Agent-based Simulation Model for the Analysis of Market Integration of Renewable Energy for the German Electricity Market

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Simulation · Solutions

Förderung (2008-2012):

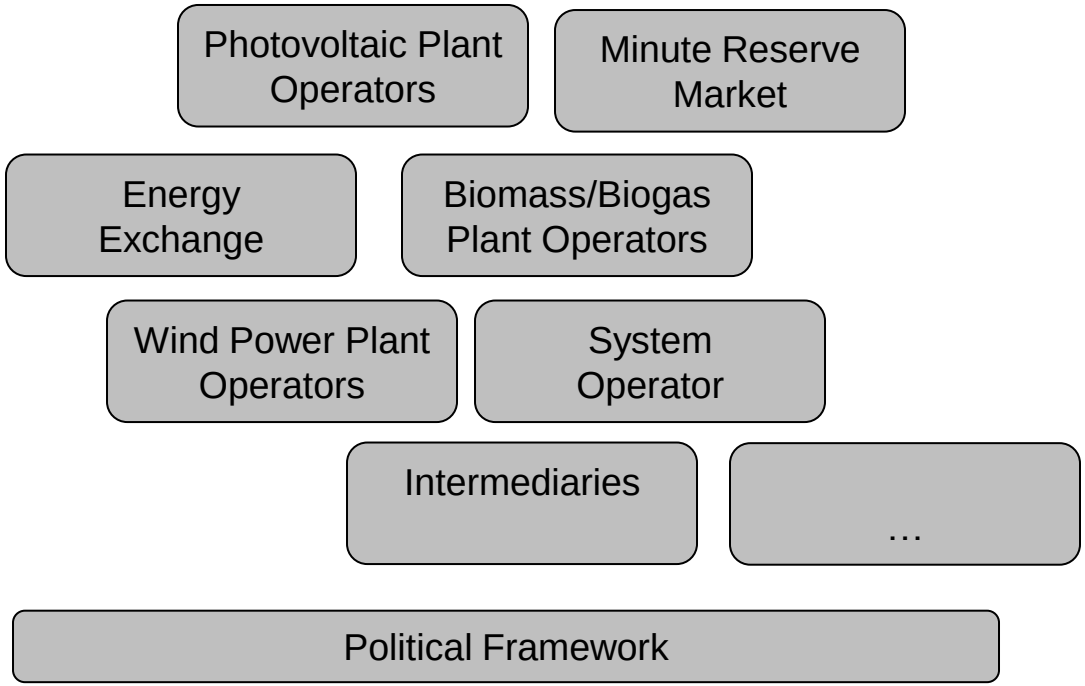
Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit

DLR

Background and Goal

Process of transformation of the electricity market

- many actors involved,
- actors are bound via complexe interdependencies
- actors reaction to changes of the political framework are very different.



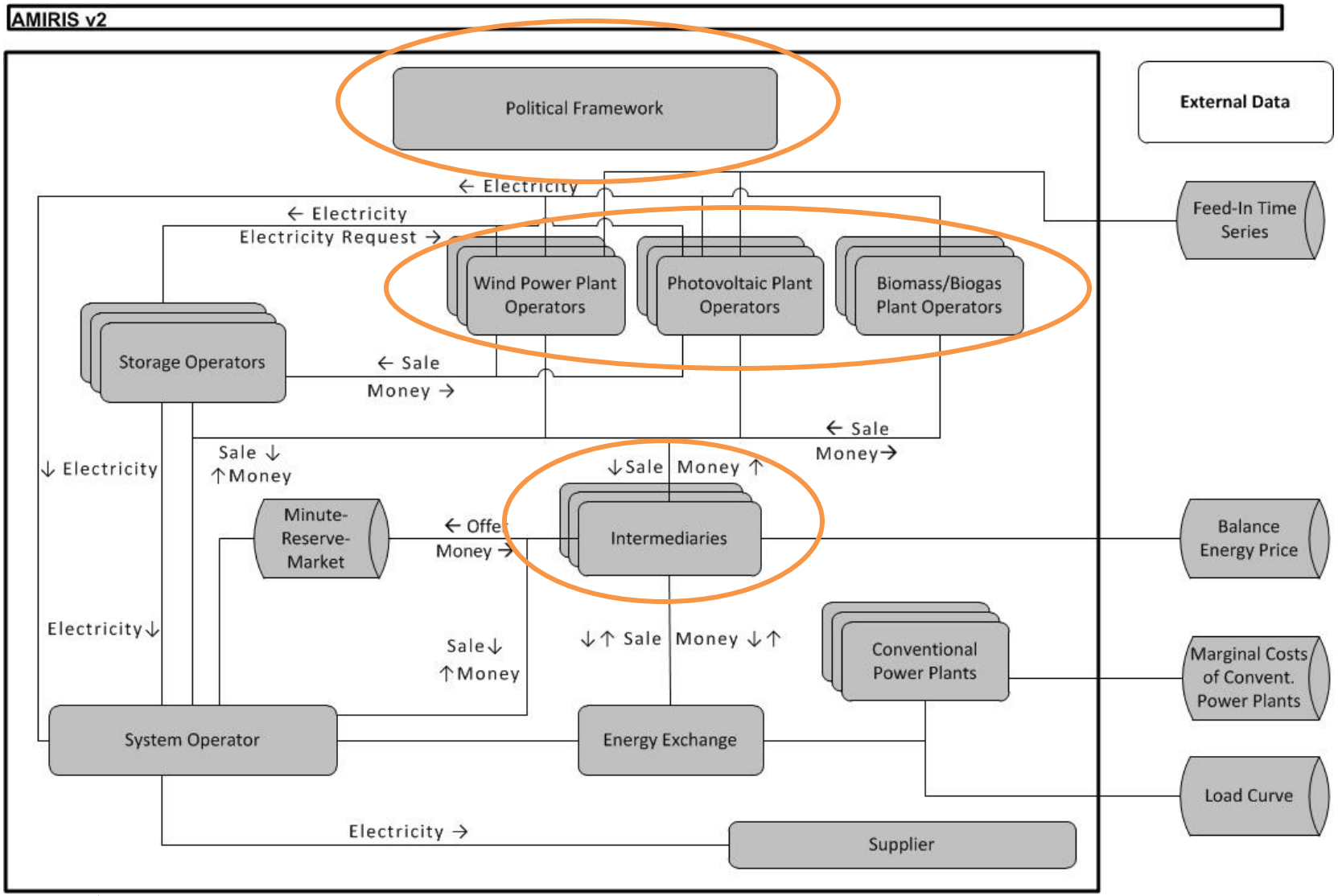
Goal: Analysing the impacts of support instruments and changes in the regulatory framework for the integration of renewable energies on the market actors and the market system of renewable energies.

AMIRIS – **A**genten-based **M**odel for **I**ntegration of **R**enewables **I**nto electricity market**S**

Reality: Actors		**Model: Agents**
Type of actors (Renewable Power Plant Operators, Storage Operators, System Operators ,…)	Implementation →	**Type of actors** (…)
Characteristics (Limited rationality and uncertainty, Individual goals, Developing strategies, learning, …)		**Characteristics** (…)
Actions (Communication, Cooperation, …)		**Actions** (…)

Based on socio-scientific analysis of actors

Structure of AMIRIS model



Type of actors

Power plant operators

(1) Privat persons
(2) Farmers
(3) Bank and Fonds
(4) Project manager
(5) Municipal Utility
(6) Big Utility
(7) Industry

Intermediaries (INT)

Big Utility	(1) Big Utility
International Utility	(2) International Utility
Municipal Utility	(3) Municipal Utility Big
	(4) Municipal Utility Pioneer
	(5) Municipal Utility Small
Grünstromhändler	(6) Green Electricity Trader for Households
	(7) Green Electricity Trader for Business/Industry
Intermediaries for exchange market	(8) Specialized INT with Experience
	(9) Specialized INT without Experience

Simulation process

- Hourly simulation steps for the years 2012-2019
- RE roll-out as given in Leitstudie 2012, Scenario A (yearly)
- RE electricity feed-in from based on energy system model REMix and normed weather time series (hourly)
- RE remuneration according to EEG 2012

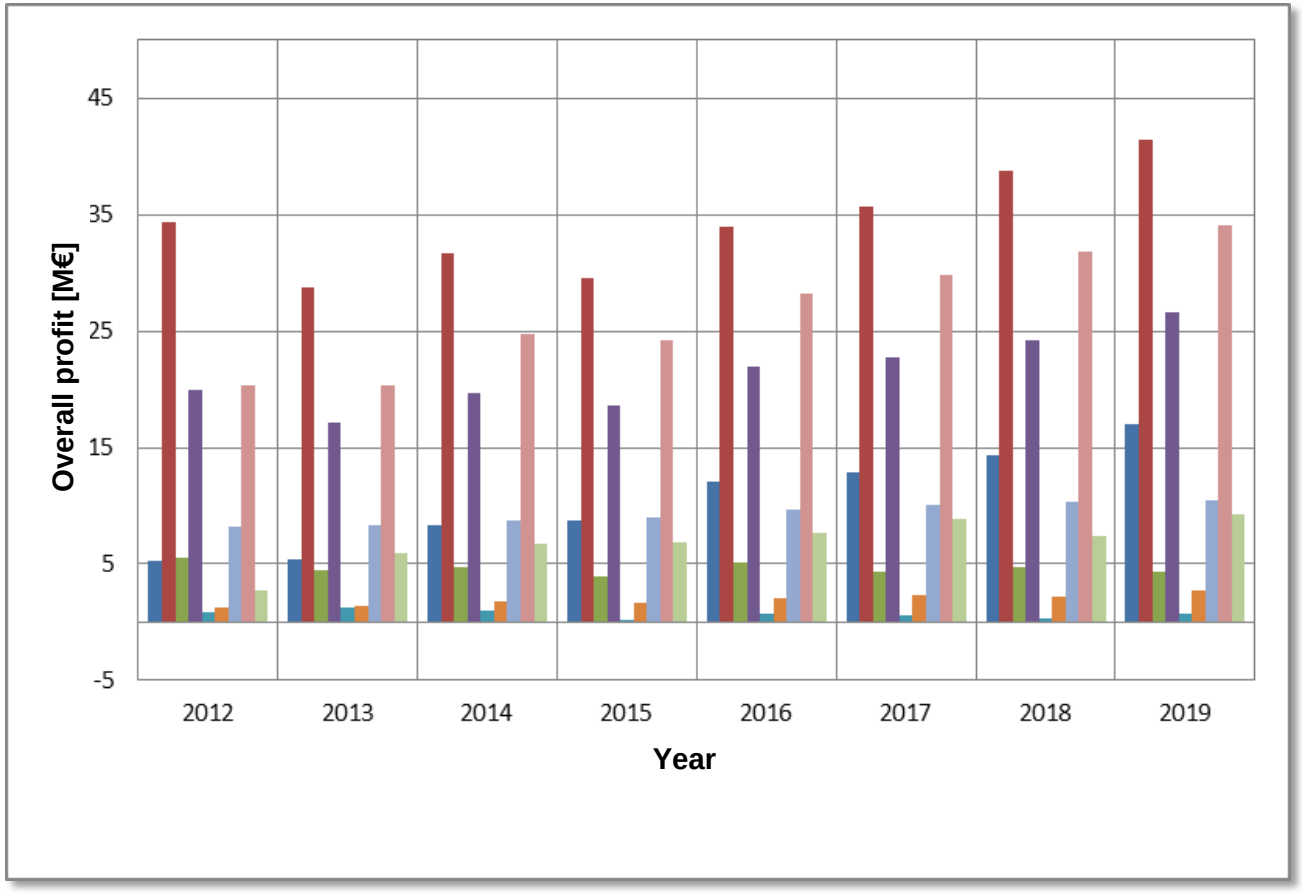
Focus of following study:

Direct marketing of RE electricity making use of the floating market premium (regarding three variants of the management premium)

$$MP = RER - MV$$
$$MP_{all} = MP + ManP$$

MP	$Market\ Premium$
RER	$RE\ renumeration$
MV	$Monthly\ market\ value$
$ManP$	$Management\ premium$

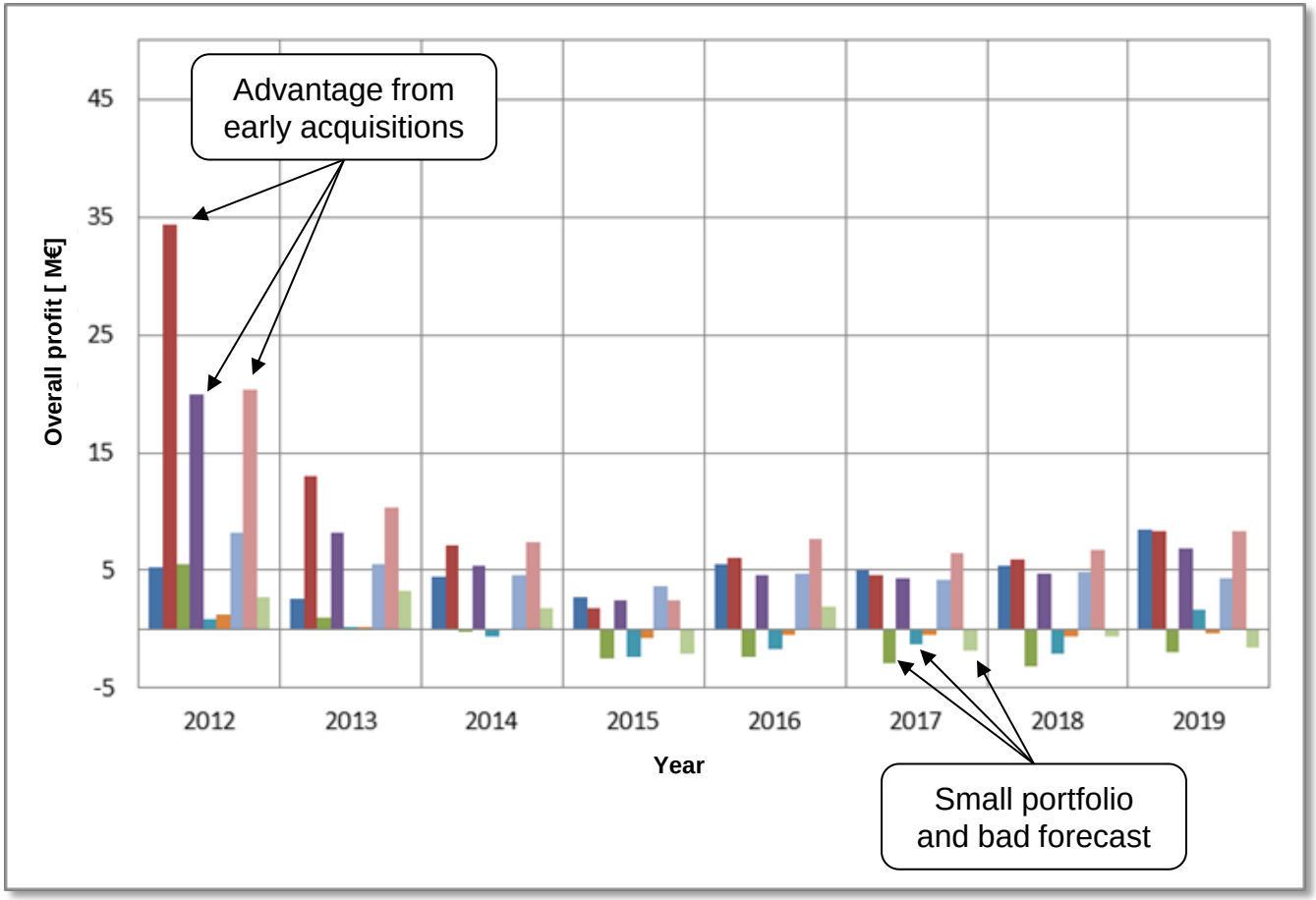
Intermediary overall profit before reduction of management premium (ManP v1)



- INT 1 Big Utility
- INT 2 International Utility
- INT 3 Municipal Utility Big
- INT 4 Municipal Utility Pioneer
- INT 5 Municipal Utility Small
- INT 6 Green Electricity Trader for Households
- INT 7 Green Electricity Trader for Business/Industry
- INT 8 Specialized INT with Experience
- INT 9 Specialized INT without Experience

* Overall profit includes all income and expenditure accumulated per accounting year and which are directly or indirectly related to direct marketing.

Intermediary overall profit before reduction of management premium (ManP v2)



- INT 1 Big Utility
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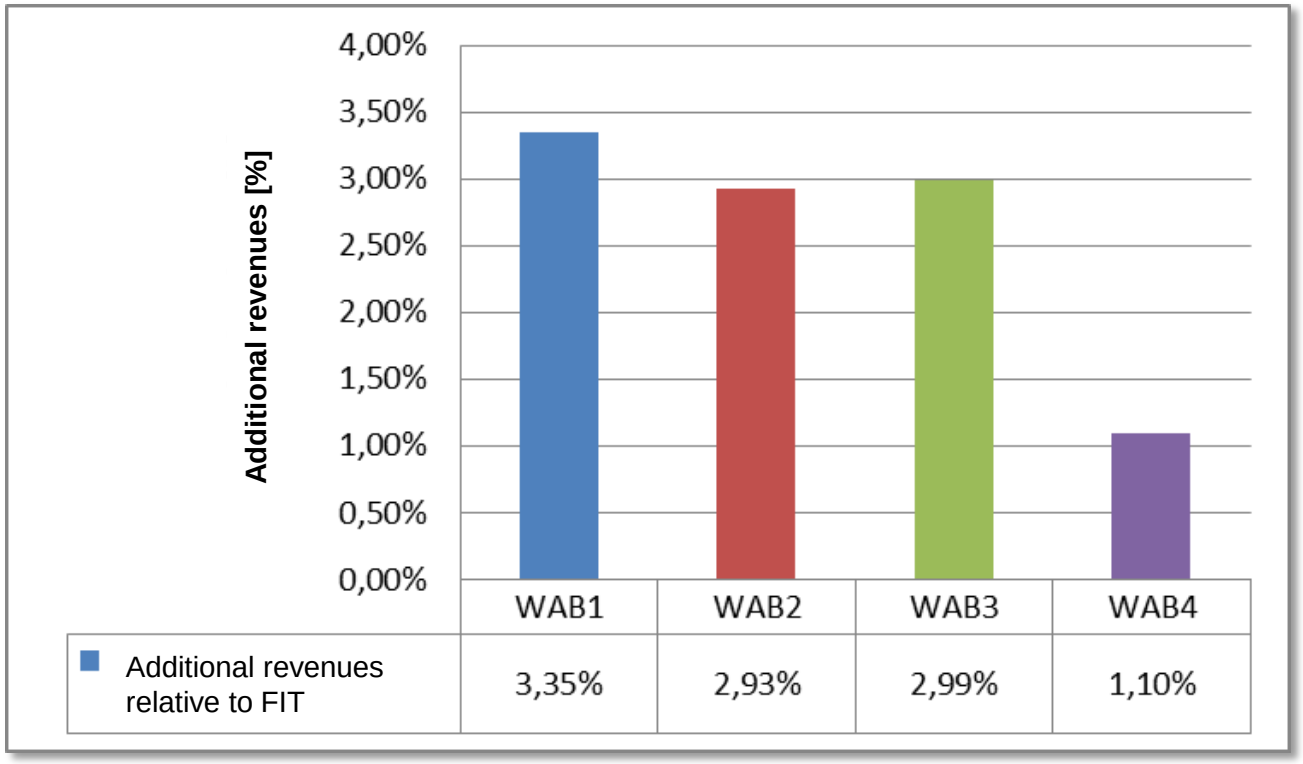
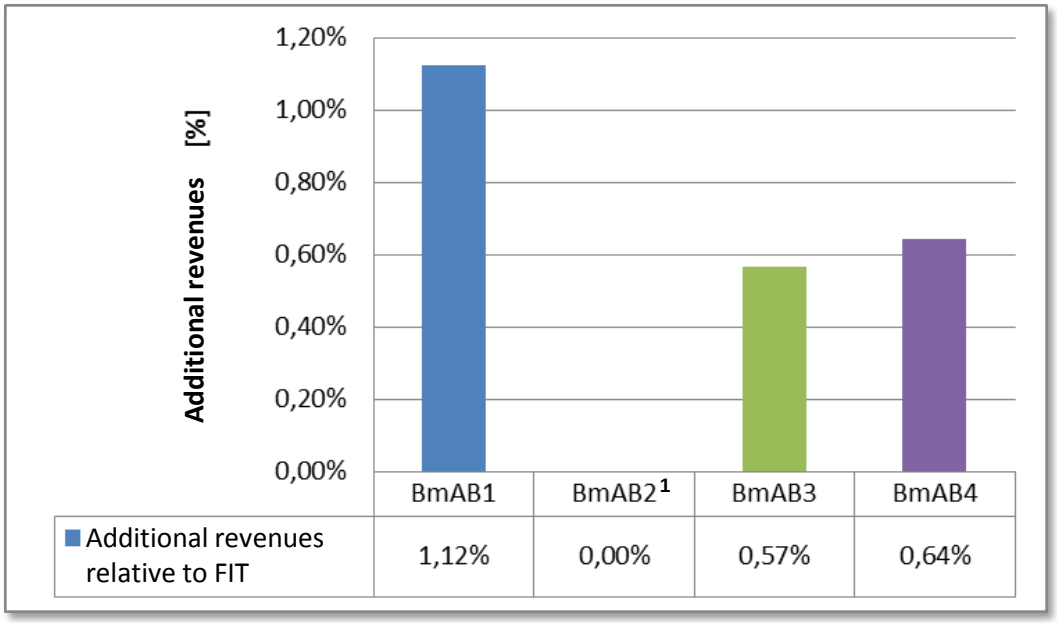
⇨ Market concentration ?

Additional revenues of wind power plant operators by participating at direct marketing (ManP v2)



Additional revenues* of biomass power plant operators by participating in direct marketing (ManP v2)



[1] Biomass wood gasifier: no direct marketing

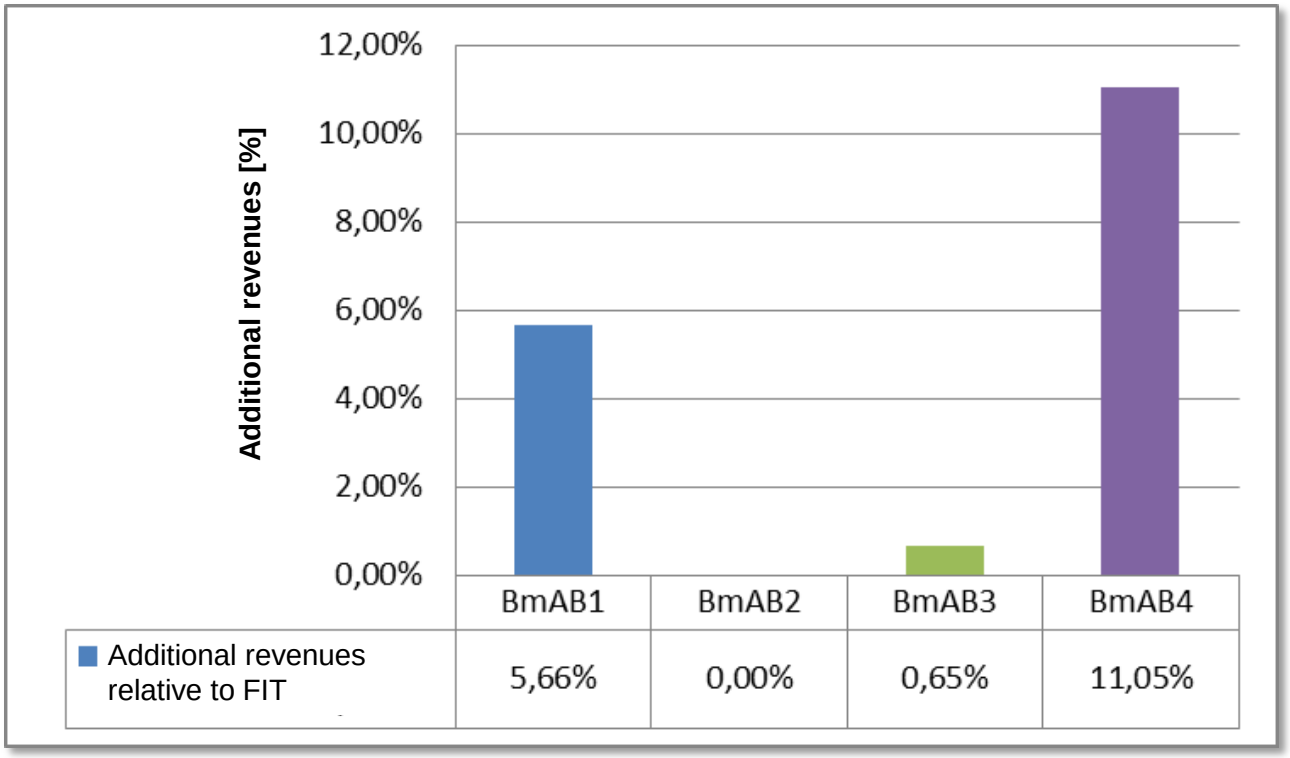
Small incentive to participate in direct marketing:

- Relative market value decreases due to interdependencies with other RE (w/o balancing market, feed-in profile: simplified day-night-cycle*)
- Bonus for controllable RE compared to fluctuating RE small (ManP very low)
- High EEG-remuneration for biogas plants

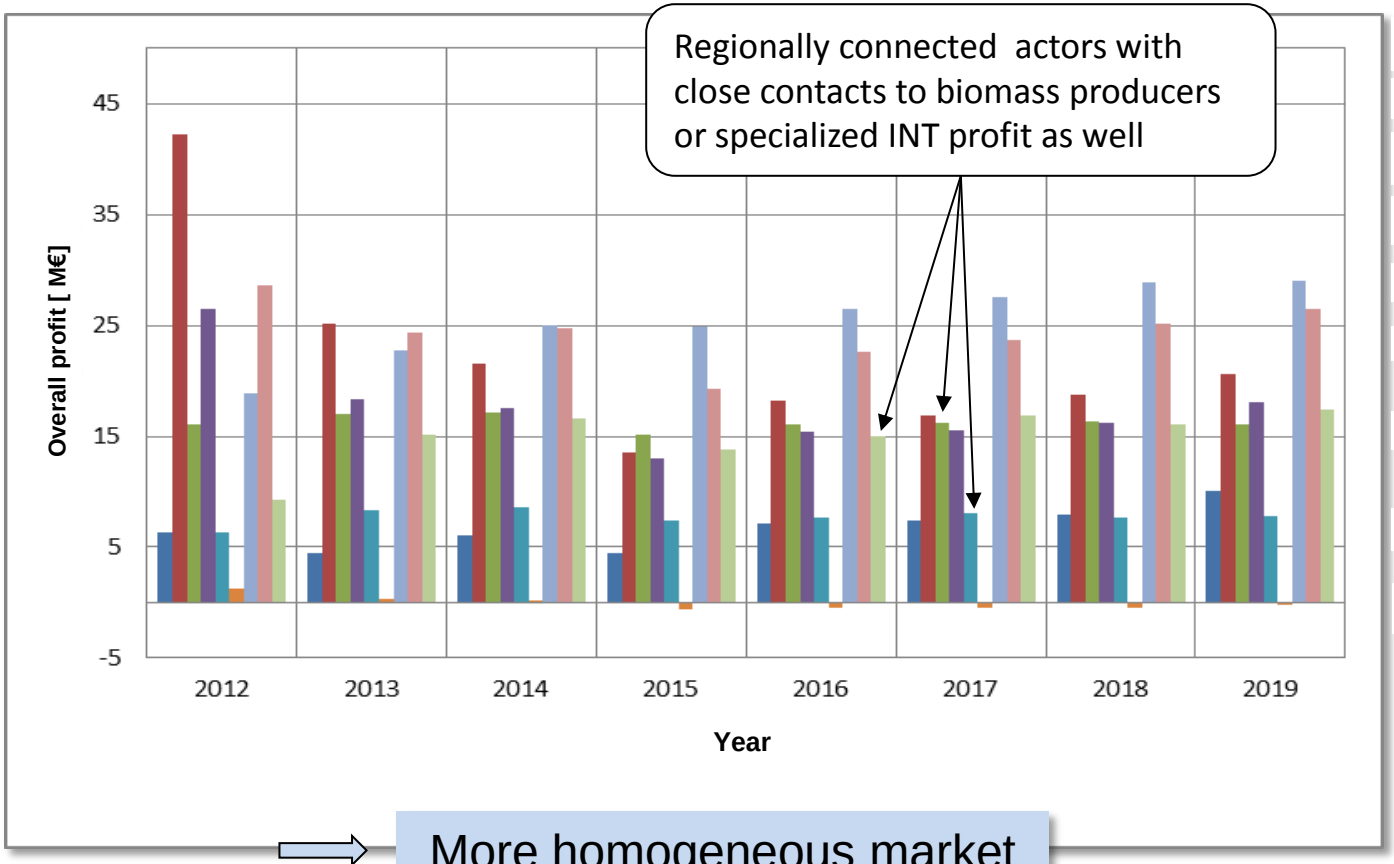
* Not considering the flexibility premium

* BmAB1 (HeizdampfKW, FBS): 2012:10%, 2019: 25%
BmAB3 (BGA klein): 2012: 0%, 2015: 36%
BmAB4 (BGA groß): 2012: 0%, 2014: 90%

Additional revenues of biomass power plant operators by participating in direct marketing and in minute reserve market (ManP v2)



Intermediary overall profit by participating in balance energy market (ManP v2)



More homogeneous market

* Big PV on roofs, open area plants, biogas plants for balance energy.

Further results (optional market premium, ManP v2)

Demand orientation: flexible operation of biomass plants

› Simplified day-night cycle insufficient for refinancing neccessary modification via Day-Ahead-Spotmarket, especially for BmAB1, as relative market values fall below 100 % until 2020 (w/o considering flexibility premium)

Curtailment: Effects from price signals on system level

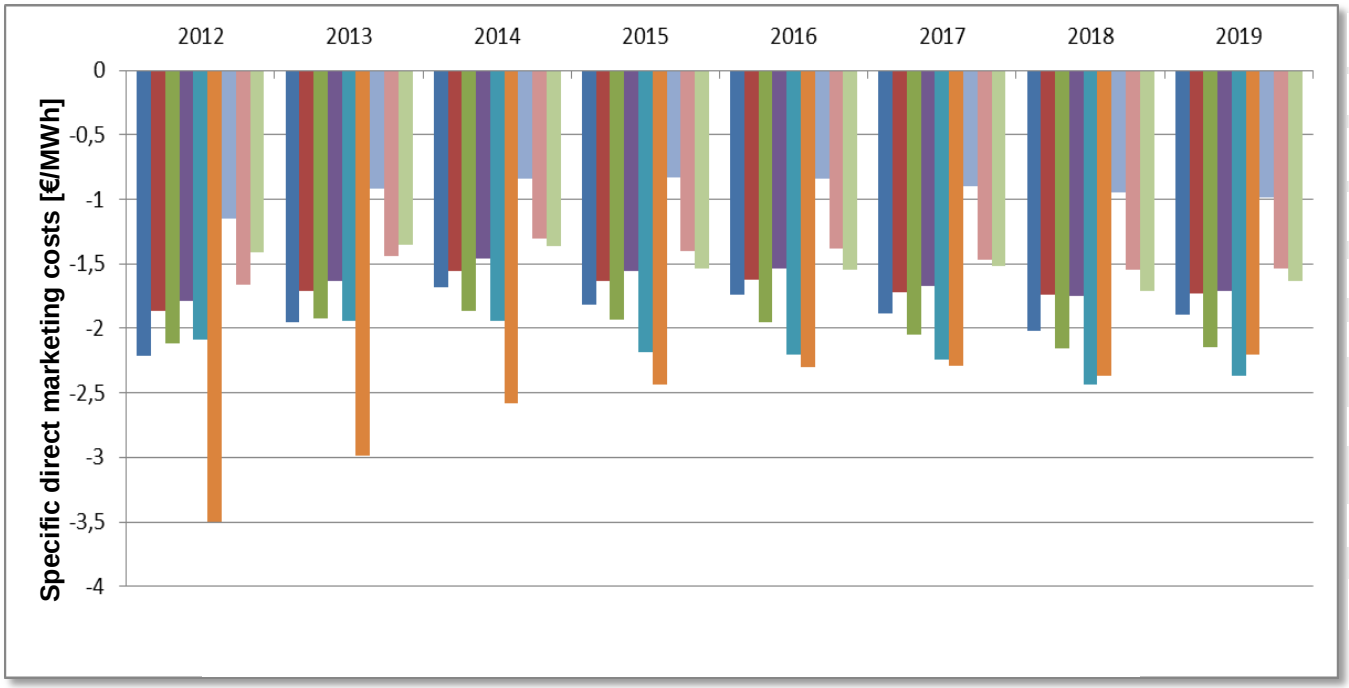
(2012-2019, cumulated)

› Wind: 1.700 GWh
› PV: 26,6 GWh
› Biomass: 200 GWh

Volume of support scheme

› Politically expected savings of about 110 – 210 Mio. €/a due to reduction of ManP are confirmed by model results.
› Support costs increase by 410 Mio. €/a until 2019 due to market premium compared to a FIT only support scheme.
› Average specific costs for promotion of RE will decrease from 112 €/MWh (2012) to 104 €/MWh (2019) – not considering flexible feed-in/price sensitivity.

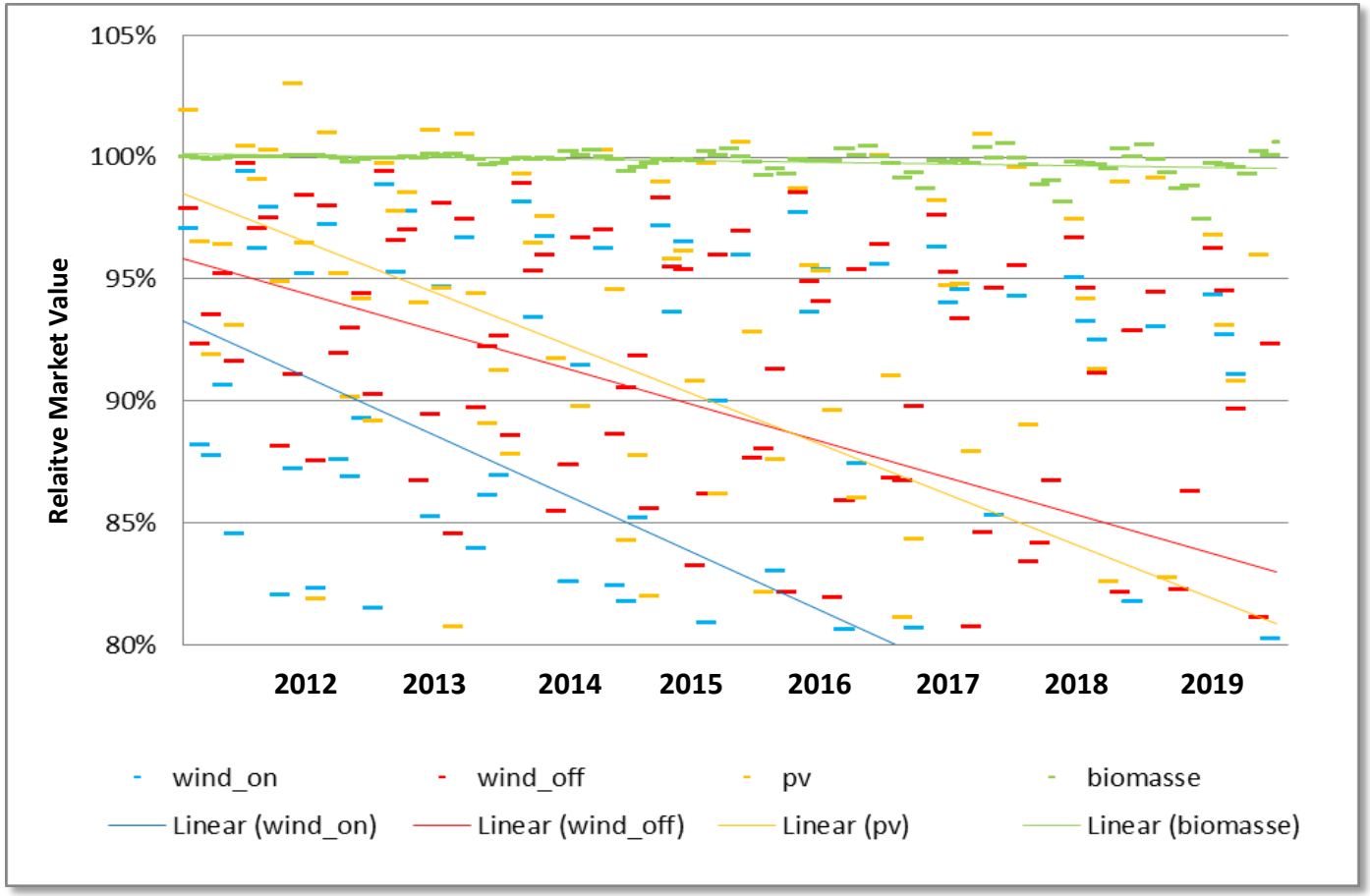
Obligatory market premium (ManP = 0 €/MWh)



Marketing costs are not compensated via ManP
→ INT charge plant operators for marketing costs

Specific costs may be regarded as decrease of renumeration for plant operators

Relative market values of RE for years 2012-2019



Outlook

Planned developments

- More sophisticated mapping of conventional power plants, development of prices for fuel and CO_2.
- Mapping of intraday market.
- Mapping of load and demand response.
- Development of an investment agent.
- Sophisticated algorithms for model endogenous, agent based decision making.

Thanks a lot!

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Simulationsablaufschema

0 Initialization of contracts and communication structure

1 PO: Generation
INT: Adjustment of bonus from MP
GO: Adjustment of forecast qualitiy

2 EM: Merit order calculation

3 PO: Distribution of electricity

4 EM: Determination of residual load and prices due to merit order
GO: Determination of full load hours wind und PV (yearly)

5 GO: Determination of balance energy and prices for reserve capacity
REF: Calculation of MP (monthly)

6 PO: Forecast of MP
INT: Calculation of balance energy and its costs , offer at control energy market
EM: Payment to INT
GO: Payment of FIT and MP

7 INT: Balance of accounts, strategy for tariffs, payout to POs

8 PO: Calculation of income
INT: Forecast of generation
GO: Forecast of generation

9 INT: Forecast of EM prices, evtl. shutdown of plants in direct marketing, adjust terms for marketing, choose marketing path
GO: Impact of renewables on thermal power plants
PO: Adjustment of FIT (yearly) and direct marketing (monthly)

hourly

PO:	Plant Operator	REF:	Renewable Energy Framework
INT:	Intermediary		
GO:	Grid Operator	MP:	Market Premium
EM:	Electricity Market	FIT:	Feed-In-Tariff

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