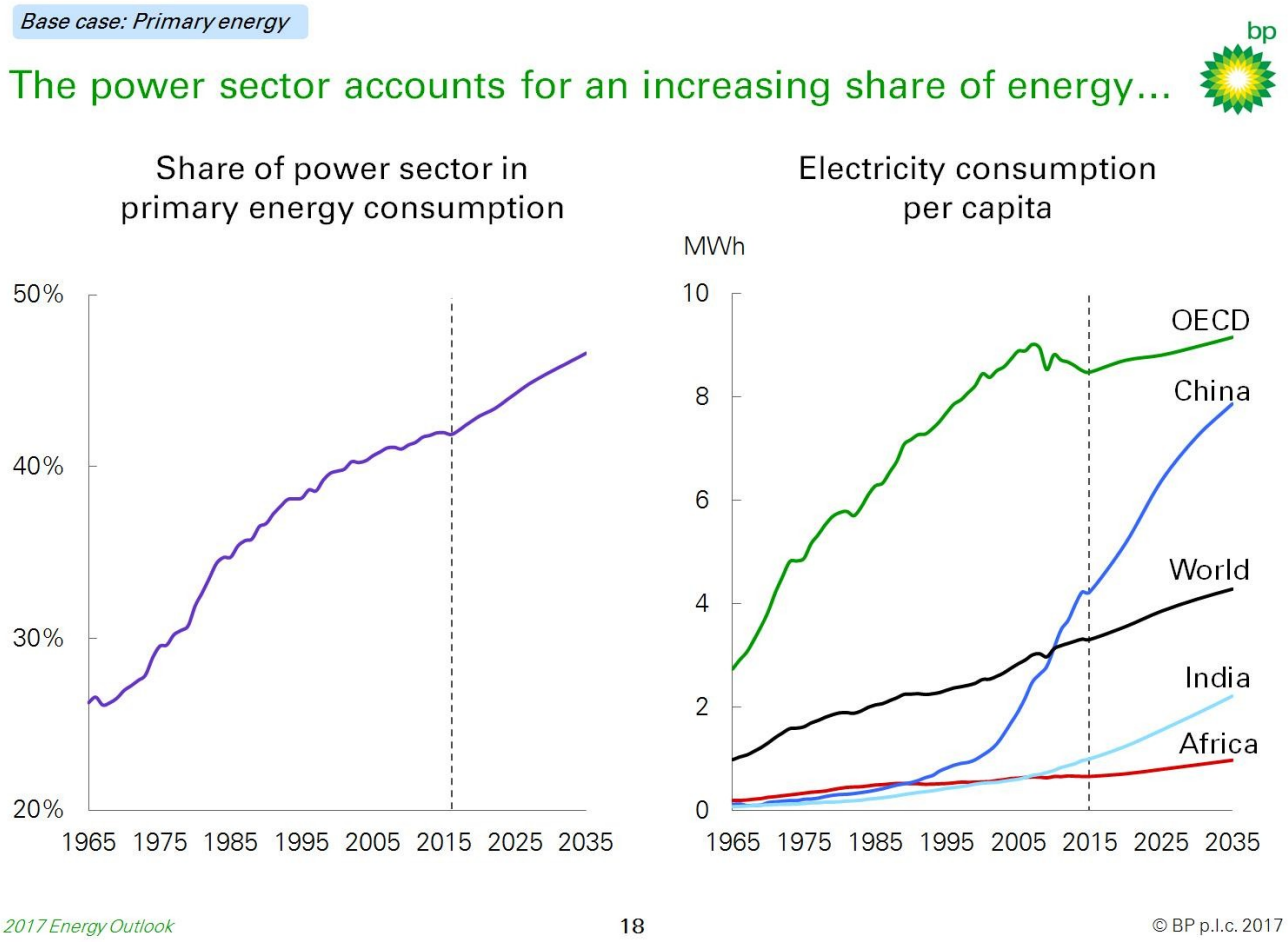
Overall objective – understand how senior management use economic models to make investment decisions

1. Introduction to key themes in the global energy market
2. Introduction to financial modelling as a management tool
    1. Understanding some key concepts
3. Starting a model for a shale oil and gas field – revenues and prices
4. Inputting the costs – capital expenditure, operating costs and taxes
5. Calculating a discounted cashflow
    1. Why is it important
    2. How is it used to make decisions
6. **Power plants – a gas-fired CCGT and a wind farm**
7. Testing the investment decisions: running some numbers under different assumptions
8. Answering your questions

A Combined Cycle Gas Turbine

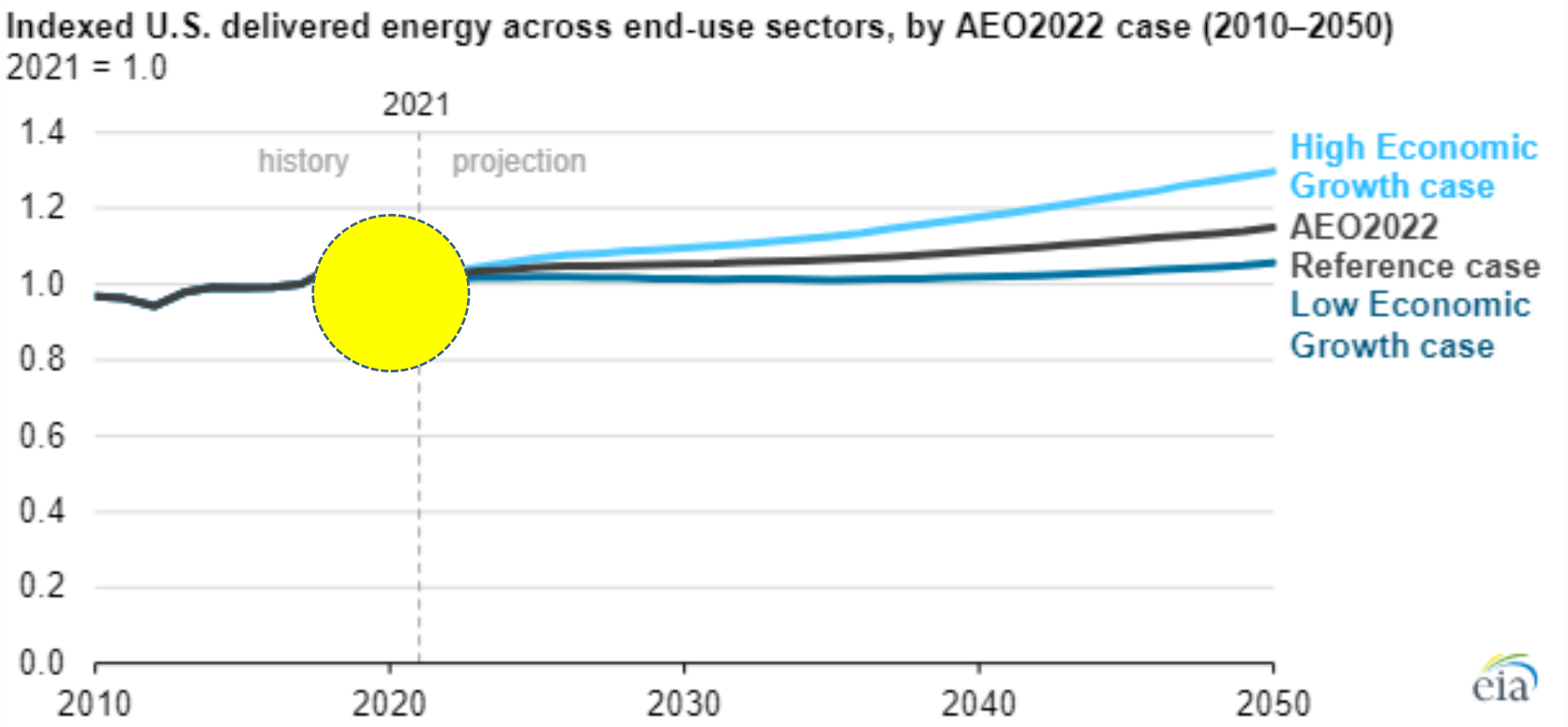
- Power sector accounts for a huge share of gas demand in many regions
- Provides base load power on which other demand is built
- Combined-cycle gas turbines (CCGT) are relatively cheap and efficient, and also provide vital flexibility
- The economics are based on low capital and operating costs and the price of the key input – gas supply
- It is also very important to consider how much the plants run – the more they operate the better their commercial outcome

Electricity consumption is set to rise



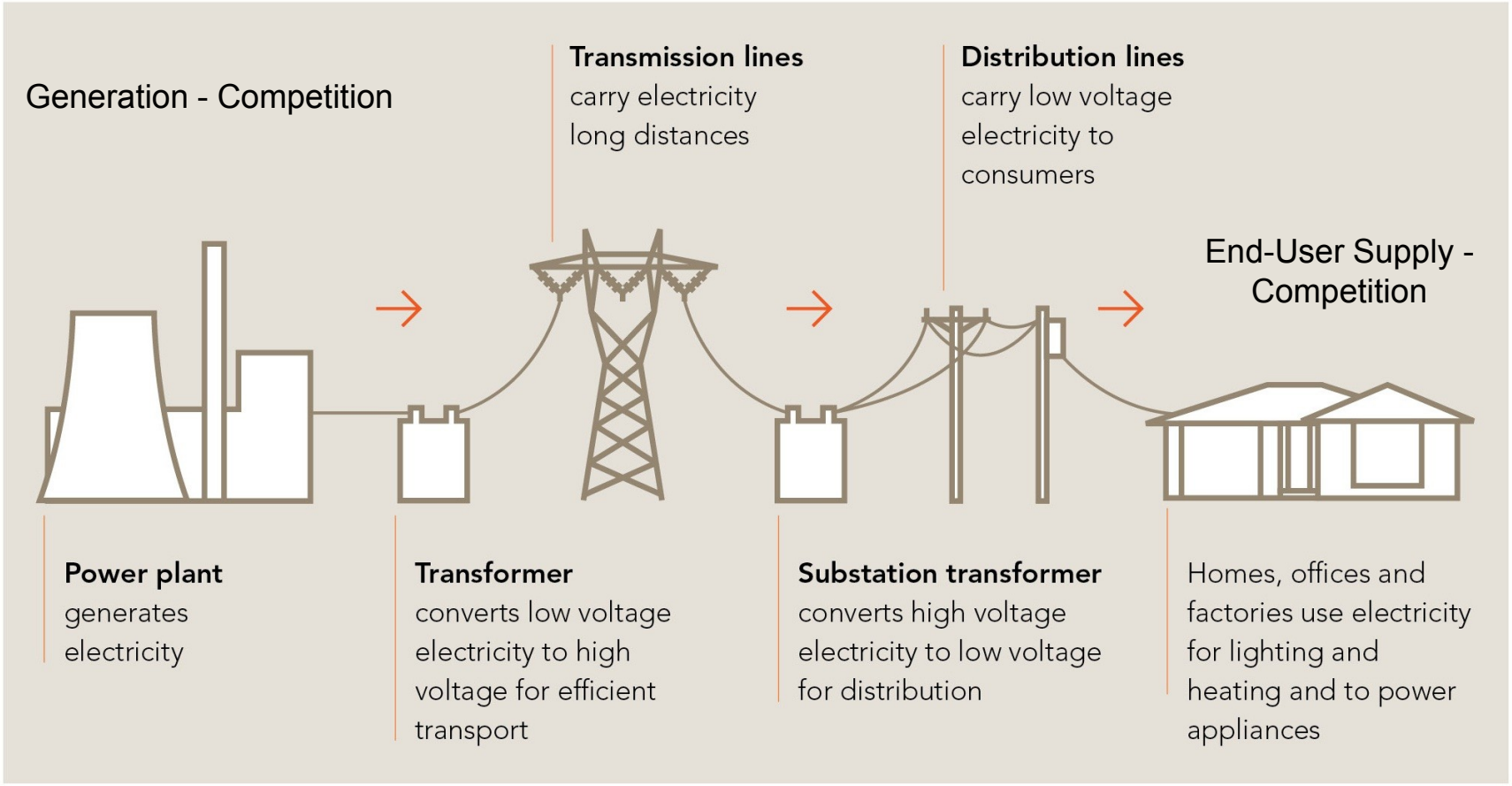
- Electricity demand is likely to rise as part of a decarbonisation strategy
- As a result, the focus of the energy economy will be on how power stations are fuelled, with the assumption that renewables will grow
- Key question for fossil fuels – how fast will the decline be?

US electricity consumption forecast



- Covid-19 impact and recovery followed by steady growth

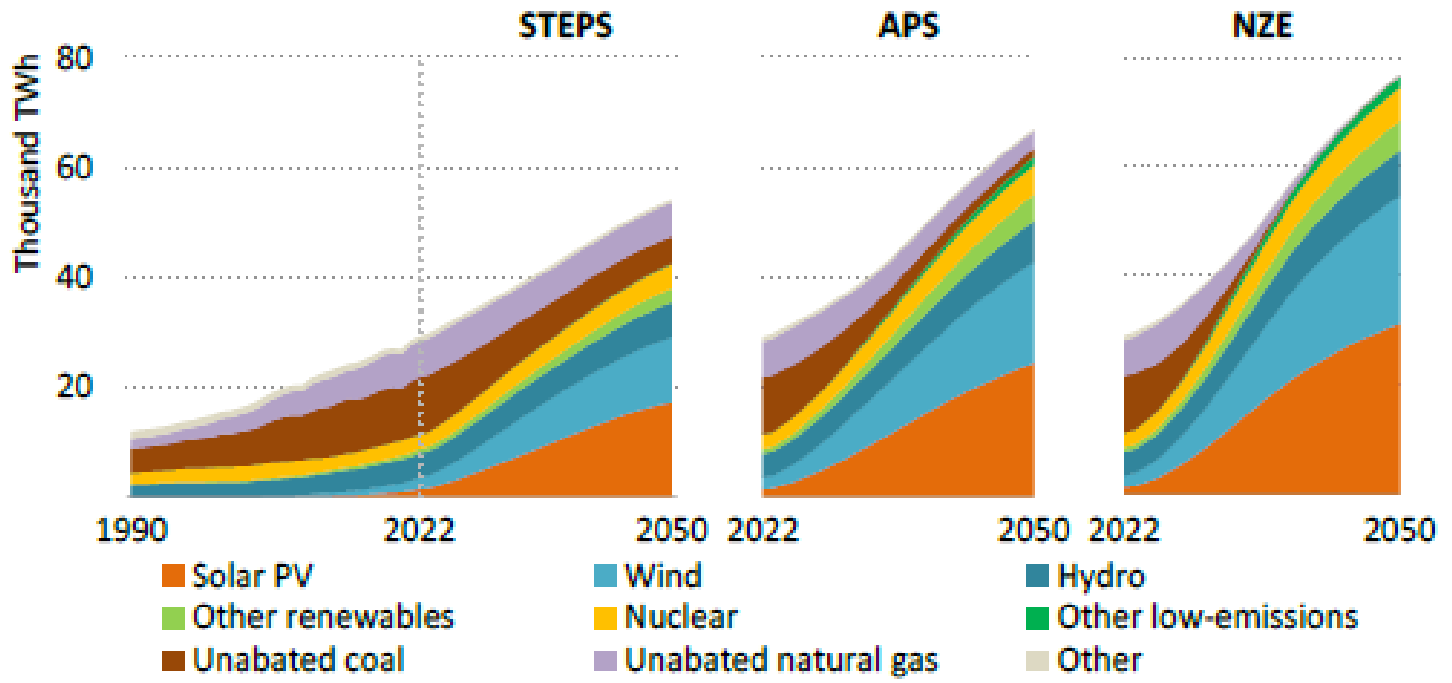
The Electricity Sector Value Chain



- Electricity sector is a mixture of regulated and unregulated segments
- As renewable energy is introduced, and as demand patterns change, the complexity for energy companies in all parts of the chain increases

Renewables will increasingly dominate the power sector

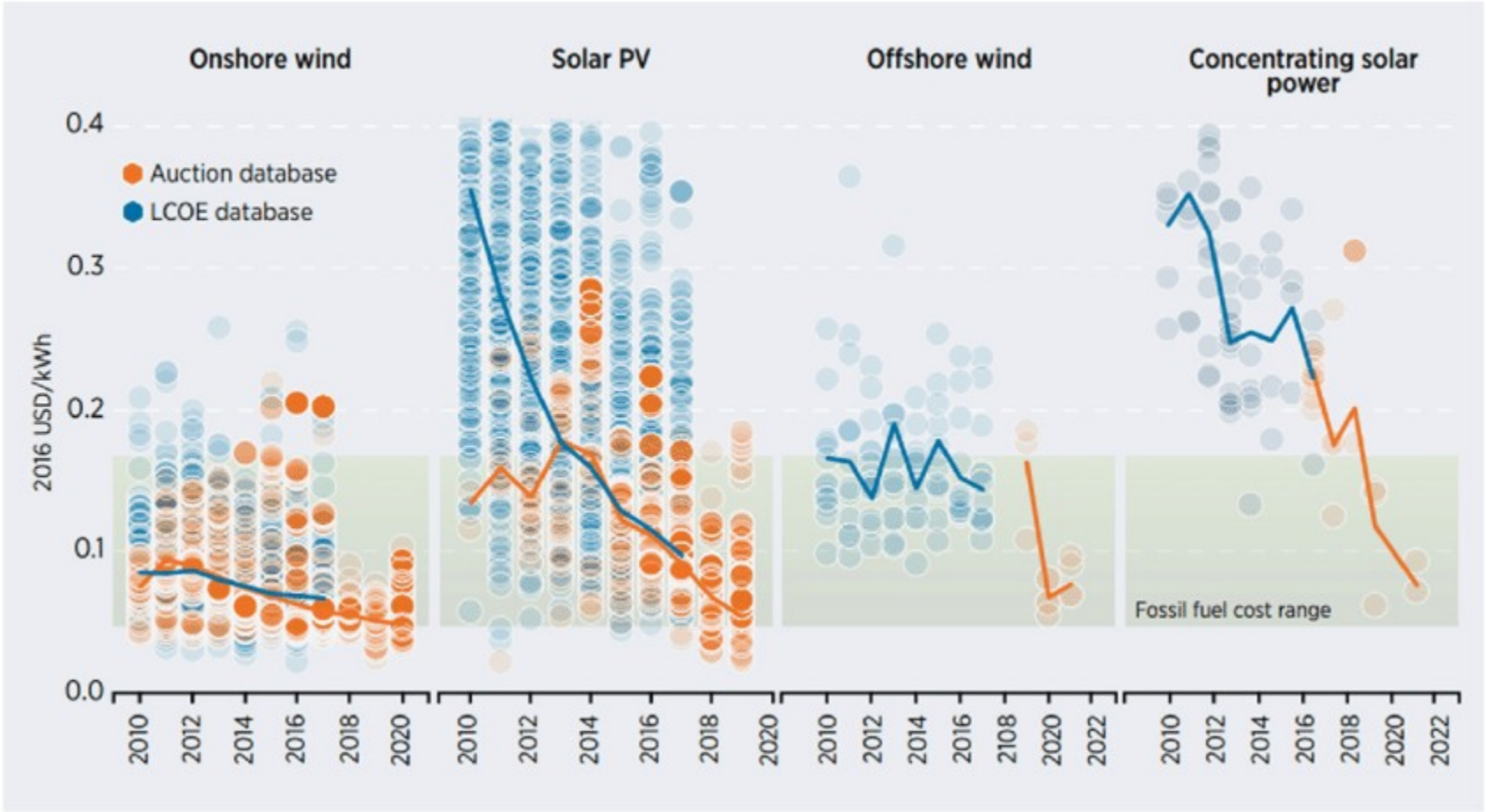
Figure 3.15 ▷ Global electricity generation by source and scenario, 1990-2050



Renewables outpace electricity demand growth to 2030 in the STEPS, leading to a peak in coal-fired power in the near term though announced pledges call for faster declines

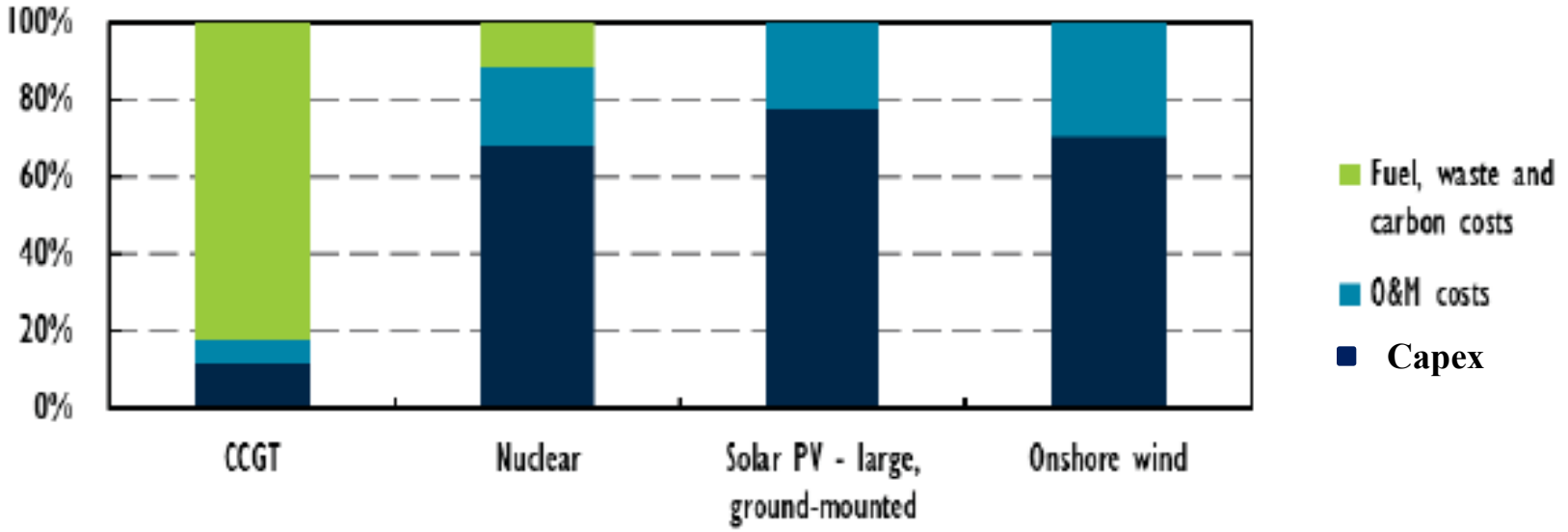
Notes: TWh = terawatt-hours. Other low-emissions include fossil fuels with CCUS, hydrogen and ammonia.

Outlook for costs based on auctions



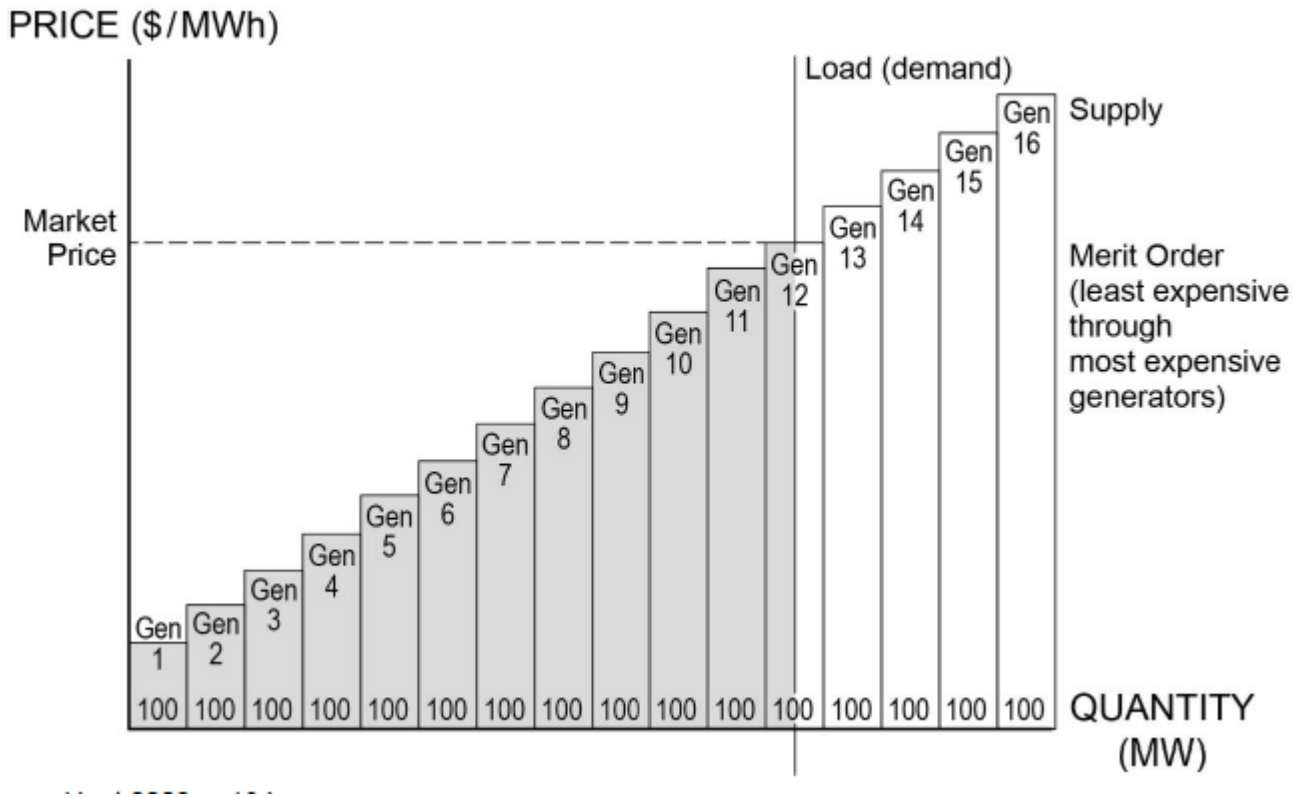
- The cost of renewable energy is falling fast, and is now inside the range of fossil fuel generation
- Once subsidies are no longer required, a tipping point will be reached
- Key question revolves around the cost of intermittency and the need to provide back-up capacity

Breakdown of levelised costs for different power technologies



- The cost breakdown of renewables is very different from most fossil-fuel and nuclear technologies
- High capital costs necessitate government support via subsidies to ensure a rate of return for the developer
- Low operating costs mean that short run marginal costs are very low, so that a low price can be bid for dispatch
- Effectively, when the wind blows strongly or the sun shines brightly the price of excess renewable energy can be zero or even negative

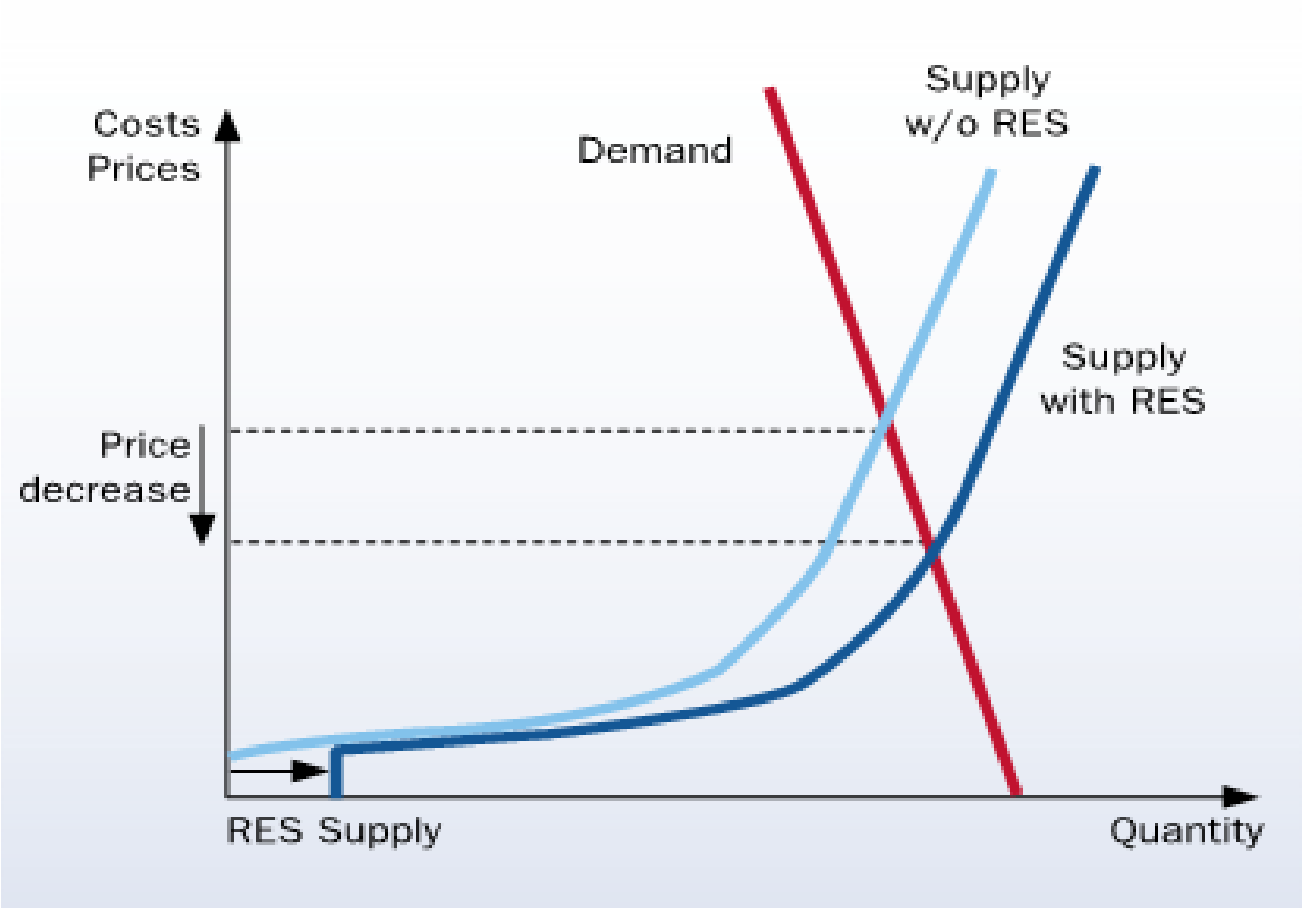
Stylised merit order for power generation



- Historically generating companies have competed on the basis of a merit order of generating costs
- The market price is set at the marginal price, which is paid to all power producers who are called upon to dispatch electricity

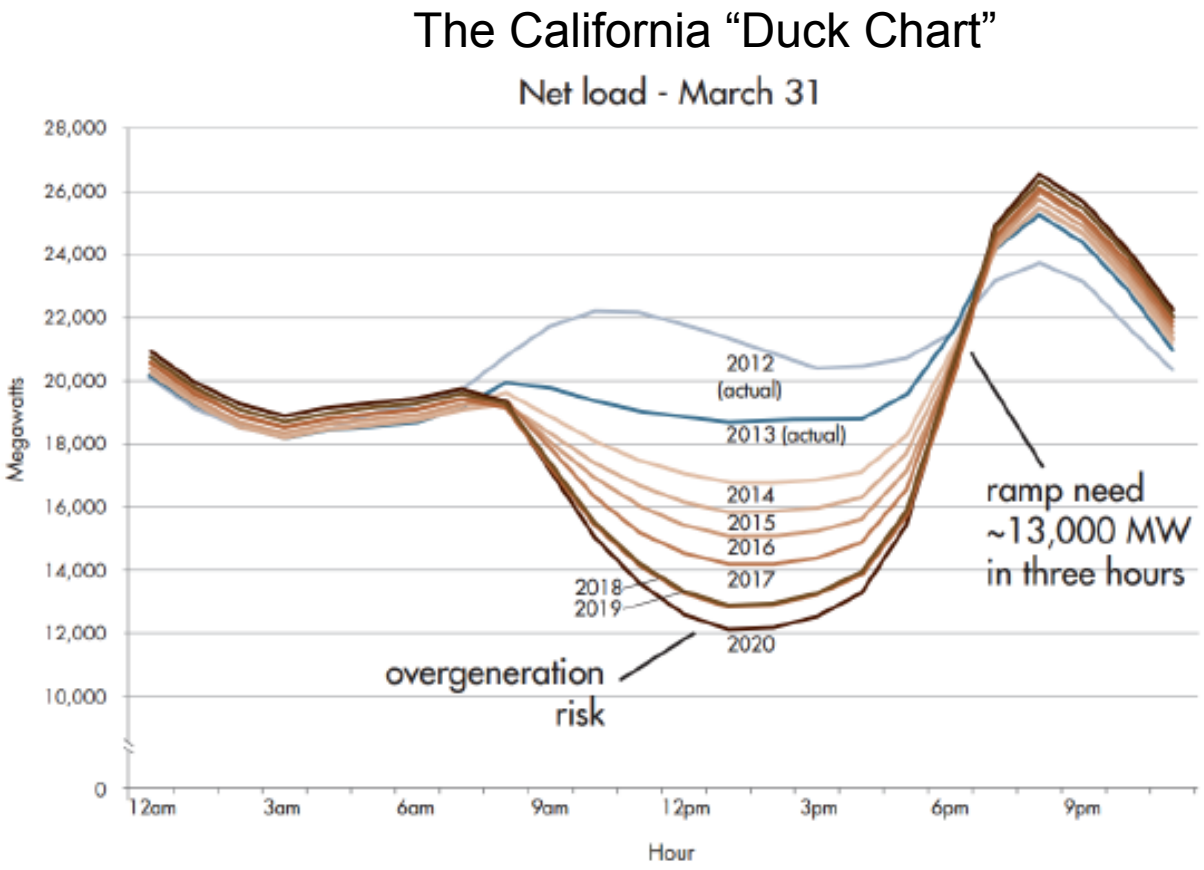
Renewables and the merit order effect

Introduction of renewables alters supply curve



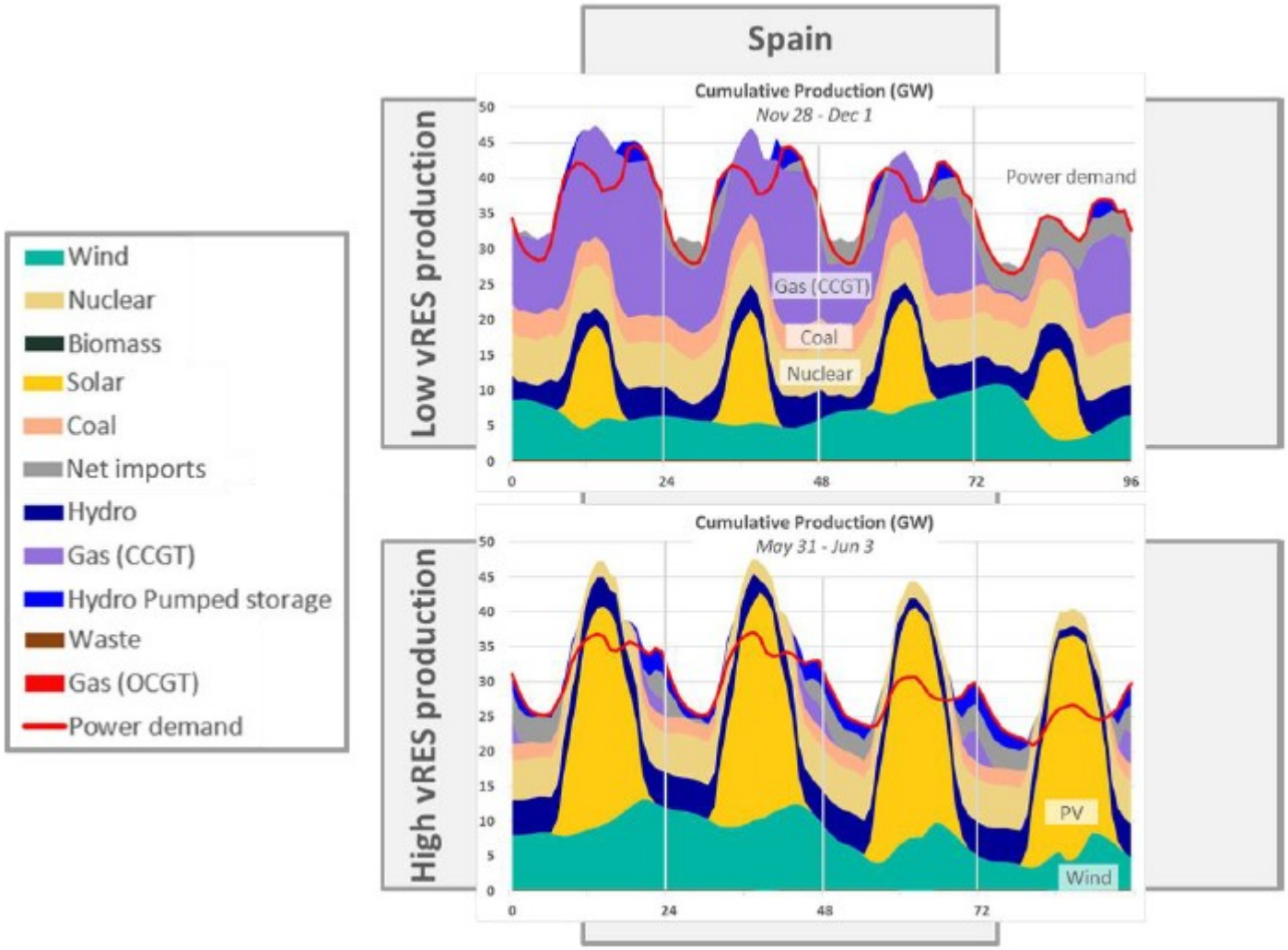
- Renewable energy has guaranteed dispatch, and so moves all higher cost supply out
- The wholesale price declines as demand is satisfied at a lower level

Renewables create over-generation risk



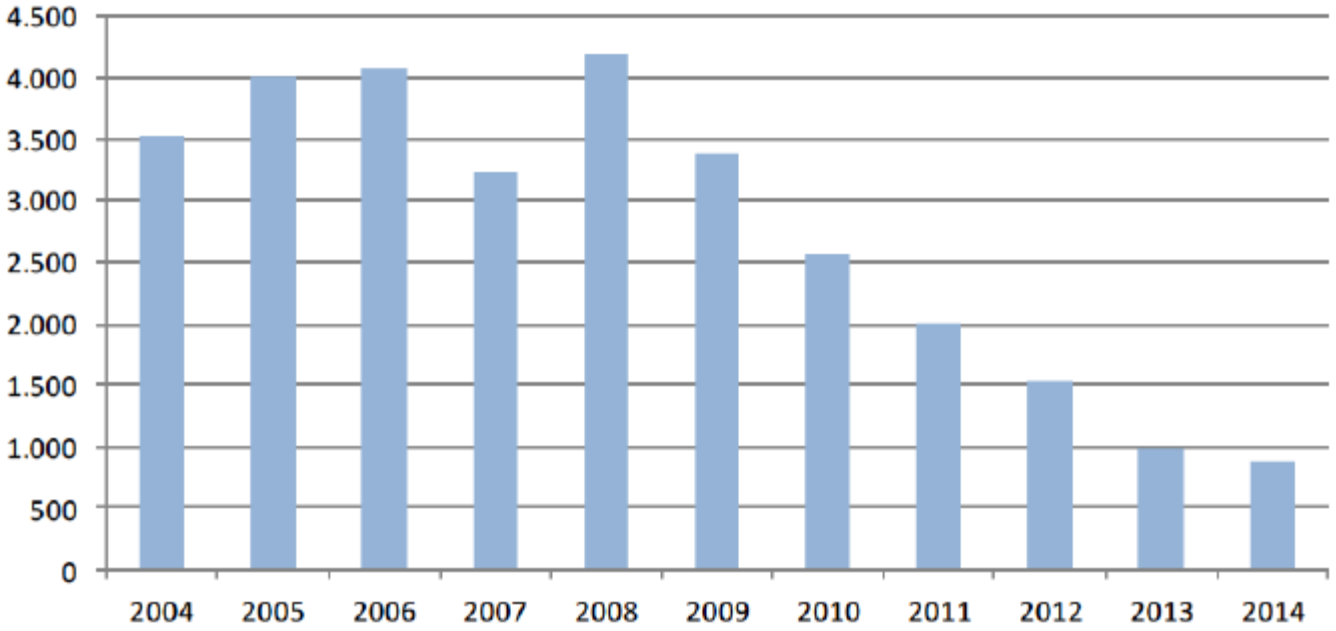
- Net load (total electricity demand less generation from wind and solar PV) varies dramatically according to weather
- As renewable generation increases, so low point gets lower, increasing the risk of having too much base load capacity
- In a worst case scenario curtailment is required, undermining project economics

The impact of renewables on fuel inputs for power generation



- Dramatic difference in fossil fuel use between seasons
- What incentives are needed to keep a fossil fuel plant open?

Hours of effective operation by Gas-Fired Plants in Spain

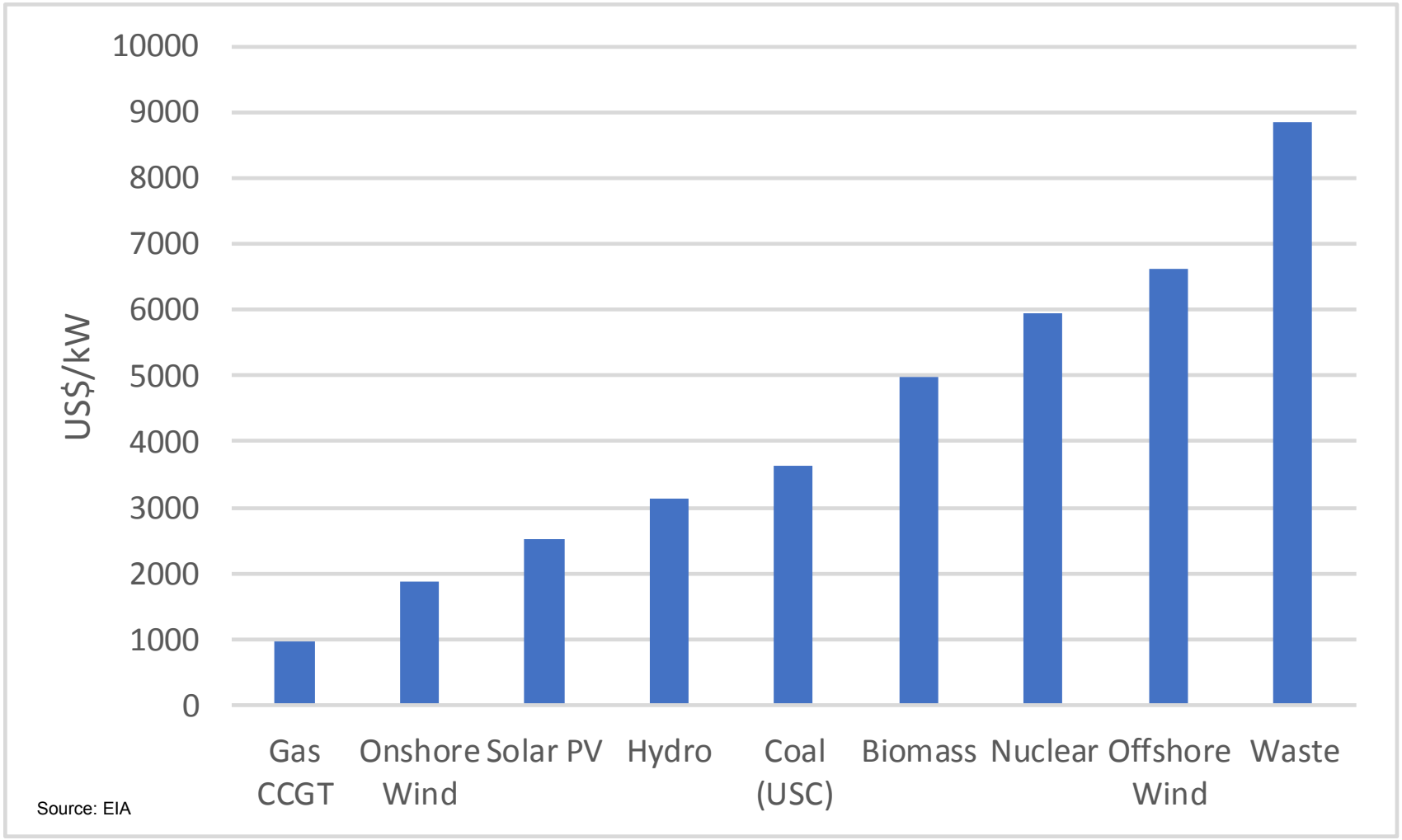


- The Spanish market provides a good example of the impact of renewables of fossil fuel generation
- Gas-fired plant utilisation has fallen to below 20% on average, and many station have been mothballed of shut down
- Low coal prices have also encouraged a renewables-coal mix, which has also been seen in Germany

Key Economic Concerns

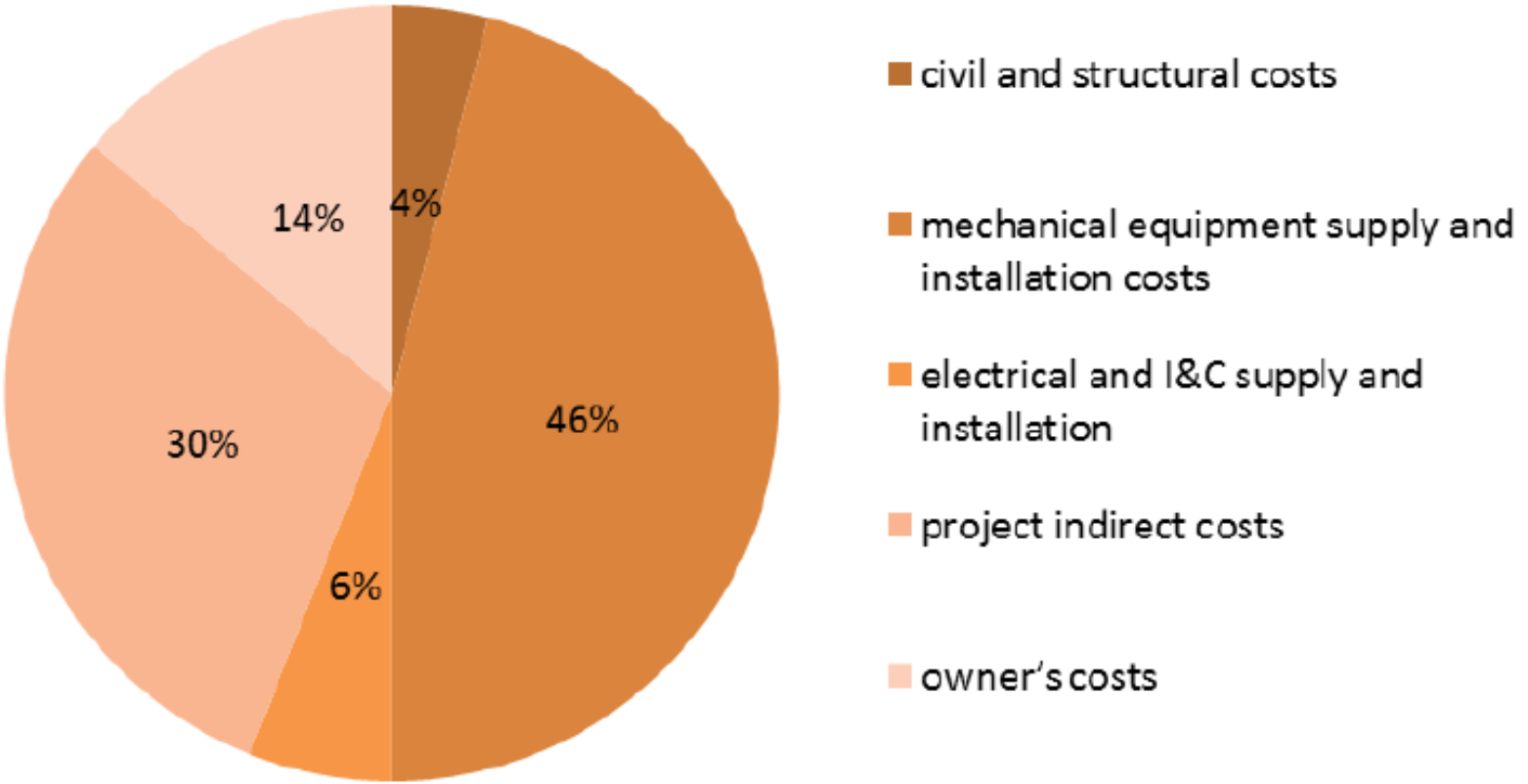
- Capital and operating costs – but these are largely known
- Electricity prices
- Input price of gas (for a CCGT)
- Carbon price
- Capacity utilisation/load factor/availability (for renewables)

Capital cost comparison



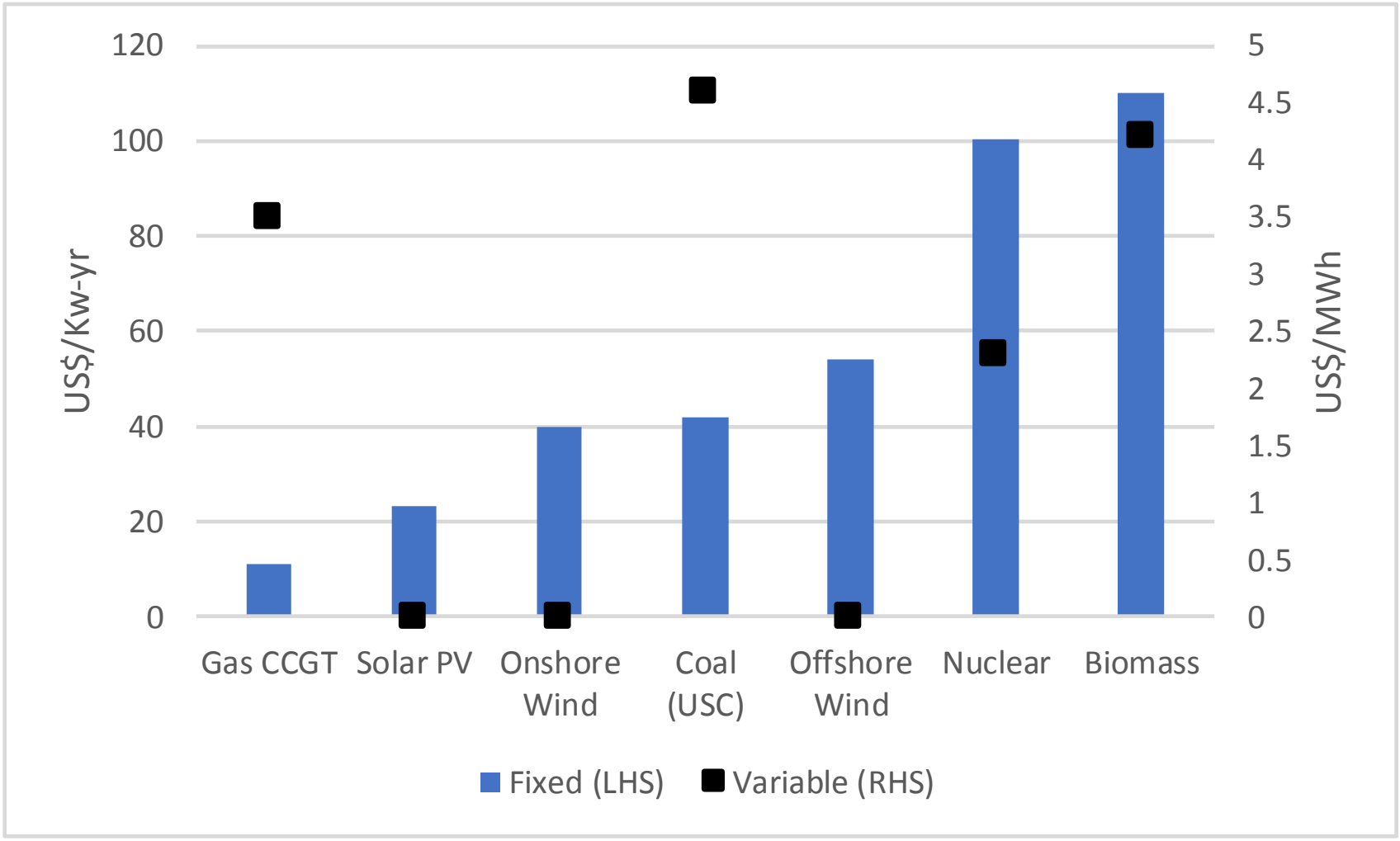
- Gas looks very cheap compared to alternatives on a capital cost basis

Breakdown of costs for CCGT



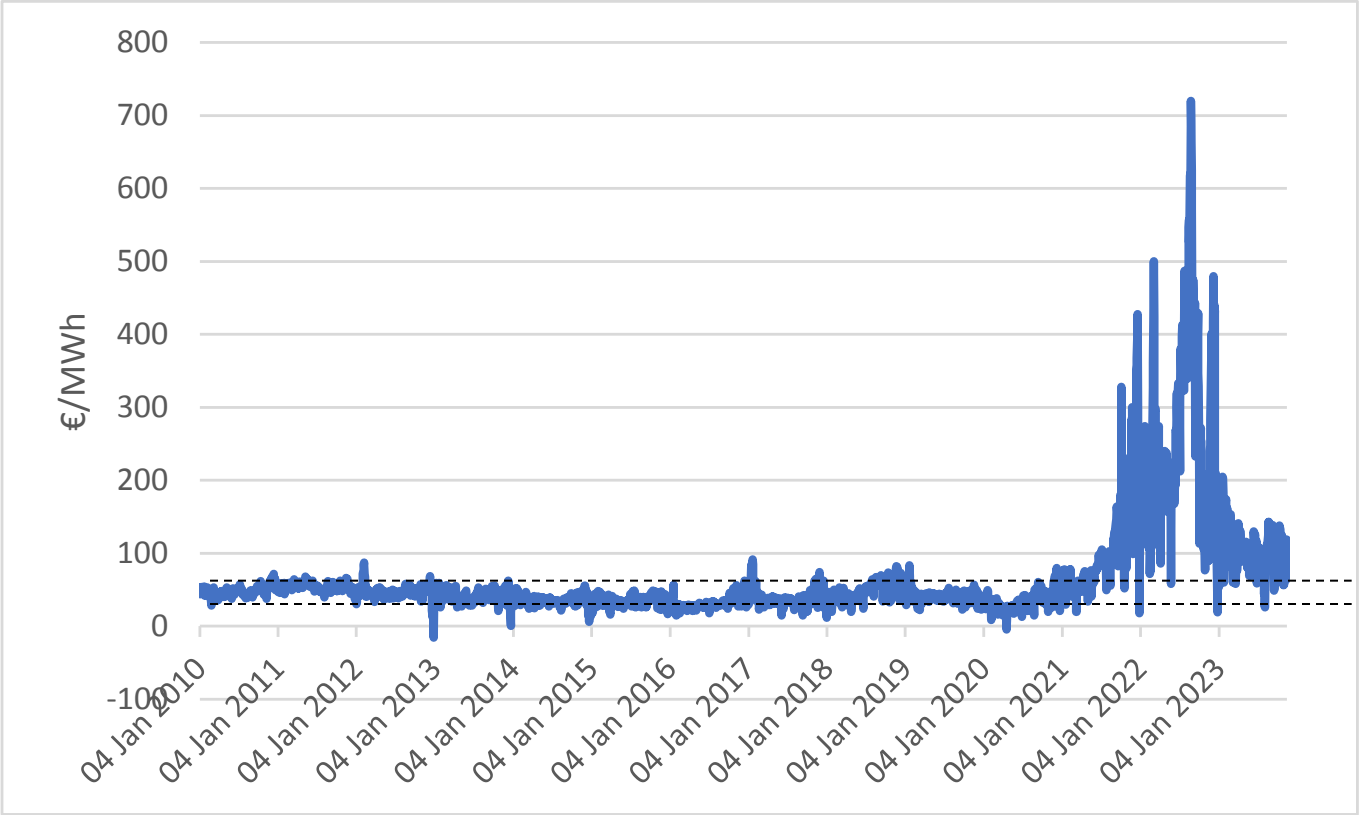
- Different contractors for each element, can costs will vary by region and level of competition

Operating cost comparison



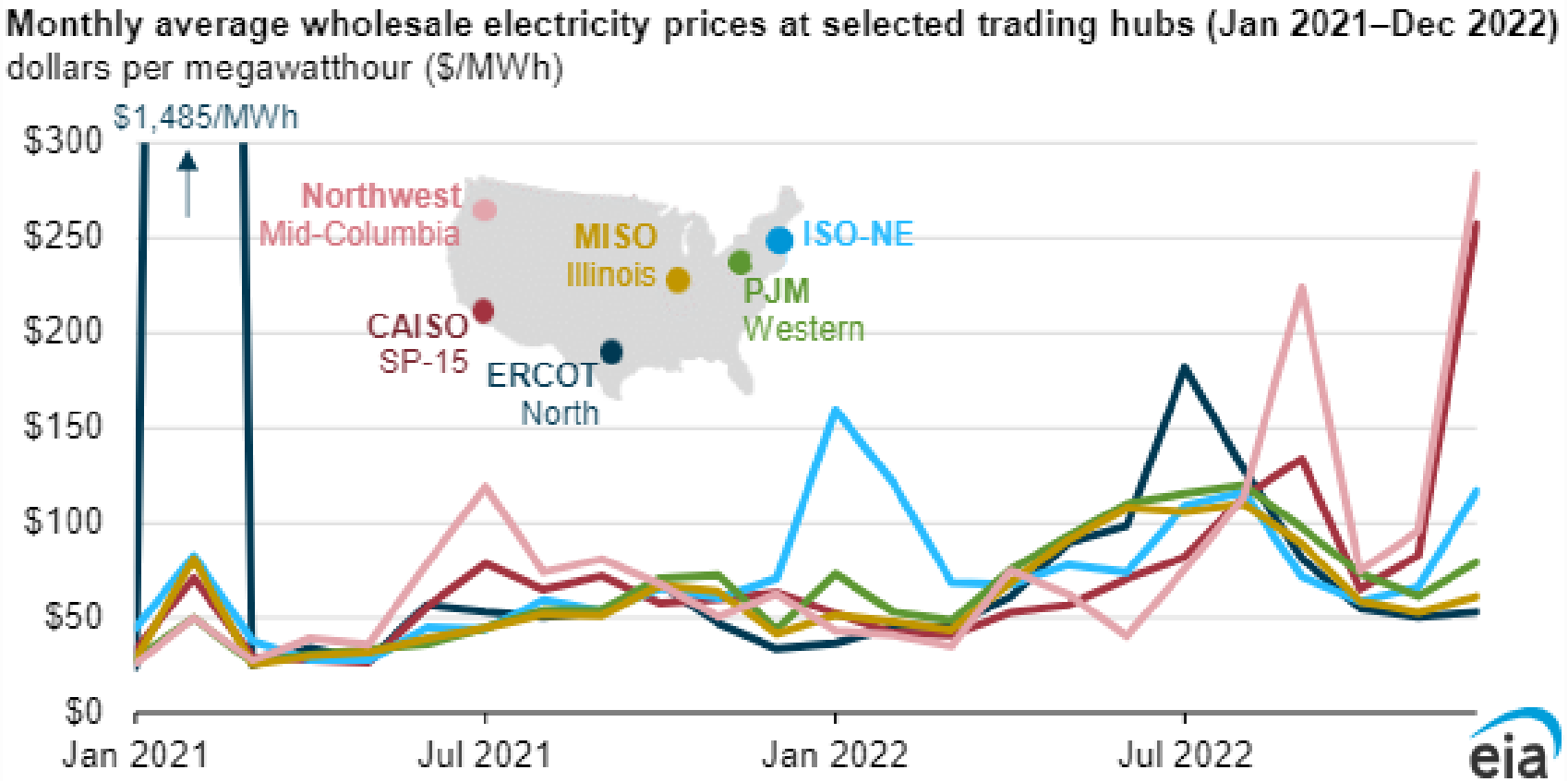
- Note difference between fixed and variable costs – renewables have no variable opex

European electricity price



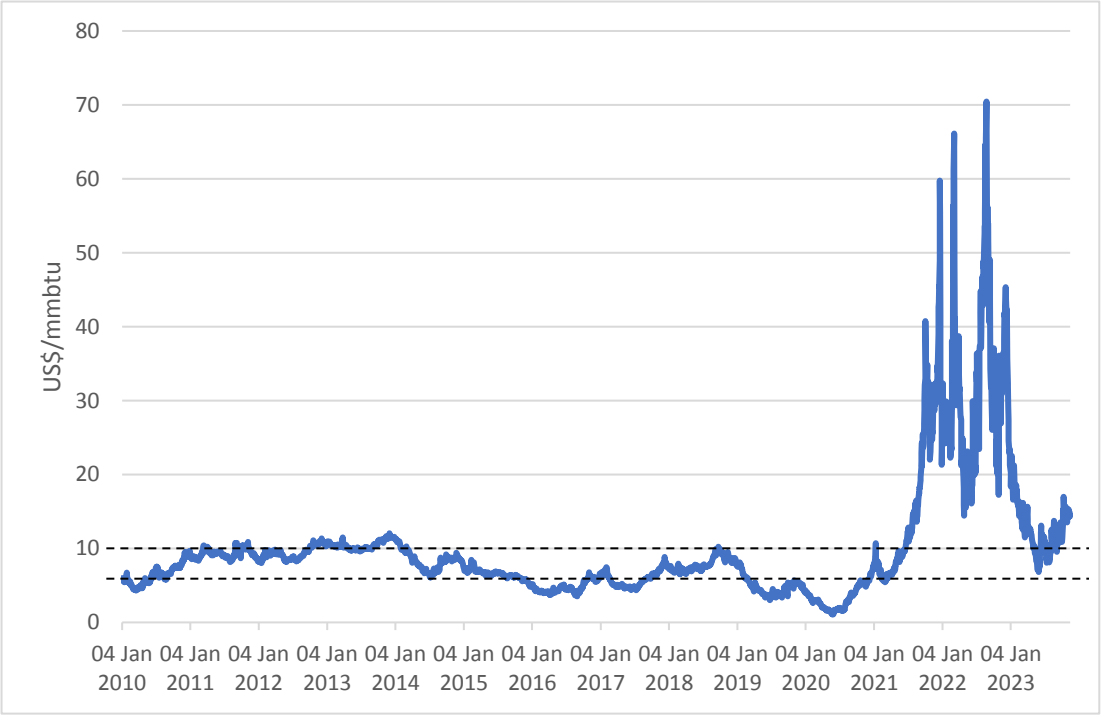
- European electricity prices were relatively stable until end of 2021
- Impact of Ukraine war on gas prices fed straight through to power market
- How do we model electricity prices going forward?

US electricity price already quite volatile



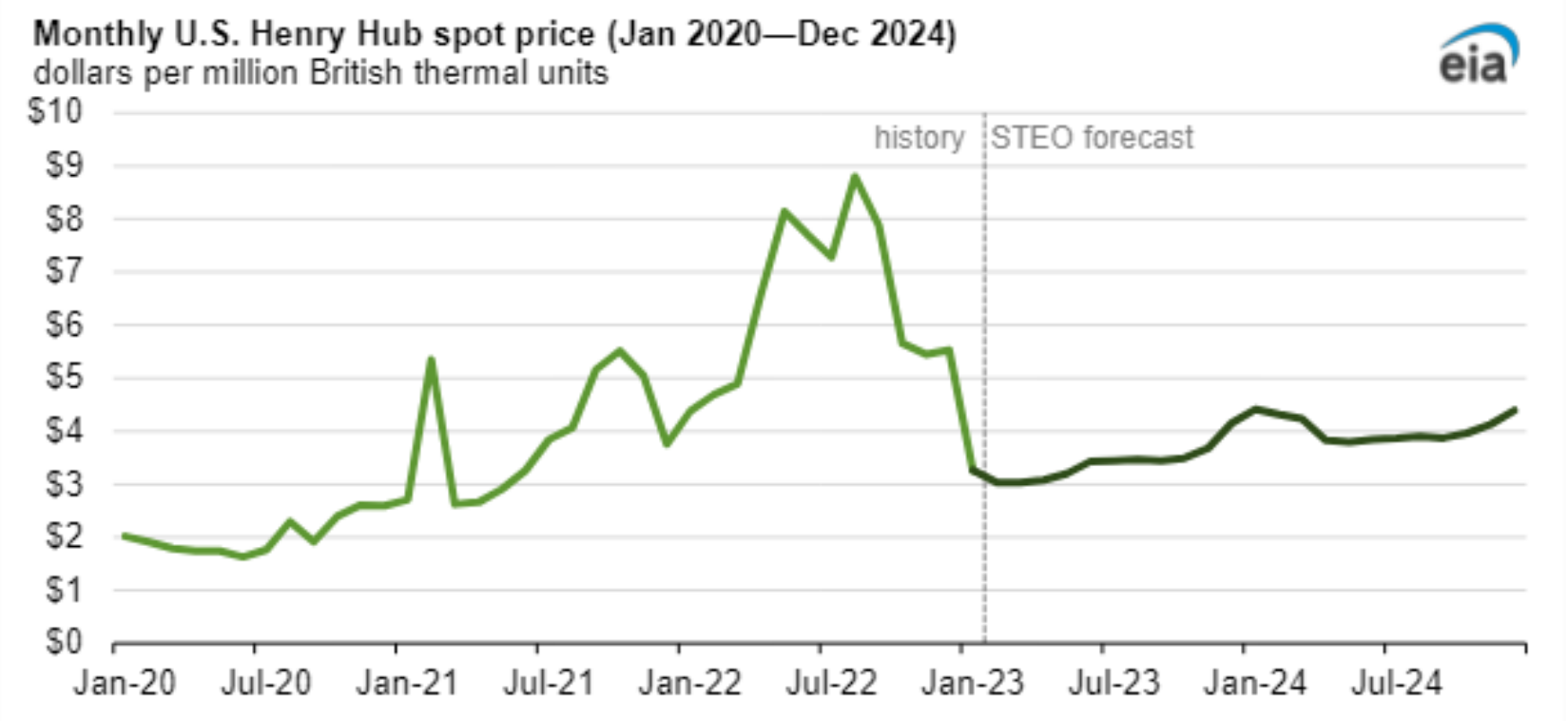
- Electricity prices in USA vary by region and source of power
- West Coast impacted by brown outs in 2022 – lack of renewable supply led to switch to high priced gas
- Elsewhere weather plays a key role in setting prices

European gas price



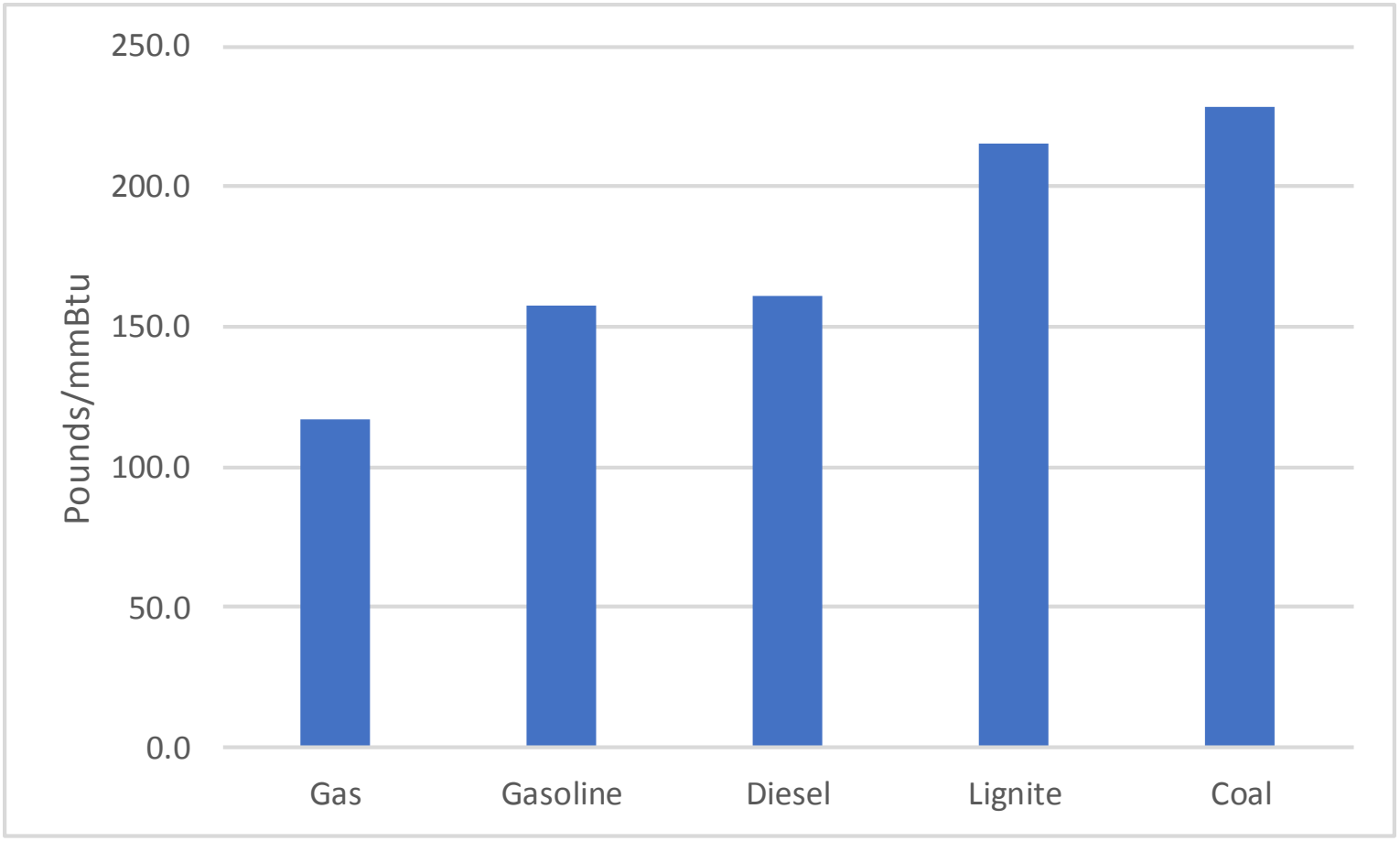
- History of European gas prices has been driven by availability of Russian gas and LNG
- That all changed in 2022 – now competing with the rest of the world for LNG
- Is historic range now irrelevant, or will we return to past range of prices?

US gas price has driven industrial and power sector growth



- Discovery of shale gas has been a key factor in US industrial re-generation
- Also sparked a move away from coal on the power sector
- Can the shale “miracle” continue?
- Will the demand for LNG exports impact US domestic prices?

Carbon output by fuel

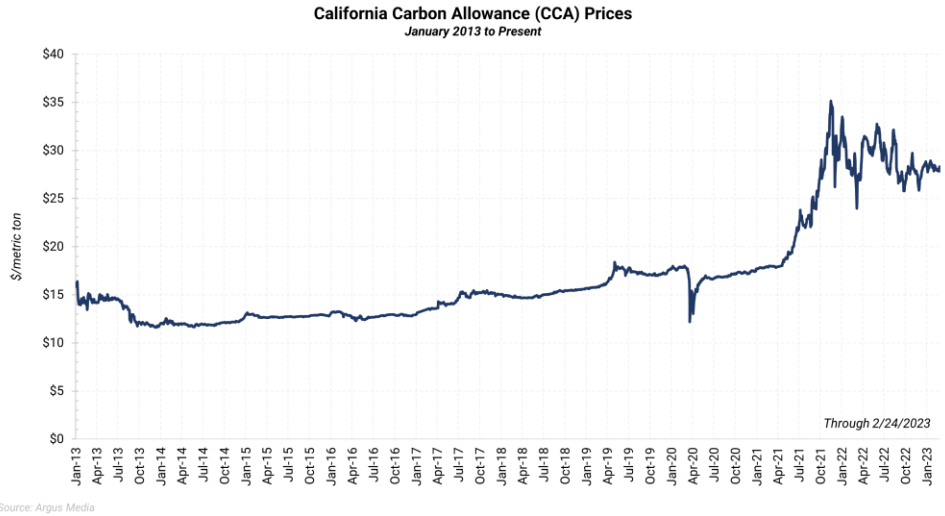


- Coal emits roughly twice as much carbon as natural gas

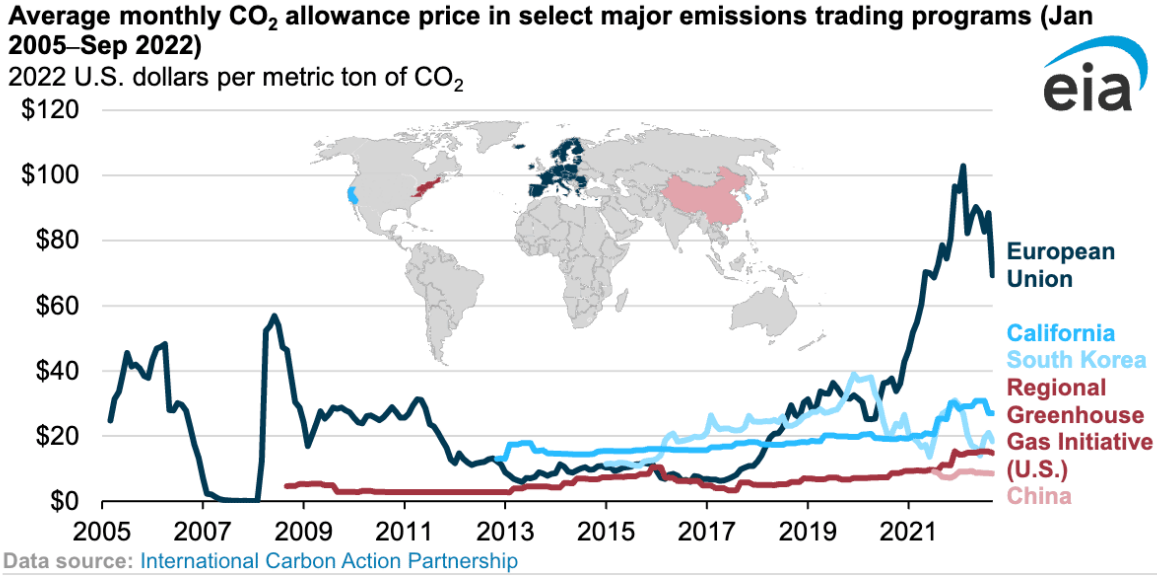
Carbon prices vary widely across global markets

EU ETS price history

California carbon price history



Global carbon price comparison



Key Questions

- What is electricity demand likely to be?
- How much of it will be satisfied by renewable energy?
- What will this do to the electricity price?
- What will this do to utilisation of hydrocarbon-fuelled power stations?

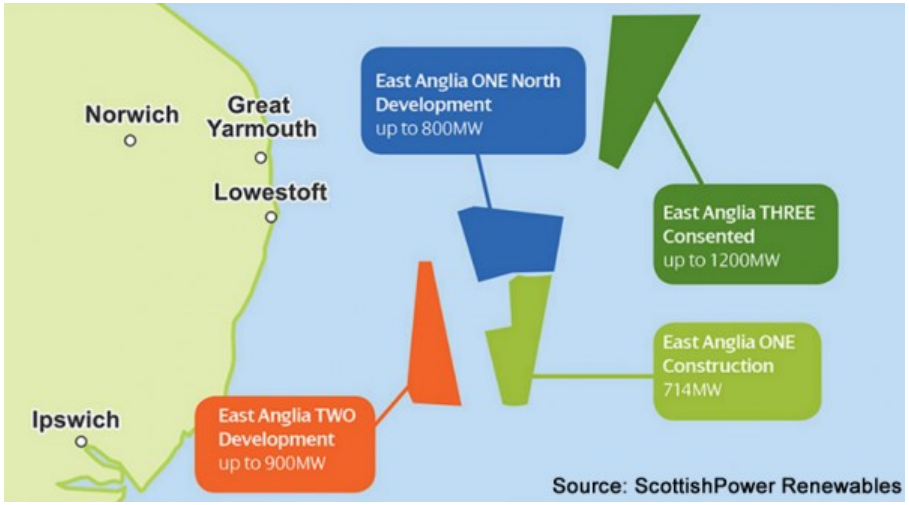
Let’s build a model

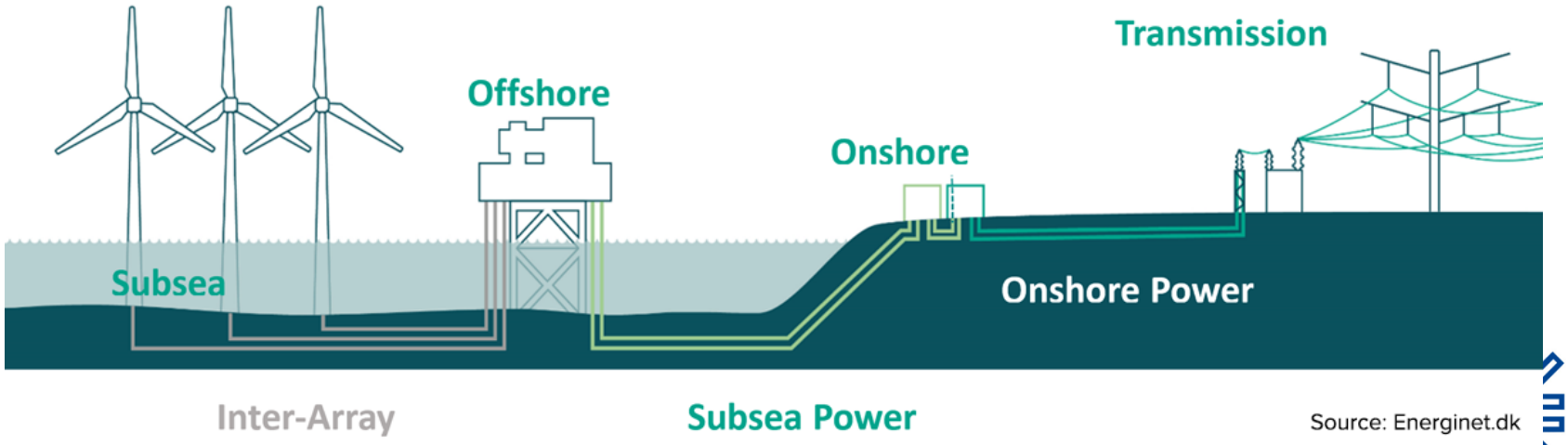
- Capacity – 750MW, efficiency 54%
- Capital Cost – US$978/kW (construction time 3 years)
- Fixed Cost – US$11/kW
- Variable Costs – US$3.5/MWh
- Assumed utilisation – 85% for 20 years production life
- Gas price – US$4/mcf; carbon price $30 per tonne
- Electricity price - $66/MWh
- Project life – 20 years – straight line depreciation
- Tax rate – 20%

WACC assumptions

- Risk-free rate – 4.6%
- Equity market return – 10.57%
- Company Beta - 0.49
- Company interest rate – 5.19%
- Tax rate – 20%
- Debt:Equity split – 77:23

A Wind Farm – near where I live!

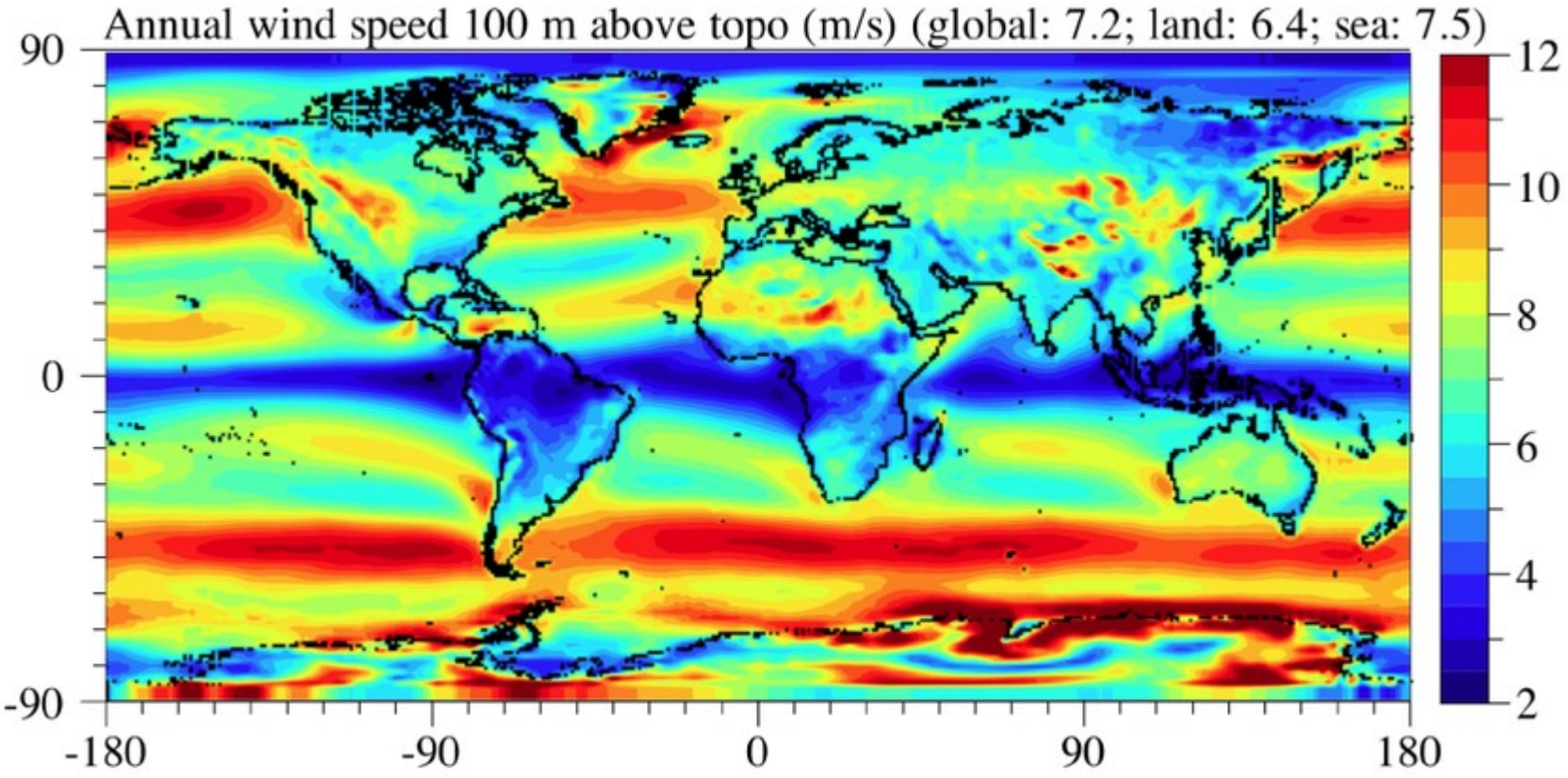




Key Questions for Wind Farm Economics

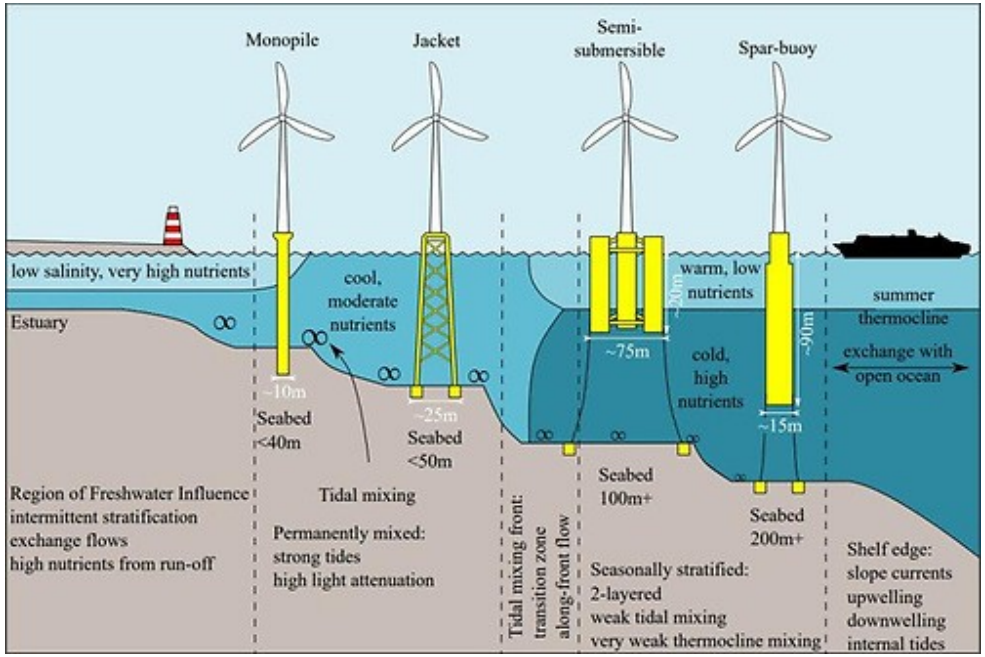
- Wind availability and speed
- If offshore, water depth and sea-bed conditions
- Cost of equipment – supply chain issues
- Power price
- Cost of finance
- Environmental impact

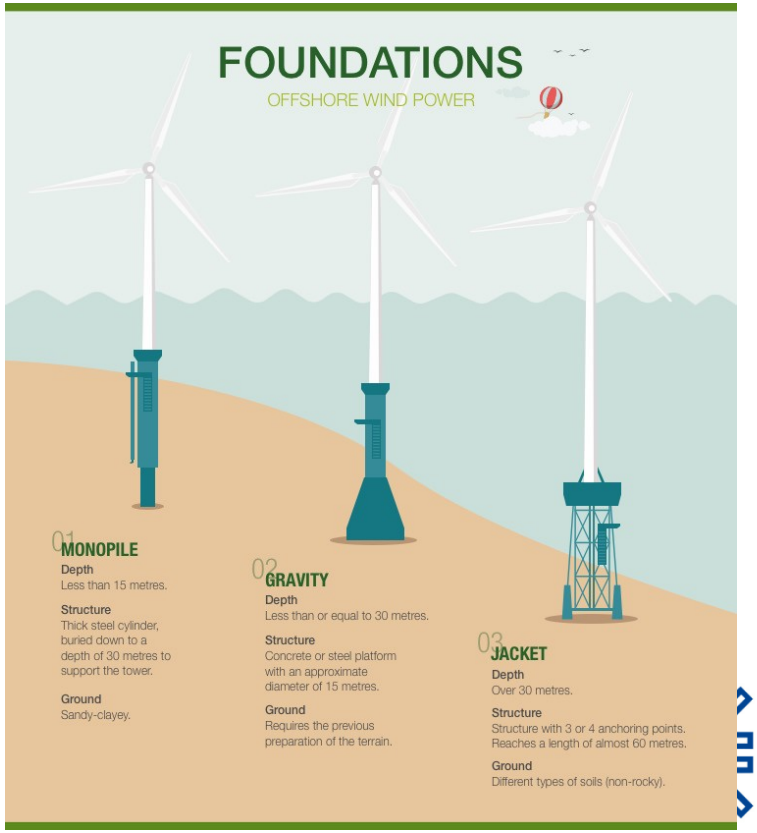
Global wind availability (metres/sec)



- Offshore in major oceans ideal – if possible
- Sea-bed conditions as important as wind speed though

Impact of sea-bed, tides, water content



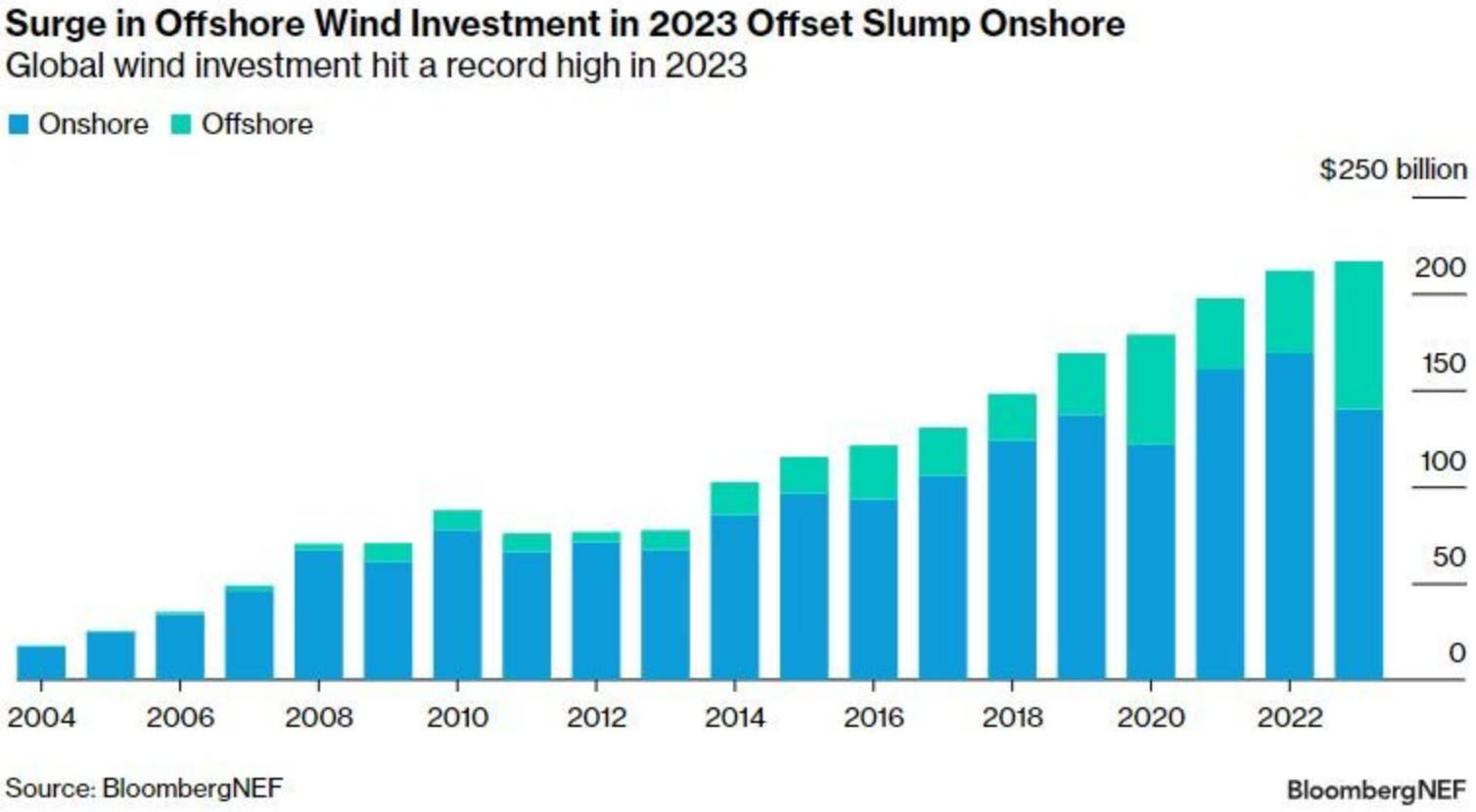


Impact on environment also critical

Sea birds, but also fish and other micro-organisms on sea-bed

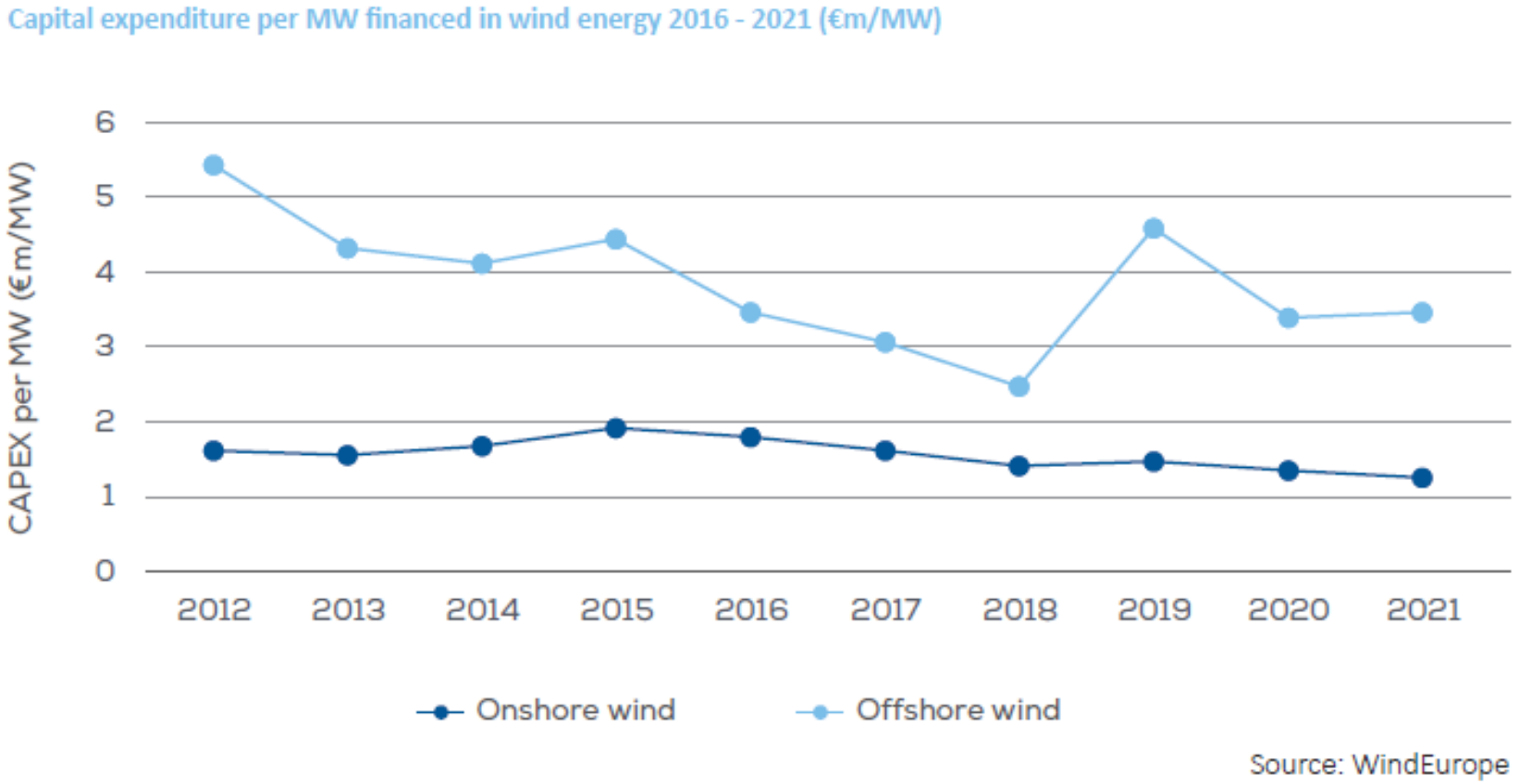
Presence of wind farms will alter bio-diversity in the area

Investment in global wind capacity

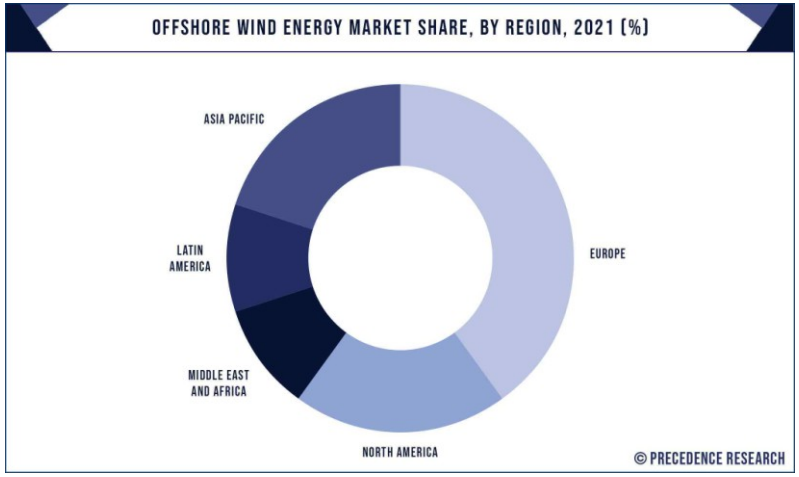


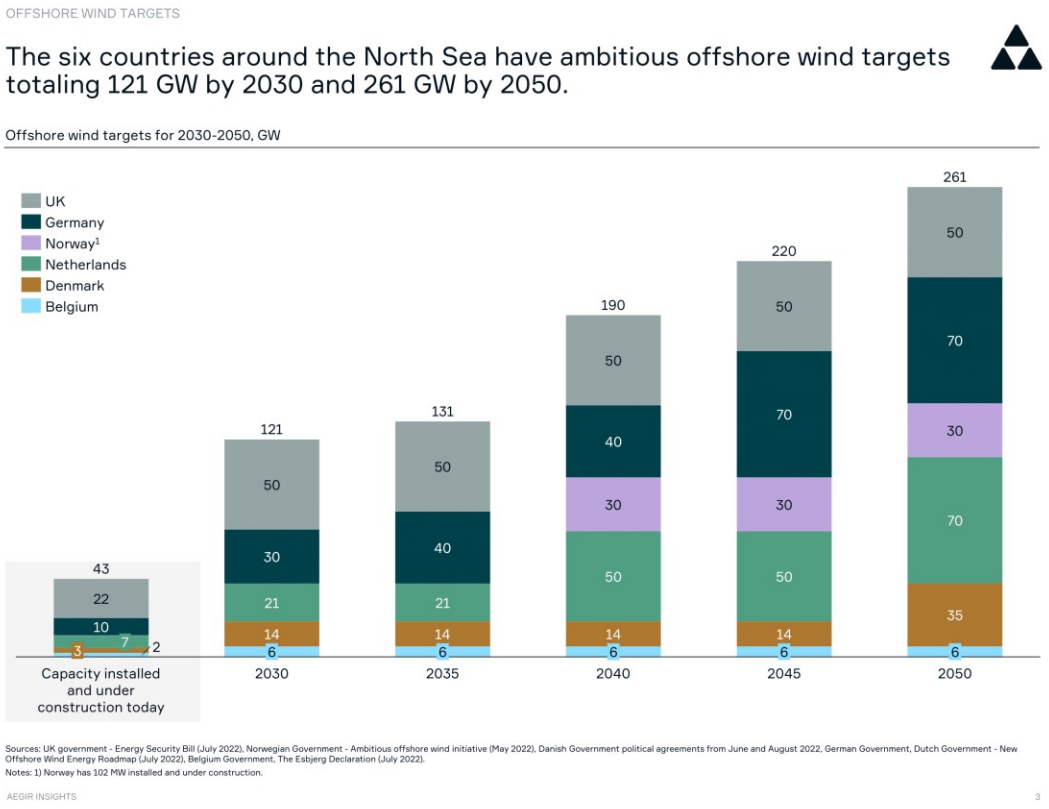
- Wind power is becoming a major source of renewable electricity
- Offshore wind has huge potential, although fixed platform is limited by geography – floating will be the ultimate answer

Offshore Wind Capex in €/MWh



The North Sea has been the big growth area in Europe





- Auctions in the UK and Germany have generated huge interest in the past 3-5 years
- $13 billion bid for licences offshore Germany in 2023 by BP and Total

Let's look at a wind farm

- Capacity – 4000MW, efficiency 100%
- Capital Cost – US$3617/kW (construction time 4 years)
- Fixed Cost – US$92.7/kW
- Variable Costs – US$??/MWh
- Assumed load factor (availability) – 40% for 30 years life
- Gas & Carbon price – ??
- Electricity price - €??/MWh
- Project life – 30 years – straight line depreciation
- Tax rate – 20%

WACC assumptions

- Risk-free rate – 4.61%
- Equity market return – 10.57%
- Company Beta – 0.73
- Company interest rate – 5.19%
- Tax rate – 20%
- Debt:Equity split – 77:23

Let’s make some forecasts!

- Base case
- Upside case
- Downside case
- Disaster (worst) case
- Does the investment need to work in all of these scenarios?