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European Institute
for Energy Research
by EDF and KIT

Spatial economic potential of post feed-in tariff wind turbines in Germany

EGU General Assembly 2021 | Display material

TABLE OF CONTENT

I. Motivation and research question

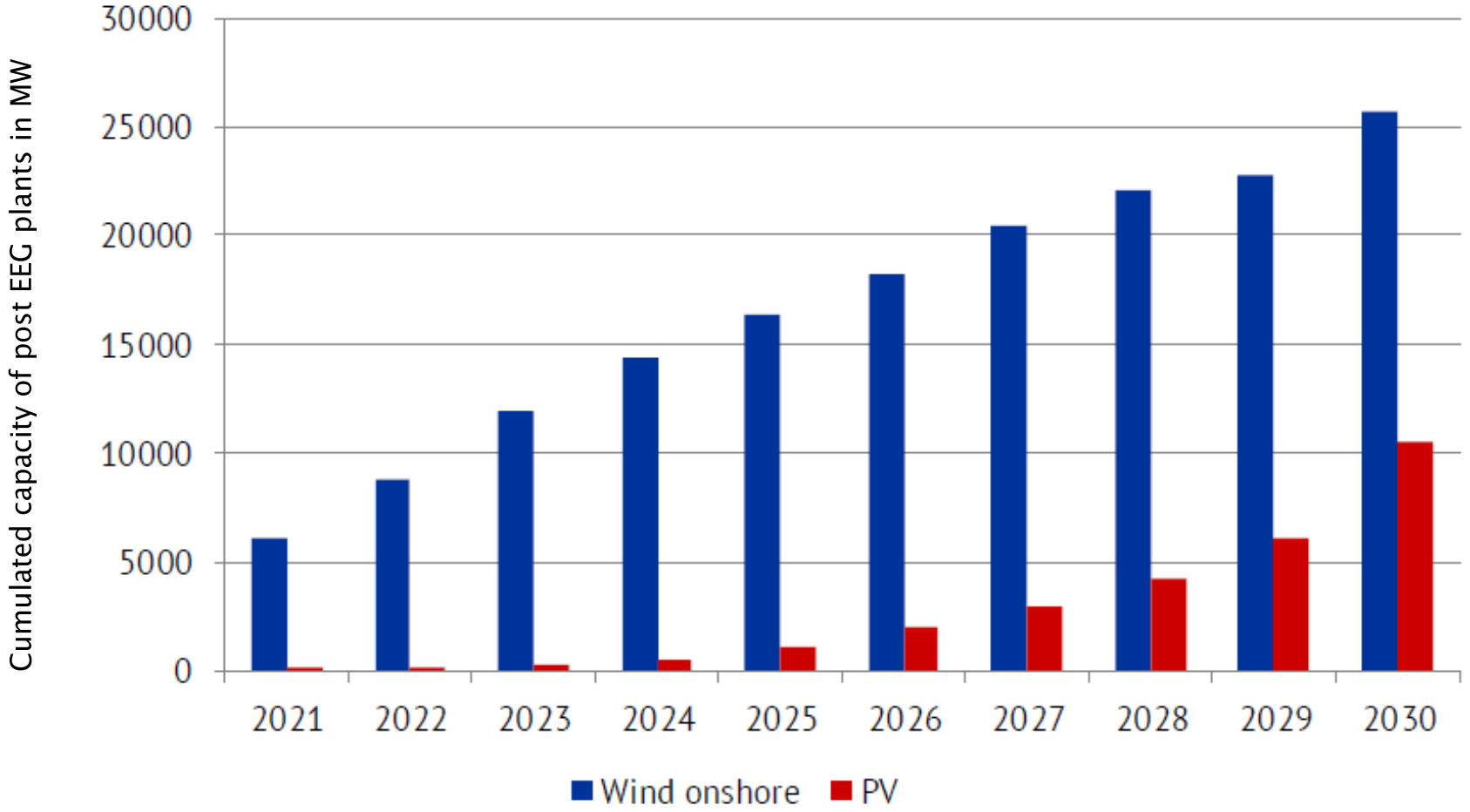
PPA – Definition

Power Purchase Agreement is a general term for direct marketing contracts

- PPA (Power Purchase Agreement) is a general term for diverse contracts for example classical direct marketing contracts as well as electricity trading contracts.
- There is no concrete definition of PPAs in the EEG (Renewable Energy Sources Act), however it is regulated through Renewables Energy Guideline 2018/2001: "'renewables power purchase agreement' means a contract under which a natural or legal person agrees to purchase renewable electricity directly from an electricity producer".
- The main focus of PPAs is to create a direct contract between the producer of electricity and the direct marketer or end consumer to reduce price volatility from the market.

Phase out of subsidies

Wind and PV plants leaving the FiT scheme are seeking for new income streams

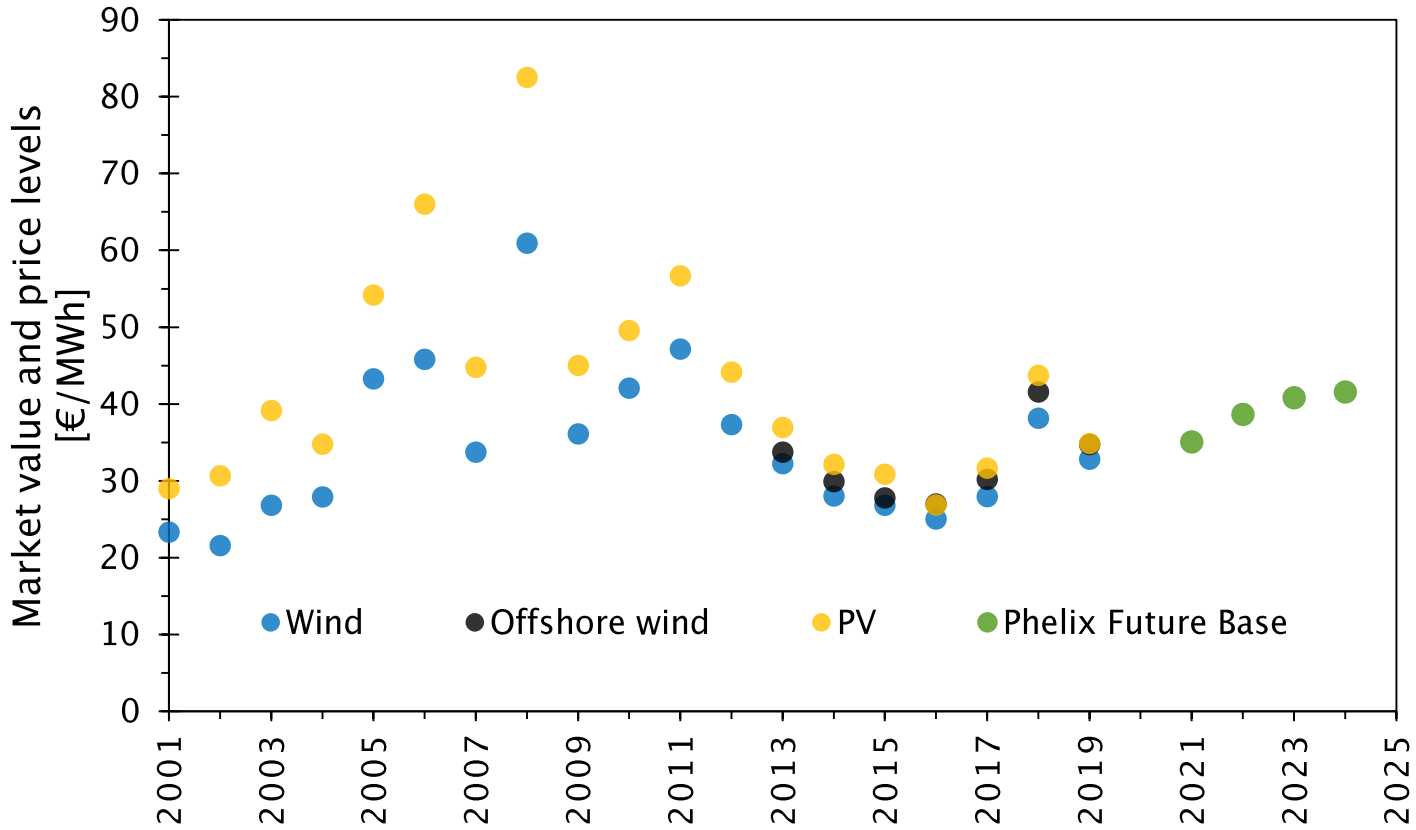


Energy Brainpool 2019: POWER PURCHASE AGREEMENTS II

Regional market value assessment

Price level drives market value evolution

Evolution of VRE market values and price levels in Germany (2001–2024)



- Market values (absolute market revenues per MWh) still strongly depend on the overall price level
- Commodity and CO_2 allowance prices itself drive overall price level
- Increasing Phelix Future Base price indicates rising price level supporting VRE revenues

Eising et al. (2020): Future wind and solar power market values in Germany — Evidence of spatial and technological dependencies?, Energy Economics

Regional market value assessment

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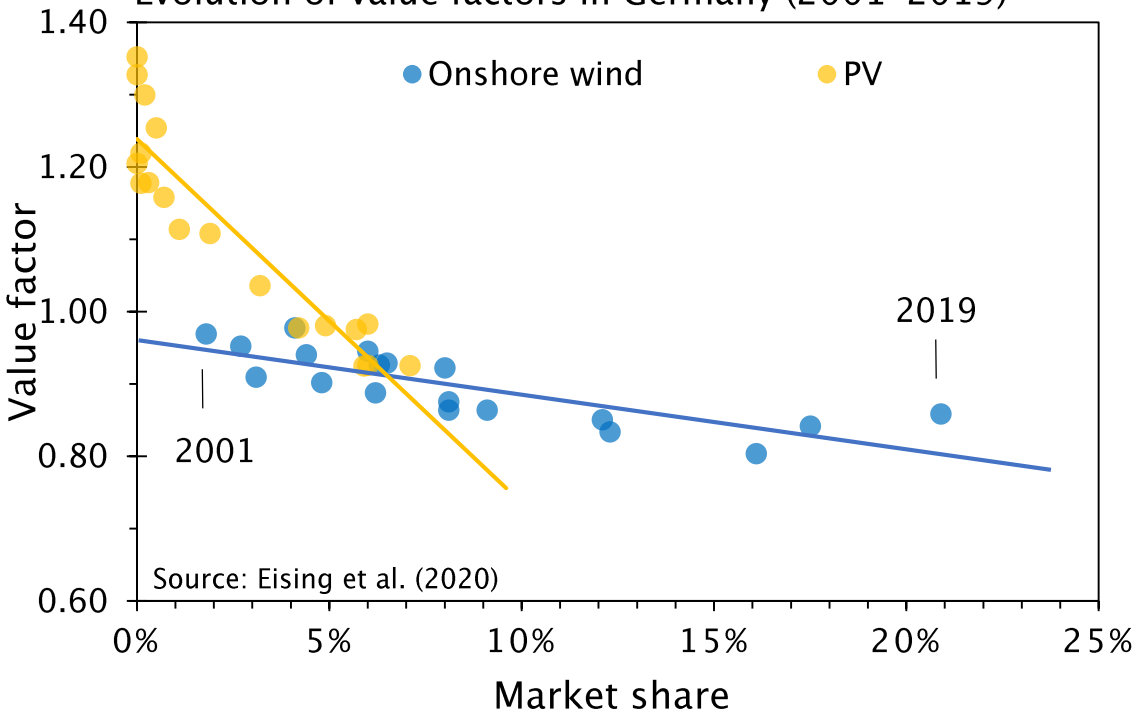
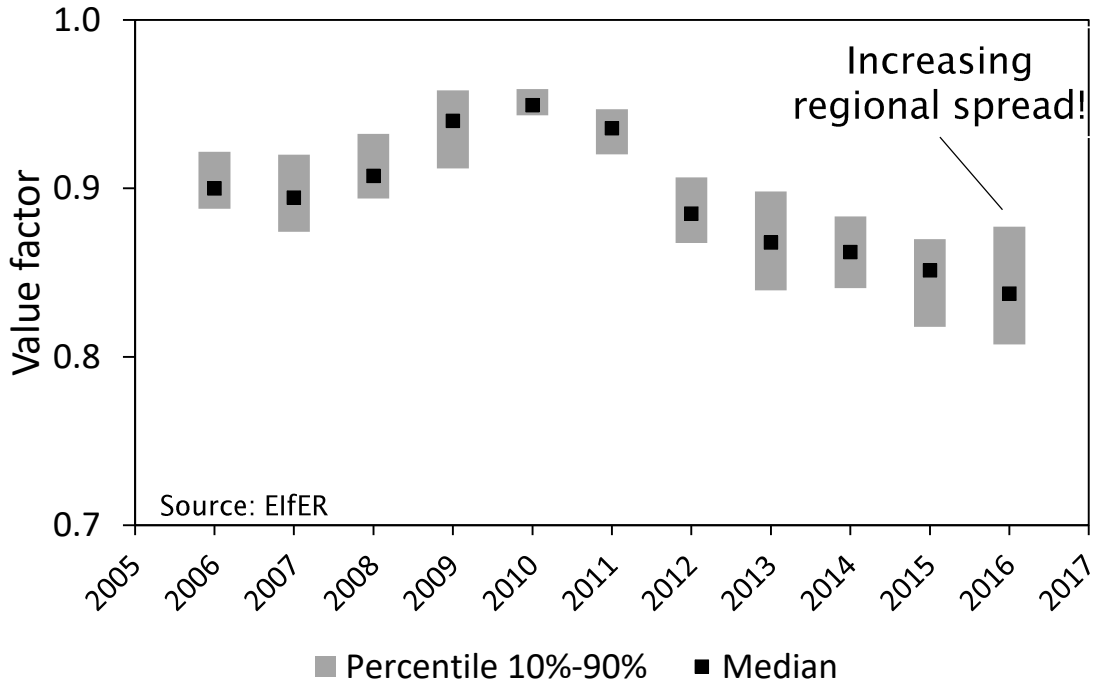
‘Cannibalization’ of value factors while regional spreads increase

Evolution of value factors in Germany (2001–2019)



Evolution of regional wind value factors (38 NUTS2 regions)



- During hours of high feed-in, wind and PV generation depress prices (merit-order effect)
- Hence, the relative value of wind and solar power drops as their market share increases

Eising et al. (2020): Future wind and solar power market values in Germany — Evidence of spatial and technological dependencies?, Energy Economics

Research question

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Motivation:

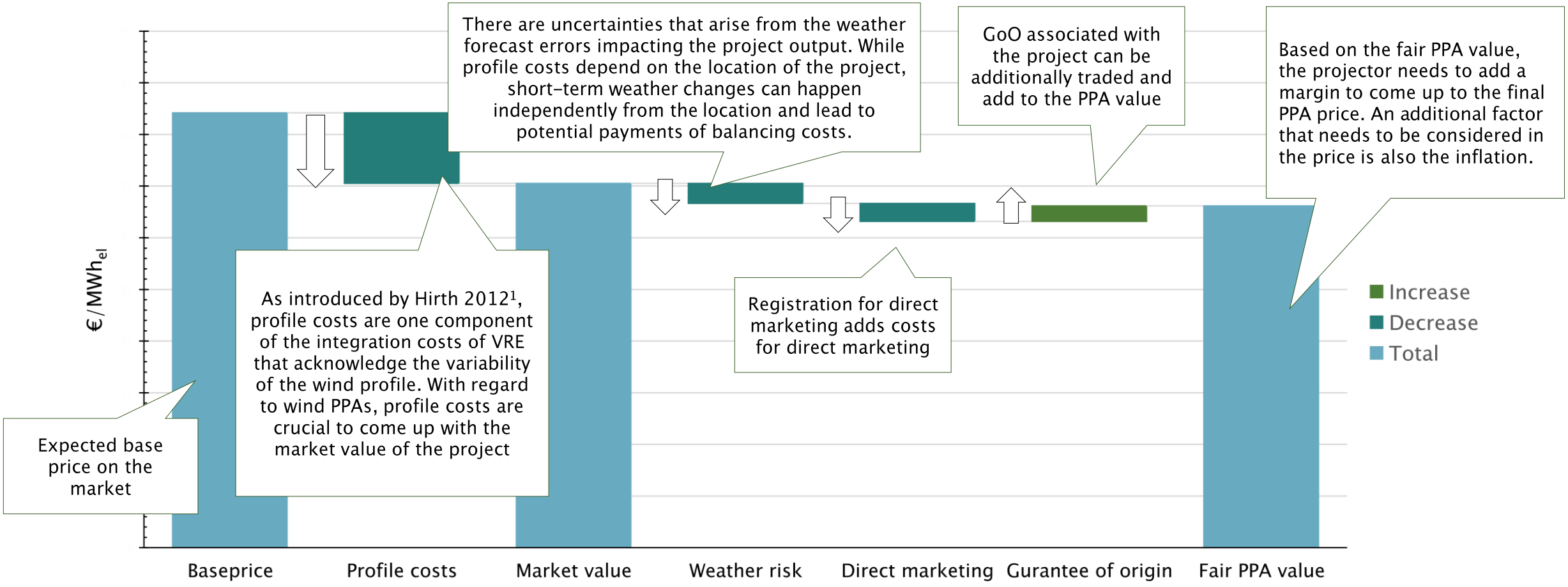
1. Increasing capacities volumes if power plants leaving the FiT support scheme until 2030.
2. Decreasing value factors potentially influence the development of PPAs values.
3. Value factors vary between regions.

Research question:

1. Which regions are most suitable for continuing operation of post Feed-in Tariff wind turbines?
2. What is the revenue potential of post feed-in tariff PPAs?

Fair PPA value

Factors influencing the PPA value



[1] Hirth, Lion, Integration Costs and the Value of Wind Power (December 10, 2012). USAEE Working Paper No. 12-150

II. Methods

PPA economic evaluation model

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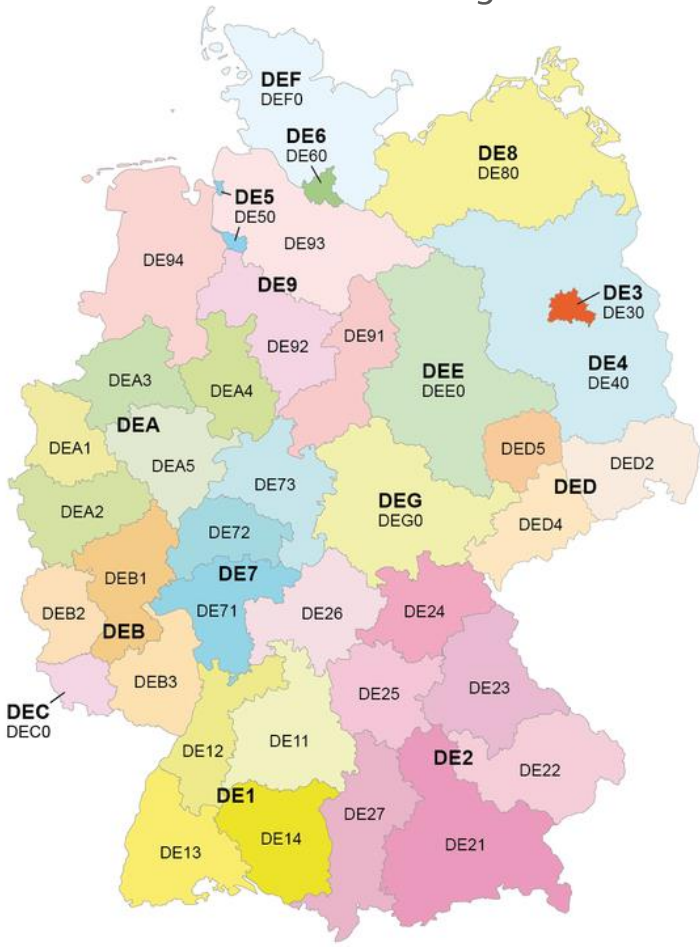
Model description

- Objective:
  - Reveal regional operational marginal returns of Post-EEG wind onshore power plants
  - Support decision on further operation of wind onshore power plants
- Function
  - Operational marginal return = regional wind market value – operational costs
- Input data:
  - Recalculated hourly wind feed-in time series (1980-2016) for German NUTS2 regions
  - Hourly German day-ahead price time series (2006-2019)
  - Operation cost range: 20-46 €/MWh_{el}

German NUTS-2* regions



DE11	Stuttgart
DE12	Karlsruhe
DE13	Freiburg
DE14	Tübingen
DE21	Oberbayern
DE22	Niederbayern
DE23	Oberpfalz
DE24	Oberfranken
DE25	Mittelfranken
DE26	Unterfranken
DE27	Schwaben
DE30	Berlin
DE40	Brandenburg
DE50	Bremen
DE60	Hamburg
DE71	Darmstadt
DE72	Gießen
DE73	Kassel
DE80	Mecklenburg-Vorpommern
DE91	Braunschweig
DE92	Hannover
DE93	Lüneburg
DE94	Weser-Ems
DEA1	Düsseldorf
DEA2	Köln
DEA3	Münster
DEA4	Detmold
DEA5	Arnsberg
DEB1	Koblenz
DEB2	Trier
DEB3	Rheinhessen-Pfalz
DEC0	Saarland
DED2	Dresden
DED4	Chemnitz
DED5	Leipzig
DEE0	Sachsen-Anhalt
DEF0	Schleswig-Holstein
DEG0	Thüringen

* NUTS = Nomenclature des unités territoriales statistiques. In Germany NUTS-2 regions usually refer to the level of Regierungsbezirke.

PPA economic evaluation model

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Model description

1. Calculation of regional wind value factors, market values (EUR/MWh) and market revenues [EUR]

(1) Value factor: $VF^{Wind} = \frac{\bar{p}^{Wind}}{\bar{p}}$

(2) Market value: $\bar{p}^{Wind} = \frac{\sum_{t=1}^{T} g_t^{Wind} * p_t}{\sum_{t=1}^{T} g_t^{tech}}$

(3) Average wholesale price: $\bar{p} = \sum_{t=1}^{T} \frac{p_t}{T}$

p_t hourly wholesale price

g_t^{Wind} hourly wind generation

2. Review of operational cost assumptions (EUR/MWh, EUR/MW)

3. Calculation of regional marginal profits/losses (EUR/MW)

III. Results

Regional market value assessment

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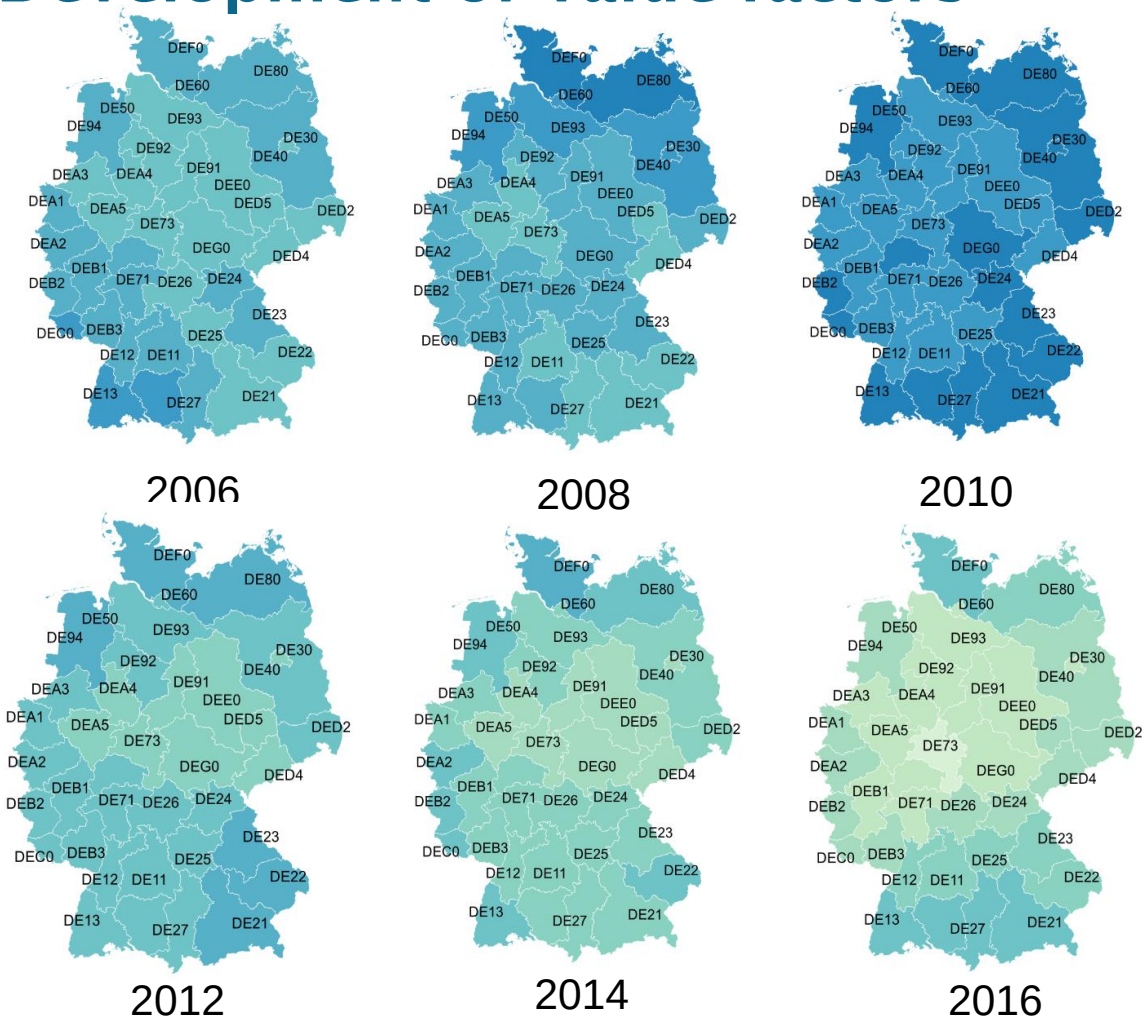
Development of value factors



Source: ElfER

- Regional value factors reveal increasing spatial spreads
  - ! Geographical diversification* and spatial investment decision is becoming more relevant than the full-load hours/LCOE only
- Wind power plant cluster with high regional wind capacity installed show significantly lower value factors
  - ! This regional "cannibalization effect"* is fostered by the spatio-temporal correlation of wind generation sites to another

*For details see Eising et al. (2020)

Regional market value assessment

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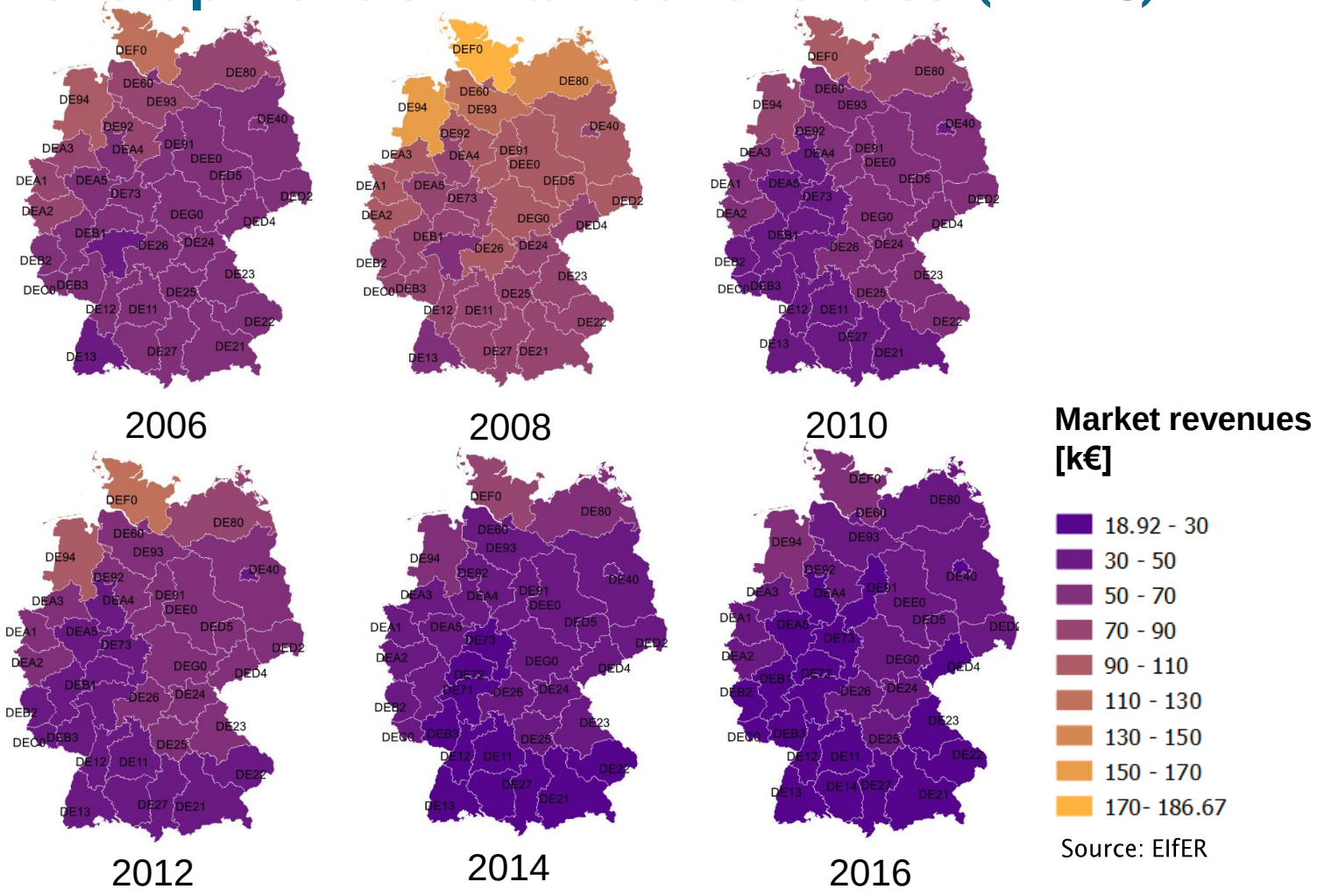
Development of market revenues (in k€)



Source: EIfER

- Absolute market revenues [in k€] depend on regional market value [€/MWh] and the overall generation outcome (full-load-hours) per region
- Overall market revenues are strongly dependent by the spot price level of the respective year

Market values

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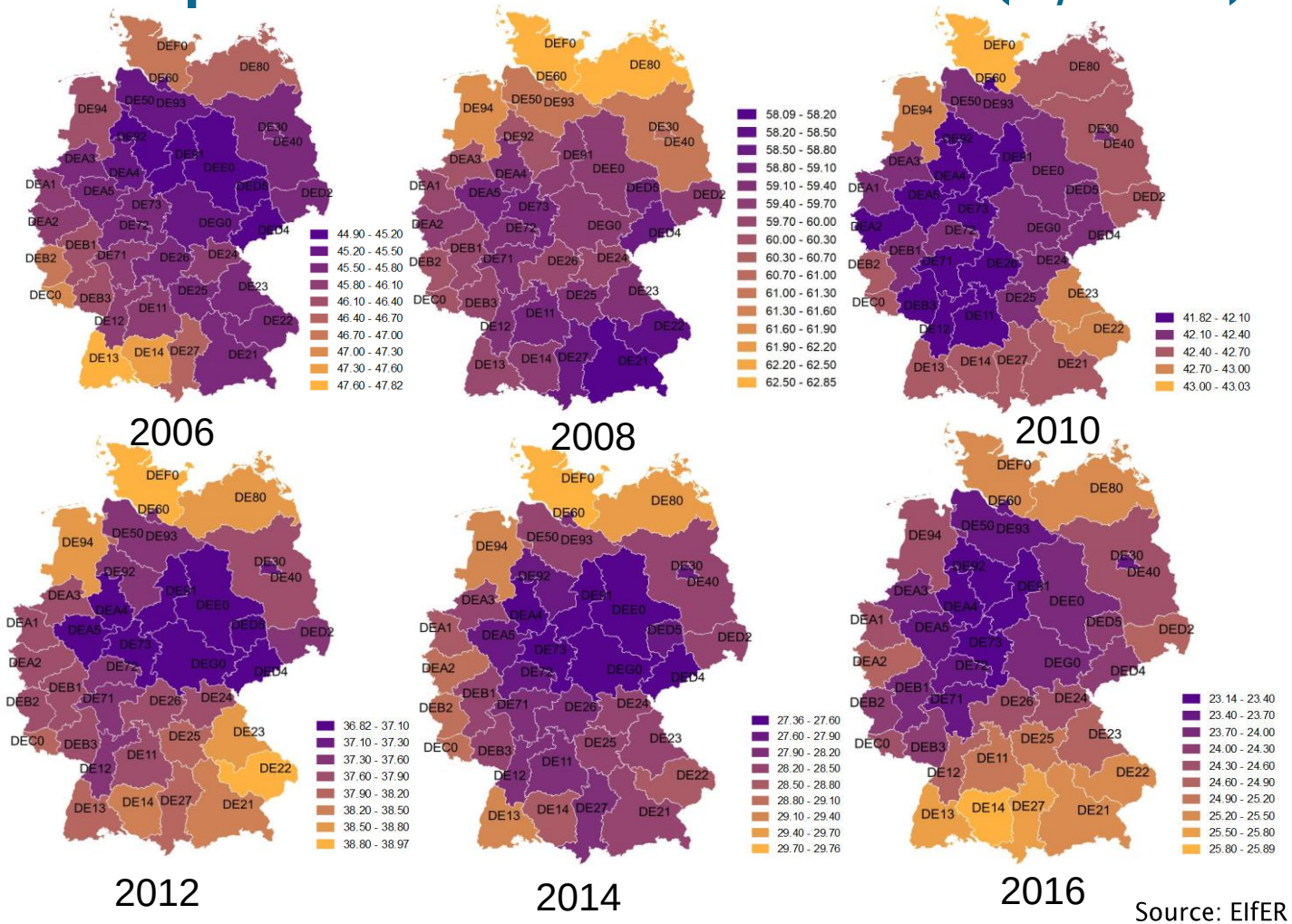
Development of market values in (€/MWh)



- Market values [€/MWh] are defined as the generation weighted average from wholesale price realized the sales of VRE[1]
- Market values are an important indicator for investment decisions in renewables
- Depiction in equal intervals of 0.3 €/MWh

[1]Eising et al. (2020): Future wind and solar power market values in Germany — Evidence of spatial and technological dependencies?, Energy Economics

Source: ElfER

PPA evaluation for Post-EEG wind turbines

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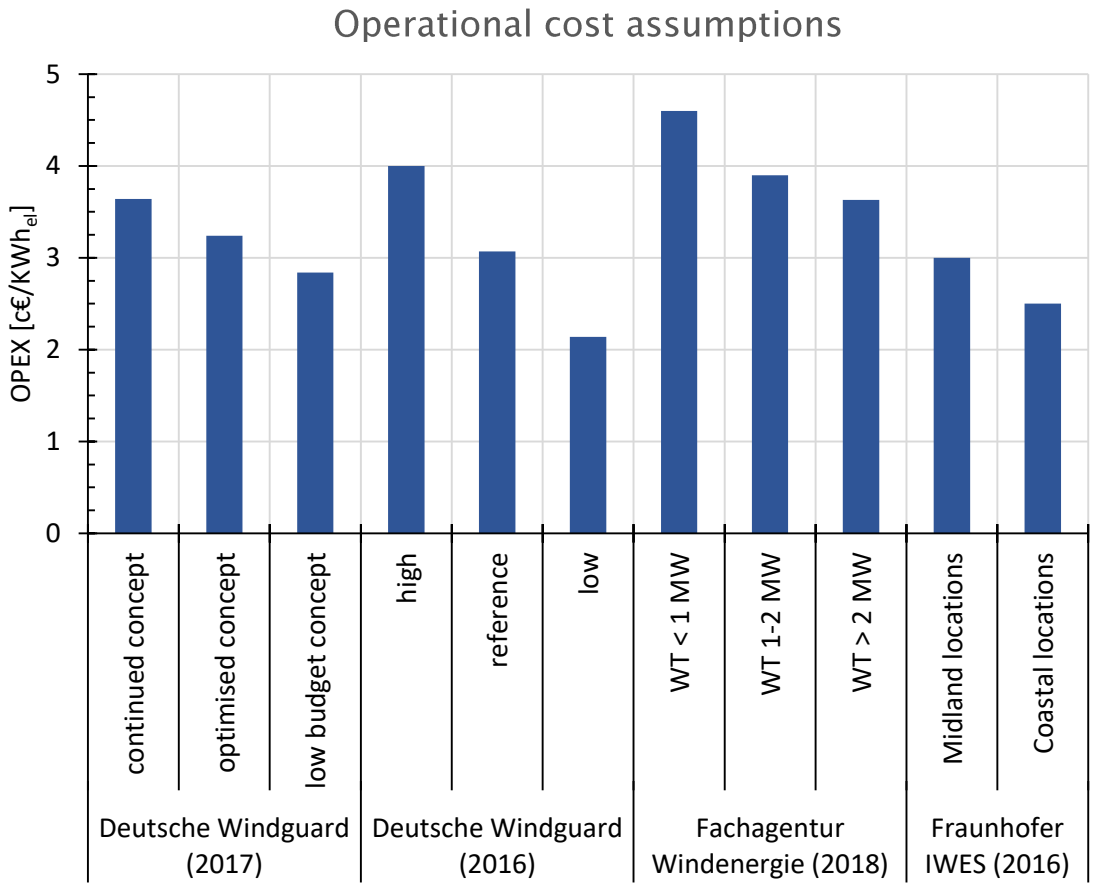
Operational cost for ongoing operation



- Operational costs of onshore wind for ongoing operation after 20 years diversify by:
  - » Installed power
  - » Location
  - » Turbine state
  - » Commissioning year
  - » Operation mode and maintenance costs strategy
- For further calculations we assume a cost range of 20-46€/MWh$_{el}$
- However, how to deal with fixed cost degression of operational costs? Here they are related towards energy [MWh$_{el}$] instead of power [MW]
  - ► Thus, profits of wind intense sites are generally underrated due to energy related cost assumptions!

Regional operational marginal return (1/4)

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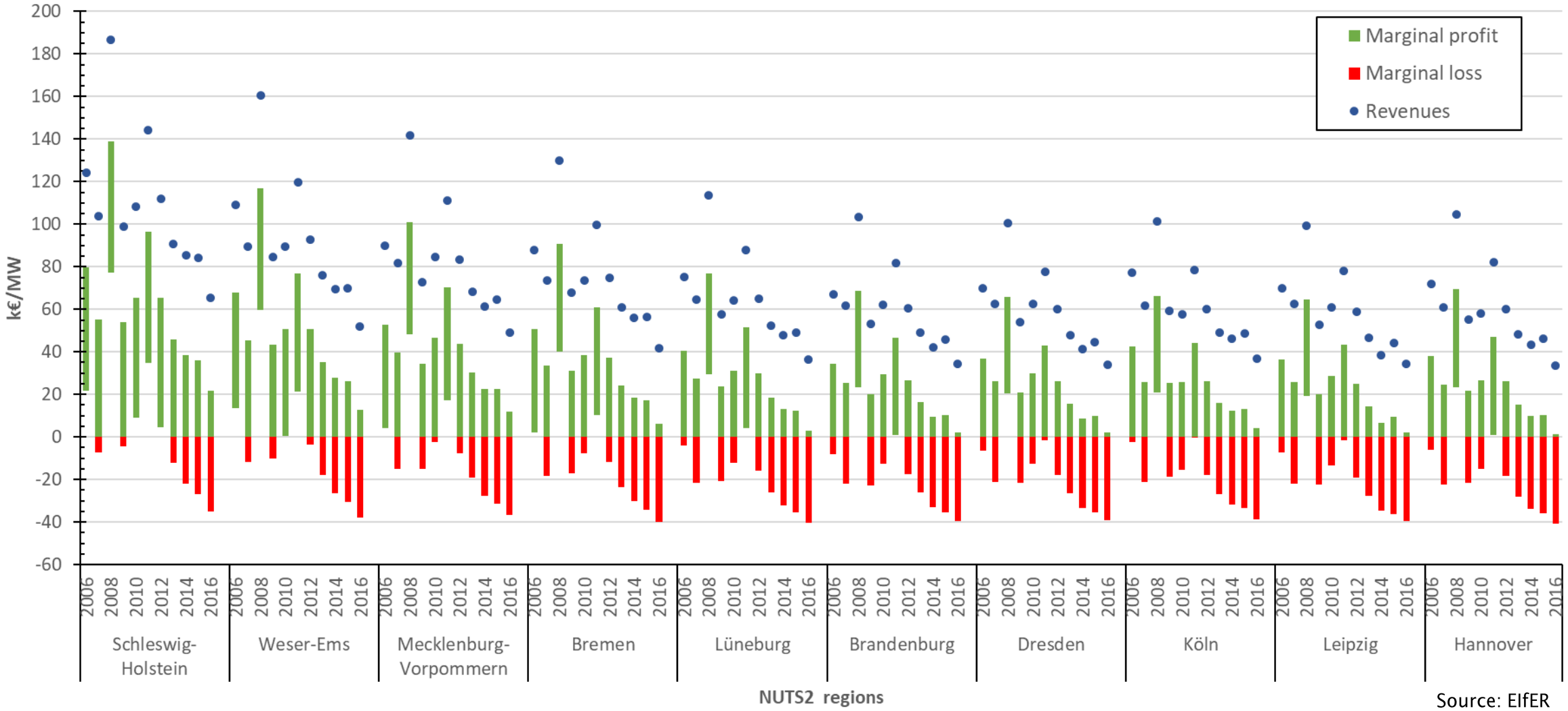
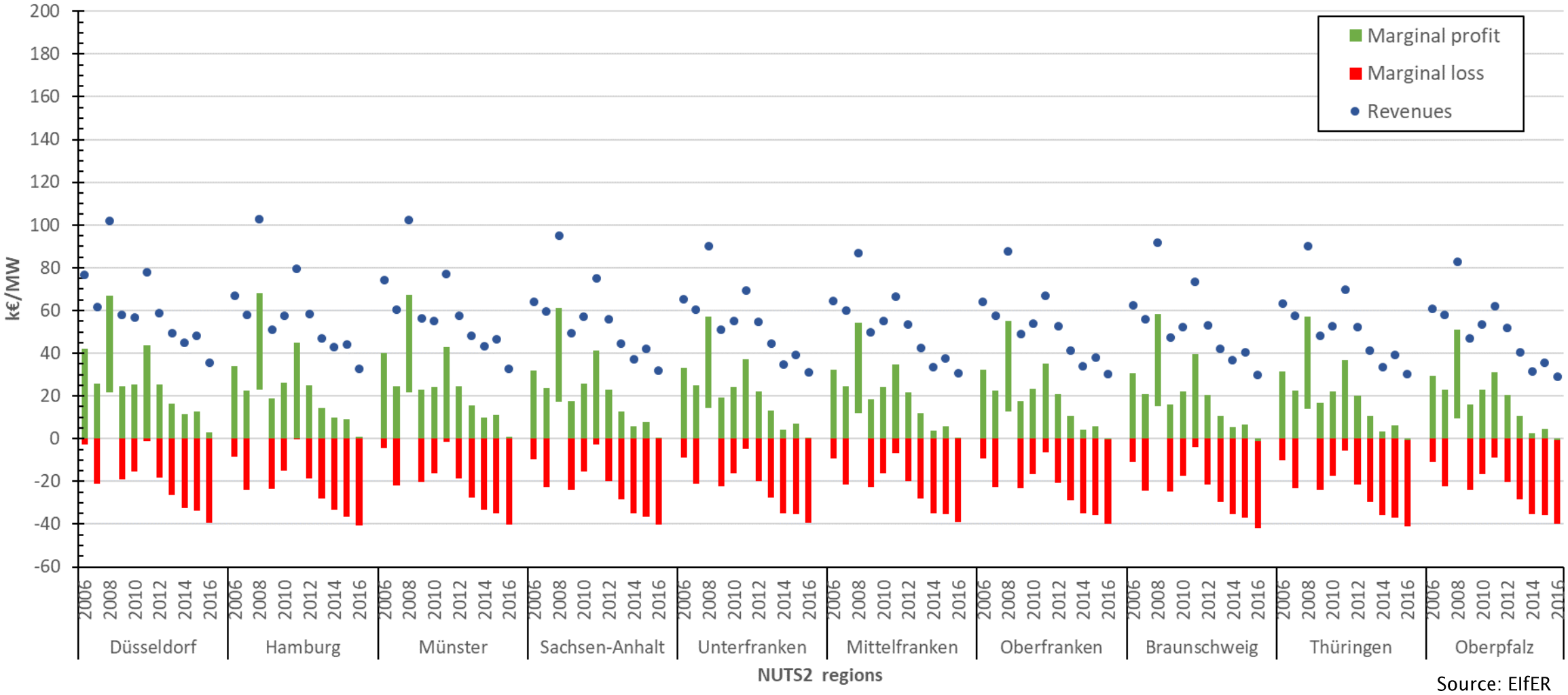


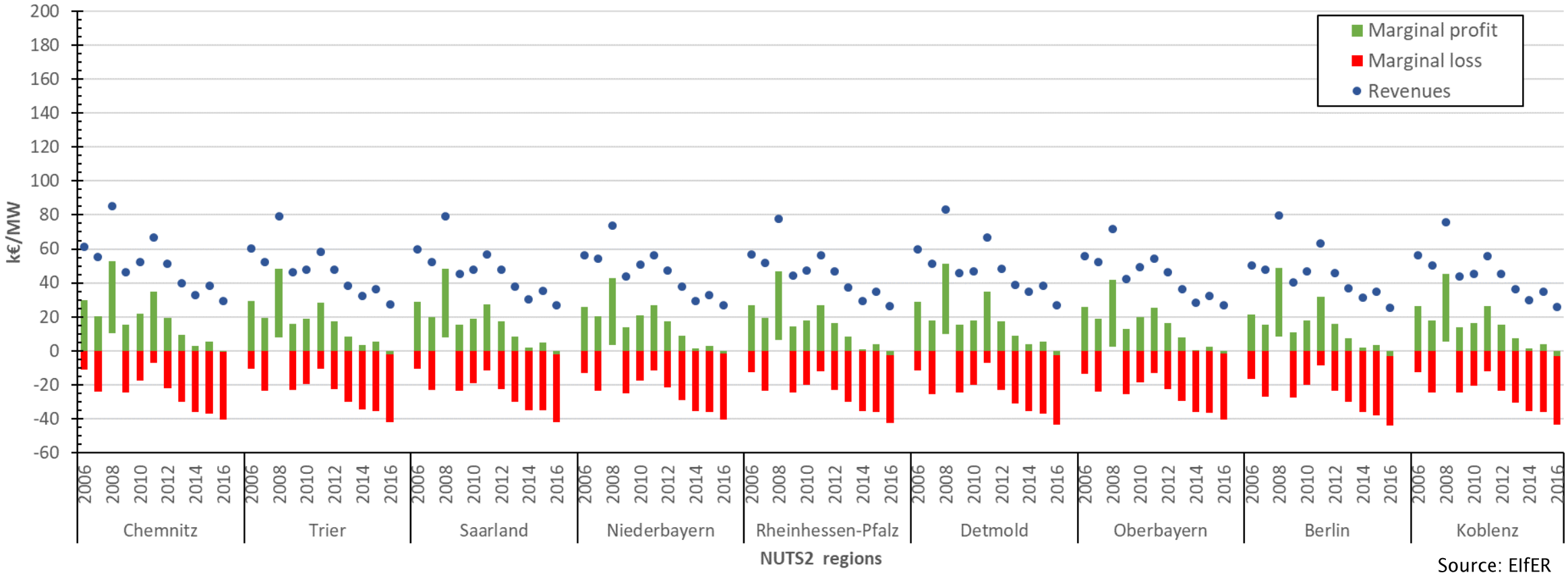
Source: ElfER

Regional operational marginal return (2/4)



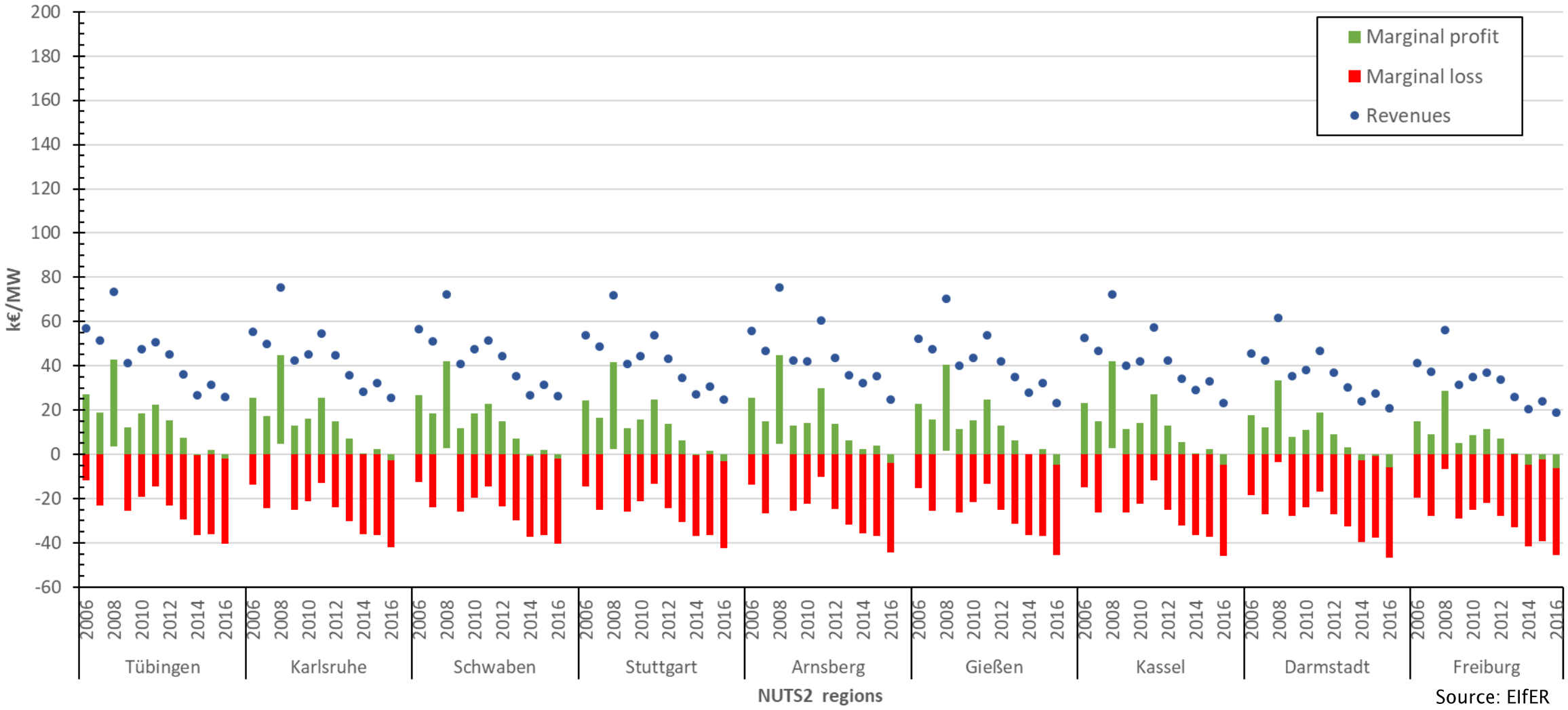
Source: ElfER

Regional operational marginal return (3/4)



Source: ElfER

Regional operational marginal return (4/4)



Source: ElfER

IV. Summary and outlook

Conclusion and Outlook

Conclusion

- Market values are the main driver for the PPA value
- Regional market values depend on regional feed-in profile volatility and its correlation towards day-ahead price time series
- In the recent years regional spread in market values has shown to increase
- Analysis of regional market values together with full-load hours reveal strong regional differences in overall revenue potential
- Increasing regional effect: Eising et al. (2020) show ever increasing regional disparities in future revenue potentials in particular for wind onshore
- Development of overall power price level and cost mitigation strategy as the main driver for economic feasibility of Post-EEG operation

Outlook

- Potentially: now- and forecasting of regional market values based on current day-ahead prices and forward prices (but certain error deviation)
- Calculation of site-specific or portfolio-specific marginal profits requires detailed feed-in time series. However, evaluation on NUTS2 level is a first good guess
- We assumed operational cost with a ratio of 50% fixed and 50% variable. Some studies argued that in average even higher assumptions for variable operational costs are justified[1]
- Regional LCOEs may help to increase project results

[1] Wallasch et al. 2015

Relevance of PPAs for the energy system

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Can PPAs speed up the renewable energy transition?

- In times of changing regulatory frameworks and uncertain remuneration schemes, PPAs opens the opportunity for stable revenues outside the EEG – although with relevant risks.
- As argued by May and Neuhoff 2019, PPAs lack the financial security of public remuneration schemes.
- The risk of variable electricity prices may lead to relevant income losses for the buyers who cannot fully compensate the risk over alternative revenue streams.
- Therefore, new renewable projects financed via PPAs may lead to higher CapEx in comparison to publicly financed renewable tenders that secure a fixed income because buyers need to consider missed revenues in their prices.
- For post-EEG plants, these cost assumptions may be less relevant since investment cost have been already amortised.
- PPAs may influence the number of participants on the renewable market. Increasing requirements for the availability of risk capital favour large utilities instead of small community based projects.
- PPAs have both potential to accelerate or to decelerate the expansion of renewables. Generally, non-subsidised renewable energy projects can better react on changes in demand and therefore can increase the number of renewable projects.
- However, if market prices decrease, project planners have no incentive to invest in renewable PPAs – an only PPA based renewable expansion would decelerate or stop completely.
- From the system perspective, subsidies are therefore not only relevant to ensure an ongoing renewable expansion but also to remain cost-efficiency of the energy transition.

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Thank You

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