Can an Energy-Only Market support investment – empirical evidence from the last 16 years?

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Dauphine | PSL
CHAIRE EUROPEAN ELECTRICITY MARKETS

AGENDA

1. EMPIRICAL ANALYSIS
2. POTENTIAL RELEVANCE OF ANALYSIS FOR COST OF CAPITAL
3. CONCLUSIONS

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THE INVESTIGATION – EXTENT OF FULL-COST RECOVERY FROM WHOLESALE MARKET ALONE AND THE VOLATILITY OF RETURNS

- Determination of gross margins earned **only in wholesale market** (i.e. without renewables subsidies or any capacity payments) and the extent to which they cover full costs for:
  - Two thermal plant types: CCGT and hard coal (the most modern versions available since 2000)
  - Nuclear plant (2nd generation)
  - Three renewables plant types: onshore wind, offshore wind, and utility-scale solar PV
  - Two countries (DE and FR)
  - Coverage of 2005-2019 as far as available data permitted (varies by commodity and country)
  - Hourly granularity = up to 130,000 data-points per plant type and country
- The frequency and extent of scarcity pricing (defined as power prices in excess of 125 €/MWh)
- The volatility of gross margins and potential implications for the cost of capital

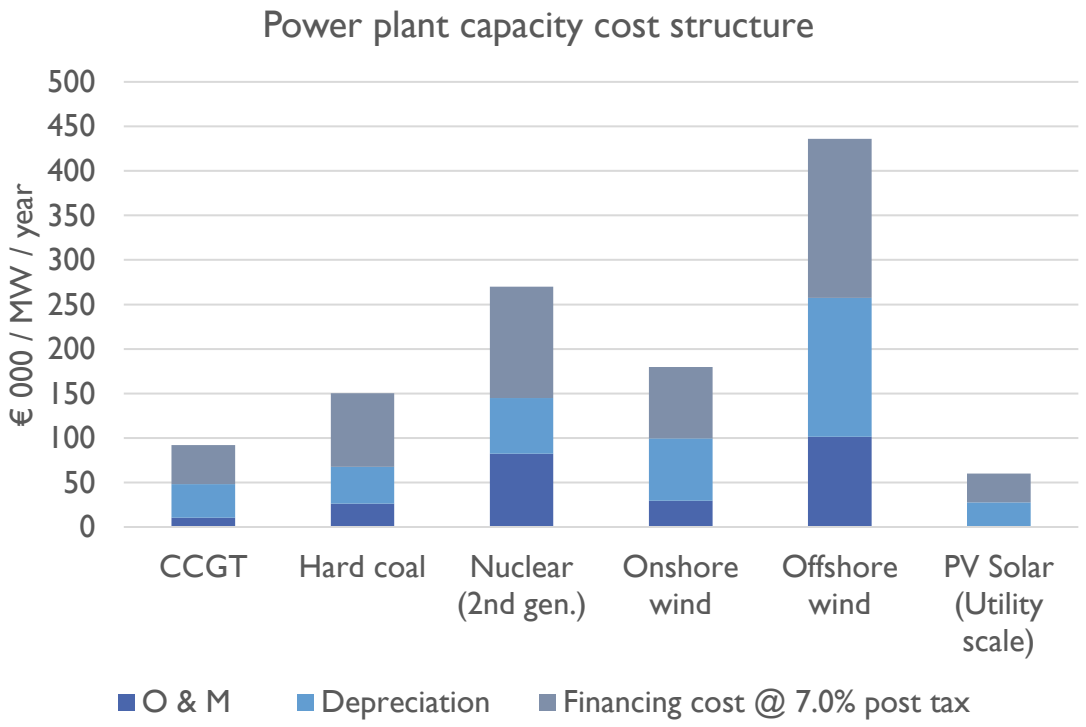
HEADLINE RESULTS

1. Returns from wholesale prices alone were not high enough to cover full costs. Average extent of full cost recovery (2008-19):
   Thermal plants ~ 40%, nuclear ~ 100%, wind plants ~ 30% and PV Solar (utility scale) ~ 60%
2. Average annual returns of thermal / nuclear plants have varied across a wide range, generally declining since 2010
3. Scarcity-pricing made only trivial contributions to the returns after 2008
4. Monthly returns of plants are an order of magnitude less volatile than those on stock market indices
   - Correlation coefficients for the period 2008-19 are negative, e.g. between -0.15 and -0.25, but are positive from 2010
   - An alternative definition of returns leads to higher monthly returns and higher coefficients
5. The problem in relying on the wholesale market alone is that returns have been structurally too low, especially since ~2010
6. Limitations of conventional statistical methods have made it difficult to draw conclusions about the appropriate cost of capital

KEY ASPECTS OF METHODOLOGY

- A uniform basic cost of capital (7.0% nominal, pre-tax) was applied based on RWE AG annual report for 2015 as representative of industry practice. (In practice lower rates would have been applied for subsidised renewables.)
- It was assumed that thermal plants operate in every hour when the margin is positive
- Hourly data for operation of renewables plants was available from ENTSOE Transparency Platform
- No additional income was included for ancillary services as this could not be reasonably estimated
- Costs for starting and ramping plants were also not included
- Data for specific capex costs, operating lives, O&M, and thermal efficiency was taken from a Fraunhofer Institute study with modifications based on industry knowledge
- Gross monthly margins were defined as Clean Spreads
- For Return-on-Investment calculations depreciation and O&M costs were deducted from gross monthly margins

POWER PLANT FIXED COST STRUCTURE IN MERCHANT MARKET – WHAT NEEDS TO BE RECOVERED ON AVERAGE EVERY YEAR

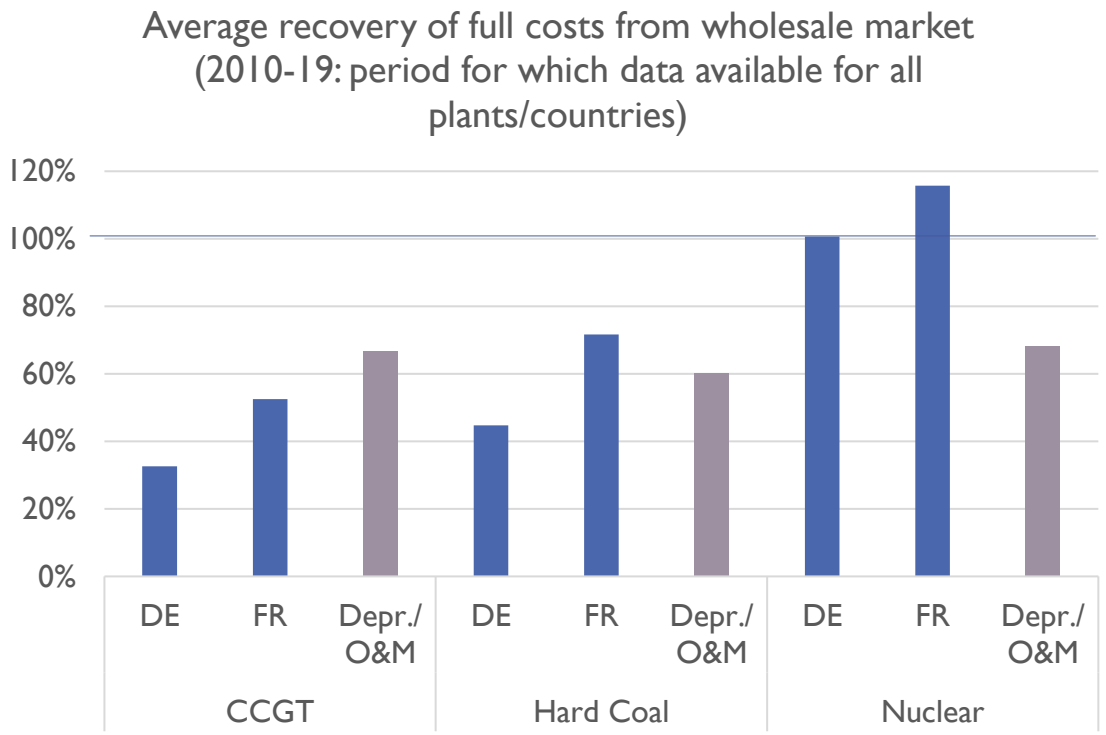


- Project life determines depreciation costs
  - Also, along with cost of capital it determines financing cost
  - But it is subject to significant uncertainty and therefore capital destruction if plant is closed early
- The financing cost is set for merchant plants assuming no second source of income

Main plant assumptions

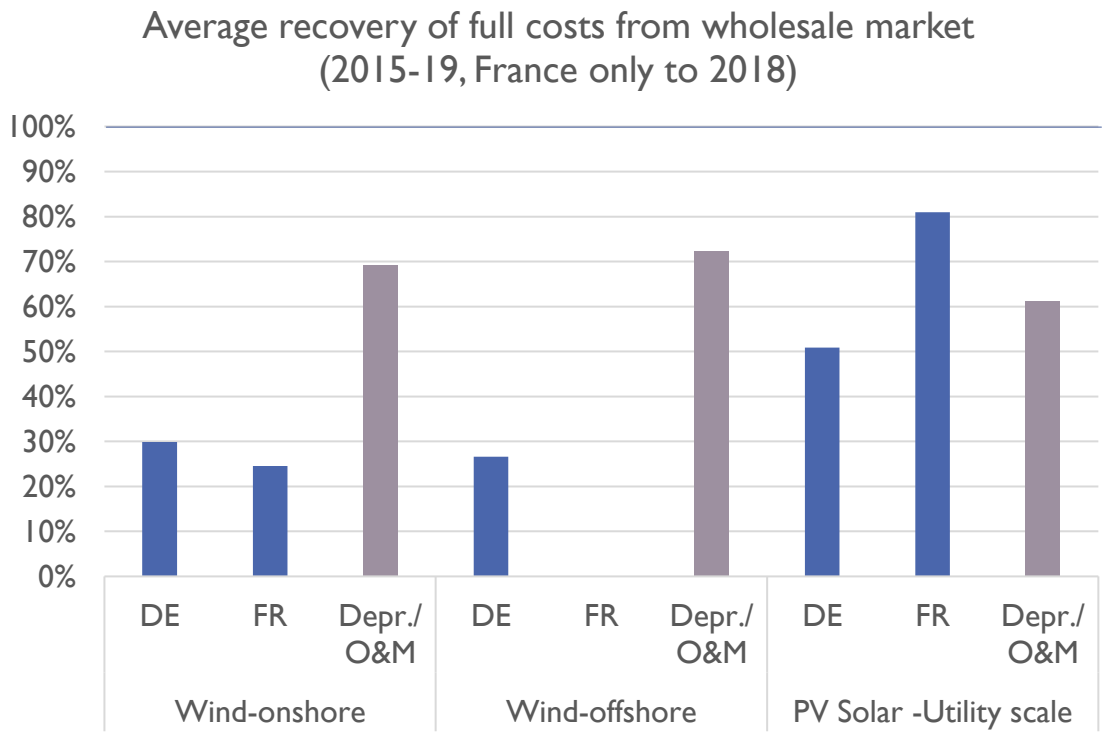
	CCGT	Hard coal	Nuclear (2nd gen.)	Onshore wind	Offshore wind	PV Solar (Utility scale)
Specific cost (€ 000/MW)	950	1650	2500	1750	3900	700
Project life (years)	25	40	40	25	25	25
Efficiency (HCV)	52%	44%	33%			

AVERAGE RECOVERY OF FULL COSTS FROM WHOLESALE MARKET BY COUNTRY – THERMAL PLANTS



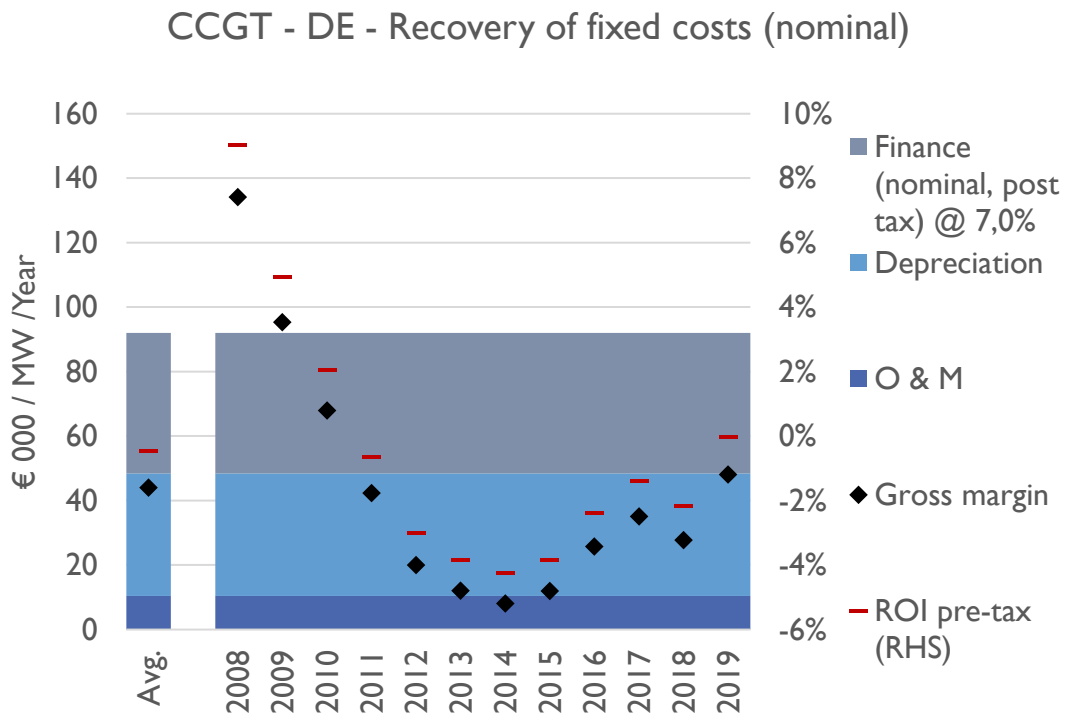
- CCGTs did not on average recover depreciation + O&M costs – there was no return on investment
  - Inclusion of 2008/9 (as far as data available) would have led to higher results
- Hard coal plants were in a similar position to CCGTs in Germany but did somewhat better in France
- Nuclear plants (planned and brought into operation well before liberalization in 1998) did recover their full costs

AVERAGE RECOVERY OF FULL COSTS FROM WHOLESALE MARKET BY COUNTRY – RENEWABLE PLANTS

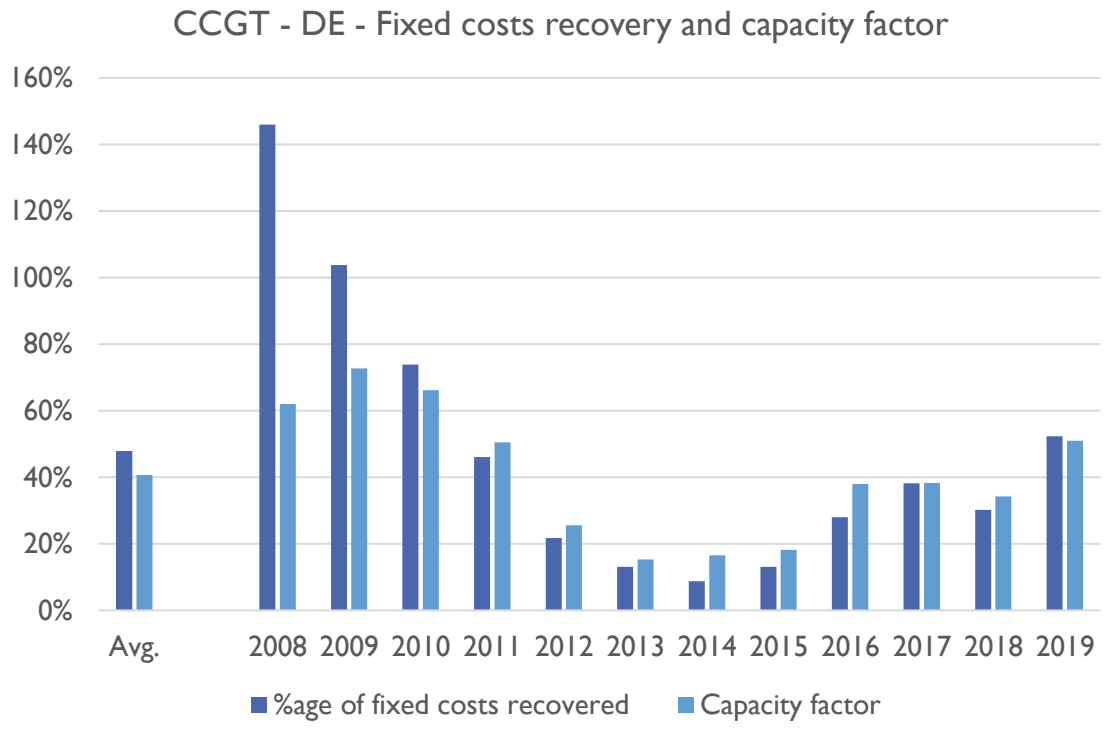


- Wind plants – wholesale market returns would have been totally inadequate
  - Raises doubts about prospects for operators who made zero subsidy bids on various offshore projects to recover their costs
- PV Solar – wholesale markets cover depreciation and O&M but not financing costs

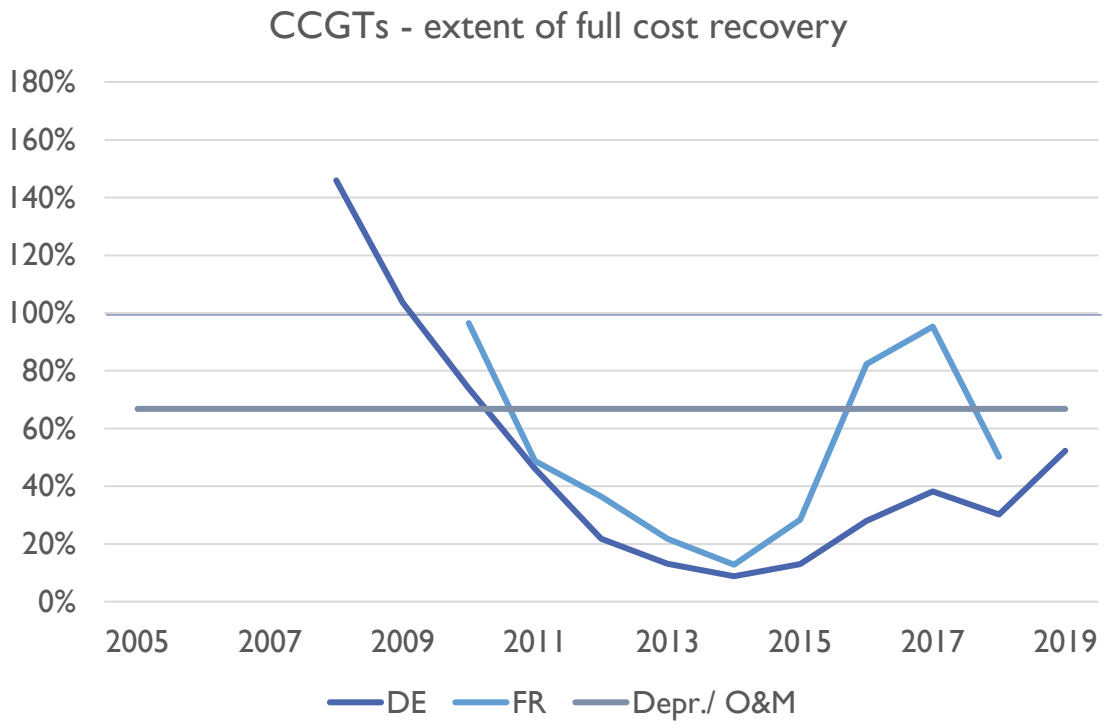
DETAILED ANALYSIS FOR CCGTs IN GERMANY: ON AVERAGE ONLY 48% OF FIXED COSTS RECOVERED

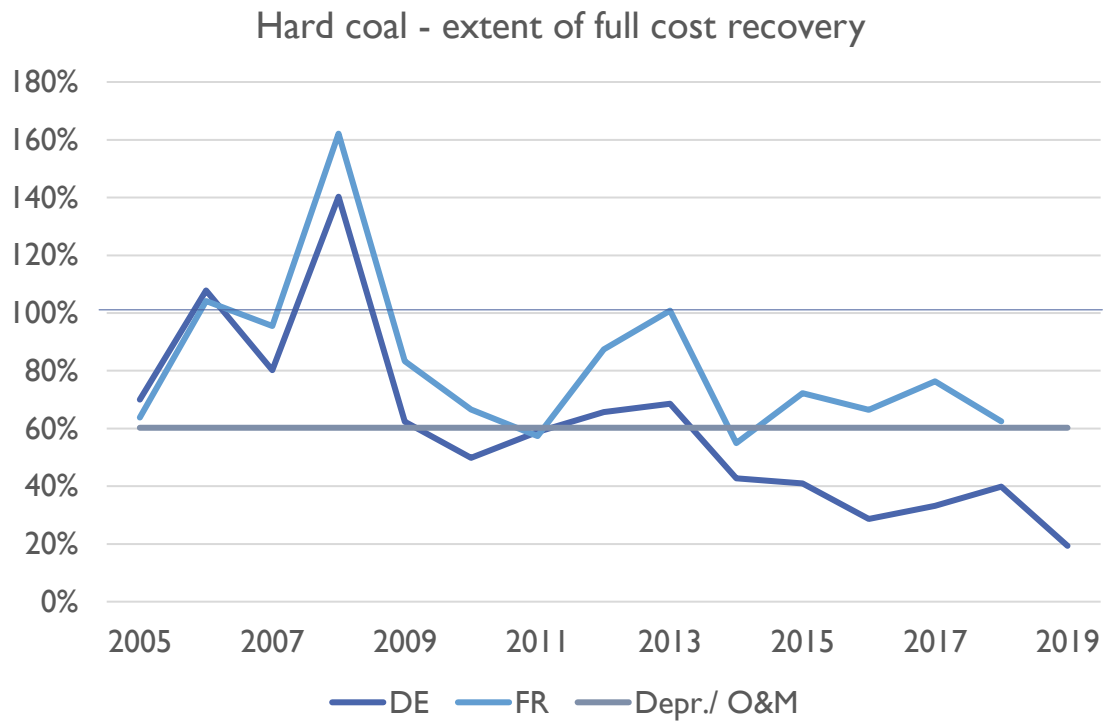


Note: Depreciation is equivalent to finance @ 0%

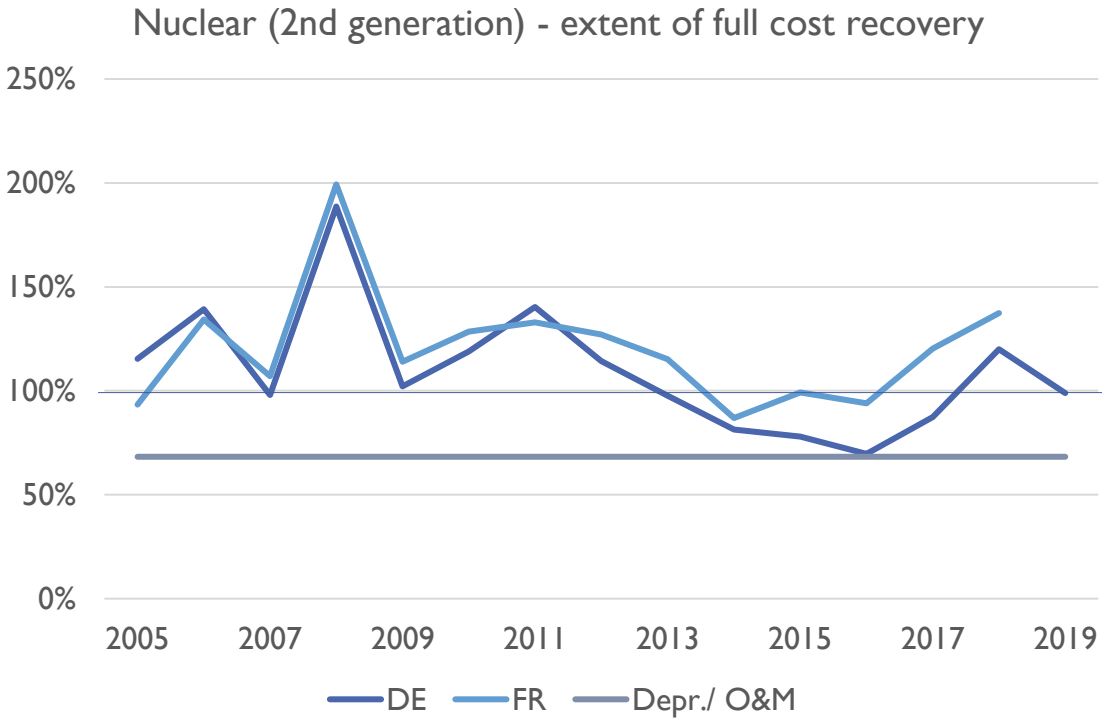


EXTENT OF FULL-COST RECOVERY OVER TIME – CCGTs AND HARD COAL PLANTS IN FRANCE AND GERMANY



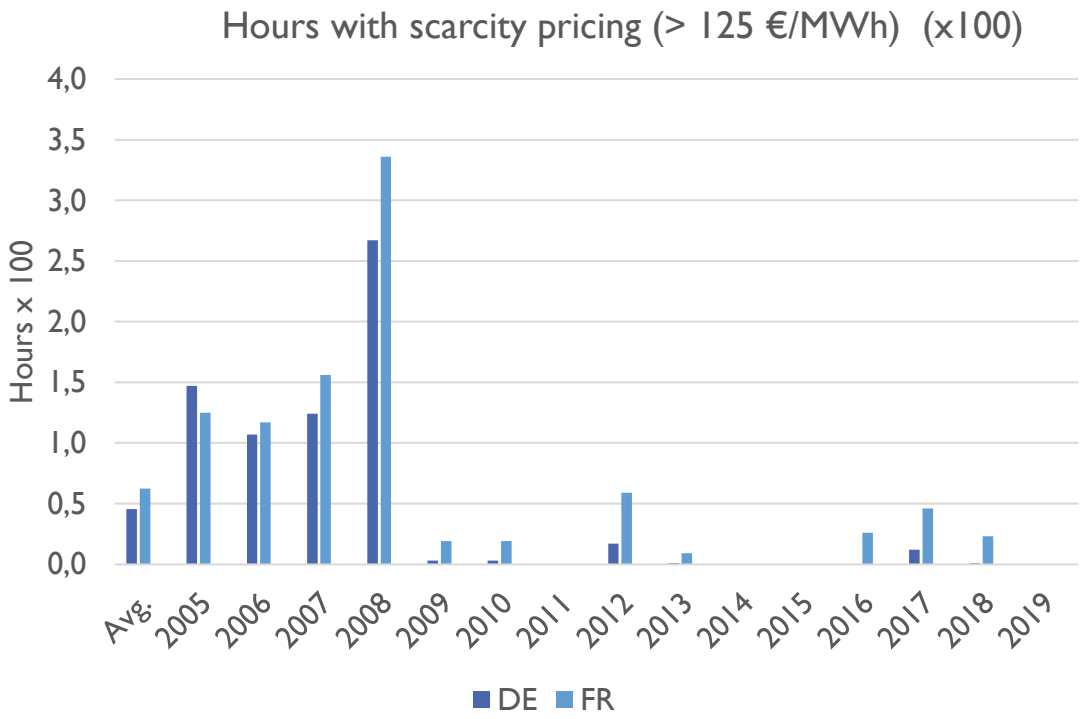


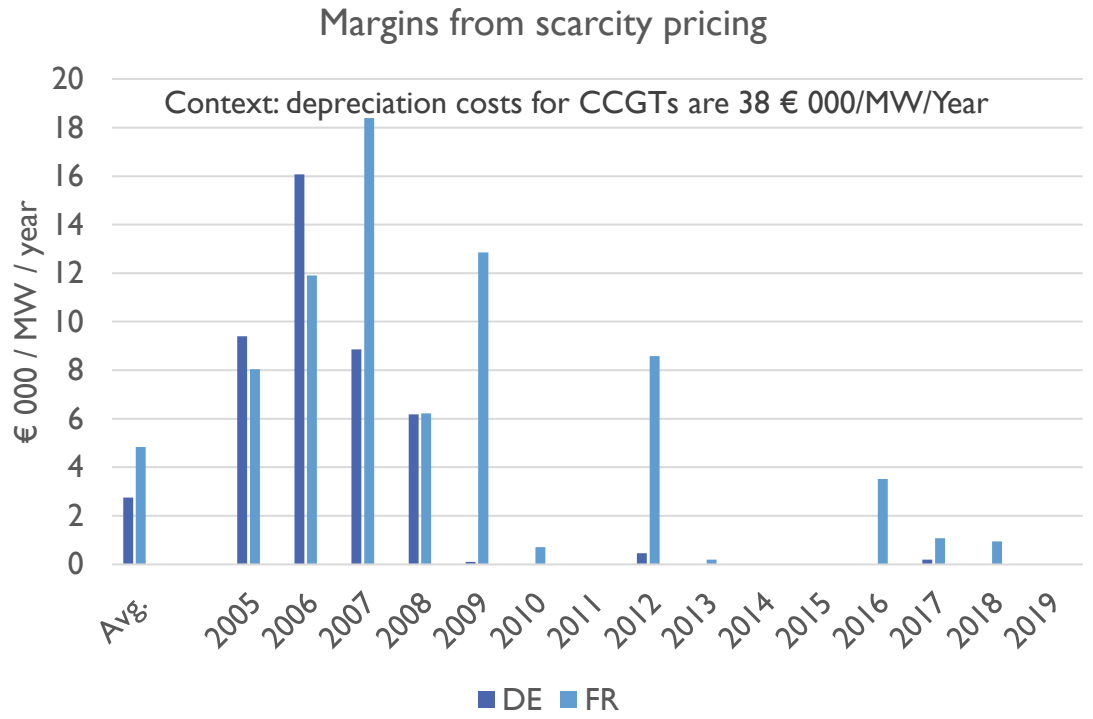
EXTENT OF FULL-COST RECOVERY OVER TIME – NUCLEAR PLANTS



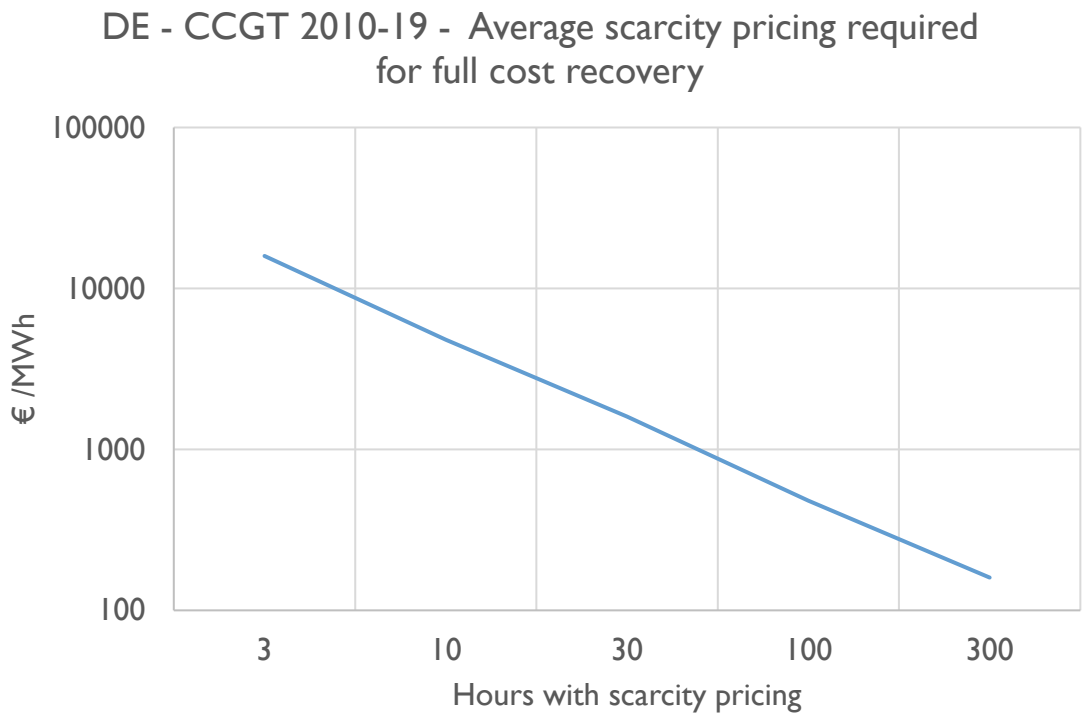
- In the period between 2008-2010 both thermal and nuclear plants had a high recovery of their full costs
- Afterwards except for nuclear and hard coal in France the recovery rate was much lower
- Factors which may explain the lower recovery can include:
  - Over-capacity due to reduced demand following the2008/9 Global Financial Crisis which also caused the CO_2 price to fall sharply
  - Improved inter-connections, effectively increasing the availability of capacity
  - The increased share of renewables

SCARCITY PRICING – FELL OFF A CLIFF AFTER GLOBAL CRISIS





HOW MUCH ADDITIONAL SCARCITY PRICING WOULD HAVE BEEN REQUIRED TO COVER FULL COSTS?

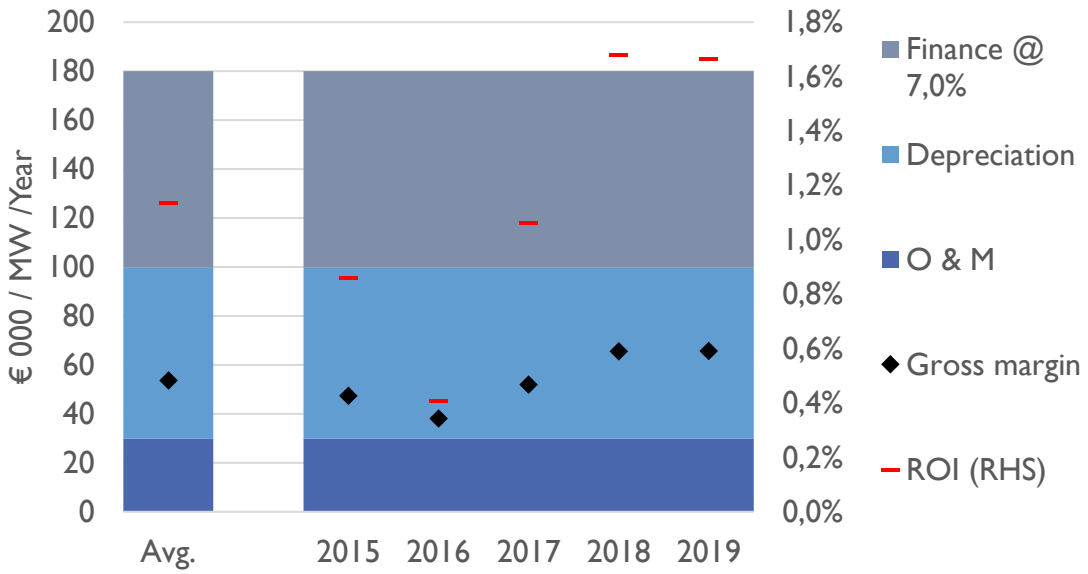


OBSERVATIONS

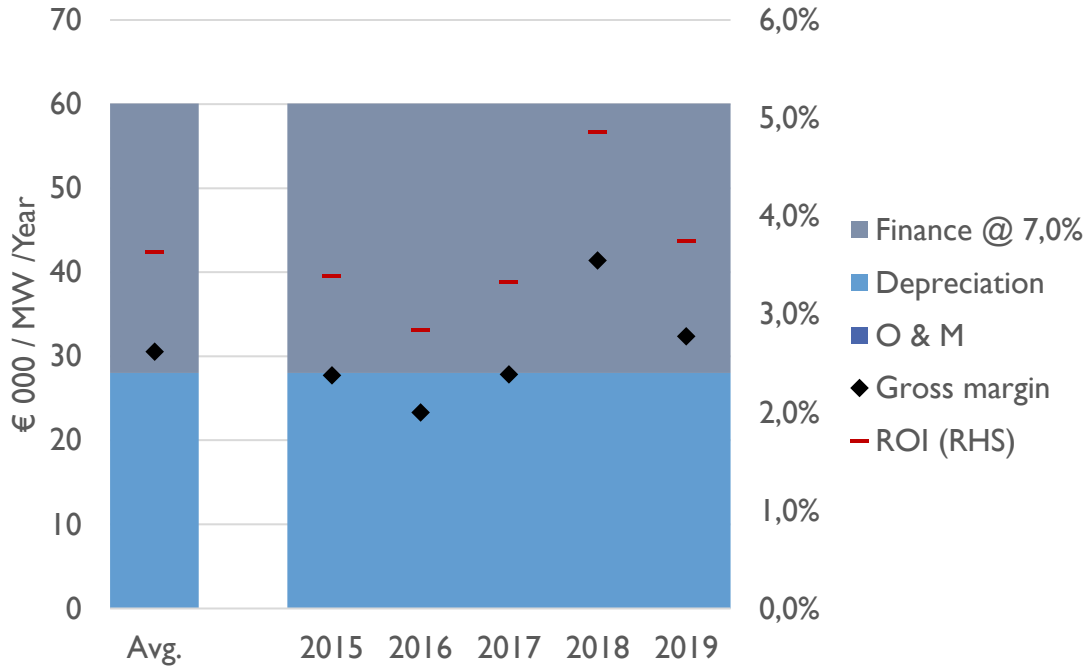
- It is unlikely that scarcity prices based on 30 hours or less and therefore on average ca. € 5 000 / MWh would be accepted:
  - Depending upon the frequency distribution, in many hours the prices would be well over € 10 000 / MWh
    - France allows 3 hours loss of load p.a. and concluded that a capacity market was required since prices above € 3 000 / MWh would not be acceptable and are capped at this level
  - It is conceivable that average scarcity prices around € 500 / MWh would be accepted
    - But how can it be arranged and guaranteed that this would happen?

RECOVERY OF FIXED COSTS – WIND (ONSHORE) AND PV PLANTS IN GERMANY

Onshore wind - DE - Recovery of fixed costs (nominal)

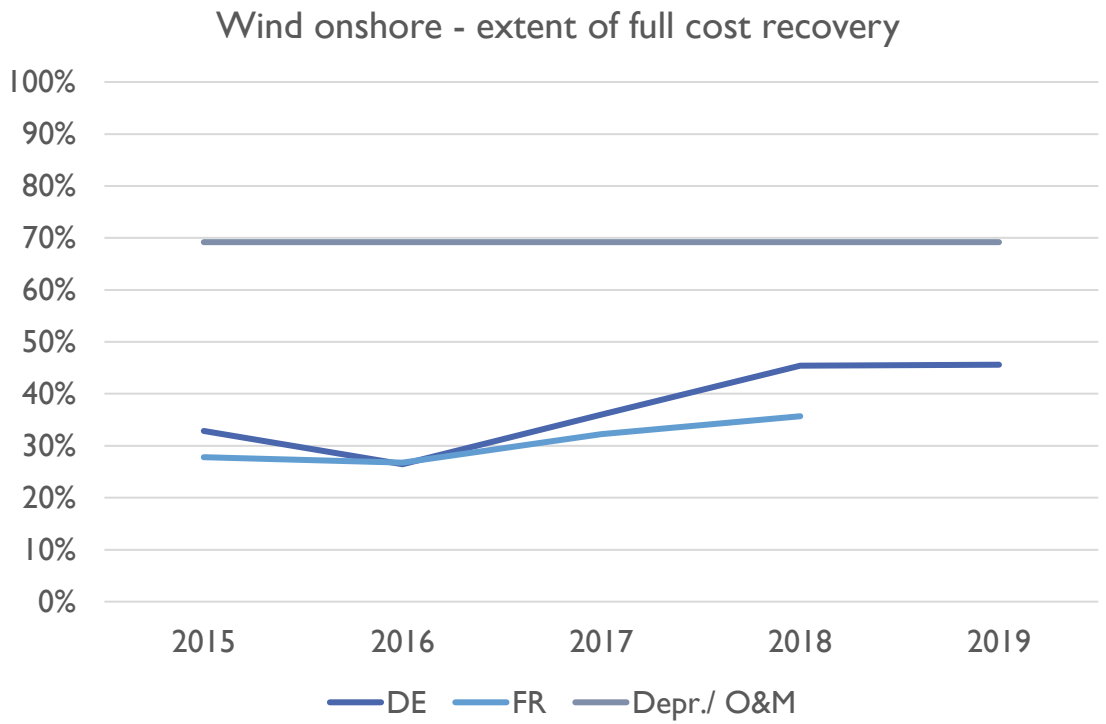


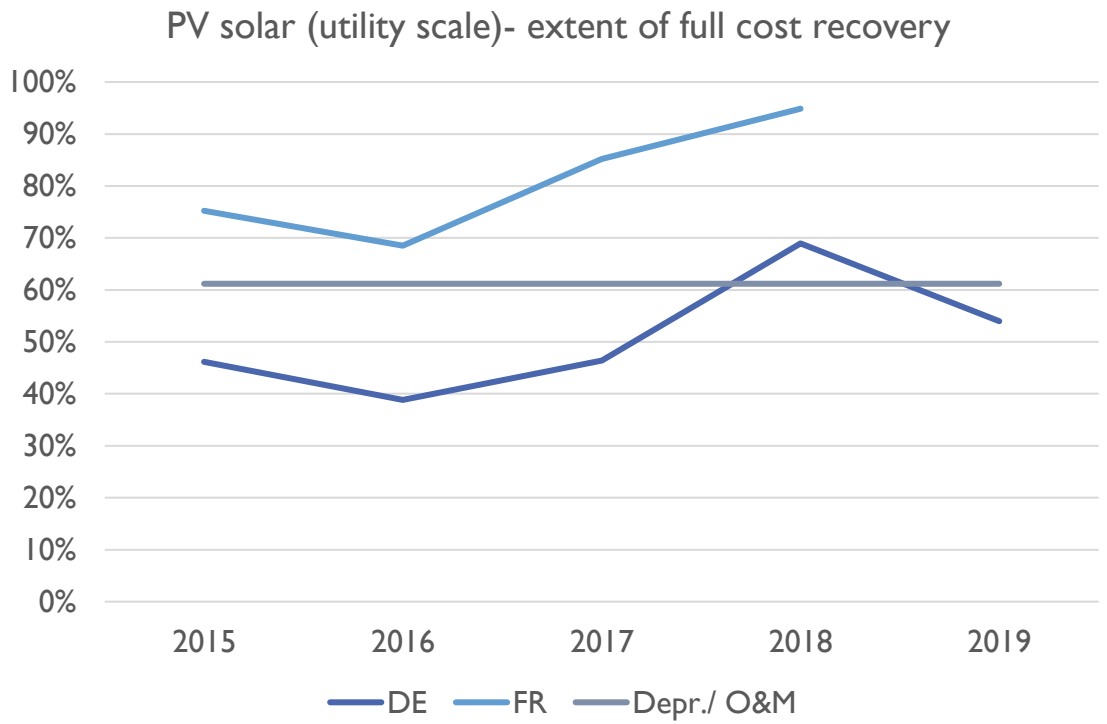
PV Solar - DE - Recovery of fixed costs (nominal)



Note: Offshore wind has similar results

EXTENT OF FULL COST RECOVERY – WIND (ONSHORE) AND PV PLANTS





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TO THE EXTENT THAT THERE IS A SHORTFALL, WHY IS THE RETURN FROM WHOLESALE MARKET INADEQUATE?

- Structural overcapacity and therefore low utilisation
  - Long-term impact of Global Crisis (2008) – electricity demand in Europe was ca. 3% lower than expected for several years; lower CO_2 price
  - Renewables plants were being added without price signals
  - Increased interconnection effectively raised level of available capacity in markets
  - Classic micro-economic conditions for adding capacity were never realised when SRMC(existing plant) => LRMC(new plant) because of substantial differences in thermal efficiency
  - Barriers to closing plants – closure costs are high, and prospects of improved returns or modification for other fuel delay decisions
- Gradient of supply-curve did not allow high infra-marginal rents
  - Investment in coal-plants (in Germany) to increase their flexibility displaced the higher variable-cost gas plants
- As compared to other commodity markets the cost structure of plants is extremely heterogeneous
  - There is no a priori reason why infra-marginal rent should be sufficient to remunerate the full fixed costs of different types of plants
- Scarcity pricing was strong until 2008 and then almost completely ceased
  - Mainly consequence of structural over-supply

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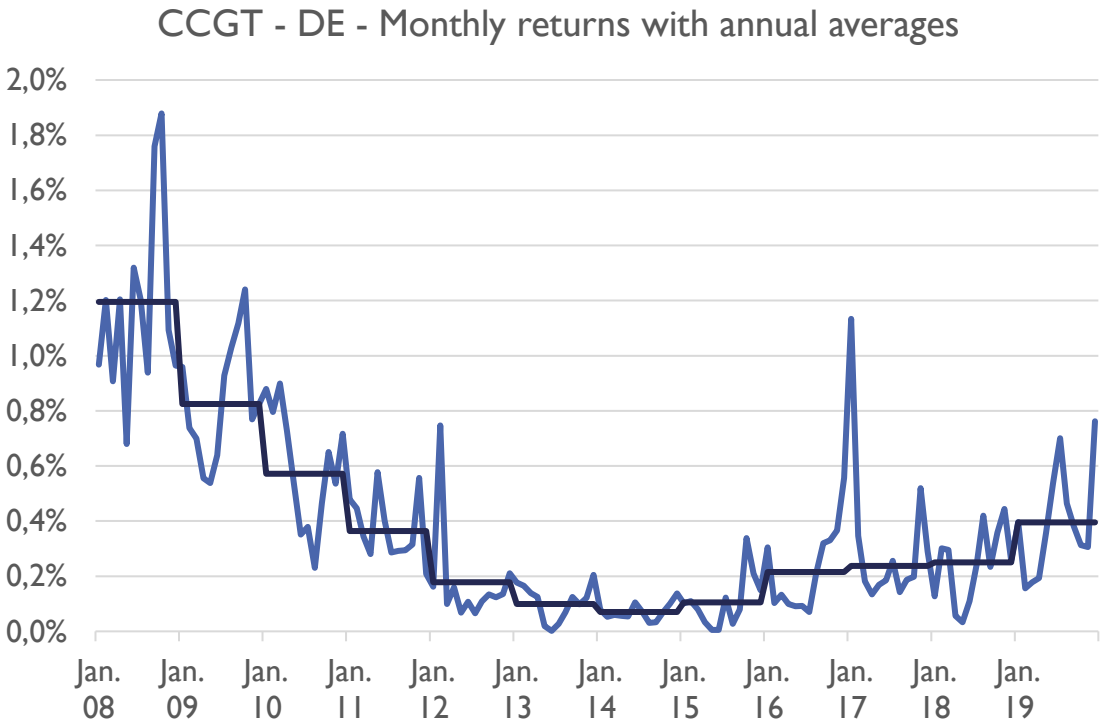
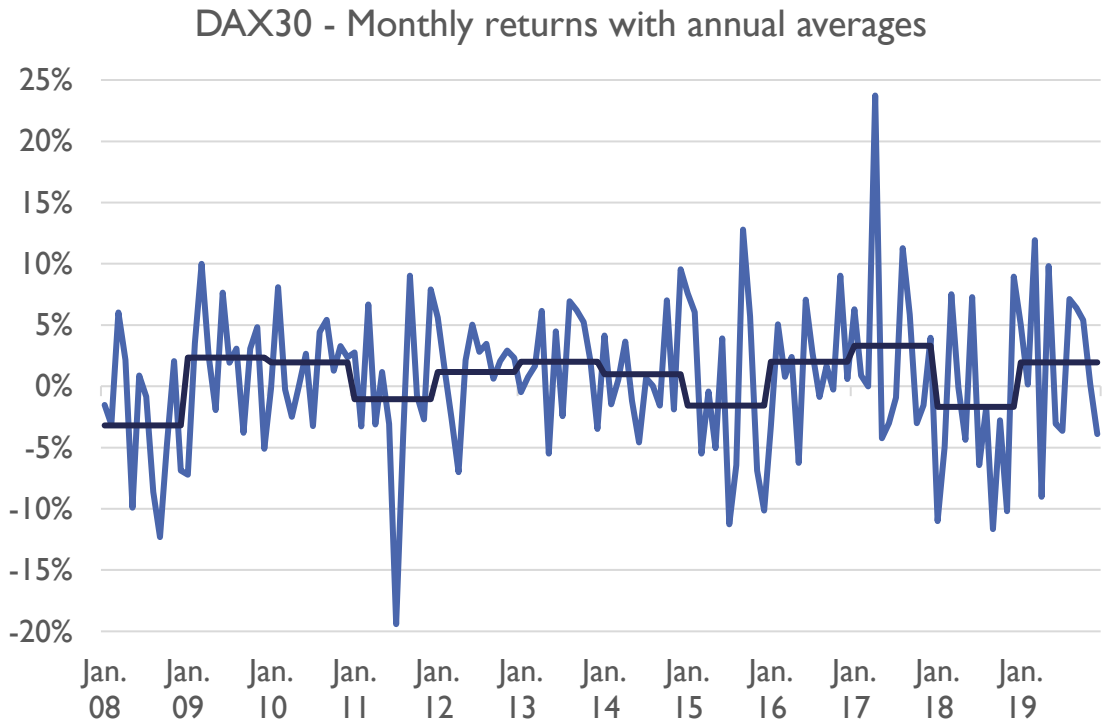
CAN THE EMPIRICAL ANALYSIS HELP DETERMINE THE APPROPRIATE COST OF CAPITAL FOR POWER PLANTS?

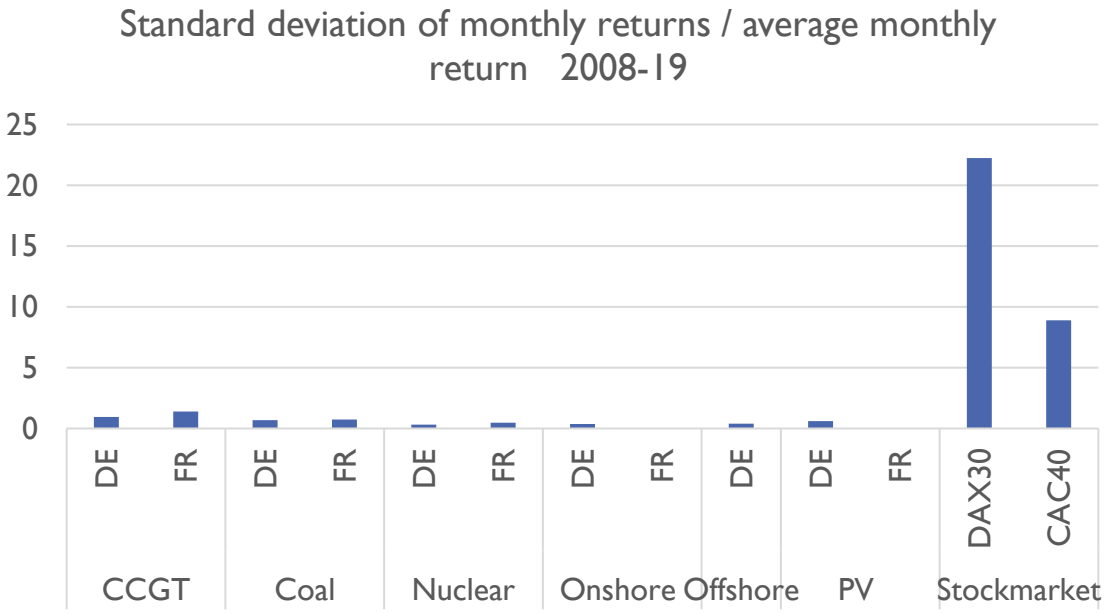
- The normal approach to calculate the beta of a stock is to determine the correlation coefficient with the relevant market index with monthly granularity and for 36 months
- It is questionable as to whether the Capital Asset Pricing Model (CAPM) can be applied to physical asset returns:
  - Monthly returns on a stock index do not include depreciation, and the returns accumulate on top off original value of index
  - Monthly returns on a physical asset normally include depreciation and at end of its economic life the asset has no residual value
- One approach is to apply cash margins alone from the physical plant (clean spreads – O&M costs) in the CAPM
- An alternative approach is to compare the volatility of the returns, although there is not be a unique definition of such returns
  - The approach also has its limitations when the returns have moved from one level for several years to a much lower level
- The time-frame chosen makes a considerable difference as the years 2008-10 showed much higher asset returns for thermal plants; commodity data was not available before 2008
- Statistical methods all have their limitations and even the CAPM applied alone to financial assets may not always be suitable

THE STATISTICAL CONUNDRUM – TIME-SERIES WITH VERY DIFFERENT CHARACTERISTICS

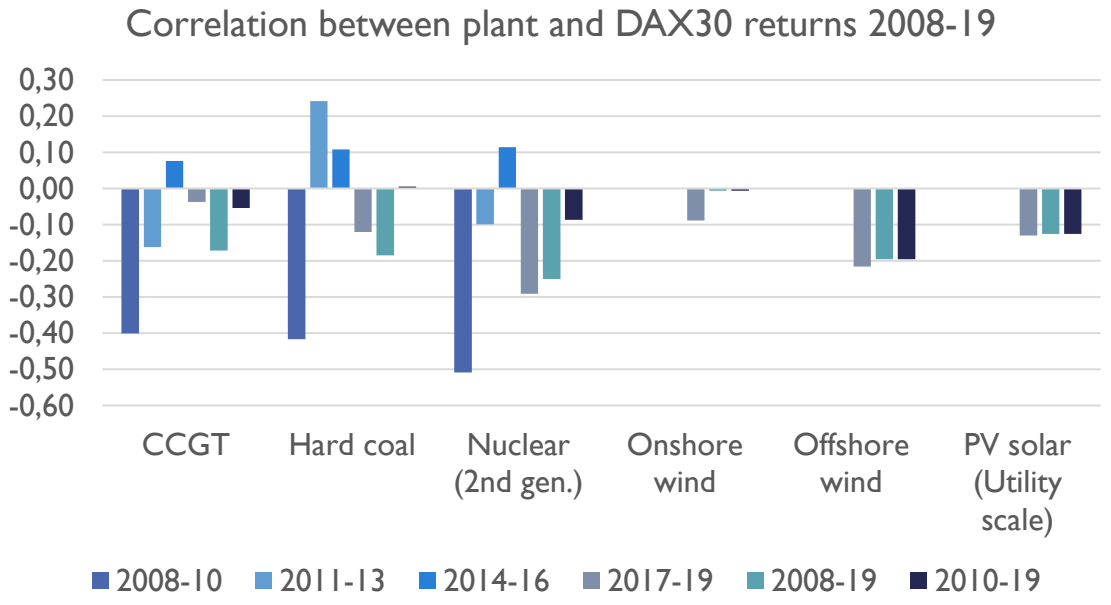




VOLATILITY OF STOCK MARKET AND THERMAL PLANT RETURNS: THE FORMER ARE AN ORDER OF MAGNITUDE HIGHER



Note: alternative definitions of returns will lead to very different results



Note: an alternative method led to betas for CCGTs of 1.17 for the period 2010-19 but -2.69 for 2008-19

OBSERVATIONS

- The monthly returns on power plant assets (using one definition) are much less volatile (in relation to the average value) than returns on the stock market indices
  - A consideration of the relevant drivers (RH table) partly explains this
- The correlation between the two sets of monthly returns over the long-run is negative and between -0.15 and -0.25
- Directionally the results are pointing towards a beta below 1.0 but the empirical analysis is not sufficiently compelling to help determine the betas for power plants in merchant markets
- The greater problem which does emerge more conclusively from the analysis is that the annual level of returns have reduced considerable and on average are structurally too low

Factors potentially driving returns:	Stock markets	Power plants
Market sentiment and expectations	XXX	
GDP	XX	X
Asset / company returns – past / forecast	XX	XXX
Commodity prices		XX
Weather		XX
Other?		

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RELEVANCE OF ANALYSIS FOR FUTURE PLANT INVESTMENTS

Renewables

- The analysis suggests strongly that subsidies will continue to be required in the future, since depreciation of wind plants not fully covered
- Whilst there is hope that renewables' costs will continue to decline in absolute terms and in relation to the wholesale price, there are also strong reasons as to why they might stabilise or even increase:
  - Tightness in different parts of the supply chain, land scarcity, leading to its value being bid up, and cannibalisation with increased curtailment

Firm capacity to meet peak demand: peaker plants and storage

- The analysis shows no prospects of full cost recovery from wholesale market for new peaker-plants or storage required to cover peak demand, with cost-structure similar to other thermal plants, but with need to recover full cost over relatively few hours
  - This is partly due to over-capacity in the periods considered
  - But because of multiple societal requirements of the power sector, it is unlikely this will change much in the future
- Scarcity pricing cannot be expected to contribute materially
- Therefore, again a second source of income will be required to enable the full costs to be recovered

Empirical evidence points towards an ongoing need for hybrid markets!

THANK YOU FOR YOUR INTEREST!

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