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HOCHSCHULE ZITTAU/GÖRLITZ

Regional Energy Market Model (REMM)

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Motivation in a nutshell

„The energy transition takes place on local levels."

[Agora 2017]

... but is there any additional value of regional (green) electricity marketing for energy economy and society?

Regional energy markets are not understood as self-sufficient isolated markets, but rather as integrated units in an interregional wholesale energy market.

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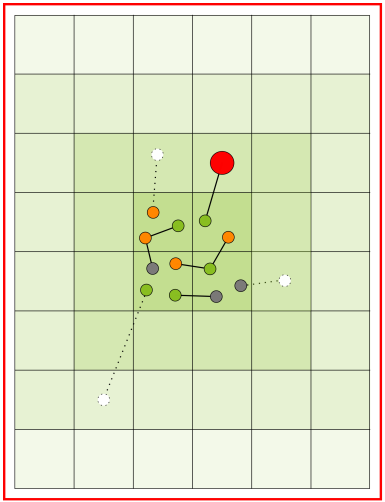
It's all about entities and their behaviour



Entities

Local utility company

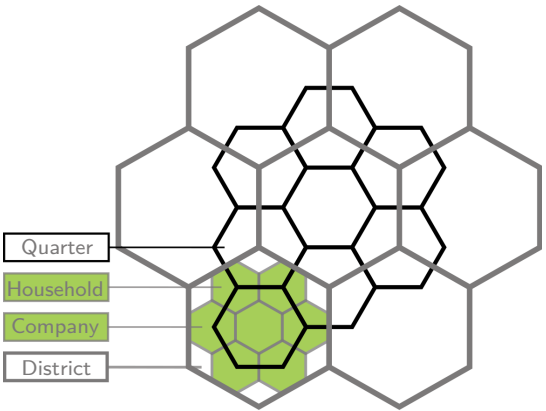
Market area

Distribution grid

ABM

Portray an economic system in which orderly behaviour emerges as a result of interaction between heterogeneous agents, none of whom has any understanding of how the overall system works.

Peer-to-peer trading in cellular structures



Cellular approach

Achieving equilibrium between electricity generation and consumption at the lowest possible level.

How to (re-)build consumer behaviour

Reality

- Electricity = homogeneous commodity (physically)
- Distinctions based on
  ⇒ Energy source
  ⇒ Place of generation

Preferences in REMM

- Environmental awareness $\rightarrow e \in]0,1]$
- Regional awareness $\rightarrow l \in]0,1]$
- Price/cost sensitivity $\rightarrow c \in]0,1]$

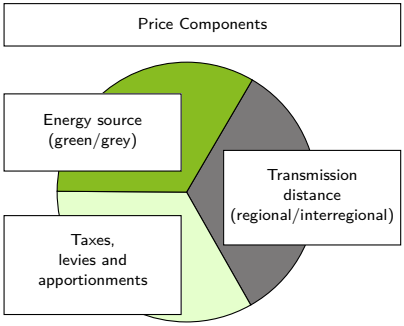
(Indicator: Income/Revenue)

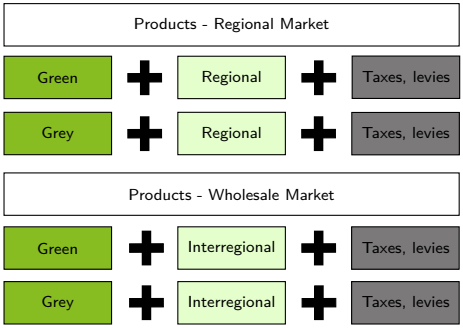
Values for prices and preferences are used to calculate utility values and to create **individual agent behaviour**.

REMM can also display decision inertia

- Preference status quo
- Lack of interest, delayed perception

Electricity products and price components lead into two-stage decision process





Stage I: energy source

$$p_{source} = \begin{cases} p_{base} & : Grey \\ p_{base} + p_{green} & : Green \end{cases}$$

Stage II: transmission distance

$p_{reg} \Rightarrow$ regional purchase

$p_{trans} \Rightarrow$ interregional purchase

Stage I: intrinsic value vs. (negative) value of (higher) costs

GREEN

Intrinsic utility value

$$u_{intr,i,t} = e_i \cdot \sqrt{p_{green,t}} \cdot c_i$$

Utility value of (higher) costs

$$u_{cost,i,t} = c_i^2 \cdot (p_{base} + p_{green,t})$$

Overall utility function ($U = u_{intr} - u_{cost}$)

$$U_{green,i,t} = e_i \cdot \sqrt{p_{green,t}} \cdot c_i - c_i^2 \cdot (p_{base} + p_{green,t})$$

GREY

Intrinsic utility value

$$u_{intr,i,t} = 0$$

Utility value of (higher) costs

$$u_{cost,i,t} = c_i^2 \cdot p_{base}$$

Overall utility function ($U = u_{intr} - u_{cost}$)

$$U_{grey,i,t} = 0 - c_i^2 \cdot p_{base}$$

Stage II: intrinsic value vs. (negative) value of (higher) costs

REGIONAL

Intrinsic utility value

$$u_{intr,i,t} = l_i^2 \cdot \sqrt{p_{reg}} \cdot c_i$$

Utility value of (higher) costs

$$u_{cost,i,t} = c_i^2 \cdot p_{reg}$$

Overall utility function ($U = u_{intr} - u_{cost}$)

$$U_{reg,i,t} = l_i^2 \cdot \sqrt{p_{reg}} \cdot c_i - c_i^2 \cdot p_{reg}$$

INTERREGIONAL

Intrinsic utility value

$$u_{intr,i,t} = 0$$

Utility value of (higher) costs

$$u_{cost,i,t} = c_i^2 \cdot p_{trans}$$

Overall utility function ($U = u_{intr} - u_{cost}$)

$$U_{trans,i,t} = 0 - c_i^2 \cdot p_{trans}$$

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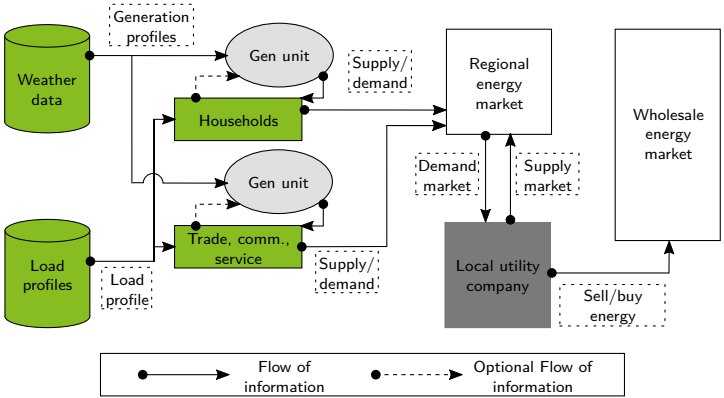
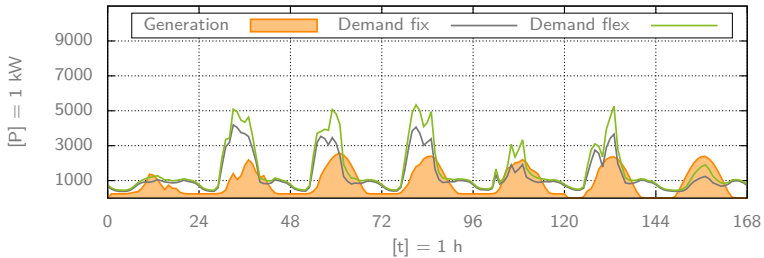
Simulated supply system

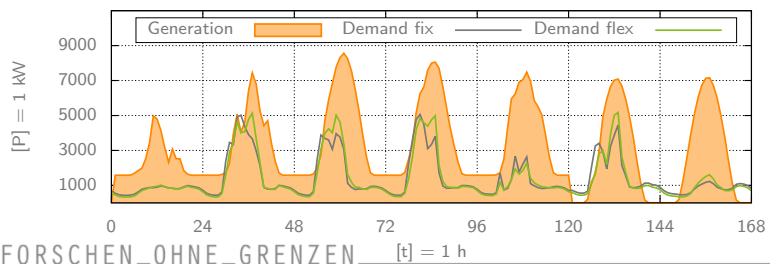


Characteristics

- Distribution grid level
- 15.400 household agents
- 1.600 TCS-companies
- *(100 "bigger" companies)*
- Database - load profiles
  H0 & G0 (& measured)
- Database - weather data
  TRY 2015

Demand for 'Green Regional' increases within flexible pricing mechanisms





Scenario

- Fix price vs. flex price
- PHHs, BSLs, BMLs
- Green and grey generation
- Share PV: 5 % | 15 %
- Share CHP: 5 % | 15 %
  $\Rightarrow$ Biogas: 33 % | 50 %

Demand $\neq$ Consumption

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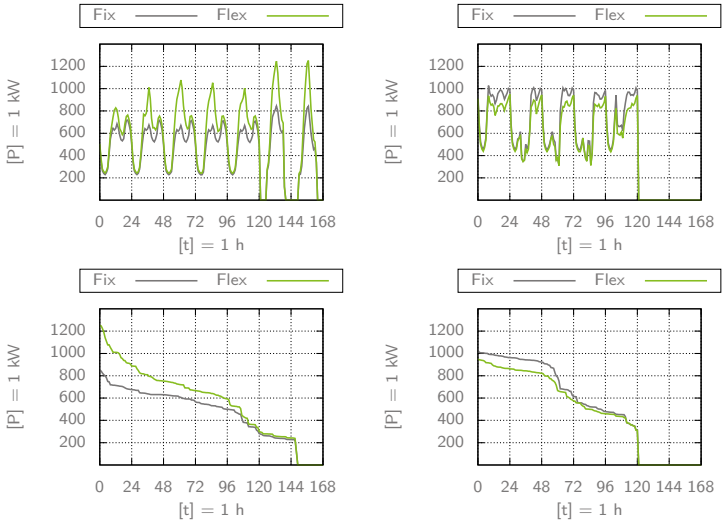
... and also: decreasing demand for 'Grey Regional'

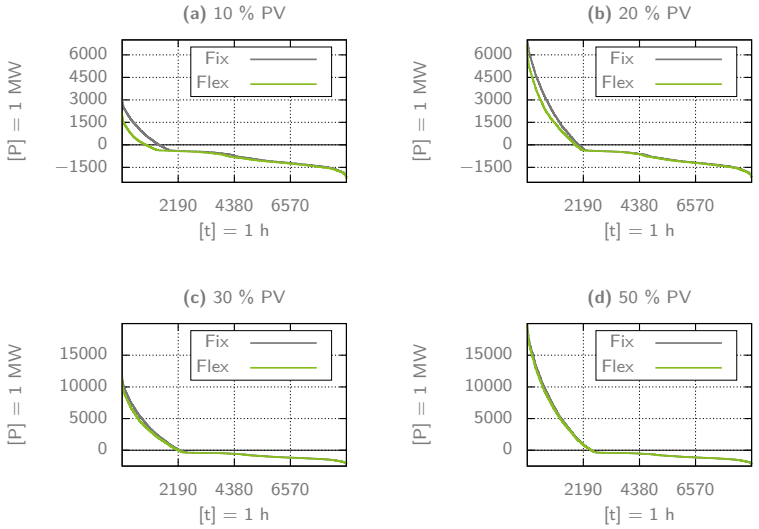


Scenario

- Fix price vs. flex price
- PHHs, BSLs (no BMLs)
- Green and grey generation
- Share PV: 5 % | 15 %
- Share CHP: 5 % | 15 %
  $\Rightarrow$ Biogas: 33 % | 50 %

Demand $\neq$ Consumption

Demand for regional products cannot be increased infinitely



Scenario

- Fix price vs. flex price
- PHHs, BSLs (no BMLs)
- Only green generation
- Solely PV scenario
  ⇒ 10 | 20 | 30 | 50 %

Residual sales volume
=
Sales Volume – Demand

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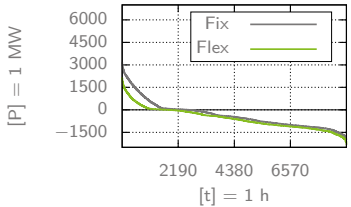
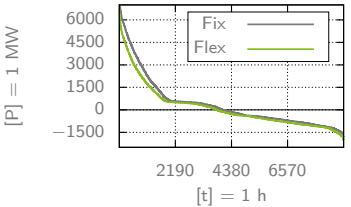
Diversified generation scenarios can partly create net-zero situations at the market

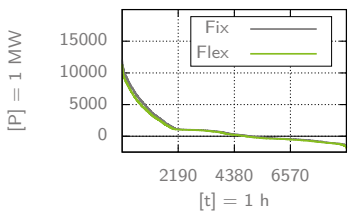
(a) 10 % PV, 5 % CHP



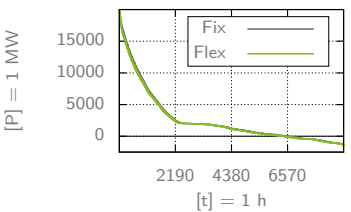
(b) 20 % PV, 10 % CHP



(c) 30 % PV, 15 % CHP



(d) 50 % PV, 25 % CHP



Scenario

- Fix price vs. flex price
- PHHs, BSLs (no BMLs)
- Only green generation
- PV & CHP scenario
  ⇒PV: 10 | 20 | 30 | 50 %
  ⇒CHP: 5 | 10 | 15 | 25 %

Residual sales volume
=
Sales Volume – Demand

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Under the bottom line ...

- REMM accurately maps markets for distribution grids
- Increasing shares of prosumers/RES reduce overall demand and thus the leverage for incentives
- Demand can not be flexibilized infinitely
- "Flex price" scenario impacts the demand in a positive manner but only in moderate expansion scenarios
- Evenly distributed generation shows more positive effects to work with financial incentives
- Discounts in the regional grid fee only appear to have an influence on the demand for "Grey Regional"

Financial incentives have the potential to reduce the effort required to achieve equilibrium between generation and consumption on a regional level. However, relying solely on financial incentives is insufficient for achieving this balance. Therefore, we emphasize the importance of exploring opportunities through the interplay of financial incentive mechanisms and technical possibilities.

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„Essentially, all models are wrong, but some are useful.“

George Box
(1919-2013)