Electricity Price Risk for Wind Farms in Ireland

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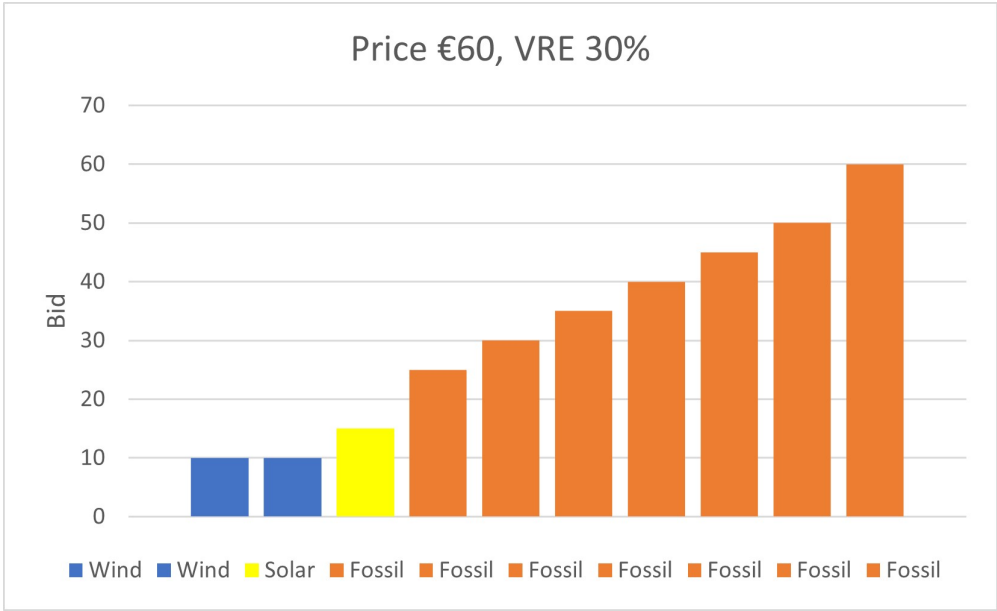
Electricity Price Risk

- **Variable Prices** (our focus),
- **Variable Production** (later in the project),
- **Variable O&M** (tomorrow)
- The cost of producing electricity from wind is driven by installation, financing (75% approx.) and to a smaller extent, O&M costs.
- Wind energy's marginal cost of production is quite small
- Merit Order Effect

Single Electricity Market Operator

- SEMO estimates power use for each hour tomorrow
- Generators bid quantity and price
- Least expensive combination is chosen
- All suppliers get the same (top) price
- The Balancing Market sorts out errors on the day itself, and has access to the interconnectors

Variable Renewable Energy



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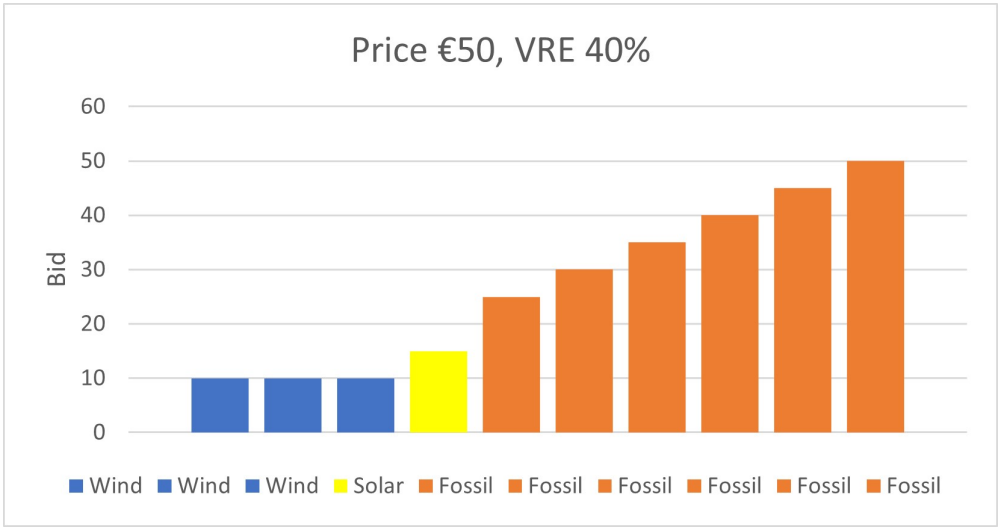

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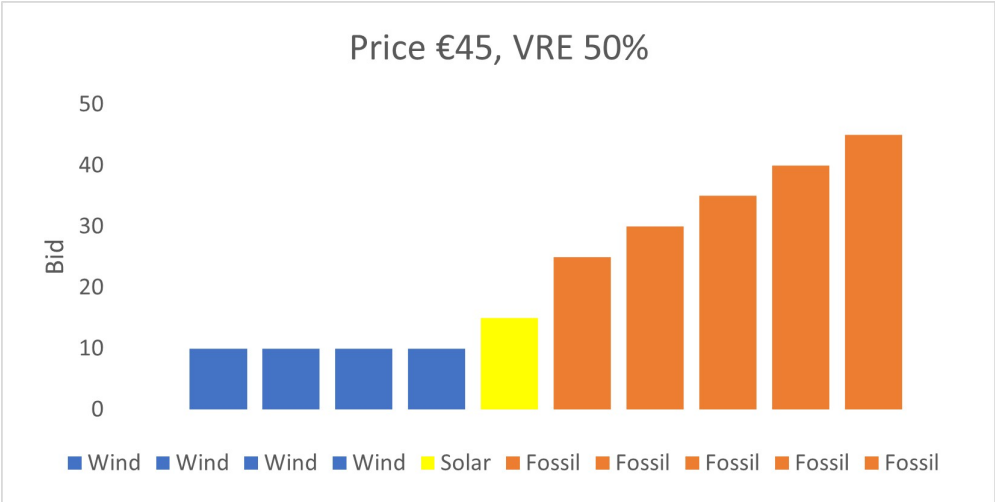

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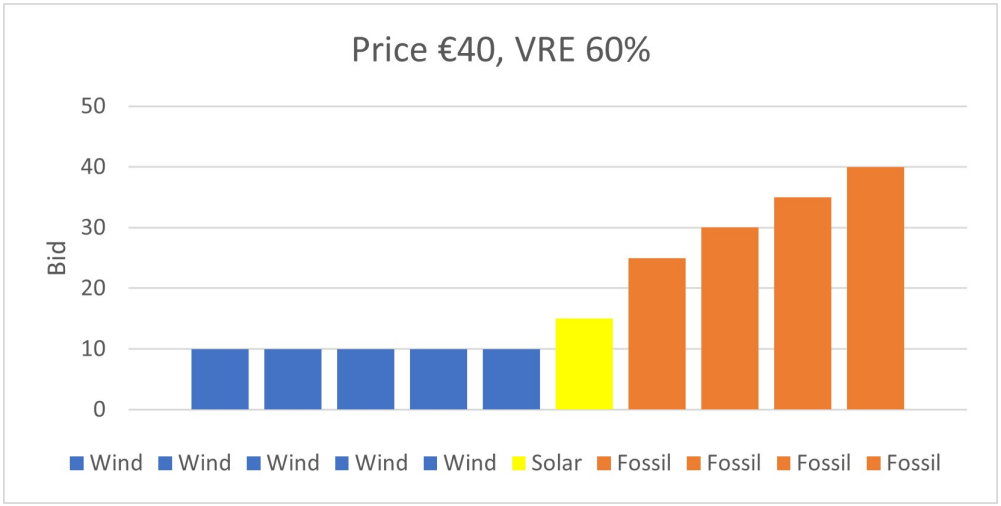

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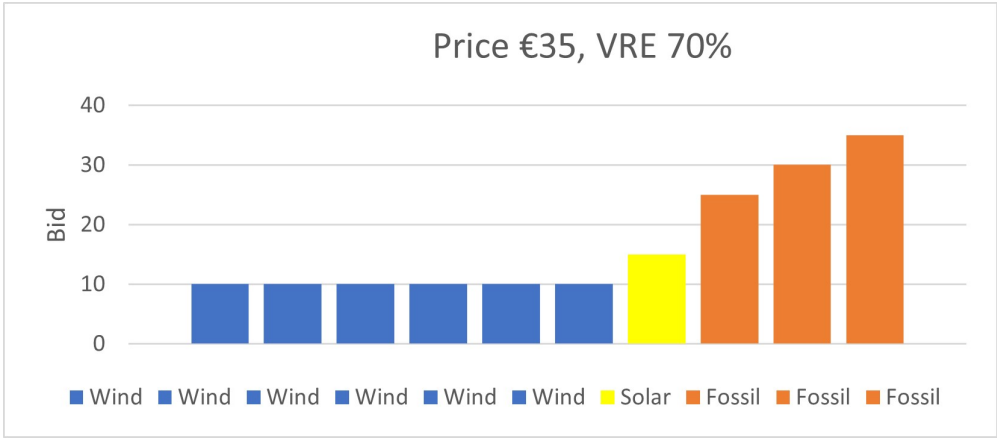

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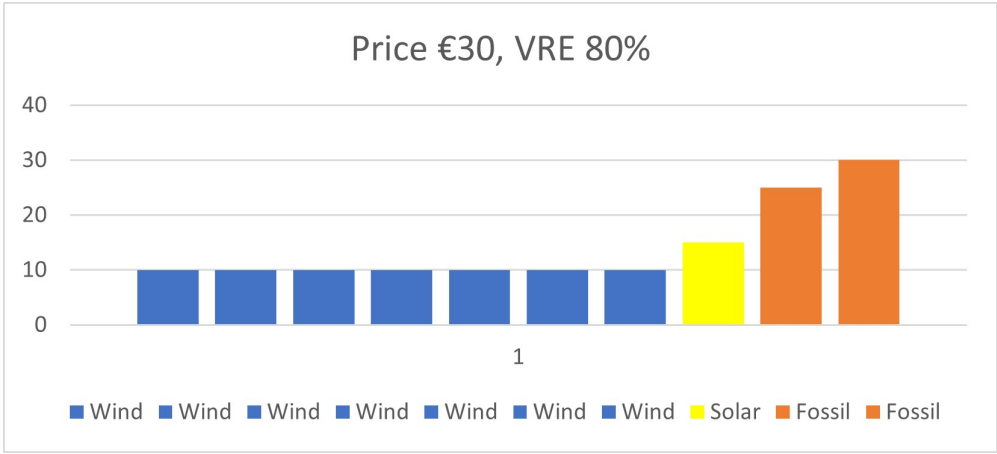

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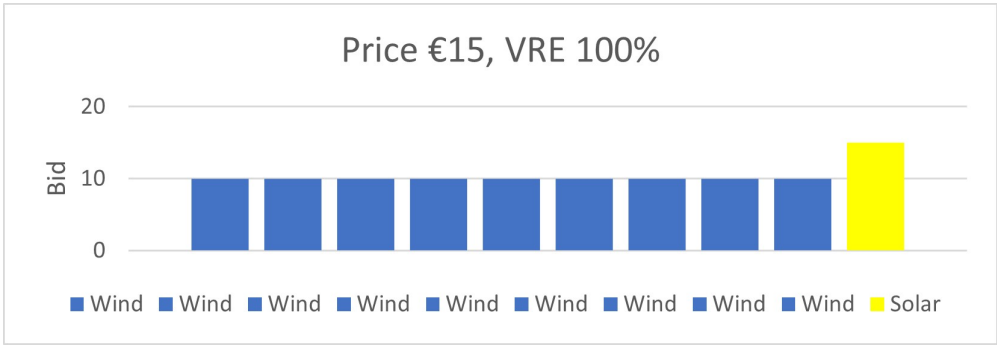
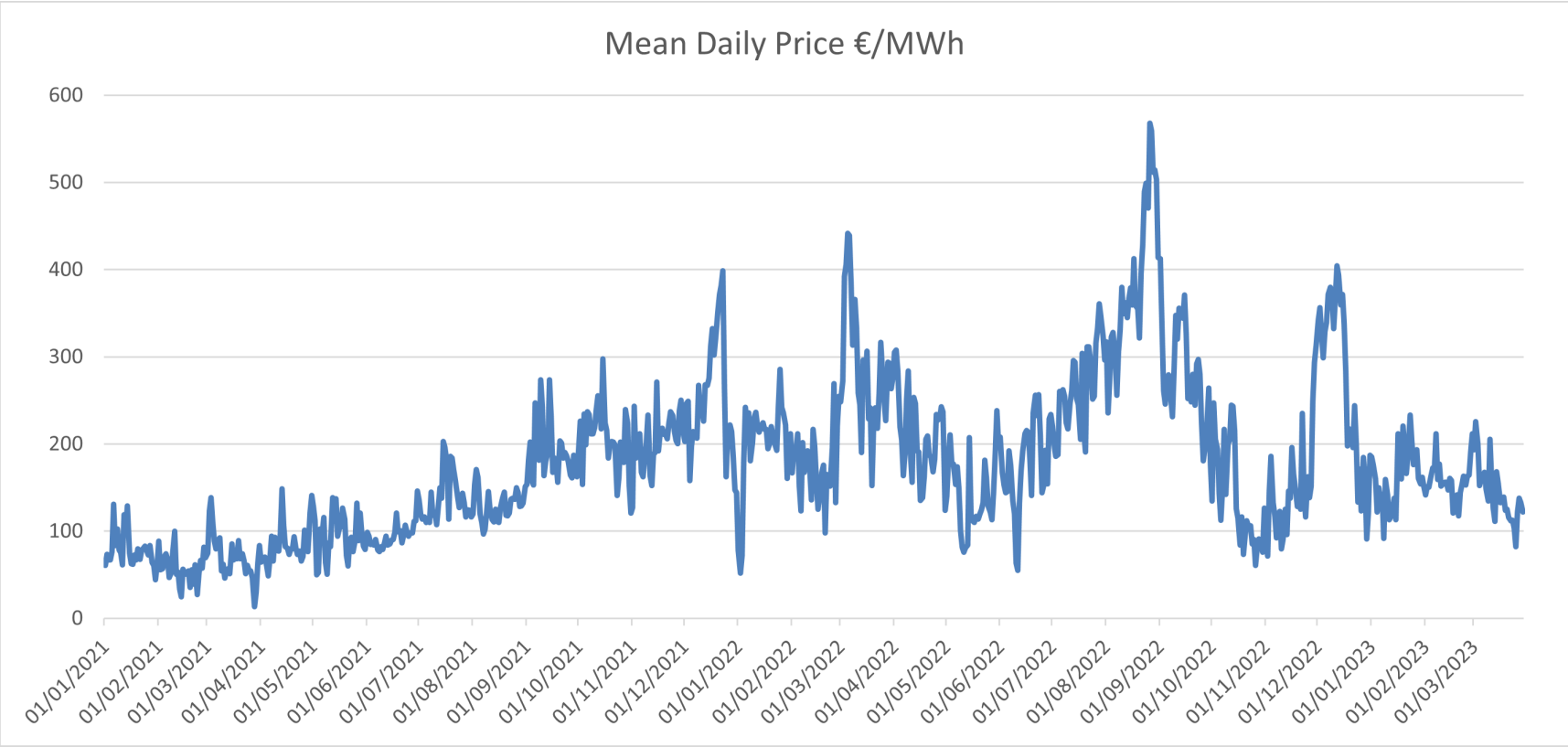


- Denmark, Urguay, Lithuania, Spain, Ireland and Portugal generate more than 30% of their electricity from solar and wind (Ember, 2022).
- As more wind and solar is on the grid the price drops.

- Day Ahead Market (DAM) 24 one hour periods per day (no interconnectors)
- Intra Day Market 1 (IDA1) 48 half hour periods per day
- Intra Day Market 2 (IDA2) 11am to 11pm 24 half hour periods per day
- Intra Day Market 3 (IDA3) 5pm to 11pm 12 half hour periods per day

The figure shows that it is at least plausible to believe we are looking at mean reversion. What do the tests indicate? This is the mean of the DAM price per day from Jan 2021 to March 2023.



- Power Purchase Agreements (PPAs) for *power as produced* mean the producer is hedged from the electricity market and can focus on generating power.

Electricity Price depends heavily on Natural Gas prices. The following simple regression model using the gas price $G(t)$ in Euro Cent per kWh and time t in years, to explain the electricity price $P(t)$ in Euro Cent per kWh,

$$P_G(t) = P_0 + \gamma t + \beta G(t) + \sigma\epsilon \tag{1}$$

where P_0 is the initial price of electricity, $\beta = 2.35$ is the regression coefficient of gas on electricity price, the mean rate of increase of electricity is $\gamma = €1.40$ per year for a MWh. ϵ is taken from a standard Normal distribution, and $\sigma = 0.55$ is the volatility. This simple model using ten years of half yearly data from SEAI has an $R^2 = 78\%$

- Electricity prices rise
- To a large extent Electricity behaves like a commodity.

Literature

Electricity price estimation for months or years into the future typically uses either statistical or machine learning methods (Peng et al., 2018) We concentrate on statistical.
Ioannou et al (2020) ARIMA
Tian et al.,(2017) GBM
Kitzing et al., (2017) GBM

- Mean Reversion: Equation 2
- A Brownian Motion with drift Equation 3

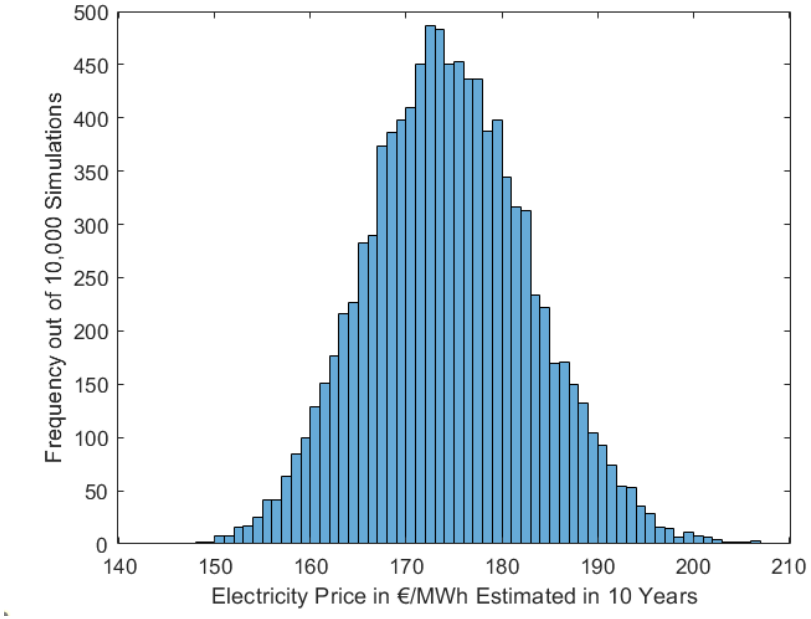
Moving Reverting Mean Model

A standard econometric model for commodities with the addition of an increasing mean.

$$dp(t) = \alpha\left(\bar{p_0} + ht - p(t)\right)dt + \sigma p(t) dB(t) \tag{2}$$

where $p(t)$ is the log of the electricity price, B(t) is a standard Brownian Motion and $\bar{p_0}$ is the mean of the log of the electricity price at time $t = 0$, h is the rate of increase of the electricity price and σ is the volatility of the log of the electricity price.
Results, following Sanchez and Pallacio (2013) on the next slide show the range is fairly limited over even a long period,

The figure shows the range of electricity prices based on a moving mean reversion model for 10 years into the future. The 95% CI is approx €158 to €192.



But what if the link to gas is broken, and electricity stops behaving like a commodity?

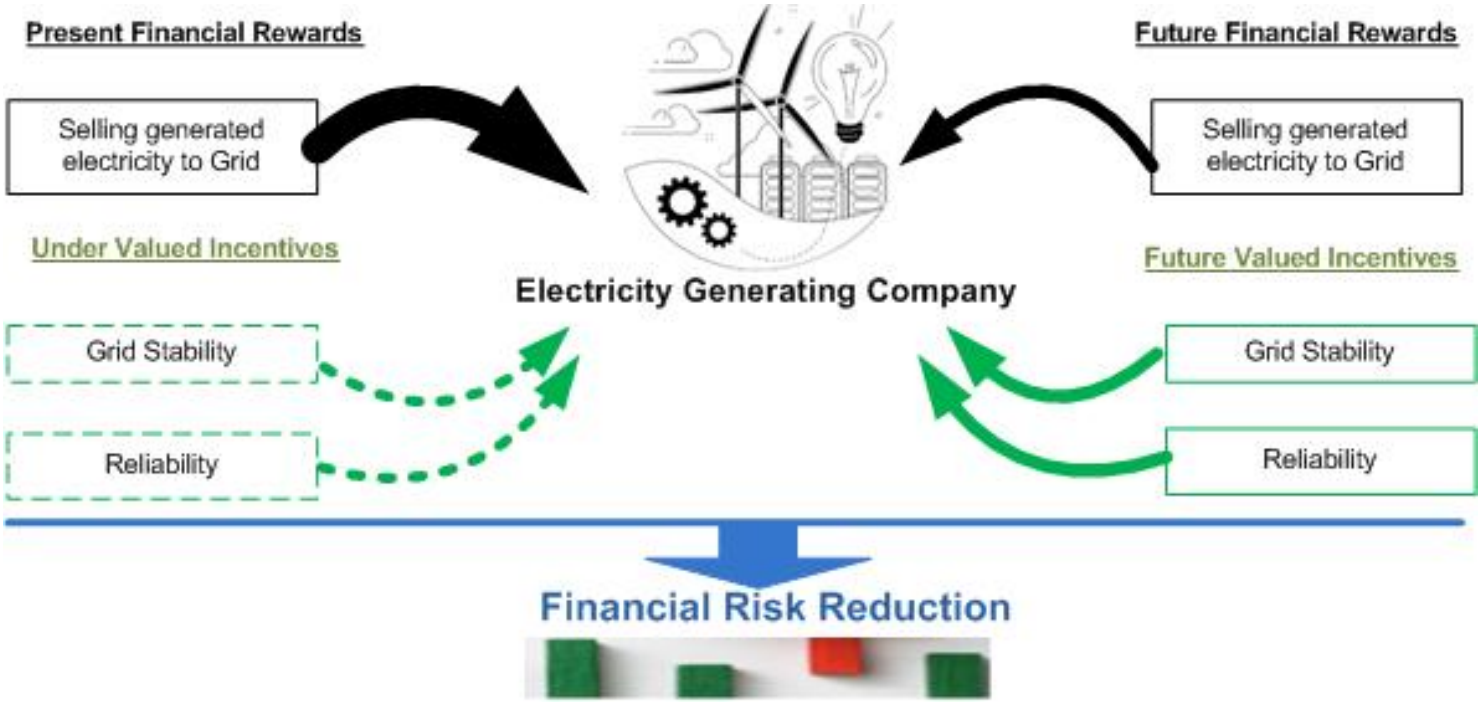
Possible Way Forward

A Brownian motion with drift, $P(t)$,

$$p(t) = p_0 + \alpha t + \sigma dB(t) \tag{3}$$

where α is the time rate of increase of electricity price. This produces a much wider variation in possible outcomes with a 95% CI from 0 to €690, a much larger risk of low prices.
This displays the difficulty of long term electricity price forecasting. There is some success form Gabrielli et al (2022b) using Fourier Analysis. This may be useful when we may daily and weekly seasonality for Power Purchase Agreements, and focus on long term trends and annual seasonality.

Market Change



- The ability to change power output was not considered valuable in itself when almost all producers used fossil fuel.
- The ability to suddenly (in seconds) supply power on demand needs to be rewarded, or it will not be attractive to investors.

European Commission Plan for the Electricity Market

The European Commission (2023) plans to :

- Encourage a surge in renewables
- Phase out gas
- Remove the effect of volatilie fossil fuel prices
- Protect consumers from price spikes
- Make the EU's industry clean and competitive
- Incentivize long term contracts
- Impove the flexibility of the power system
- Support demand response and storage
- Use Two way contracts for difference to support industry

Some Consequences of the EC Plan

- Dispatchable electricity will get paid more, but...
- Wind Generation will get paid less.
- Emission Allowance prices will make fossil fuels too expensive for general production.
- The operator will be able to determine the size of the dispatchable power industry by arranging payments for the service.
- As variable renewables, storage and interconnection increase there will be fewer price spikes.

- Long Term Energy Storage: **Hydrogen,** Pumped Storage, Batteries
- Interconnection: In addition to Moyle 500MW and EWIC 500 MW, plans are agreed for a new Celtic Interconnector 700MW (Cork - Brittany)
- Increasing Markets: Exporting **Hydrogen**, using **Hydrogen** in Ireland for metals and fertilizer production, Electrification of Domestic Heating and Transport

Risk Mitigation

- Geographical and Technological Diversification will help reduce risk for PPAs (Gabrielli et al, 2022 b)
- Public support for wind will encourage political support for the industry. Community Ownership is a way forward.
- Use of long term contracts as the normal way to sell energy
- Generation forms having turbines in widely displaced locations
- Wind and Solar PV in the one business, possibly including co-located storage

Changes for Consumers

- Electricity prices to consumers can no longer ignore time of use
- Demand management is a way for people to save money (EV charging, hot water, freezers)
- New businesses can help retail consumers to automate decisions perhaps even changing supplier frequently.
- Hotels, airlines and ferry companies have been doing this already, it's not new to consumers. The ability to take part in the market is new.

Bosch, J. et al. (2019) Global levelised cost of electricity from offshore wind, Energy
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The End

Thank You,
Questions Welcome
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