Enabling flexibilities – the role of the institutional framework

Dr. Michael Bucksteeg

THE MARKET ARCHITECTURE FOR ENHANCING FLEXIBILITY PROVISION
IN THE EU TARGET MODEL
16.04.2019, Paris

UNIVERSITÄT DUISBURG ESSEN
Open-Minded

Motivation

- Ongoing debate on the further development of the European energy system
  - Transition of the energy system towards a carbon neutral world
  - Increasing share of variable renewable energy sources
- Flexibilization of the demand side
  - Electricity demand still is largely inelastic
  - Intermittency of renewable energy sources will the demand side require to follow the generation
- An adequate institutional framework can support the development of flexibility options
  1. Market design
  2. Regulatory framework
  3. Contractual mechanisms

Demand side flexibility

Definitions – some examples

- Network Code on Demand Connection
  - "Demand offered for the purposes of, but not restricted to, providing Active or Reactive Power management, Voltage and Frequency regulation and System Reserve."
- Energy Information Administration
  - "All the activities addressed to encourage customers to modify patterns of electricity usage, including the timing and level of electricity demand. […]"
- CEER
  - "Demand-side flexibility can be defined as the capacity to change electricity usage by end-use customers (domestic and industrial) from their normal or current consumption patterns in response to market signals, […]"
- Sajjad et al. (2016)
  - "[…] possibility of deploying the **available resources** to **respond in an adequate and reliable way** to the **load and generation variations** during time at **acceptable costs**."

UNIVERSITÄT DUISBURG ESSEN

Open-Minded

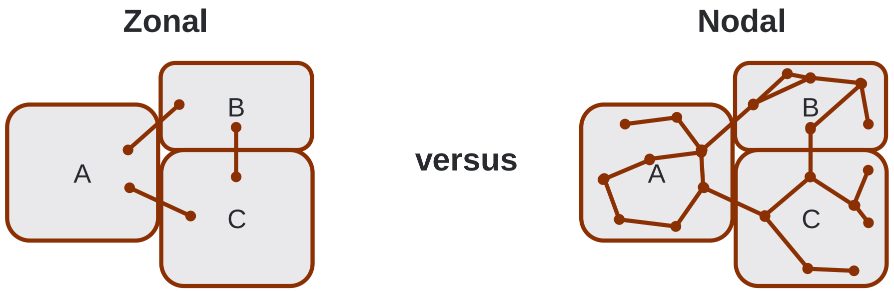
House of Energy Markets & Finance

Market design

Impact on the value of flexibility

- Temporal dimension
  – In Europe, sequential market design with hourly and quarter-hourly products on short-term markets

- Spatial dimension
  – Todays' zonal market design only partially reflects locational information

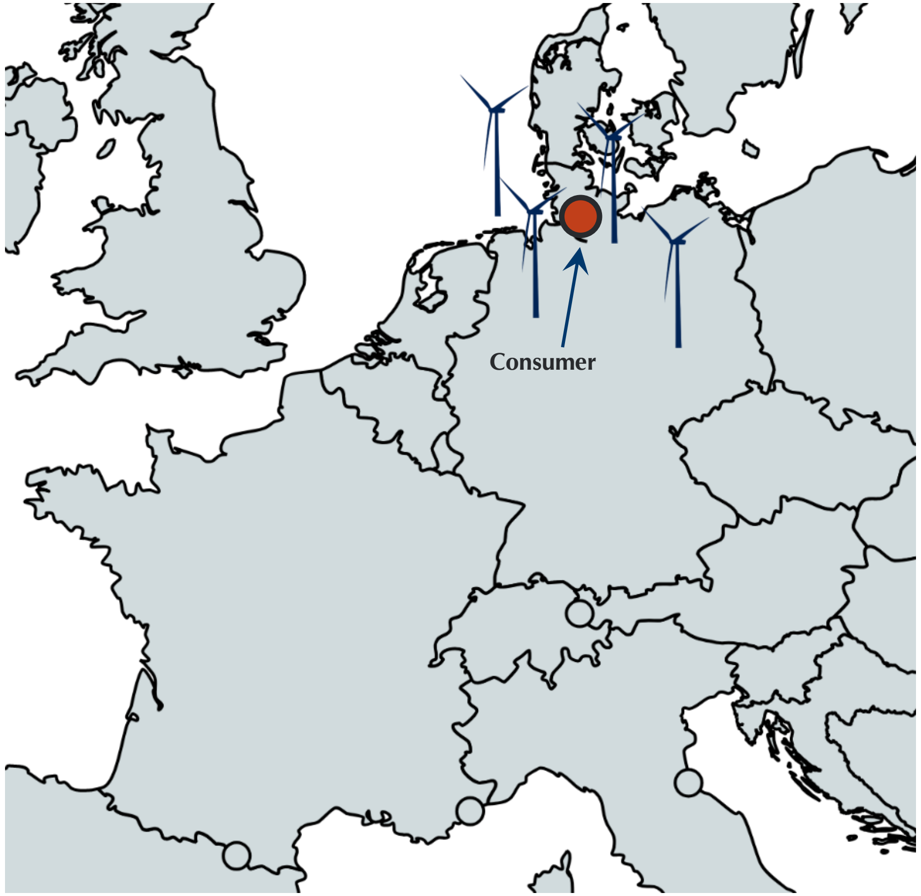


Market design

Impact on the value of flexibility

- Simple case study
  - Consumer
    - 12 MWh consumption per day
    - Connected to grid node with 1.7 GW installed wind capacity in Northern-Germany
  - Procurement on the Day-ahead market for the following day
  - Two cases
    - A: inflexible load
    - B: flexible load
  - Two market designs
    - 1: Zonal
    - 2: Nodal

	Zonal	Nodal
Inflexible	1A	2A
Flexible	1B	2B

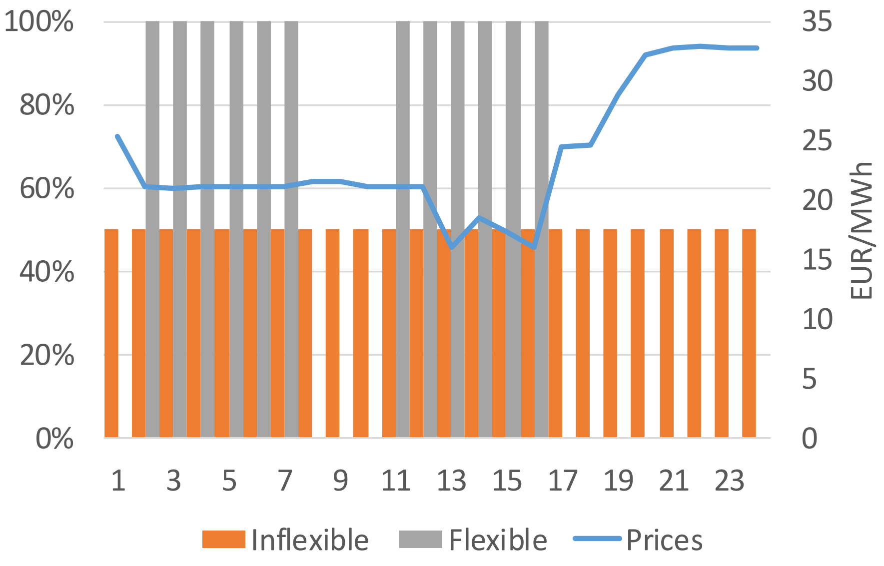


created with mapchart.net ©

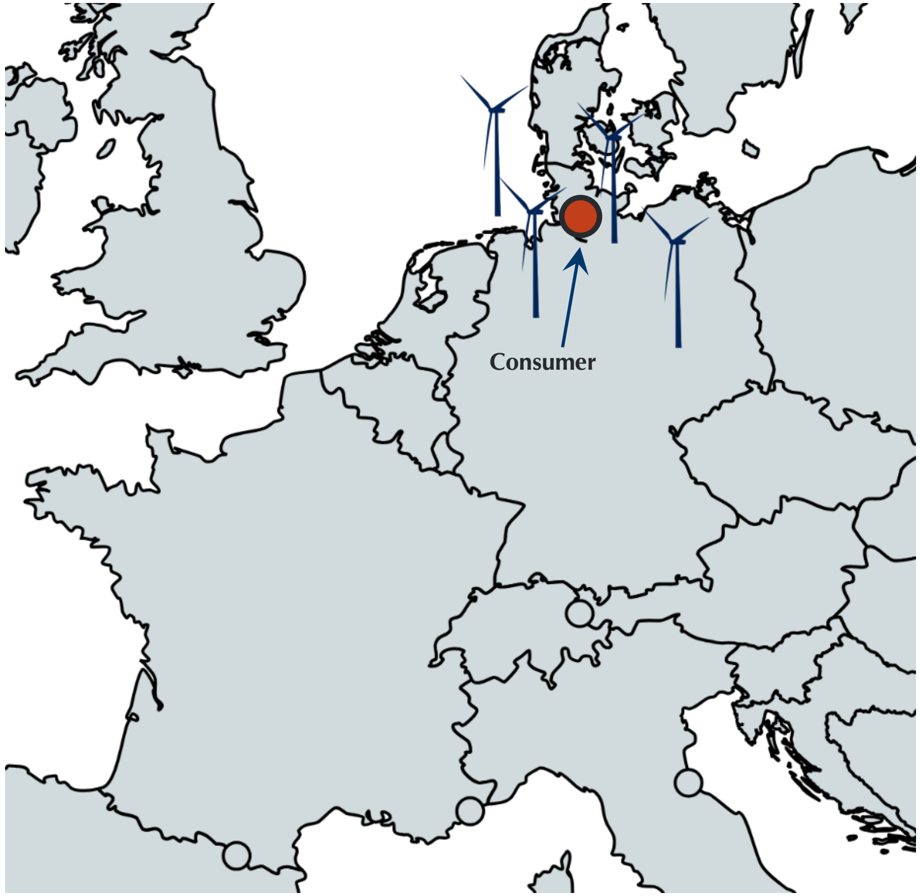
- Market value of flexibility, i.e. cost savings of Day-ahead procurement due to flexibilization

House of Energy Markets & Finance

1. Zonal market
   - Germany as one price zone
   - Average zonal price 29.99 EUR/MWh (SD: 7.20 EUR/MWh)
   - Impact of flexibilization on consumption pattern for a selected day:



Price time series based on Felten et al. (2019)



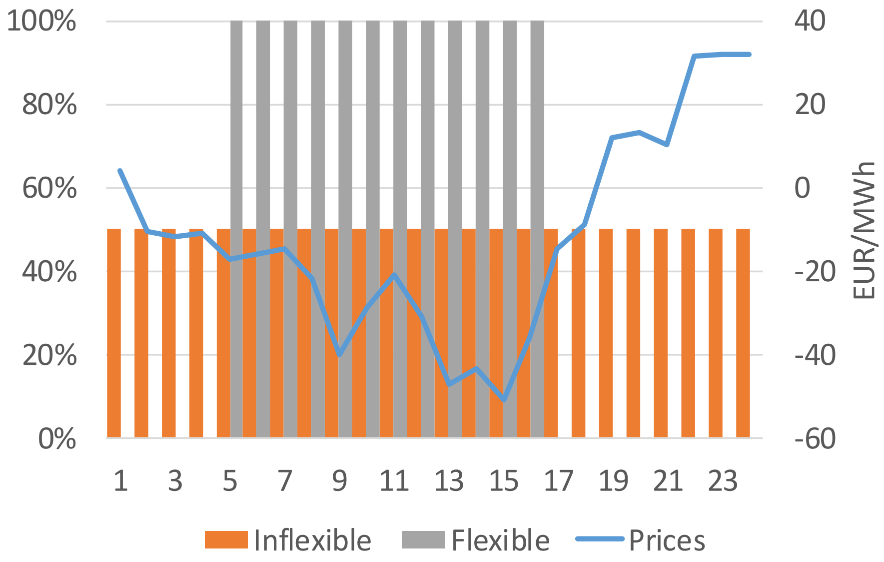
created with mapchart.net ©

House of Energy Markets & Finance

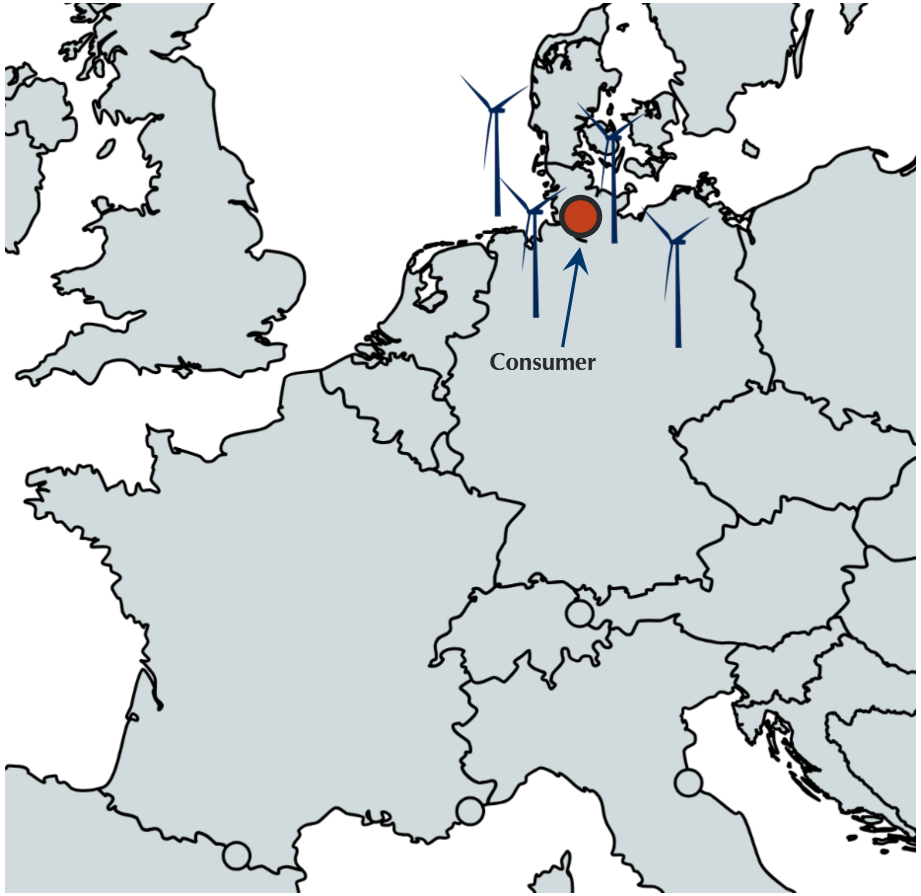
Market design

Impact on the value of flexibility

2. Nodal market
   - Locational marginal prices for each grid node
   - Average nodal price 21.27 EUR/MWh (SD: 29.66 EUR/MWh)
   - Impact of flexibilization on consumption pattern for a selected day (changed price axis):



Price time series based on Felten et al. (2019)



created with mapchart.net ©

House of Energy Markets & Finance

Market design

Impact on the value of flexibility

- Comparison of procurement costs in kEUR/a

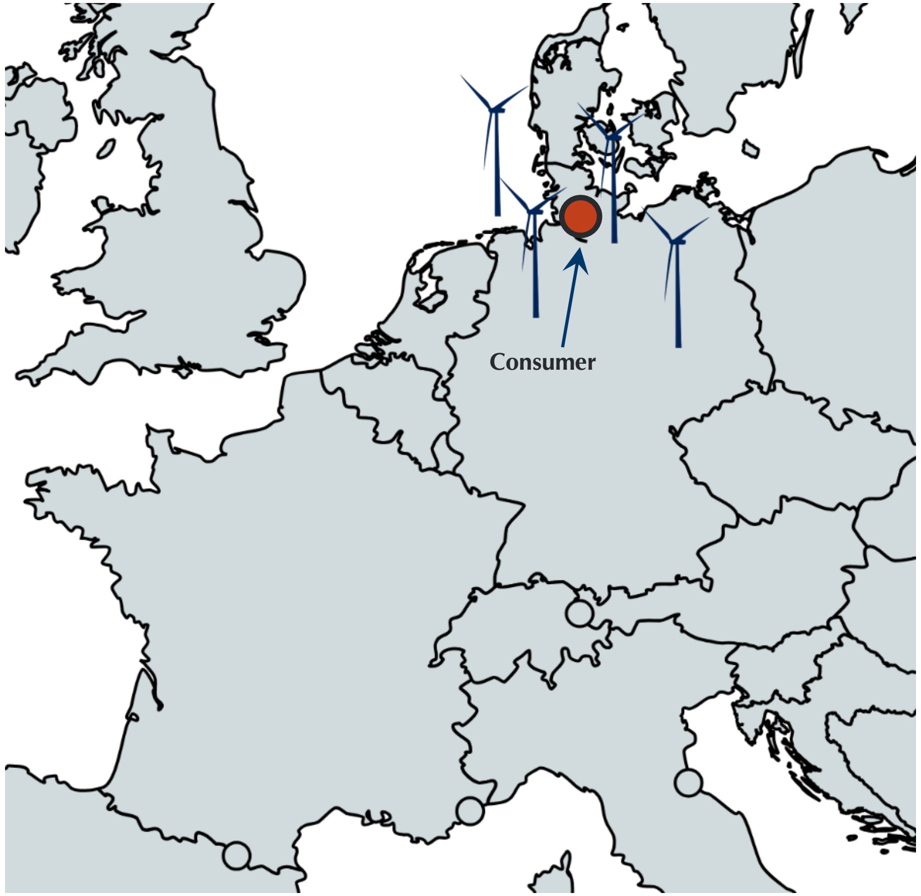
	Zonal	Nodal
Inflexible	131	93
Flexible	113	58

- Cost savings due to flexibilization in kEUR/a

Cost savings	-18	-35

- For consumers located in other regions, i.e. high load pockets, overall procurement costs increase and marginal cost savings decrease

➢ Higher spatial granularity in power markets would incentivize flexibilization of loads where needed



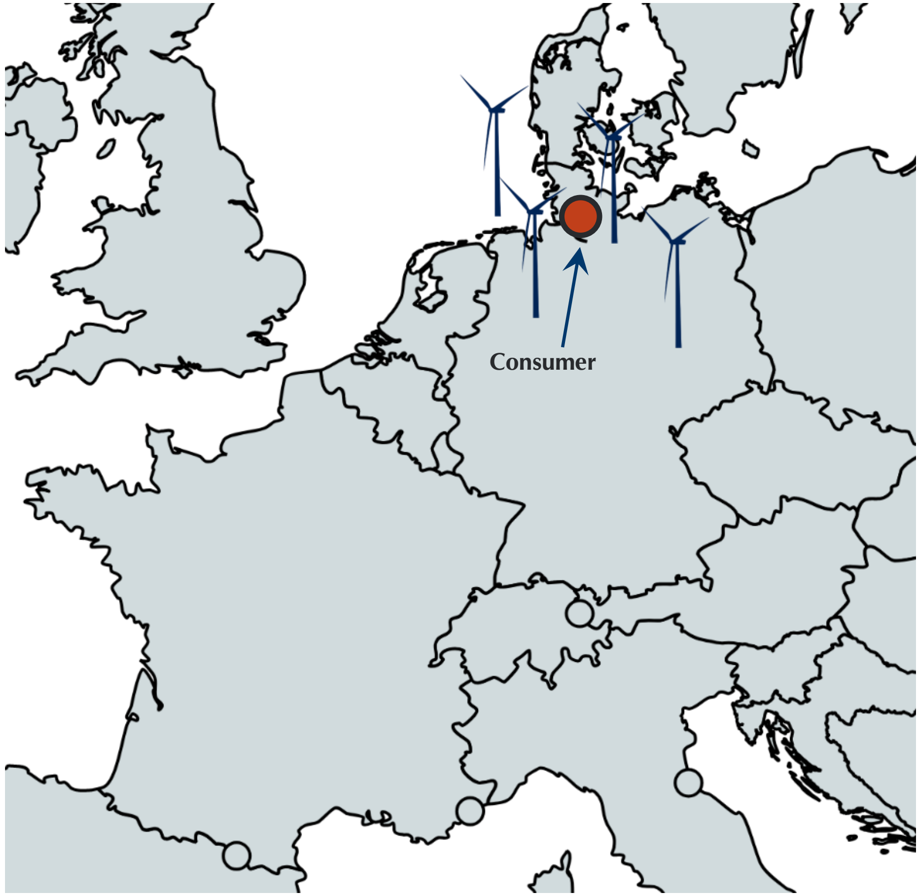
created with mapchart.net ©

House of Energy Markets & Finance

Market design

Impact on the value of flexibility

- Zonal markets
  - If chosen well, alternative price zone configurations might already improve locational incentives
- Nodal markets
  - In U.S. nodal markets end consumer prices are also aggregated at a zonal/regional level compromising locational signals
  - Are nodal markets compatible with aggregator or virtualization models (at a larger scale)?
- Continuity of the market design
  - Changes in market design, i.e. bidding zone configuration, re-assessed on a regular basis every 3 years
  - Longer lifetimes of assets, i.e. battery storages ~10 years
  - ➢ Regulatory uncertainty might impede investment decisions



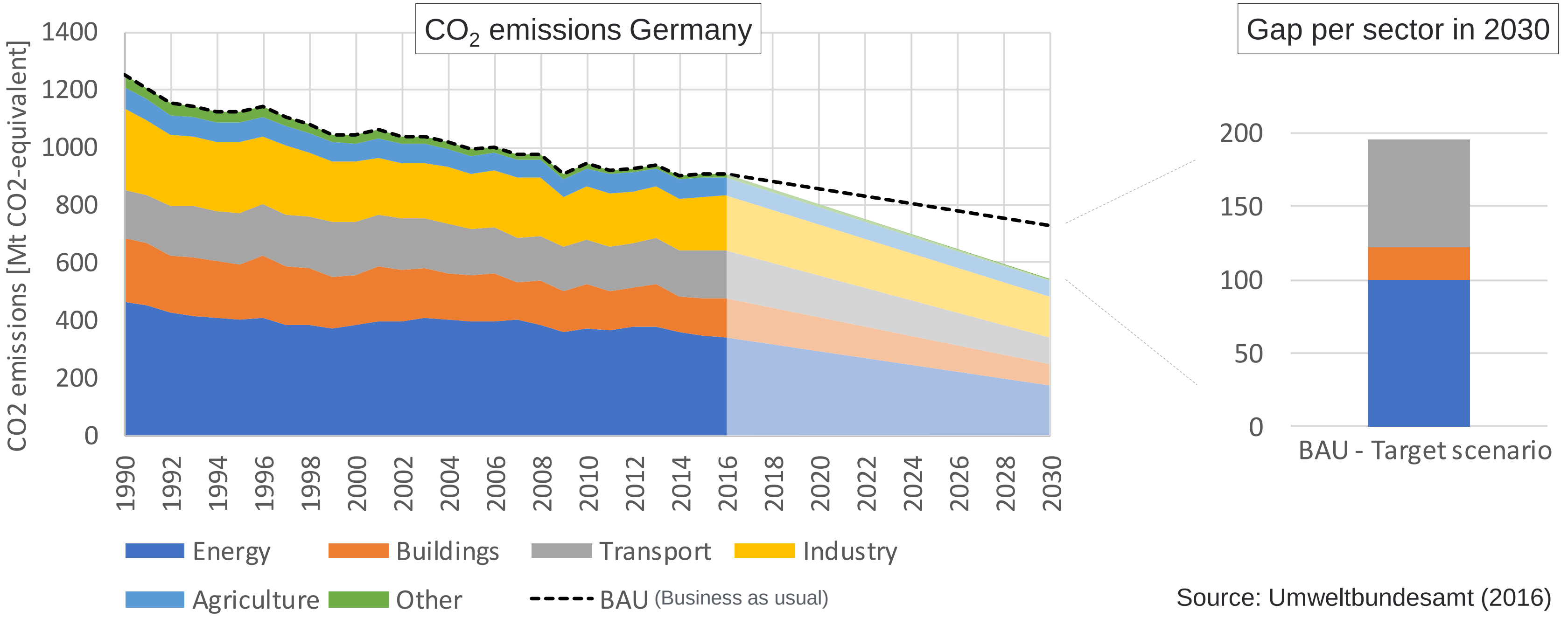
created with mapchart.net ©

House of Energy Markets & Finance

Regulatory framework

Consistent setting of regulatory incentives

- Cross-sectoral decarbonization as key element to meet the climate targets



Source: Umweltbundesamt (2016)

- ➢ Sector coupling can provide a significant degree of flexibility
- ➢ Consistent regulatory setting to guarantee a level playing field for flexibility options

Regulatory framework

UNIVERSITÄT DUISBURG ESSEN
Open-Minded

Consistent setting of regulatory incentives

- Distortion of price signals across sectors (in Germany), e.g.
  - Support of renewable energy sources through
    - levies in the electricity sector (EEG levy)
    - tax mechanisms in the heating sector
  - Allocation of support payments for CHP in the electricity sector, although the heat sector also benefits from it
- Heterogenous energy taxes and levies lead to
  - disproportionate impact on electricity prices
  - inconsistent (implicit) pricing of CO_2 emissions
  - barriers for power-to-X technologies

Energy taxes and levies with state-induced price components

		cf. Rave et al. (2013)		cf. Agora (2017)
Heating market		**Ct / liter or kWh**	**EUR/t CO_2**	**EUR/t CO_2**
Fuel oil	liter	6,14	22,87	7,68
Natural gas	kWh	0,55	27,10	18,71
Liquid gas	kWh	0,47	20,00	-
Fuel market				
Diesel	liter	47,04	178,10	57,88
Petrol	liter	65,45	280,00	65,17
Liquid gas	liter	8,96	59,50	-
Electricity market				
Electricity	kWh	2,05	19,50	185,40

Rave et al. (2013) consider all energy taxes and levies, also including non-environmental levies

Agora (2017) consider only environmental related taxes and levies, for electricity EEG and CHP levies are included

Source: Fischedick et al. (2017)

House of Energy Markets & Finance

Regulatory framework

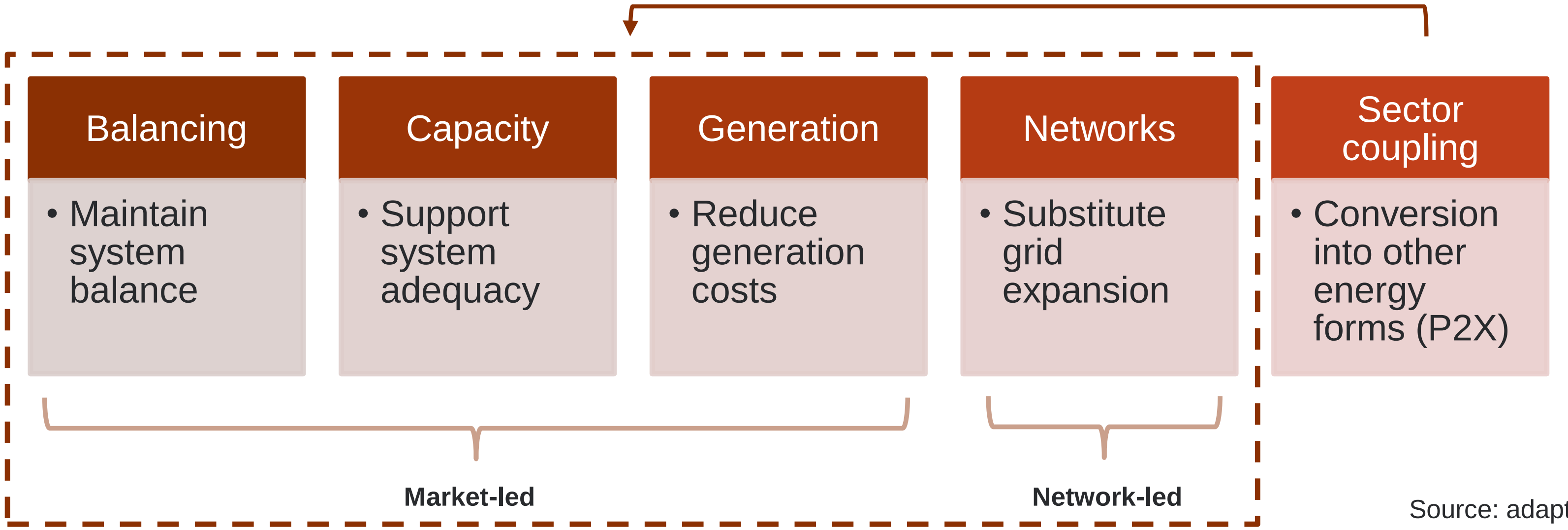
Consistent setting of regulatory incentives

- Benefits from a consistent pricing of CO_2 emissions across all sectors
  - Adequate incentives for storages, demand side management and sector coupling
  - Prices that better reflect actual scarcities (higher price differences between periods with scarcity and excess supply)
  - Appropriate costs and prices for CO_2 emitting generation technologies
  - Price based (not administrative) displacement of coal fired power plants
  - Proper incentives for the renewable energy mix and controllable renewables like biomass
  - Support of the spatial diversification of renewable technologies
- Challenges of CO_2 pricing
  - Distributional effects in the short-term → to mitigate those effects other taxes and levies without environmental effects should be omitted
  - Interdependencies with the ETS → national CO2 prices can be an intermediate solution, in the longer term an international solution should be envisaged

See also Weber (2018)

Contractual mechanisms

- Use of flexibility across the electricity system



Source: adapted from CEER (2013)

- Focus of regulations and market rules mainly on large-scale flexibilities (until a few years ago)
- With new technologies like battery storages and the increasing role of consumers, aggregation and virtualization models are becoming more important

Contractual mechanisms

Key elements of contracts

- The example of battery storage systems
  - More than 100.000 solar power home battery storage systems in Germany in 2018
    - Average battery capacity of ~8 kWh
    - Primarily located in Southern Germany
    - Mainly to increase self-consumption and stabilize the local distribution grid
- The utilization of home battery storage systems for the provision of grid services requires their aggregation or virtualization
  - At the TSO level utility scale batteries already participate in the balancing market
  - At the DSO level however the utilization for system services, e.g. congestion management, is still in its initial phase
    - Pilot projects mainly driven by large DSOs
    - For a comprehensive utilization also smaller DSOs need to be involved

➢ Standardized contracts would support utilization of flexibilities for system services at DSO level

Contractual mechanisms

Key elements of contracts

- Contract type
  - Option vs. firm contracts
  - Banding vs. operation control contracts
  - Only real-time management or schedule prescriptions or both
- Technical elements
  - Duration
  - Limitations in frequency, energy or other characteristics of option calls
  - Availability requirements
  - Set point definition in active/reactive power, voltage or energy terms
- Value and risks
  - Pricing (base fee, energy fee)
  - Contractual handling of liabilities and risks (e.g. through penalties, index-based pricing, insurance clauses)
- Interference with grid fees (extra capacity fees) & grid connection regulations (e.g. obligatory provision of local services)

Conclusion

- Market design
  - Market architecture and rules can have a significant impact on incentives for flexibilization
  - Continuity of market design will support the development of flexibility options
- Regulatory framework
  - Sector coupling as a key element to support the decarbonization
  - Cross-sectoral and consistent pricing of CO2-emissions will reduce barriers for flexibilization
  - To avoid negative interdependencies European solutions should be envisaged
- Contractual mechanisms
  - Increasing role of consumers drives the development of aggregator and virtualization models
  - Standardized contracts would
    - support the utilization of flexibilities for system services at the DSO level
    - help to develop promising business models and reduce barriers

Thank you for your attention!

Dr. Michael Bucksteeg

Member of the chair management
House of Energy Markets and Finance
University of Duisburg-Essen

Email: Michael.Bucksteeg@uni-due.de
LinkedIn: https://www.linkedin.com/in/michael-bucksteeg
www.ewl.wiwi.uni-due.de/en

References

Agora Energiewende (2017): „Neue Preismodelle für Energie. Grundlagen einer Reform der Entgelte, Steuern, Abgaben und Umlagen auf Strom und fossile Energieträger.“ Hintergrund. Berlin, April 2017. available at: https://www.agora-energiewende.de/fileadmin2/Projekte/2017/Abgaben_Umlagen/Agora_Abgaben_Umlagen_WEB.pdf

CEER (Council of European Energy Regulators) (2013): Regulatory and Market Aspects of Demand-Side Flexibility - A CEER Public Consultation Document.

EIA (U.S. Energy Information Administration) (2019): Glossary, available at: https://www.eia.gov/tools/glossary/index.php?id=D

EU Commission (2016): Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection (Text with EEA relevance), available at: http://data.europa.eu/eli/reg/2016/1388/oj

Felten, B., Felling, T., Voswinkel, S., Weber, C. (2019): „Flow-Based Market Coupling – The Effects of Using Heuristics, Lack of Cooperation and Process-Induced Uncertainties “ - unpublished working paper.

Figgener, M. et al. (2018): „Sektorenkopplung in Nordrhein-Westfalen - Handlungsoptionen und Herausforderungen für das Energieland NRW,“ available at: http://www.speichermonitoring.de/fileadmin/user_upload/Speichermonitoring_Jahresbericht_2018_ISEA_RWTH_Aachen.pdf

Sajjad, I.A. et al. (2016): „Definitions of Demand Flexibility for Aggregate Residential Loads,” in IEEE TRANSACTIONS ON SMART GRID, VOL. 7, NO. 6, NOVEMBER 2016.

Solarwirtschaft (2018): „Der 100.000. Solarstromspeicher in Deutschland,“ https://www.solarwirtschaft.de/index.php?id=875

Umweltbundesamt (2016): „Treibhausgas-Emissionen in Deutschland 1990 bis 2016 nach Kategorien der UNFCCC-Berichterstattung,“ available at: https://www.umweltbundesamt.de/themen/klima-energie/klimaschutz-energiepolitik-in-deutschland/treibhausgas-emissionen/emissionsquellen#textpart-1

Weber, C. (2018): „Konsistente CO2-Bepreisung und Sektorkopplung – Notwendigkeiten und Hemmnisse,“ Eurosolar-Symposien 2017, available at: https://www.ewl.wiwi.uni-due.de/fileadmin/fileupload/BWL-ENERGIE/Dokumente/Meldungen/Seiten_22b25_aus_SZA_1_2018.pdf