

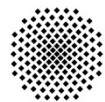
# AMIRIS – An Agent-Based Simulation Model for the Analysis of Market Integration of Renewable Energies under Various Frameworks

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Project Partners:

CIRIUS - Stuttgart  
Research Center on  
Interdisciplinary Risk and  
Innovation Studies



**University of Stuttgart**  
Germany



Thomas Kast  
Simulation • Solutions



Knowledge for Tomorrow



# AMIRIS - Our agent-based modelling (ABM) Approach

## ► Need for sound scientific policy device for the energy transition

- 1 We use advantages of ABM to model agents with:
  - Autonomous behavior
  - Own goals
  - Adaptation of strategies
  - Imperfect knowledge
  - Heterogeneity
  - Prototyped market orientated behavior
- 2 We conduct sound actor analysis based on theoretical assumptions derived from sociological neo-institutionalism with:
  - Document analysis
  - Semi-structured interviews
  - Expert workshops

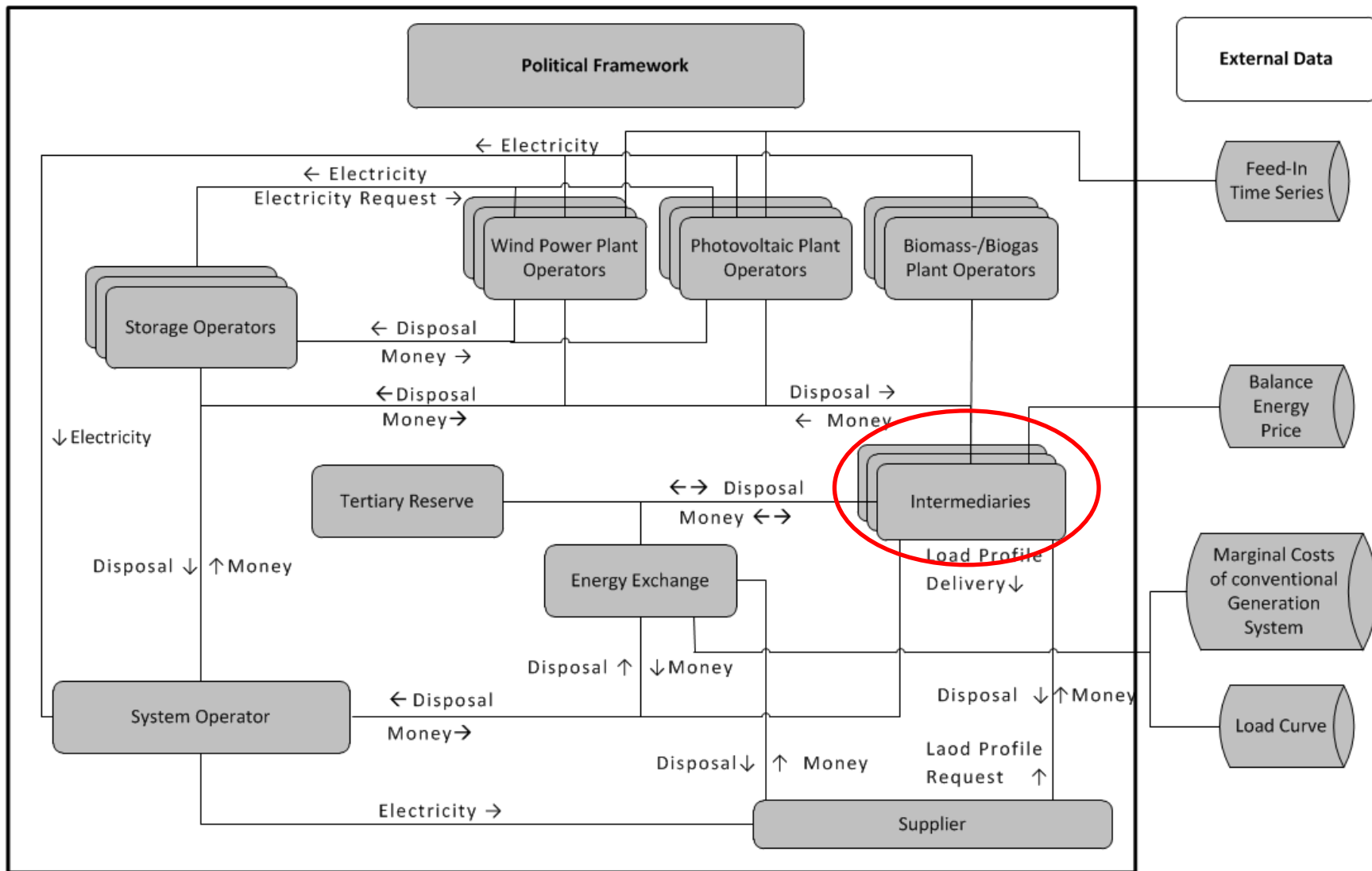
see also IAEE Paper Wassermann

- 3 We build an ABM as policy analysis and design tool to:
  - Analyse impact on agents as result of changes in policy design (micro-economic effects)
  - Analyse interdependencies and interactions of agents
  - Analyse impacts on overall system (macro-economic effects)

→ so far focus on direct marketing of RES electricity

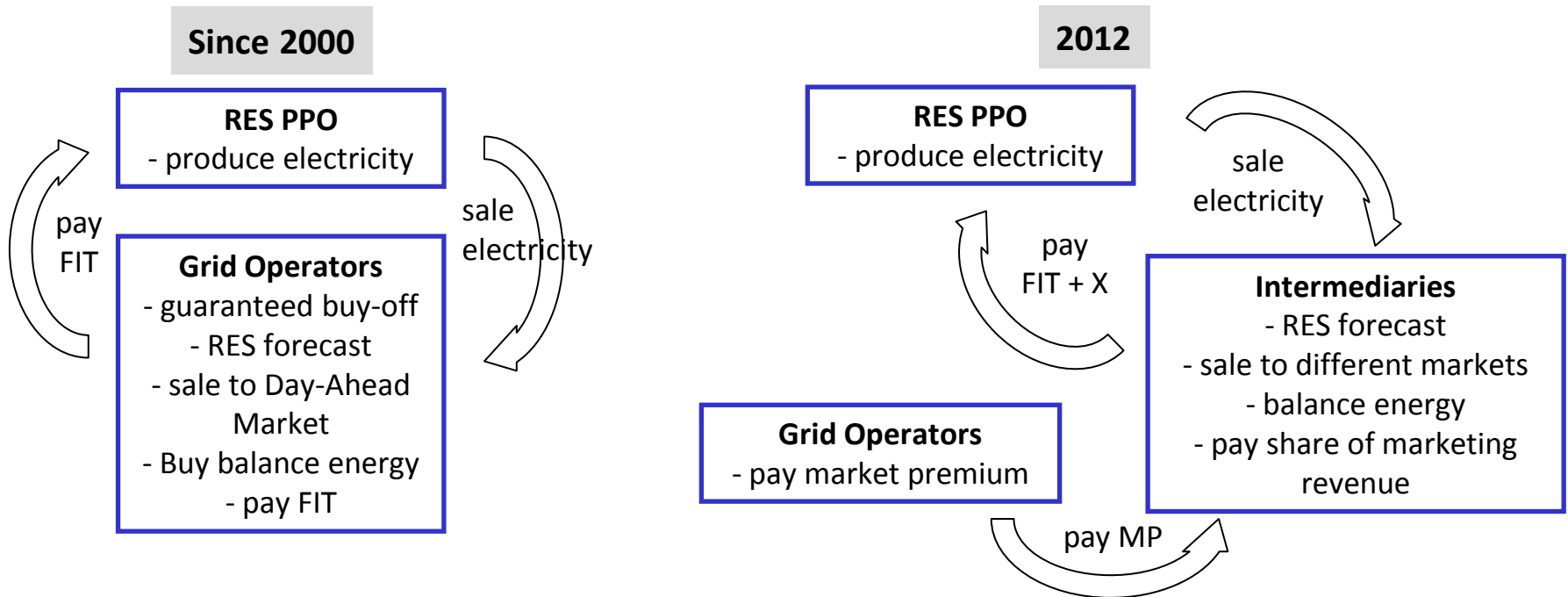


# AMIRIS Model Structure



# EEG 2012 Amendment – Market Premium

- German Renewable Energy Source Act (EEG) provides feed-in-tariffs (FIT) and buy-off of electricity by the transmission system operator (TSO) for the RES power plant operator (PPO) since 2000.
- After successful market introduction of RES, market integration is seen as next big step.
- Since 2012: Direct marketing of RES is supported by the optional ‘market premium’ (MP)



Management Premium: intermittent RES 2012: 12 €/MWh → 2015: 7 €/MWh  
 dispatchable RES 2012: 3 €/MWh → 2015: 2,25 €/MWh



# Actor Analysis I - Intermediaries

## 1. Differentiation for first static simulation runs (no competition):

	Prototype	Capital resources (million €)	Market premium	Tariff	Forecast quality
(1)	Big national utility	100	2012	FIT+X	Good
(2)	International utility	15	2012	FIT+X	Good
(3)	Big municipal utility	15	2012	FIT+X	Medium
(4)	Municipal utility "Pioneer"	15	2012	FIT+X	Good
(5)	Small municipal utility	7	2012	FIT+X	Bad
(6)	Green electricity trader for households	7	2012	FIT+X	Good
(7)	Green electricity trader for business/industry	7	2012	FIT+X	Good
(8)	Green electricity trader for local marketing	1	-	FIT+X	Medium
(9)	Functional intermediary as spin-off from a big utility	3	2012	FIT+X	Good
(10)	Functional intermediary as start-up	0,1	2012	FIT+X	Medium

## 2. Further differentiation for dynamic simulation runs (with competition):

- Searching cost for contract partners
- Multiple marketing strategies: market premium, green electricity privilege, local direct marketing, bidding on reserve and control energy market

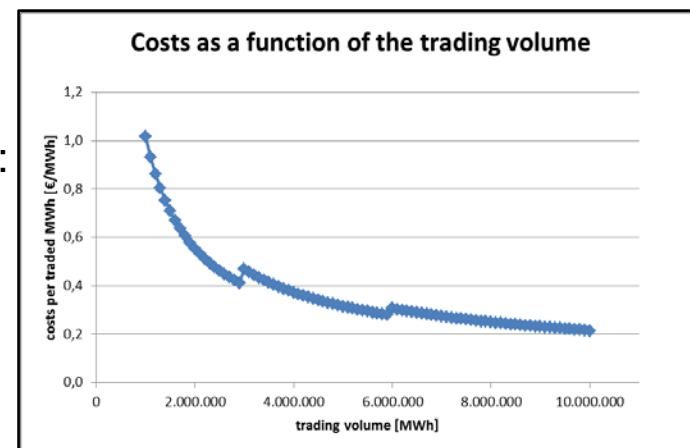




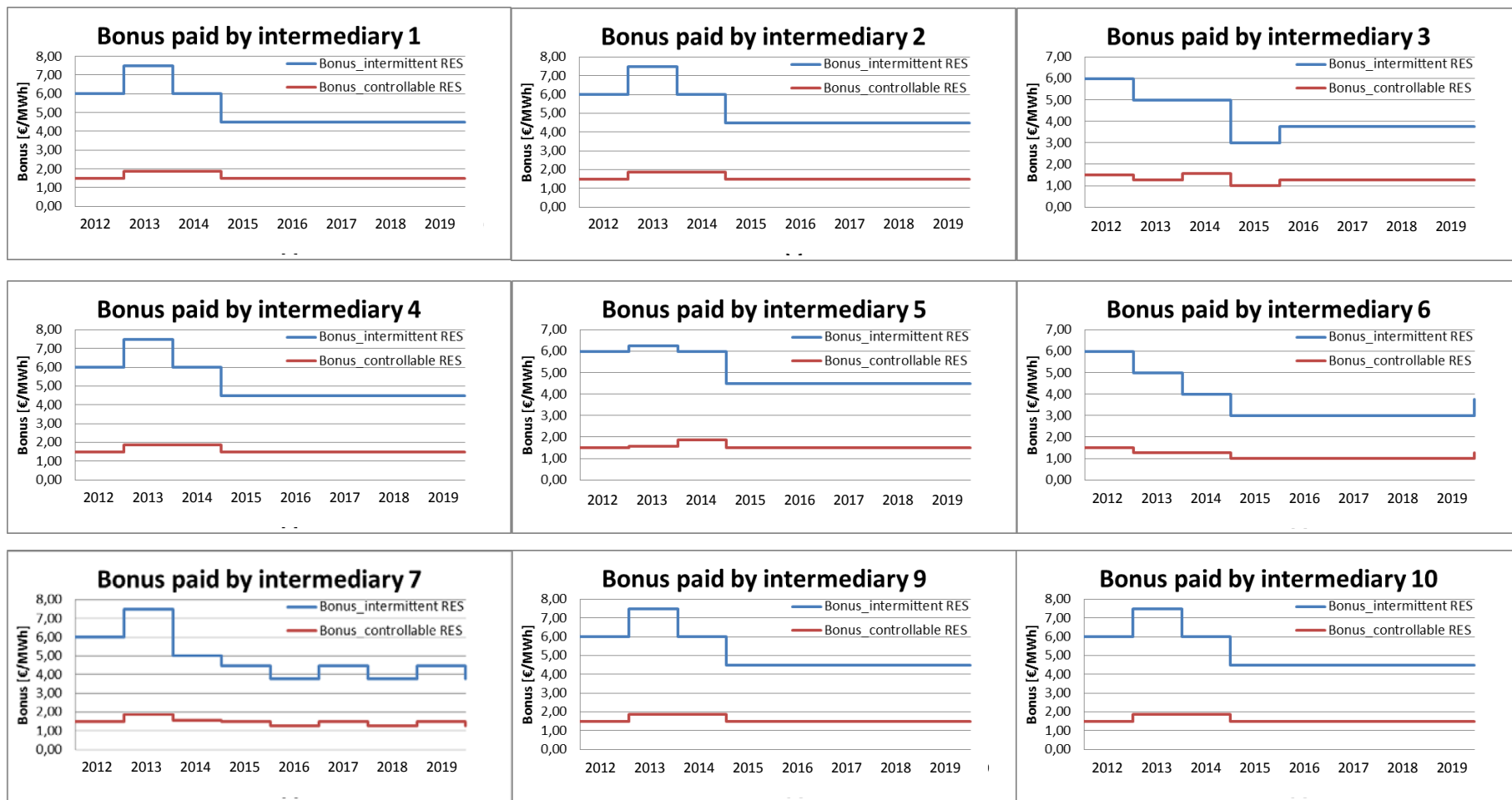
# Intermediary Agents – Cost Structure

Fixed costs				Variable costs			
1.	Office rent	133	€/a*m <sup>2</sup>	1.	EEX Trading fee	0,0075	€/MWh
2.	Office space factor:			3.	Specific labour costs (staff)	0,052	€/MWh
	Number of employees(E)	< 5	42		Supervised volume / employee	1.250.000	MWh/E
		5 - 10	36				
		10 - 20	35	4.	Forecasting costs:		€/MW
		20 - 50	26		Small portfolio	500-1500	MW --> €/MW: 15
		> 50	25		Medium portfolio	1500-3000	MW --> €/MW: 10
3.	EEX access	25.000	€/a		Big portfolio	3000-5000	MW --> €/MW: 5
4.	IT-/ Office equipment	10.000	€/a*E	5.	Forecasting quality:		
5.	Labour costs:				Good	Number of purchased forecasts:	3
	Trader	130.000	€/a*E		Medium	Number of purchased forecasts:	2
	Other staff	65.000	€/a*E		Bad	Number of purchased forecasts:	1

- At end of each year: intermediary agents carry out balance check and calculate EBIT per employee.
- According to EBIT the tariff is adjusted if necessary:
  - € 100,000-300,000: bonus remains the same
  - € 300,000-500,000: bonus is risen by 25 %
  - > € 500,000: bonus is risen by 50 %
  - € 50,000 - 100,000: bonus is lowered by 25 %
  - < € 50,000: bonus is lowered by 50 %

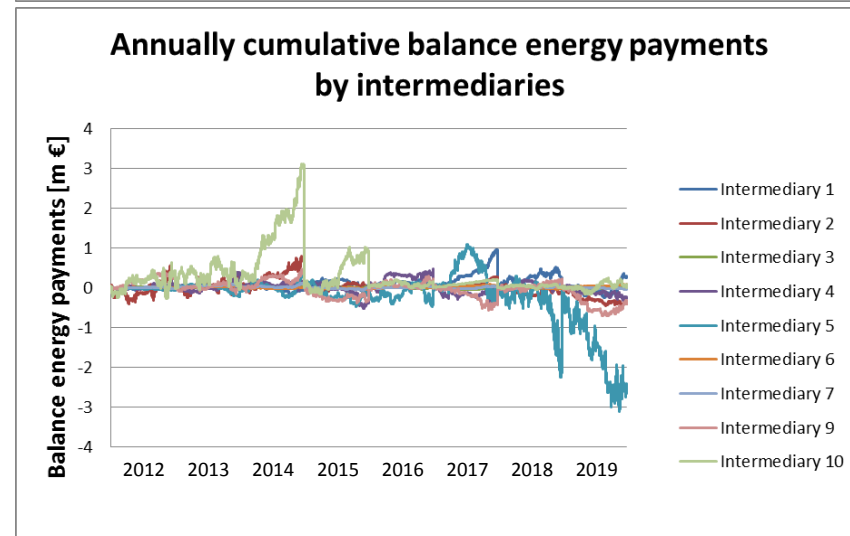
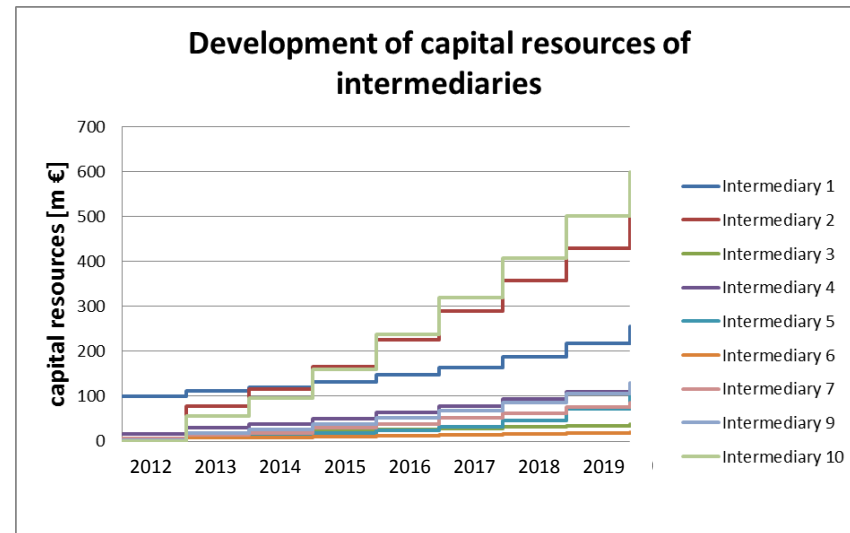


# First Results I: Bonuses Paid by Intermediaries (static simulation run)



# First Results II: Impact on Intermediaries (static simulation run)

- Intermediaries 2 und 10 seem to profit the most from introduction of MP
- This is mainly due to fixed direct marketing shares at start of simulation
- No intermediary can pay higher bonus than these two (7,5 €/MWh in 2013)  
→ hint leading to the conclusion that these two will be able to defend their position.
- Compared to others, intermediary 10 also seems to profit from balance energy payments
- Results have to be interpreted with caution as revenues are highly dependent on balance energy payments





## Conclusions

- New approach for sound policy advice which takes stakeholders perspective into account.
- New tool to “test” support schemes and market designs.
- Whether MP only produces wind-fall-profits depends on the question if actors will invest extra earnings on equipment for remote control and more demand oriented feed-in → so far they are not forced to do so!
- MP has definitely created a market for direct marketing, but height of support is questionable.

## Outlook

- Future work will deal with more dynamic sampling of the model.
- Implementation and analysis of different market-designs for time periods when high shares of RES are integrated into the energy system.



# Thank you very much for your attention...

## ...Questions?

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# Backup



# Actor Analysis II - Power Plant Operators

## 1. Differentiation by av. feed-in-remuneration, size of plant, technology and resource used:

Classes Year	Classes				Sum 1-3	Feed-in-remuneration [€/MWh]			
	1 [MW]	2 [MW]	3 [MW]	4 [MW]		1 [€/MWh]	2 [€/MWh]	3 [€/MWh]	4 [€/MWh]
2012	1978	12025	15894	242	29897	61,9	84,8	90,9	190,0
...	...	...	...	...	...	...	...	...	...
2020	14053	11244	9409	40000	34706	59,3	84,2	91,1	173,9

Class 1: 'basic remuneration' level, class 2 and 3 'increased starting remuneration' level and class 4 off-shore wind turbines

Classes Year	Classes				Sum 1-4	Feed-in-remuneration [€/MWh]			
	1 [MW]	2 [MW]	3 [MW]	4 [MW]		1 [€/MWh]	2 [€/MWh]	3 [€/MWh]	4 [€/MWh]
2012	14266	8923	348	3444	26981	305,4	333,8	253,7	253,0
...	...	...	...	...	...	...	...	...	...
2020	27372	17835	872	7113	53192	196,9	217,1	158,4	163,8

Class 1: rooftops < 30 kW, class 2: rooftop 30-1000 kW, class 3: rooftop > 1000 kW and class 4: PV on conversion and free space

Classes Year	Classes				Sum 1-4	Feed-in-remuneration [€/MWh]			
	1 [MW]	2 [MW]	3 [MW]	4 [MW]		1 [€/MWh]	2 [€/MWh]	3 [€/MWh]	4 [€/MWh]
2012	2172	91	2522	25	4810	97,0	164,1	175,6	142,3
...	...	...	...	...	...	...	...	...	...
2020	2880	2334	3048	338	8599	97,5	168,2	178,8	129,9

Class 1: co-generation 5-20 MW fed with old wood and forest residues; class 2: innovative technologies (e.g. wood gasification); class 3: biogas 50-1000 kW fed with liquid manure and renewable crop materials; class 4: biogas > 5 MW fed with bio-waste

## 2. Further differentiation for dynamic simulation runs (with competition):

- Owner structure: private persons, farmers, funds, project developers, municipal utilities and big utilities.
- Characterized by: expectations of return on investment, readiness to assume risk, 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> mover.



# Model Parametrisation

Jan 2012	Prototype	Wind (onshore)	Wind (offshore)	PV	Biomass	
					solid	biogas
(1)	Big national utility	5 %	35 %	-	20 %	30 %
(2)	International utility	40 %	-	-	35 %	-
(3)	Big municipal utility	1 %	-	0 %	5 %	5 %
(4)	Municipal utility "Pionier"	10 %	-	0 %	0 %	5 %
(5)	Small municipal utility	1 %	55 %	-	-	-
(6)	Green electricity trader for households	1 %	-	0 %	0 %	-
(7)	Green electricity trader for business/industry	2 %	-	0 %	15 %	50 %
(8)	Green electricity trader for local marketing	-	-	-	-	-
(9)	Functional intermediary as start-up	10 %	10 %	0 %	0 %	-
(10)	Functional intermediary as spin-off from a big utility	30 %	-	100 %	25 %	10 %
	Total initial capacity in direct marketing	12.050 (MW)	48 (MW)	58 (MW)	933 (MW)	
	Total share of installed capacity in direct marketing	40 %	24 %	1 %	19 %	

Following increase of direct marketed capacity until 2015 is assumed:

- |                                |  |                                       |   |
|--------------------------------|--|---------------------------------------|---|
| 1. wind onshore (classes 1-3): | from 40 % to 90 %                        | } overall increase from<br>1 % to 40% |   |
| 2. wind offshore:              | from 24 % to 100 %                       |                                       |   |
| 3. PV class 1:                 | will not opt for direct marketing at all |                                       |   |
| 4. PV class 2:                 | up to 80 %                               |                                       |   |
| 5. PV class 3 and 4:           | up to 90 %                               |                                       |   |
| 6. biomass class 1:            | up to 90 %                               |                                       | } overall increase from<br>19 % to 75 % |
| 7. biomass class 2:            | will not opt for direct marketing at all |                                       |   |
| 8. biogas classes 3-4:         | up to 76 %                               |                                       |   |

