Impact of the German market premium scheme on the actors of the electricity market - an ABM analysis

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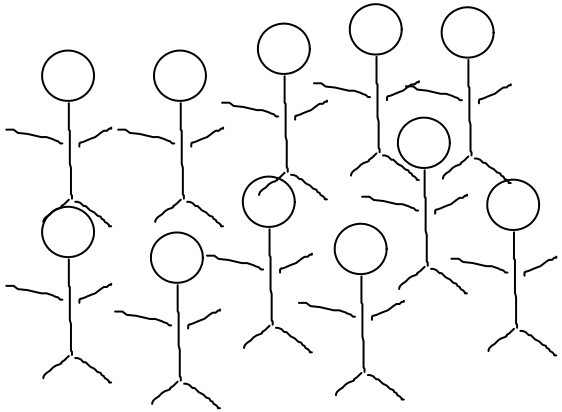
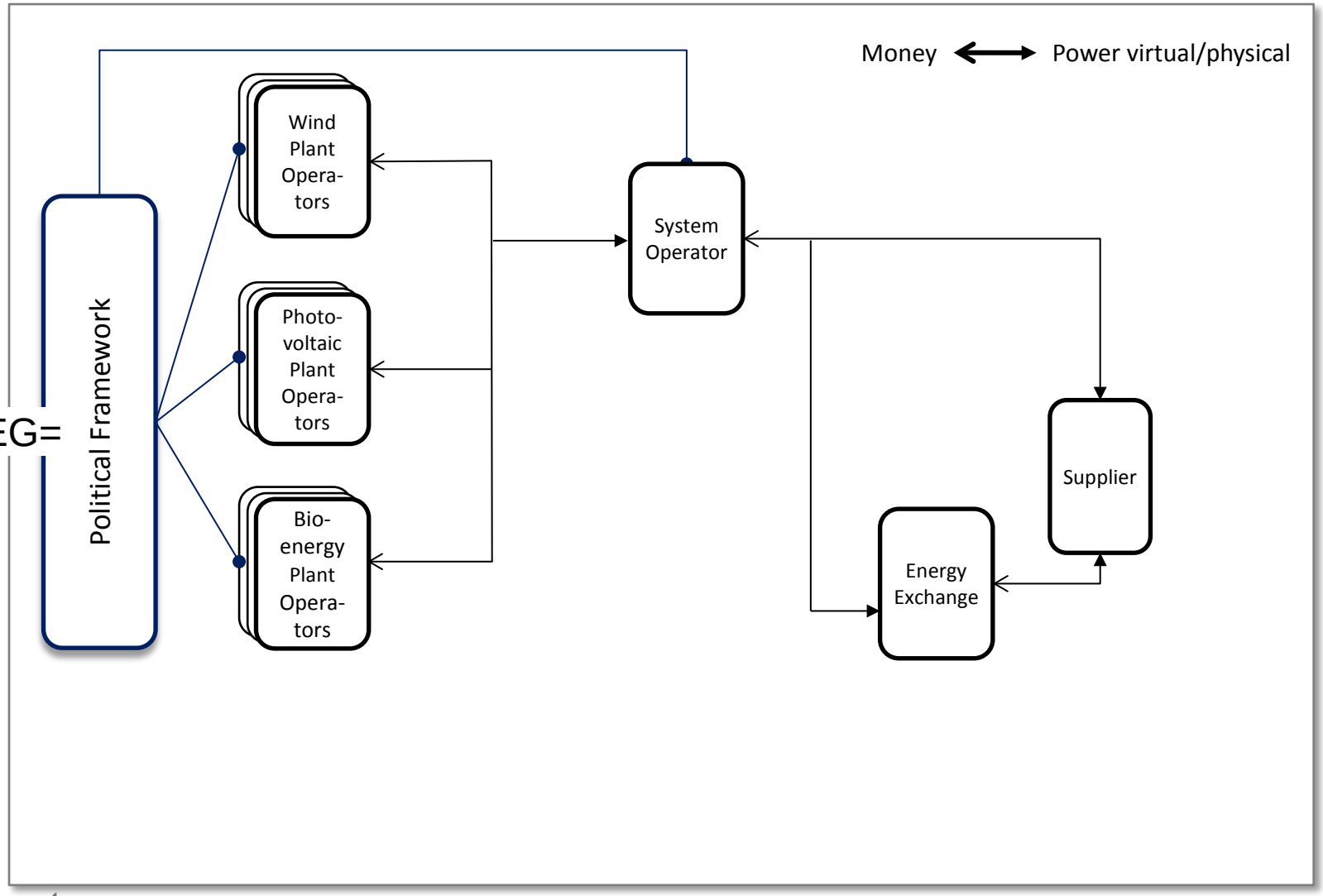
Comparison of optimization and agent-based models

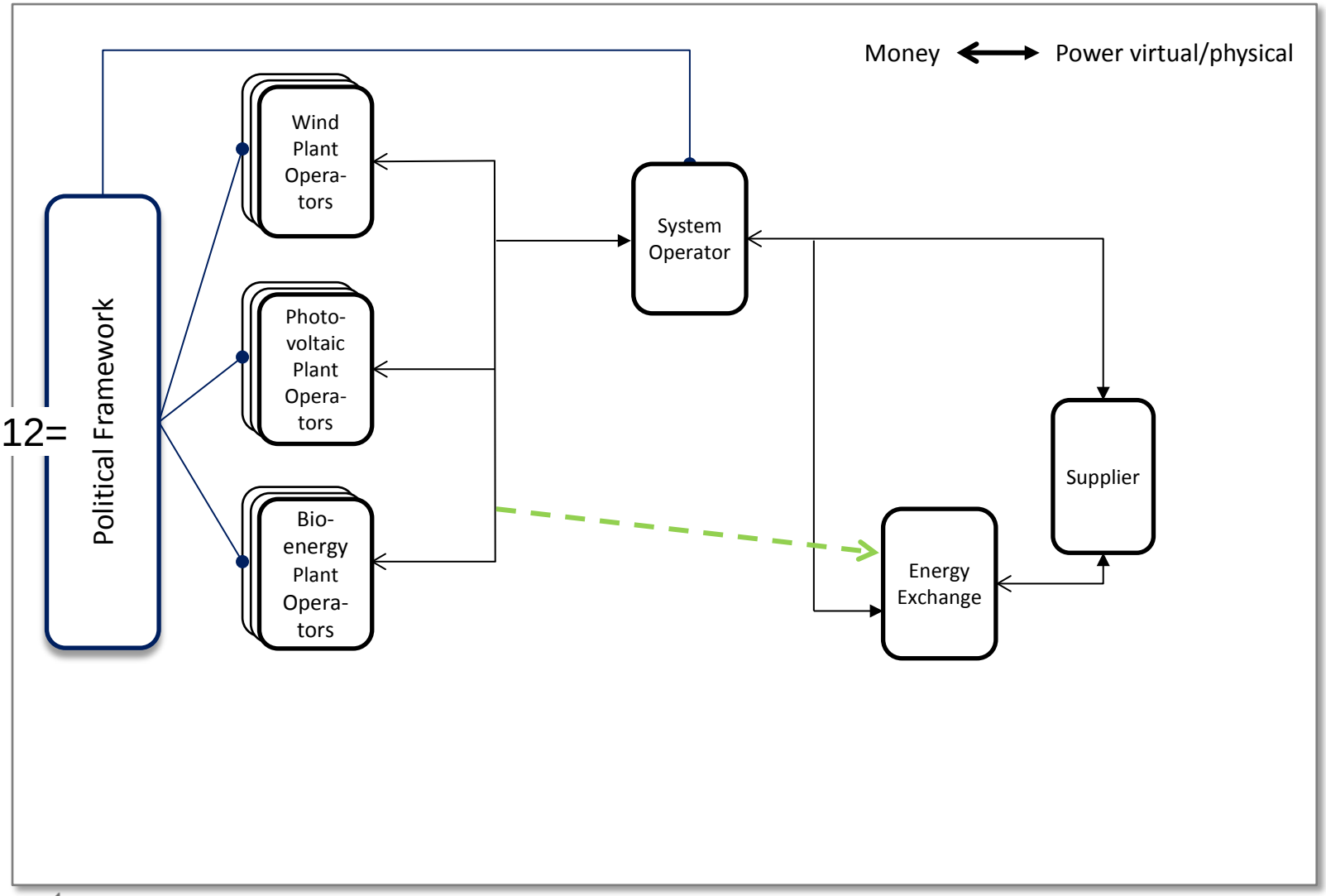
Optimization model	Agent based model
Get a system with different technologies that ensures security of supply and is **cost optimized**	**Economic success/failure** of actors in a system with different technologies, markets and policy measures
What does it cost?	*How to make money?*



German Renewable Energy Act – Part I

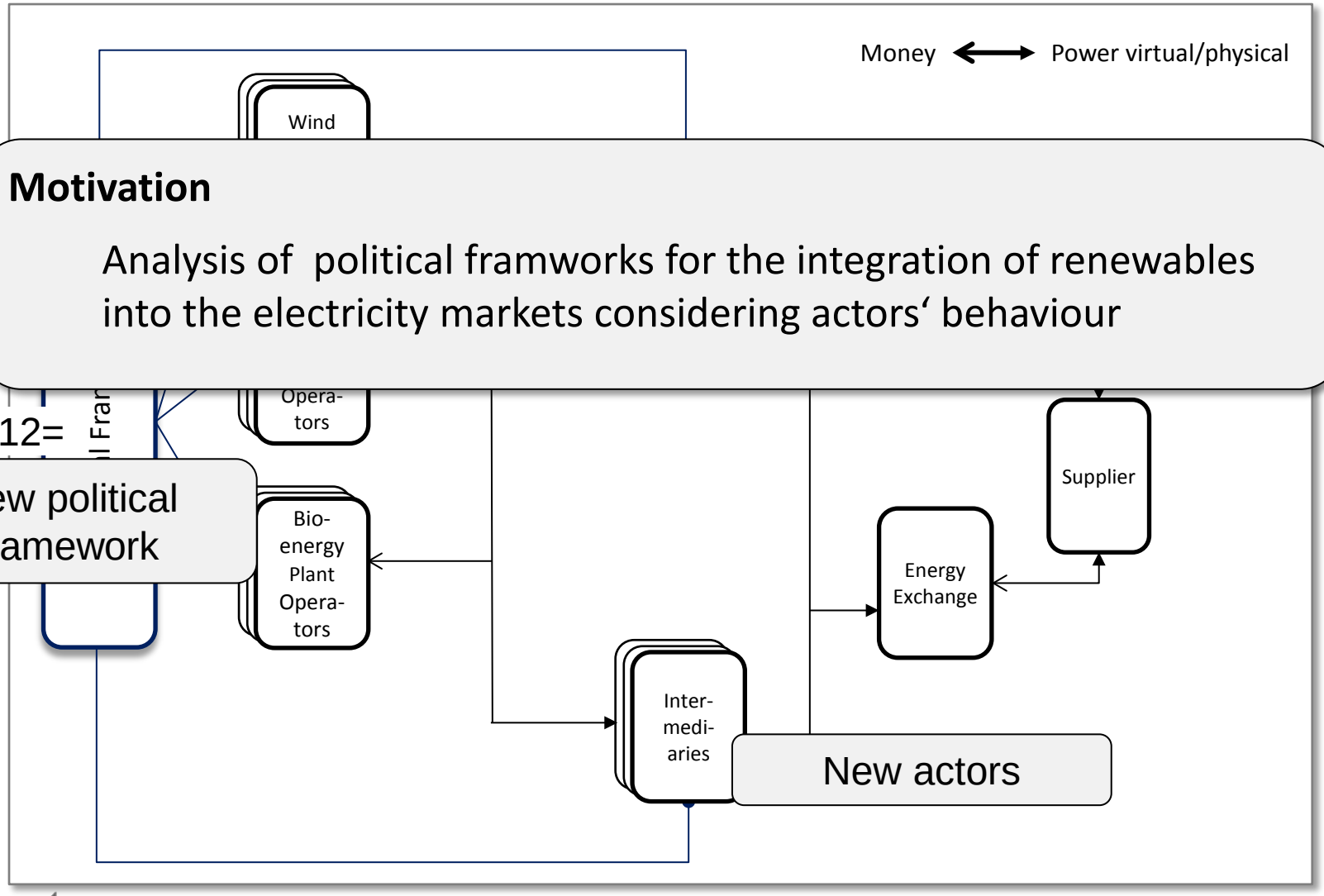


German Renewable Energy Act – Novel 2012



EEG 2012=

German Renewable Energy Act – Novel 2012



Motivation

Analysis of political framworks for the integration of renewables into the electricity markets considering actors‘ behaviour

EEG 2012= New political framework

AMIRIS – Policy analysis and design tool

Integration of new technologies into existing markets

Open Questions

- What policy instruments support new technologies?
- Which markets are necessary for (new) actors?
- Market or regulation – What's the effect on all actors?

Solution Approach

- Analyze actors and their interdepen-dencies and inter-actions
- Study impact of changes in policy & market design on actors
- Evaluate impact on overall system

Methodology

- Document research, interviews and expert workshops
- Review and study of markets and policy instruments

→ Agent-based model (agents with **autonomous** behavior, **own goals**, **imperfect** knowledge, adaptation of strategies)

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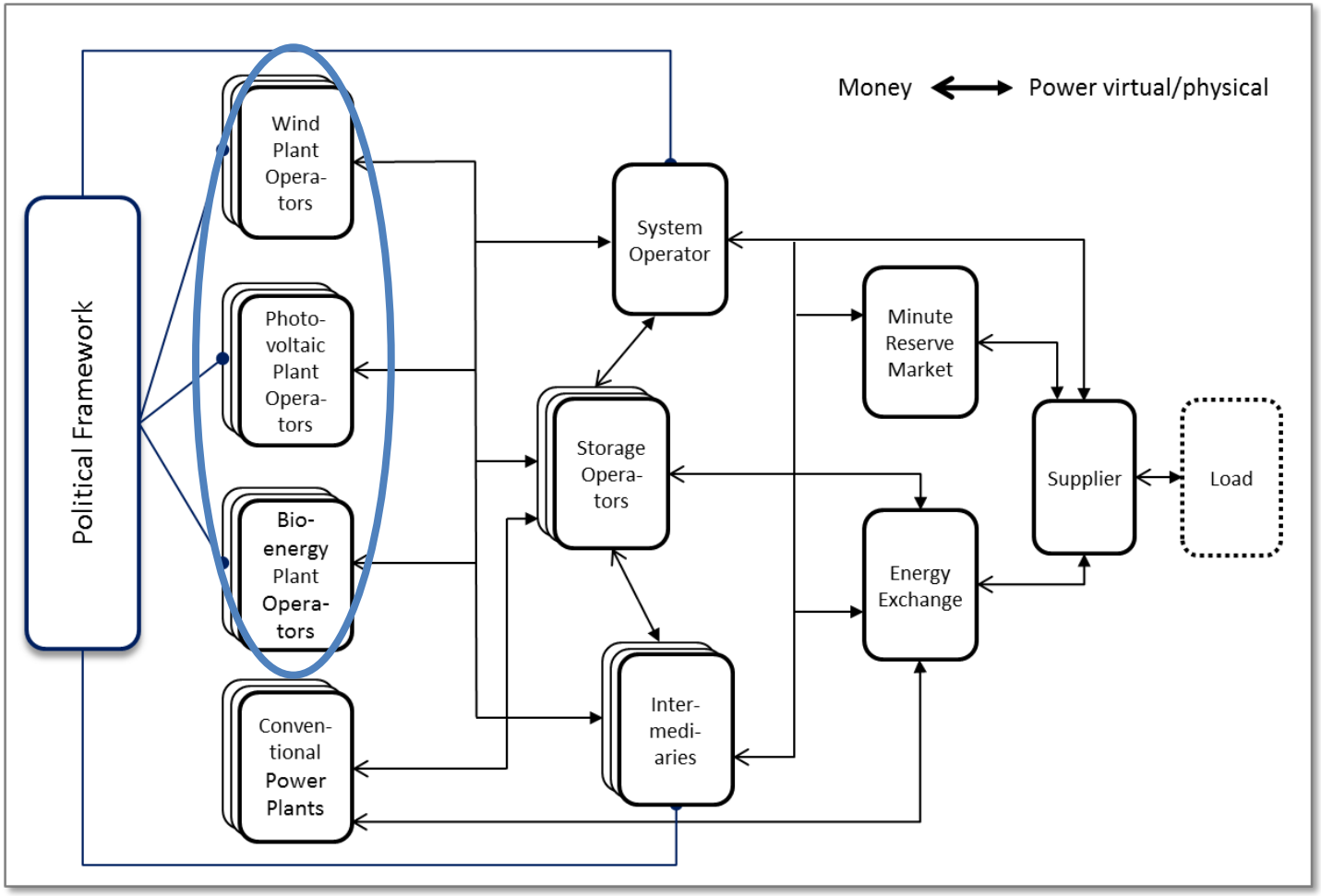
AMIRIS model

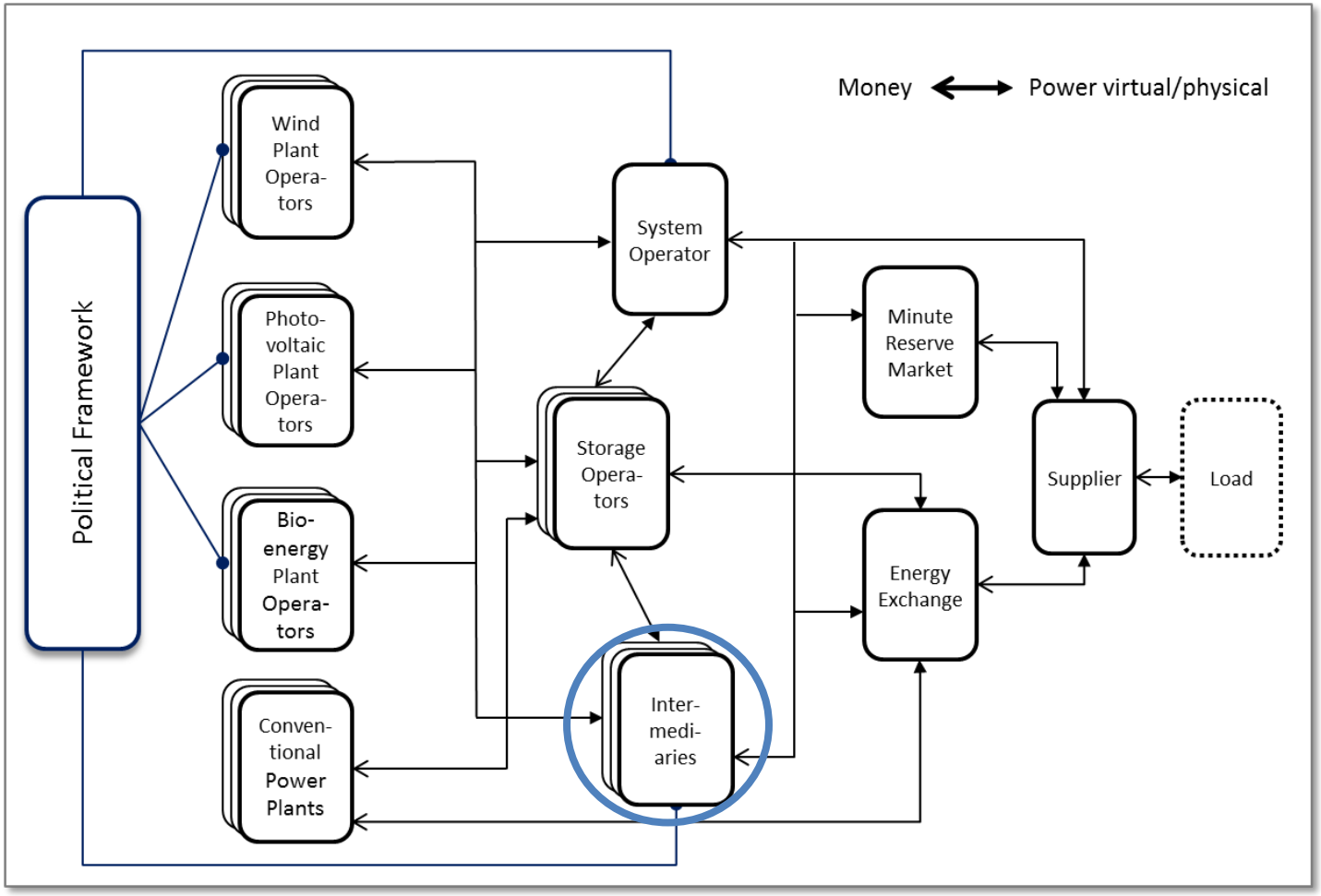


Remuneration Classes of Power Plants in the AMIRIS Model

	Wind	PV	Biomass (BM)
RC 1	Basic FIT	Roof-top < 30 kW since 2012 < 10 kW	Solid biomass 5-20 MW (matured wood, forest residues)
RC 2	Starting FIT (low average)	Roof-top 30-1000 kW, since 2012 10-1000 kW	Wood gasification
RC 3	Starting FIT (high average)	Roof-top > 1000 kW	Biogas 50-350 kW (liquid manure und re-growing resources)
RC 4	Offshore	Conversion and open space	Biogas > 350 kW (liquid manure, re-growing resources, organic waste)

RC = Remuneration Class

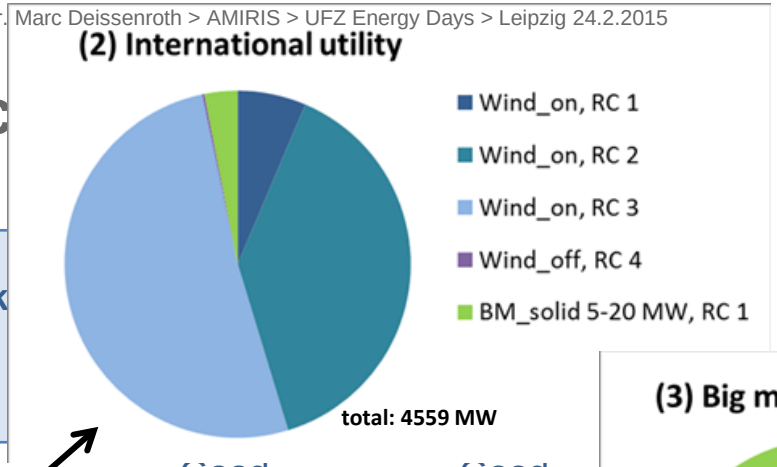
AMIRIS model

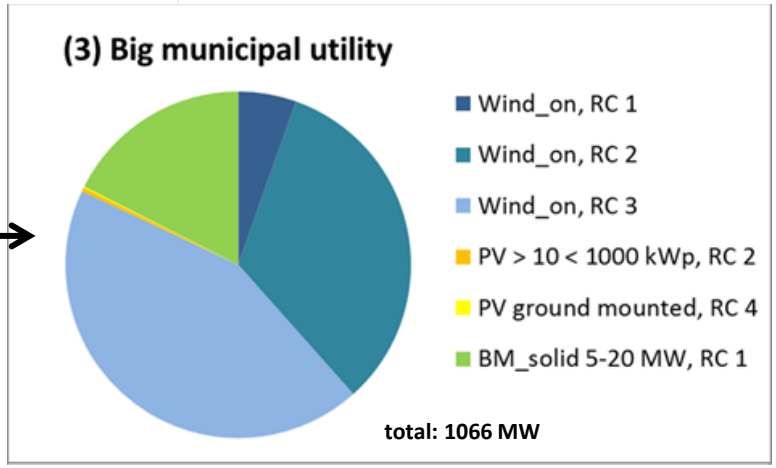


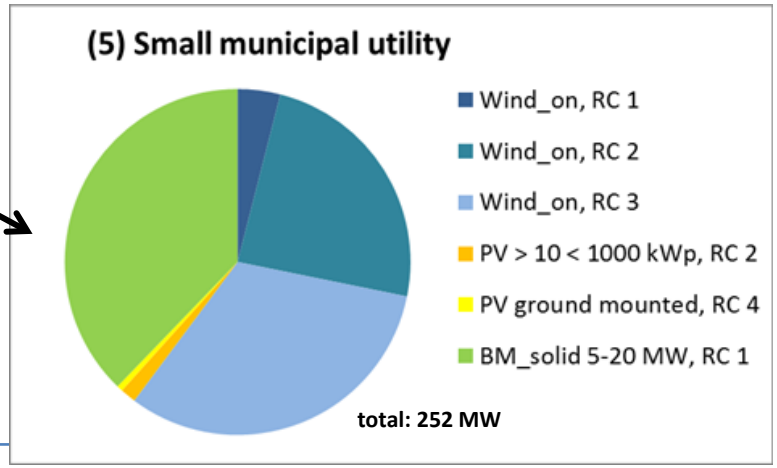
Types of direc

Types of **direct mark**

(1)	Big national utility	Good	Good
(2)	International utility	Good	Good
(3)	Big municipal utility	Medium	Good
(4)	Municipal utility “Pioneer”	Good	Good
(5)	Small municipal utility	Bad	Bad
(6)	Green electricity trader for households	Good	Medium
(7)	Green electricity trader for business/industry	Good	Medium
(8)	Specialised intermediary with experience	Good	Good
(9)	Specialised intermediary without experience	Medium	Medium



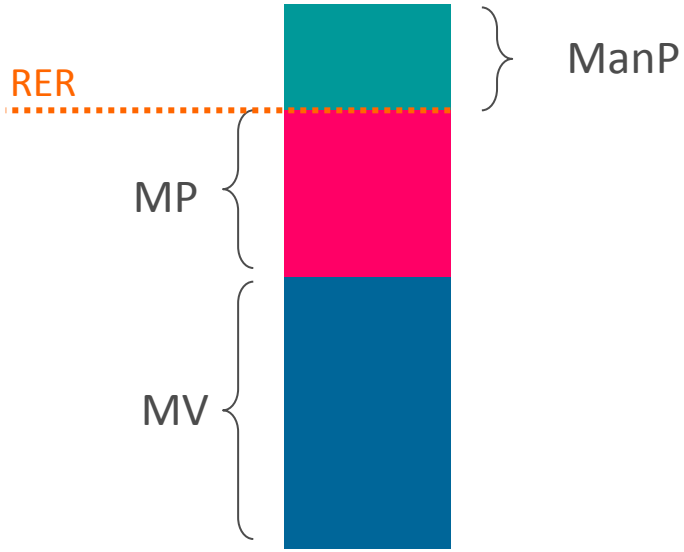




Direct marketing and the sliding market premium

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

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



Focus of study:

Direct marketing of RE electricity making use of the sliding market premium, regarding three variants of the management premium:

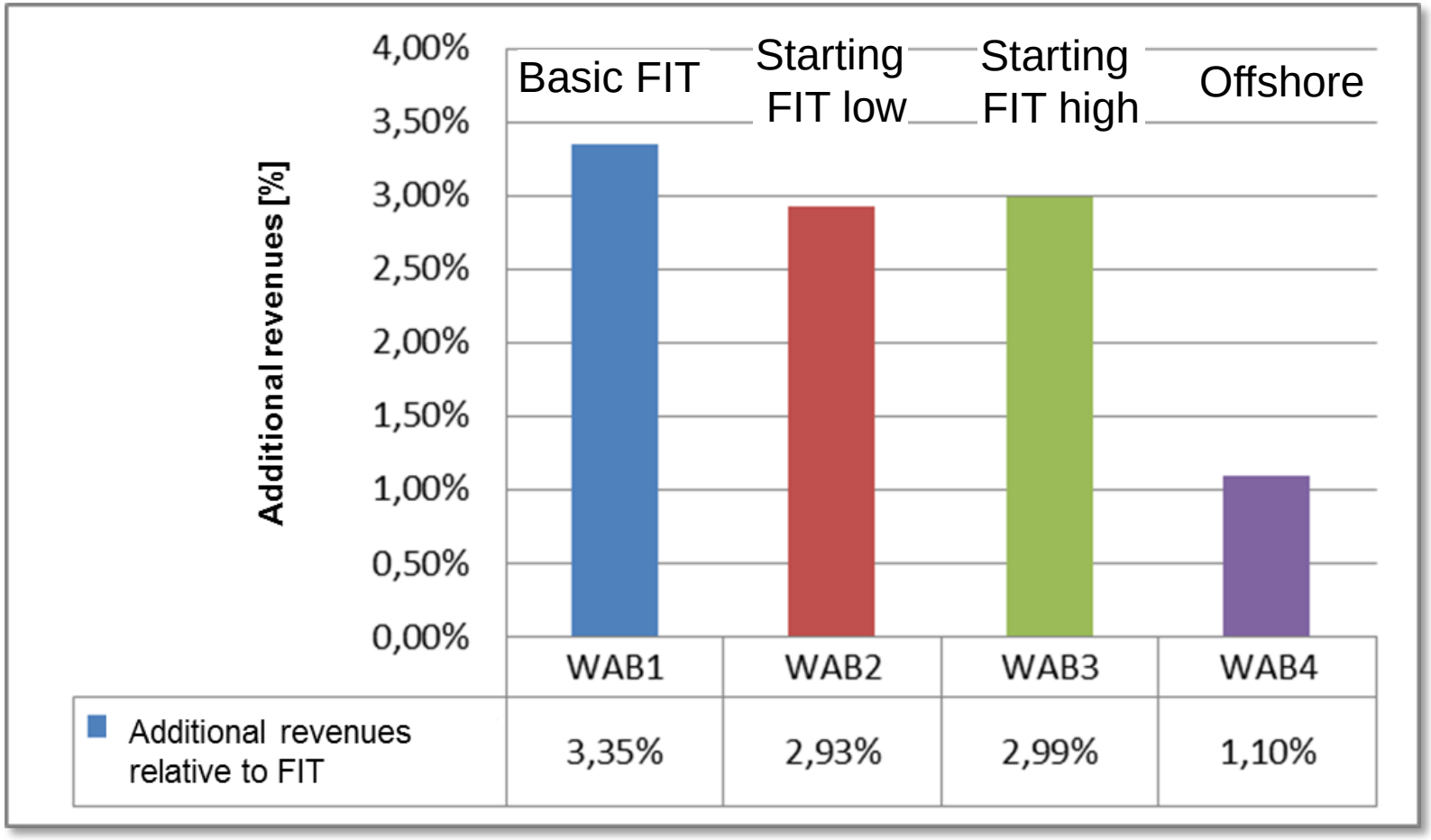
EEG 2012 (high) | MaPrV 2012 (low) | no ManP (zero)

Input and assumptions of simulation

- Renewable energy and conventional power plants installations according to Leitstudie 2012, Szenario A*
- Fossil fuel and CO2-price according to Leitstudie 2012 Preispfad A*
- Renewable energy generation from DLR energy system model REMix
- Load according to ENTSO-E
- EEG-remuneration and market premium from 2012 and variants
- Hourly simulation steps for the years 2012-2019

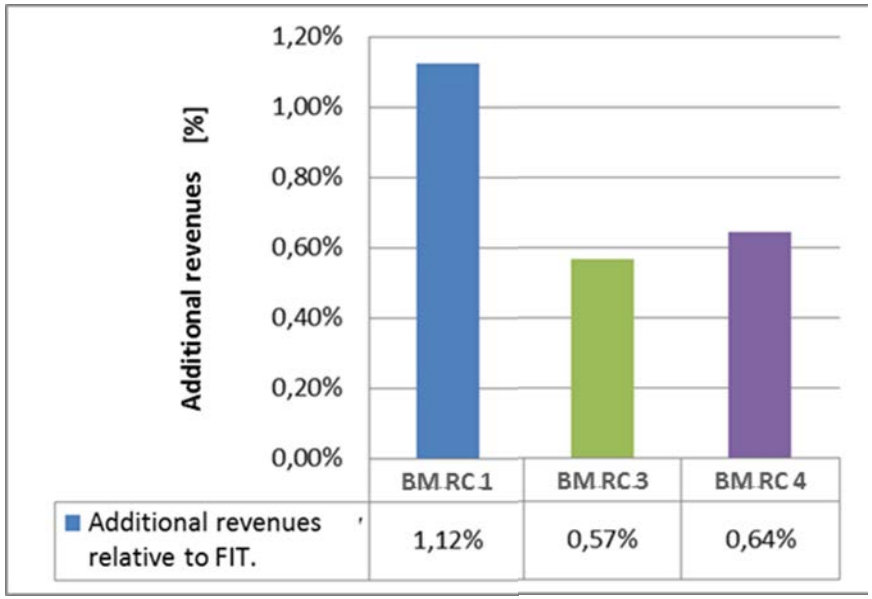
* Nitsch, J. et al. ‚Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global, *Deutsches Zentrum für Luft- und Raumfahrt (DLR), Fraunhofer Institut für Windenergie und Energiesystemtechnik (IWES), Ingenieurbüro für neue Energien (IFNE), Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU),* **2012**

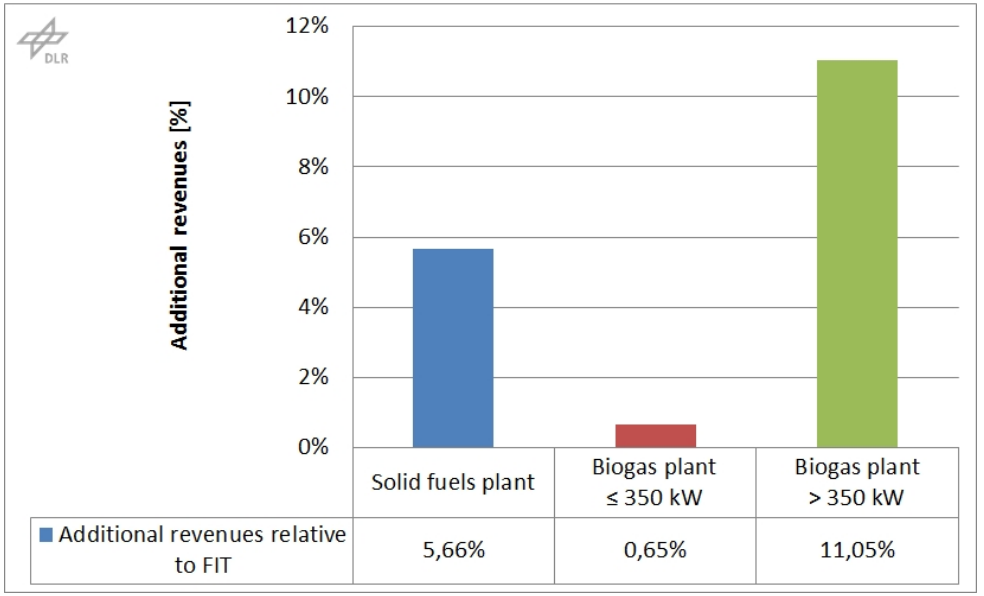
Additional revenues of wind power plant operators by participating at direct marketing (ManP low)



Additional revenues for biomass power plant operators

Scale !





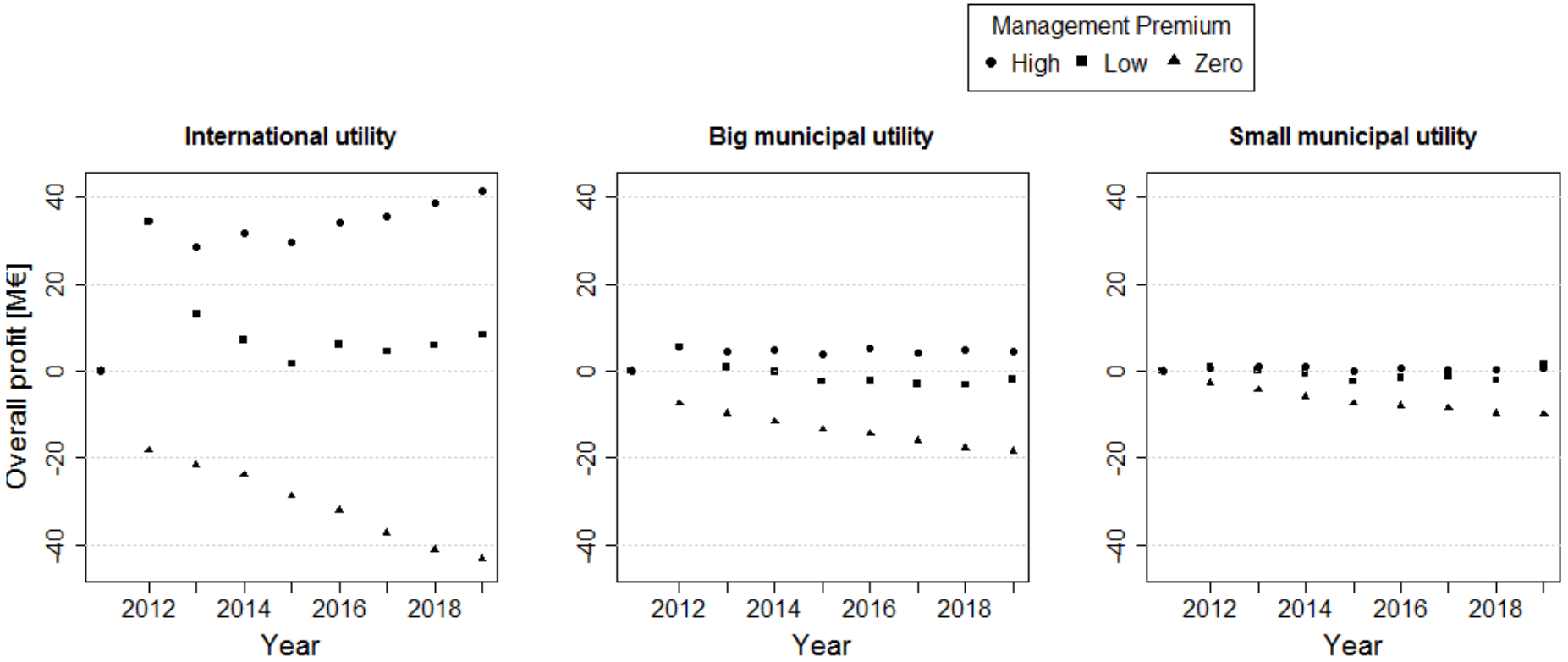
Participation in direct marketing

Participation in direct marketing & negative minute reserve market

Feed-in profile: simplified day-night-cycle

** BM RC 3 (Small Biogas Plants): No marketing at the reserve market.

Profits of selected direct marketers



The profits include all incomes and expenses that are accumulated per accounting year and which are directly or indirectly related to direct marketing issues.

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Outlook

Ongoing developments

- Storage units for optimisation of power plant operation.
- Implementing detailed load and demand response.

Planned developments

- More sophisticated mapping of conventional power plants.
- Mapping of intraday market.
- Development of an investment agent.
- Analyzing other market structures and policy instruments.

Thank you very much for your attention!

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Appendix

Simulationsprozess

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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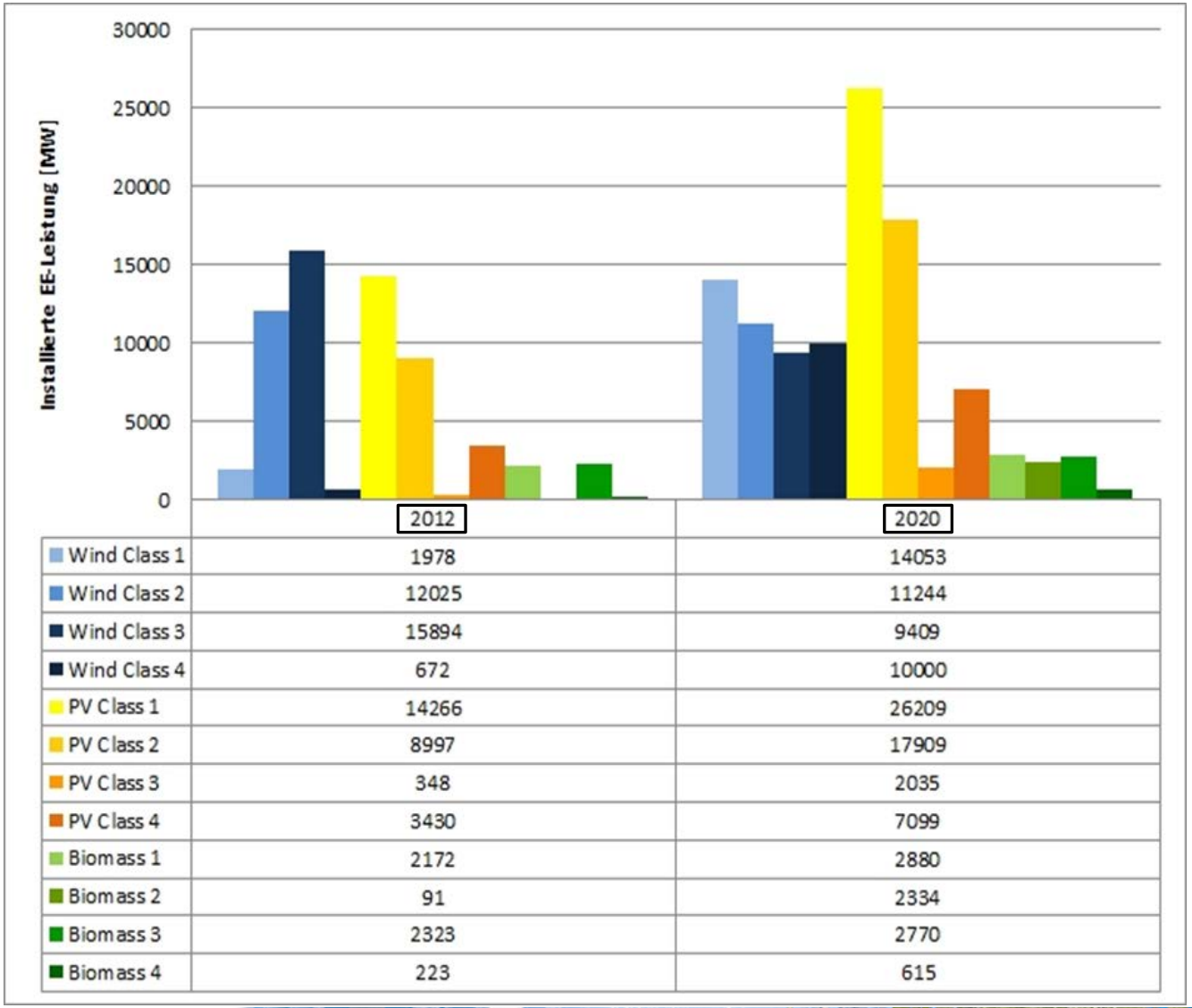
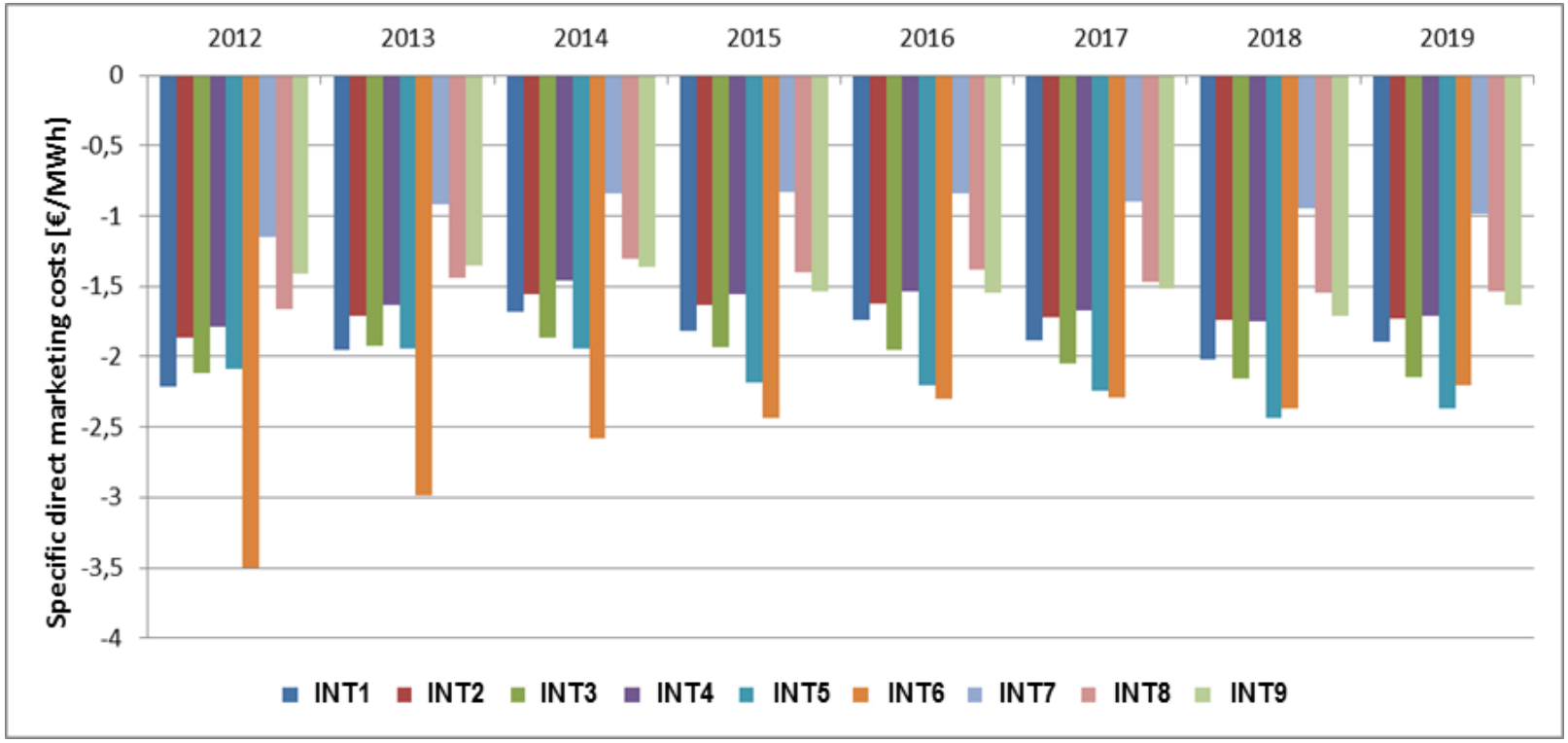
Installierte Leistung der EE nach Vergütungsklassen in AMIRIS in den Jahren 2012 und 2020.



	2012	2020
Wind Class 1	1978	14053
Wind Class 2	12025	11244
Wind Class 3	15894	9409
Wind Class 4	672	10000
PV Class 1	14266	26209
PV Class 2	8997	17909
PV Class 3	348	2035
PV Class 4	3430	7099
Biomass 1	2172	2880
Biomass 2	91	2334
Biomass 3	2323	2770
Biomass 4	223	615

Specific costs for direct marketing for different types of intermediaries in case of obligatory direct marketing without compensation for marketing costs

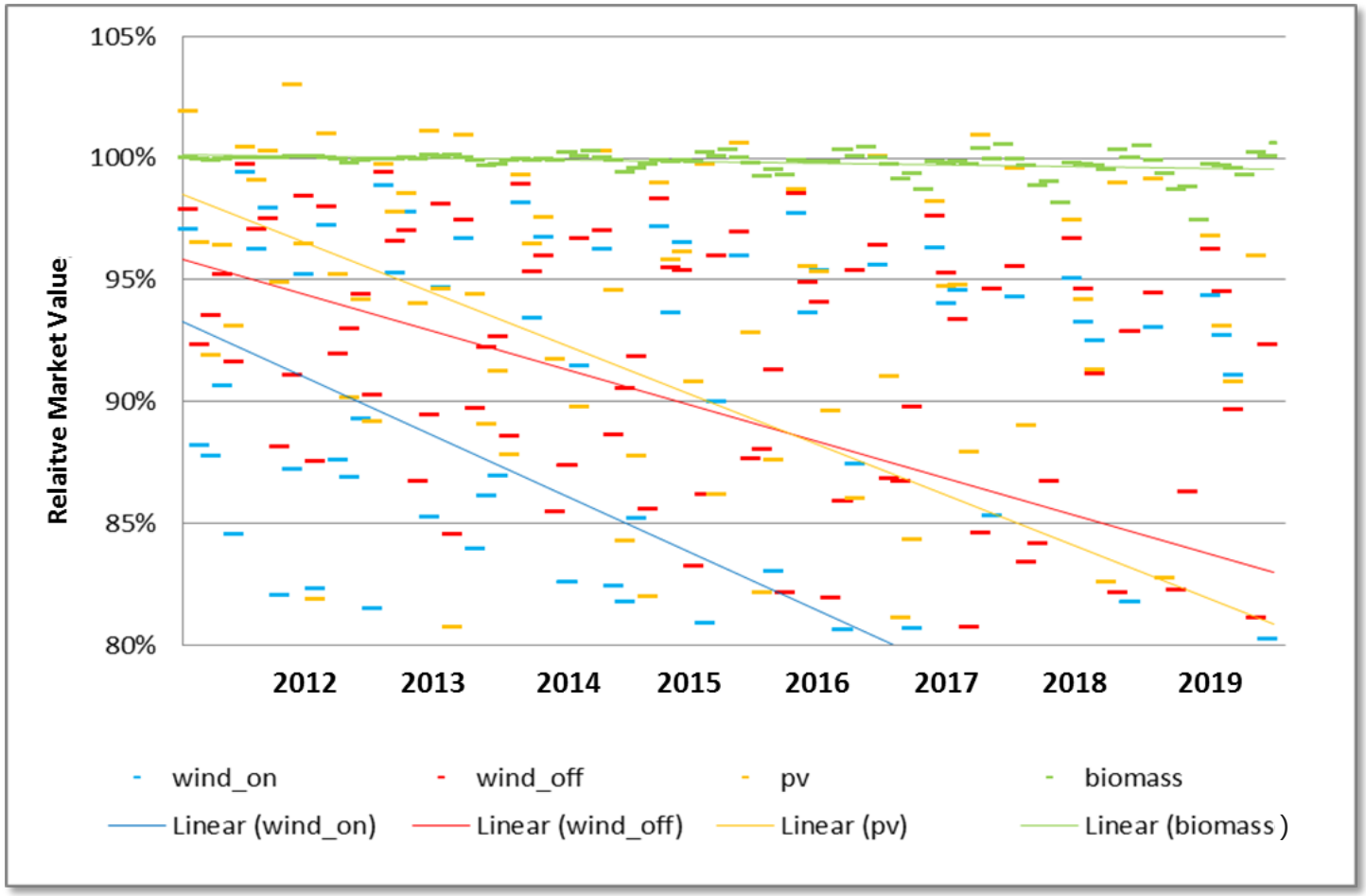


Conclusion

- The agent-based model AMIRIS analyses the impact of political frameworks on the micro- as well as on the macro level.
- The agent-based perspective allows research respecting the interdependencies of the involved actors.

- For plant operators of fluctuating RE it is financially attractive to take part in direct marketing supported by the floating market premium.
- However, biomass power plant operators which actually are well suited for demand oriented generation profit least - as long as they do not take part at the market for negative minute reserve.
- The participation of RES in direct marketing is profitabel for intermediaries as long as a premium is paid for it. In case of a low or even an abatement of the premium it seems likely that several actors encounter severe losses, thus leading to market concentration.

Relative Market Value Development for RES (Simulations for 2012-2019)



Forecasting

- Forecast quality for feed-in: 15 - 25 % nRMSE
  - > good forecast quality: 15 % nRMSE (three external predictions)
    Expectation Value = 0.05
  - > medium forecast quality: 20 % nRMSE (two external predictions)
    Expectation Value = 0.10
  - > poor forecast quality: 25 % nRMSE (one external prediction)
    Expectation Value = 0.15

- $Forecast_{Feed-in} = Generatrion\,(t_{24}) * ((1 + E_{Forecast}(INT)) + \sigma_{Forecast}(INT) * G)$

mit: $E_{Forecast}$ - Expectation value [0,05 ; 0,15]

$\sigma_{Forecast}$ - Feed-in forecast error (nRSME) [0,15 ; 0,25]

G – normal distributed random draw