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AMIRIS - Agent based model for the integration of renewables into the electricity markets
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Challenge and Motivation

In the future, the amount of intermittent renewable energies in the energy system will increase. This will also induce a challenge in coordinating the demand with the supply. In order to fullfill the basis of the triangle of energy policy (Economy, Security of Supply and Ecology) different aspects of the system have to be reorganised and restructured. Among others, a new system has to consider the following facts:

1. Numerous actors
2. Complex interactions among actors
3. Highly diverse behaviour of actors with regard to changes of political and economical framework
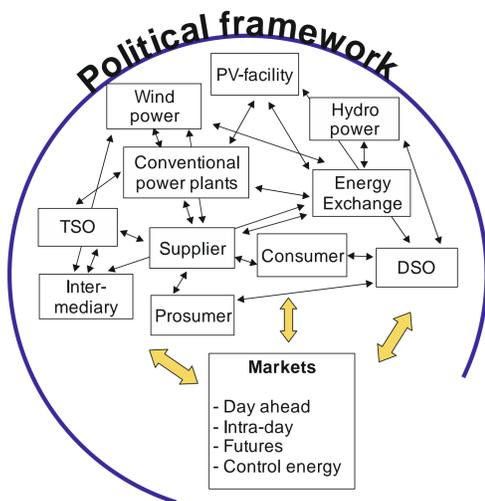
Fig. 1 Example for interactions among actors.

Agent based modelling (ABM)

ABM is based on autonomous agents that „live" in a changing environment. These agents generally show the following characteristics:

- Own „view of the world" as internal representation of the surrounding environment (uncertainty)
- Autonomous behaviour and individual objectives
- Development and adjustment of strategies to achieve objectives (learning)
- Ability to plan
- Communication and cooperation

Setup of AMIRIS

AMIRIS allows the evaluation of political instruments and promotion mechanisms regarding their impact on actors' behaviours and development of the energy system. Actually the focus is set to

- Energy economic changes due to the revised EGG 2012
- New possibilities of direct marketing of renewable electricity by § 33g (Market premium - MP), § 39 (Green electricity privilege) and local and regional direct marketing

Agents representing political framework, plant operators, intermediaries (tab. 1), energy exchange market and distribution service operator are implemented in the model. Characteristics of the agents are based on beforehand performed analysis of actors.

AMIRIS simulation process

The AMIRIS model simulates actors' behaviours on a hourly basis, i.e. each year 8760 simulation turns are processed. Each of these turns is subdivided into several steps. Within every step well defined actions of the agents take place. The various agents will react to events affecting them and adjust their behaviour and next moves correspondingly.
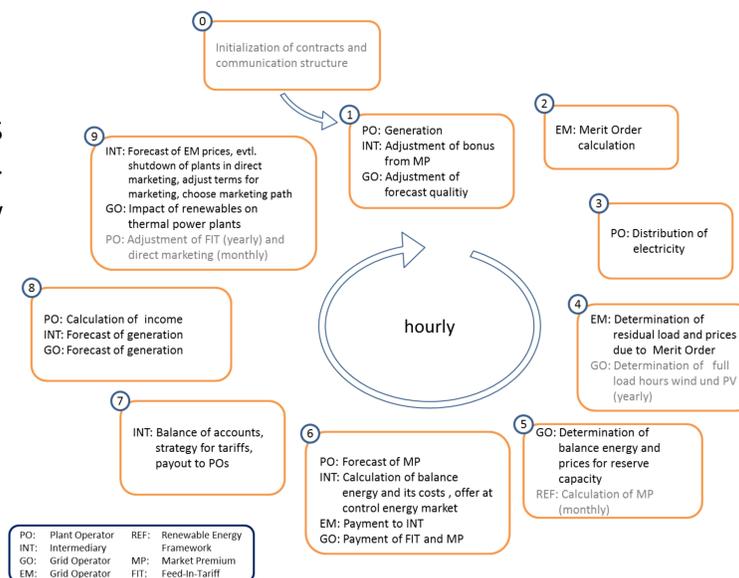
Fig. 2 AMIRIS simulation process.

INT	Intermediary
1	Big utility
2	International utility
3	Big municipal utility
4	Pioneer municipal utility
5	Small municipal utility
6	Green electricity retailer for consumers
7	Green electricity retailer for business customers
8	Green electricity retailer for direct marketing
9	Start-up with experience
10	Start-up without experience

Tab. 1 Intermediaries in the AMIRIS model.

Results and outlook

Below an extract of the most important results so far:

- Intermediaries with experience in energy trading and a greater contingent of onshore wind benefit from MP (fig. 3)
- Wind plant operator profit from bonus of intermediaries (fig. 4)
- Return for PV operators quite small (additional receipts <1,2%)
- Controllable renewable energies profit least from market premium
- System services at control energy markets can induce additional profits

The planned representation of flexibility options, e.g. storage, will supplement the simulation model.
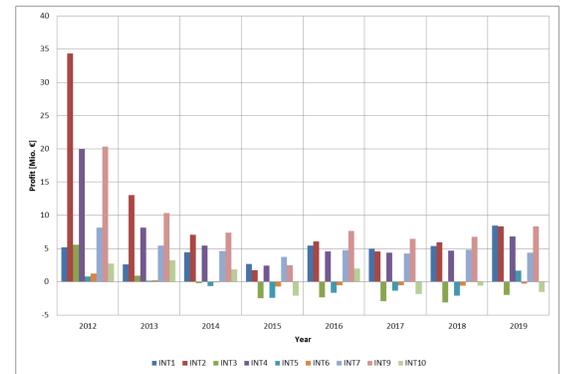
Fig. 3 Development of profits of intermediaries for the years 2012 to 2019.

WPO1	WPO2	WPO3	WPO4
3,4%	2,9%	3,0%	1,1%

WPO1: Basic remuneration
WPO2: Starting remuneration (low average)
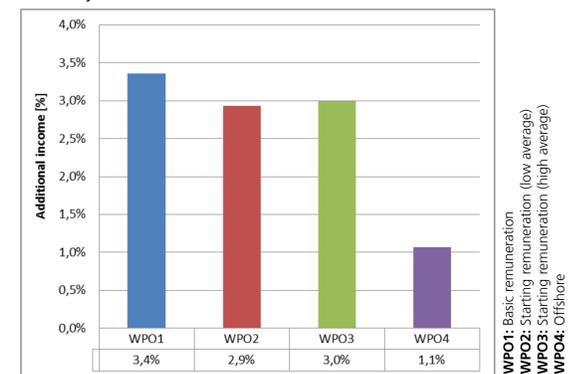WPO3: Starting remuneration (high average)
WPO4: Offshore

Fig. 4 Additional income of wind power plant operators from MP compared to EEG feed in tariff.

Publications
- Reeg, Matthias and Nienhaus, Kristina and Roloff, Nils and Pfenning, Uwe and Deissenroth, Marc and Wassermann, Sandra and Hauser, Wolfgang and Weimer-Jehle, Wolfgang and Kast, Thomas and Klann, Uwe (2013), "Weiterentwicklung eines agentenbasierten Simulationsmodells (AMIRIS) zur Untersuchung des Akteursverhaltens bei der Marktintegration von Strom aus erneuerbaren Energien unter verschiedenen Fördermechanismen." Project Report.
- Reeg, M. et al. (2012): AMIRIS – An Agent-based Simulation Model for the Analysis of Market Integration of Renewable Energy under various Policy Frameworks, in: Conference Proceedings of 12th IAEE European Conference. 12th IAEE European Conference - Energy challenge and environmental sustainability, 09.-12.09.2012, Venice, Italy.
- Reeg, M. et al. (2012): AMIRIS – An Agent-based Simulation Model for the Analysis of different Support Schemes and their Effects on Actors involved in the Integration of Renewable Energy into Energy Markets, in: Conference Proceedings of 1st IATEM Workshop of DEXA Conference 2012, 3-7.09.2012, Vienna, Austria: 339-344.
- Krewitt et al. (2011): Analyse von Rahmenbedingungen für die Integration erneuerbarer Energien in die Strommärkte auf der Basis agentenbasierter Simulation. Berlin, 2011.

Presentations
- "AMIRIS - An Agent-Based Simulation Model for the Analysis of Different support schemes and their effects on Actors involved in the integration of renewable energies into energy markets", IATEM 2012 am 3.-7. September in Wien.
- Reeg, M. et al. (2012): AMIRIS – An Agent-based Simulation Model for the Analysis of Market Integration of Renewable Energy under various Policy Frameworks, in: Conference Proceedings of 12th IAEE European Conference. 12th IAEE European Conference - Energy challenge and environmental sustainability, 09.-12.09.2012, Venice, Italy.