Can levelised revenues from auctions be used to deduct levelised cost of offshore wind farms? The case of Kriegers Flak

DeepWind 2020

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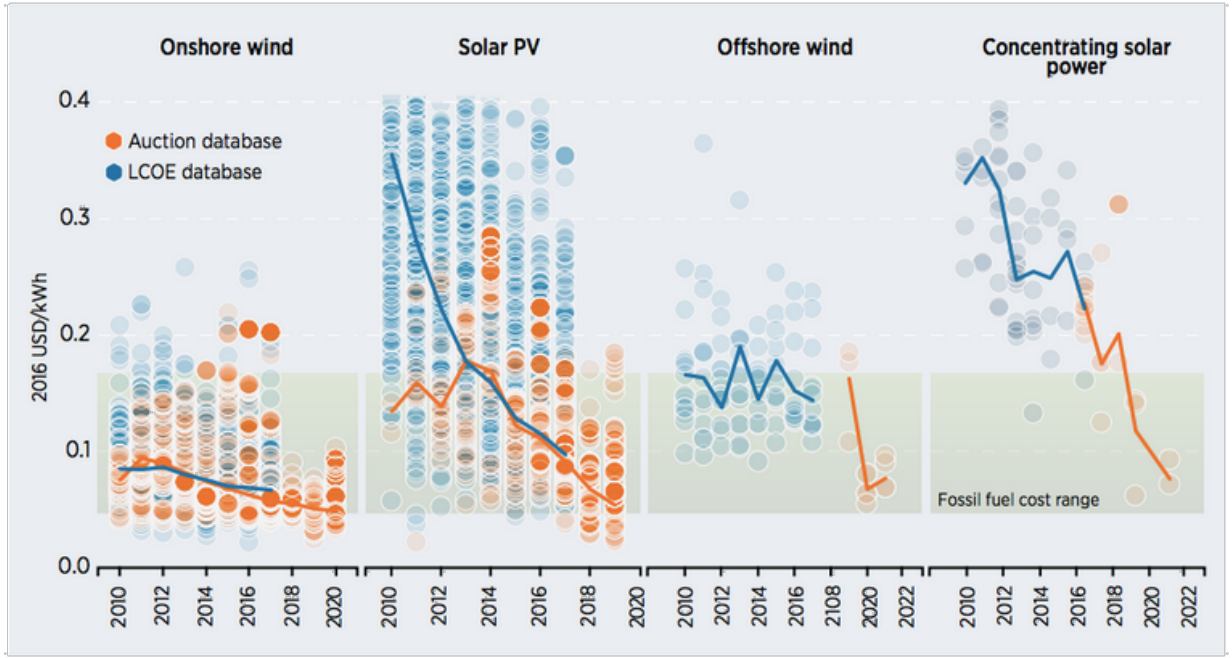
Motivation for the analysis



Source: IRENA Renewable Cost Database and Auctions Database.

Note: Each circle represents an individual project or an auction result where there was a single clearing price at auction. The centre of the circle is the value for the cost of each project on the Y axis. The thick lines are the global weighted average LCOE, or auction values, by year. For the LCOE data, the real WACC is 7.5% for OECD countries and China, and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.

- Many have started using (adjusted) auction results as a proxy for LCOE
- For other technologies, this seems to work fine – but is offshore wind a different story?

IRENA, 2018: Renewable Power Generation Cost in 2017

Levelised Cost of Energy (LCOE) and Levelised Revenue of Energy (LROE)

$$\mathrm{LCOE} = \frac{\sum_{t=0}^{n} \frac{TC_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{q_t}{(1+r)^t}}$$

Average, per production unit, discounted costs over the project's lifetime

$$\mathrm{LROE} = \frac{\sum_{t=0}^{n} \frac{TR_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{q_t}{(1+r)^t}}$$

Average, per production unit, discounted revenues over the project's lifetime

Note: both can be derived pre-tax or post-tax and real or nominal

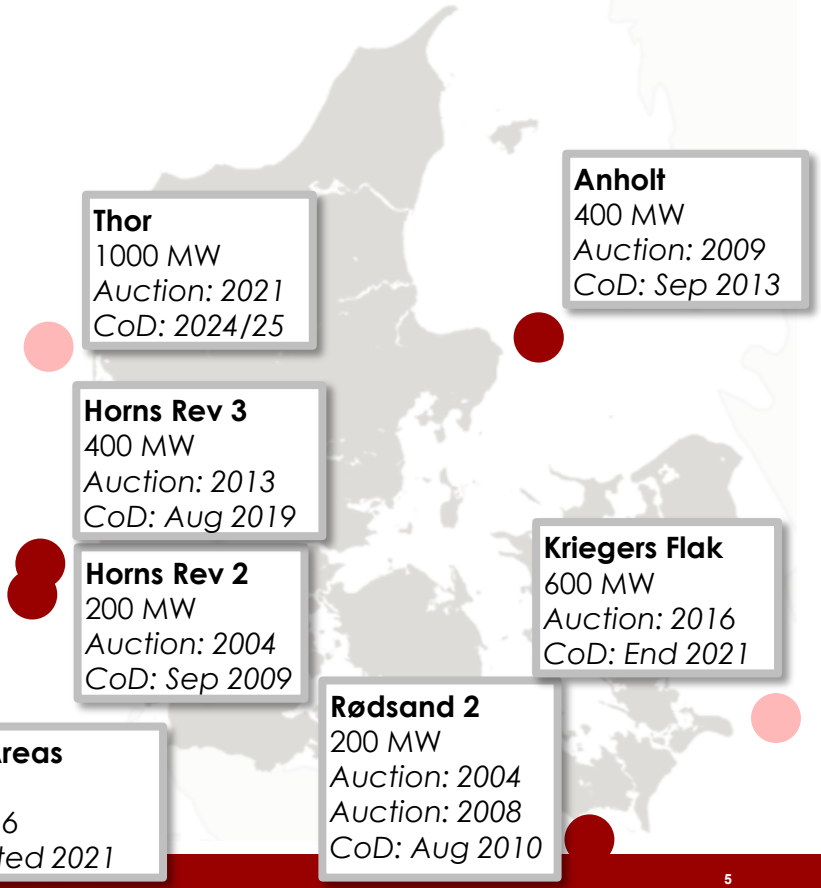
Levelised Cost of Energy (LCOE) and Levelised Revenue of Energy (LROE)

Argumentation:

- In a competitive market environment, LCOE should be directly reflected in LROE (as long as all revenue and all cost items are adequately considered).
- In competitive auction environments, investors are incentivised to reveal their ‘true cost’ in bids for required support levels (no expected losses or excessive profits).
- LROE can then be derived from auction results and used as a central element for estimating cost as well as calibrating input assumptions for bottom-up cost modeling.
- Offshore wind should be especially suited for this approach, because auctions are specific for projects, and much information is available.

Offshore wind auctions in Denmark

- First offshore wind support auction in Europe (2004)
- Tenders for guaranteed prices (Sliding premiums/contracts for difference)
- Different rules for each tender, some negotiated
- Thor plus two more GW-size project tenders upcoming (politically agreed)



Offshore wind auction results in Denmark

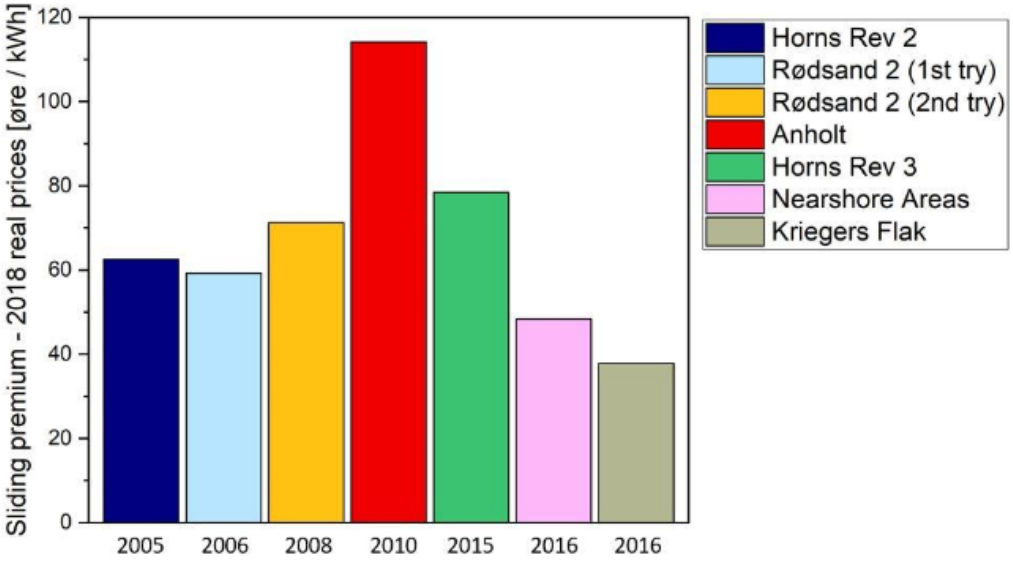


Figure 1. Comparison between the strike prices achieved in the different offshore wind energy auctions realised in Denmark until 2018. The support is provided in the form of a sliding premium tariff and it is presented in 2018 real prices.

- Significant differences in tender results – due to different market situations
- Significantly decreasing price trend in recent years
- Kriegers Flak: 372 DKK/KWh (49.9 EUR/MWh) guaranteed price for 50,000 FLH (ca. 11.2 years)

Source: Gonzales & Kitzing (2019), link

Kriegers Flak specifications

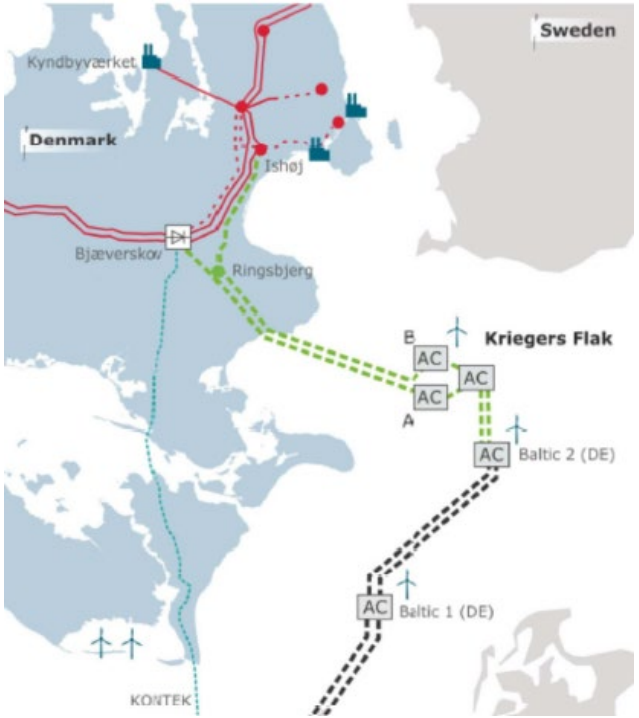
- Auction won: 2016; Turbines ordered: Nov 2017; FID: Q4 2018; CoD: end 2021
- Expected wind turbine size at auctioning: 8-10 MW

Actual specifications:

- 605 MW, 72 turbines, SG 8.0-167 DD turbines, B82 blades, monopiles
- Distance from shore: 15-40 km
- Water depth 15-30 m

- Installation of foundations from May 2019; installation of turbines scheduled for February 2021; Commercial operation end of 2021

- Financing completed in Dec 2018 (as announced by Vattenfall); incl. two Power Purchase Agreements with Novo Nordic and Novozymes for approx. 20% of output
- The project is also supported by the European Union, as a PCI (project of common interest)



Methodology of analysis

- Full cash flow analysis of the project (in Excel), then scenario analysis and deriving thresholds

$$LCOE = \frac{\sum_{t=0}^{n} \frac{TC_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{q_t}{(1+r)^t}}$$

Considered elements:
- OPEX,
- CAPEX,
- Inflation
- Tax payments

$$LROE = \frac{\sum_{t=0}^{n} \frac{TR_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{q_t}{(1+r)^t}}$$

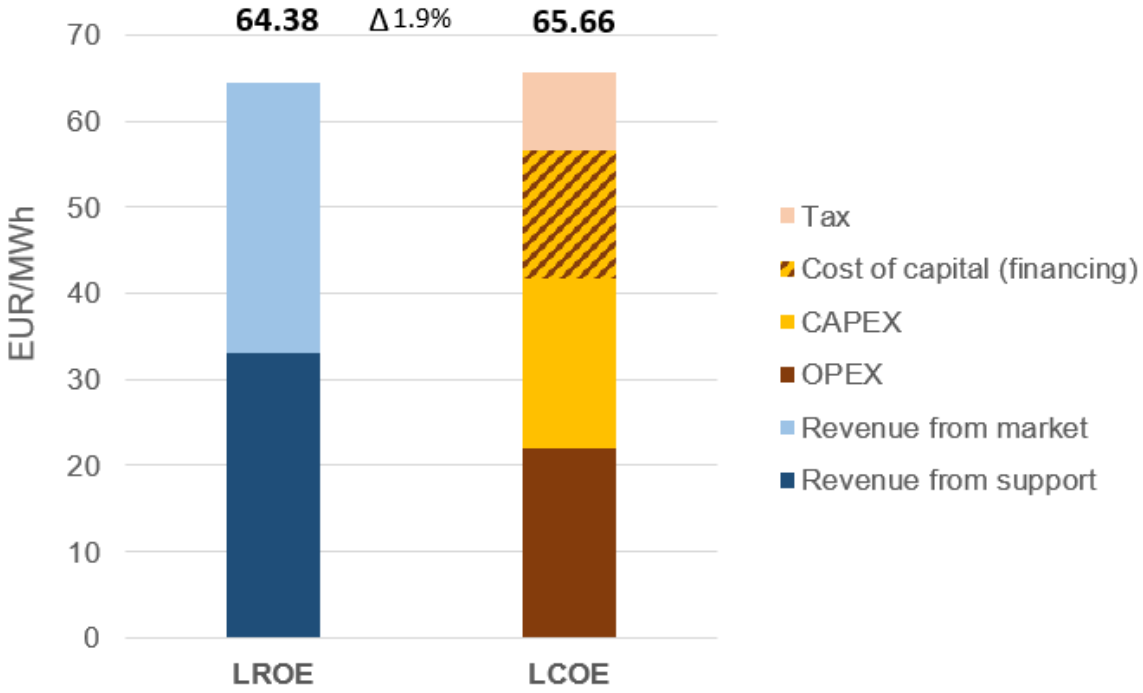
Considered elements:
- Revenues from support (guaranteed price at 49.9 EUR/MWh, nominal)
- Inflation
- Revenues from power market sales (DK2 spot, wind weighted achieved prices), DEA forecasts from 2016 and 2018

Commission Year	2021
Lifetime	25 years
Support Grant Period	11.2 years (50,000 FLH)
Capacity	600 MW
Annual Power Production	2,400 GWh/year
CAPEX	1,970 €/kW
OPEX	$62_{real,2016}$ €/kW/year
WACC, nominal	6.42%
Tax Rate	22%
Depreciation	15% declining balance

Sources: Danish Energy Agency, "Basisfremskrivning 2016", "Basisfremskrivning 2018", Technology catalogue 2019; IEA TCP Wind Task 26 offshore wind report 2018

Results: LCOE / LROE comparison for Kriegers Flak

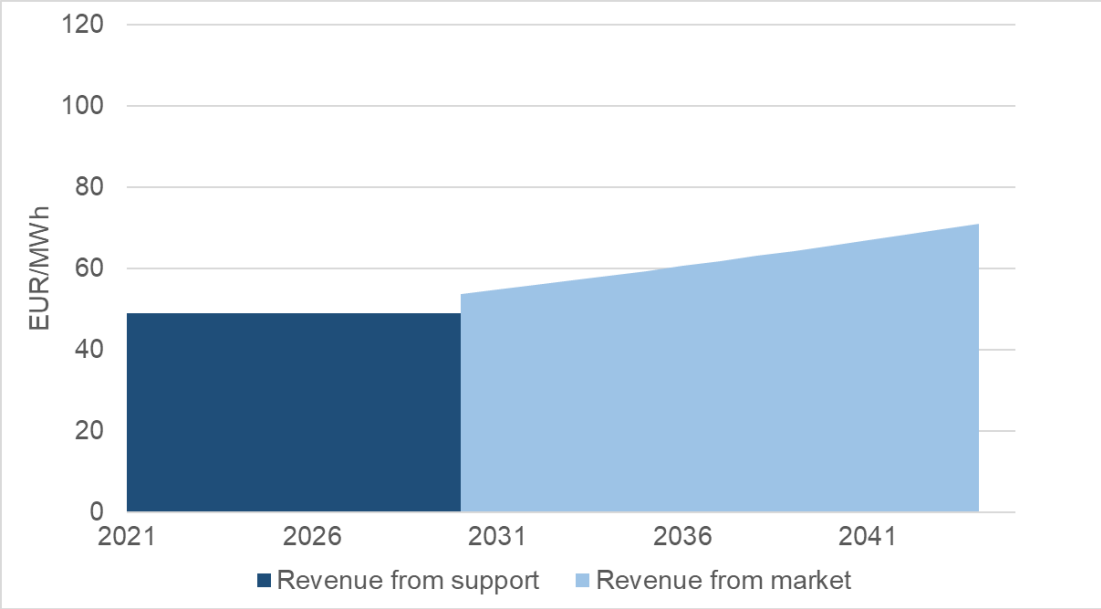
At time of auction (price assumptions from 2016)



- Slight differences could be mitigated by:
  - 8.4% lower assumed OPEX OR
  - 3.8% lower assumed CAPEX OR
  - 6.6% lower cost of capital (financing): WACC 5.99% OR
  - 4.1% higher market price expectations
- Overall, the auction bid seems to be very well in line with the (public) cost and price expectations at the time of bid

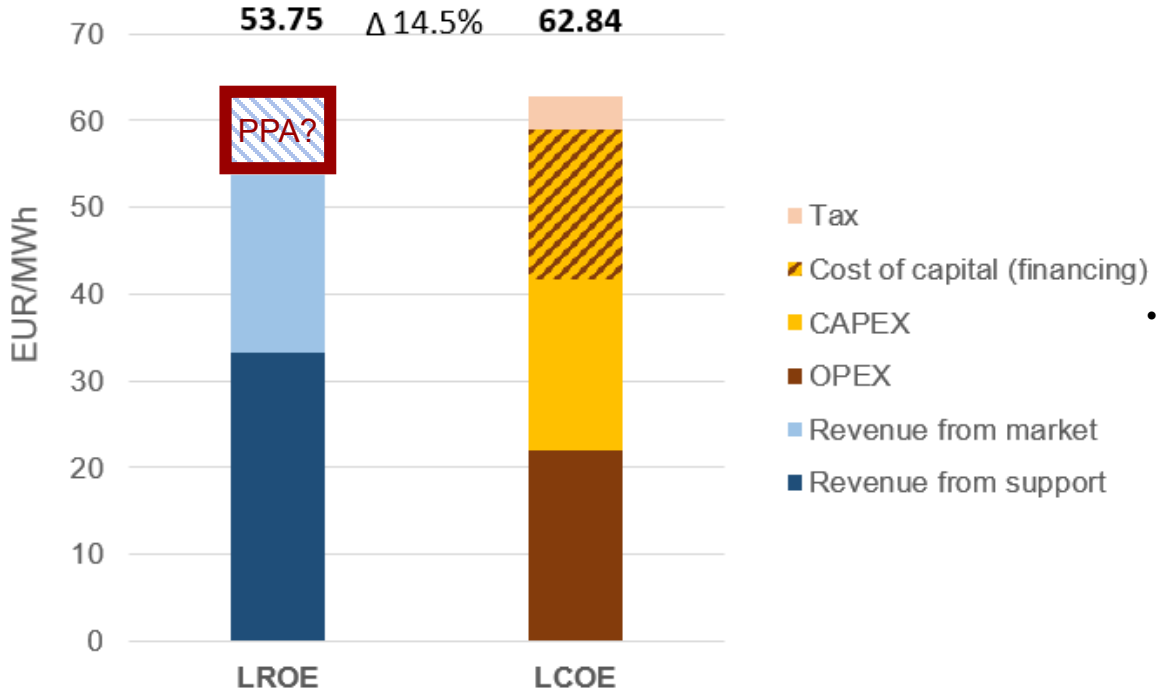
Development of power price forecasts between 2016 and 2018

At Final Investment Decision (price assumptions from 2018)



Results: LCOE / LROE comparison for Kriegers Flak

At Final Investment Decision (price assumptions from 2018)



- Much increased gap mostly due to drop in power market price forecasts. A matching of values would now require
  - 63.3% lower assumed OPEX OR
  - 28.1% lower assumed CAPEX OR
  - 46.3% lower cost of capital OR
  - 23.3% higher production OR
  - 44.1% higher market price expectations
- Even in a combination of factors, a matching of values seems unrealistic
  -> so what was behind FID?
  1) PPA for 20% of volume must have been attractive (above 65 EUR/MWh (nominal) with our simple base assumptions)
  2) hedging or insurance against power price development since 2016?
  3) major differences in assumptions? (e.g. longer lifetime, other income,…)

Conclusions

- Auction results can easily be technically translated into levelised revenues of electricity (LROE), using an approach similar to LCOE, albeit with many assumptions to be made (esp. on future power prices)

- Anyways, they are not easily used as proxy for cost (LCOE):
  - Significant simplifications
  - Timing issue related to forecasts
  - Alternative income streams often unknown

- The comparison between LROE and LCOE for Kriegers Flak (based on publicly available data / official estimations) suggests a reasonable match at time of auction, but not anymore at FID.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