TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

Faculty of Business and Economics, Chair of Energy Economics, Prof. Dr. Dominik Möst

9th Conference on Energy Economics and Technology

A European Energy Market?

11th April 2014, TU Dresden

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ENERDAY

9th Conference on Energy Economics and Technology

A European Energy Market?

Book of Abstracts

11th April 2014

Technische Universität Dresden, "Festsaal" of the Faculty of Business and Economics
Schumann-Bau / Hülsse-Bau, Münchner Platz 3, 01069 Dresden

Contact / Registration:
Mandy Bauer, TU Dresden, EE², enerday@ee2.biz, tel.: +49-(0)351-463-39771, www.ee2.biz

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Foreword

Dear participants of the 9th Enerday, the Conference on Energy Economics and Technology,

on behalf of the Chair of Energy Economics (EE2) at the Technische Universität Dresden and the Workgroup for Economic and Infrastructure Policy (WIP) at Berlin Institute of Technology (TU Berlin), it is our pleasure to welcome you most cordially to the ENERDAY, the 9th Conference on Energy Economics and Technology focusing this year on the European perspective.

There are often many national energy strategies and policies within the Member States of the European Union. A manifold of examples could be found such as different promotion mechanisms of renewable energies, different strategies concerning technologies (nuclear, fracking, natural gas, etc.), capacity mechanisms, etc. What about the European vision of an internal energy market? Are we moving forward towards this vision and what are the main challenges in the next years? Could a common European strategy be more powerful in relation to our trade partners?

The objective of this year's ENERDAY is to address challenges for energy markets, policies and energy systems with regard to a European perspective. Once again, we have an interesting program dealing with various challenges and aspects in the European energy markets. Thus, the ENERDAY shall provide a platform for intensifying the dialogue between economic and technical issues as well as between practice and theory.

Scientific cooperation partners are DIW Berlin, the German Institute for Economic Research, and GEE, the German Chapter of the International Association of Energy Economics (IAEE). It is a pleasant duty to express our sincere gratitude to the two supporters of this conference: Tennet GmbH, one of the four German transmission grid operators, and the DREWAG, utility of Dresden.

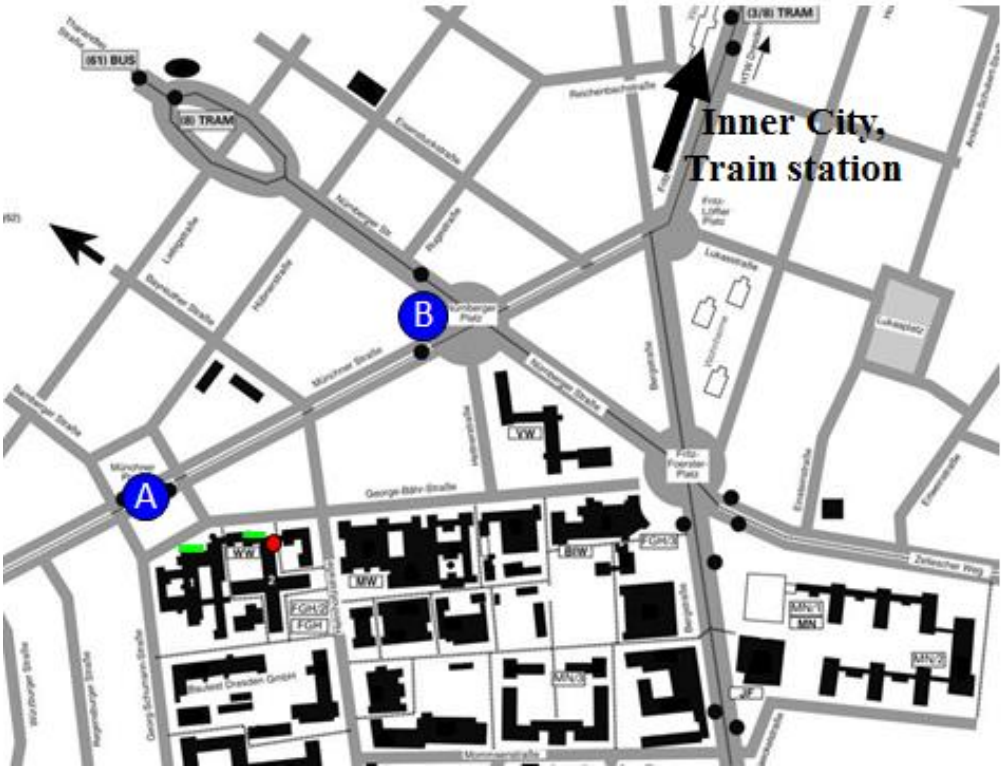
As the organizers of the conference, we were particularly delighted with the very good attendance in this year, which is reflected in the internationality of the participants and the amount of submitted contributions. As we received twice as much submissions in comparison to the available presentations slots, we were forced to a stringent selection of submissions. We are pleased to be able to contribute to a fruitful exchange of scientific approaches and their practical application in energy economics. We would like to thank all the speakers for their contributions and the participants of the workshop.

We wish you a successful conference and an enjoyable stay in Dresden and its surroundings,

Dominik Möst, Christian von Hirschhausen, Mandy Bauer
& EE2 organizing committee

Conference Location

Technische Universität Dresden
"Festsaal" of the Faculty of Business and Economics
Schumann-Bau / Hülsse-Bau
Münchner Platz 3
01069 Dresden, Germany



- **ENERDAY** registration
- Building entrances
- A Tram station: Münchner Platz Line 3
- B Tram/Bus station: Nürnberger Platz Line 8 and Line 62

By car:

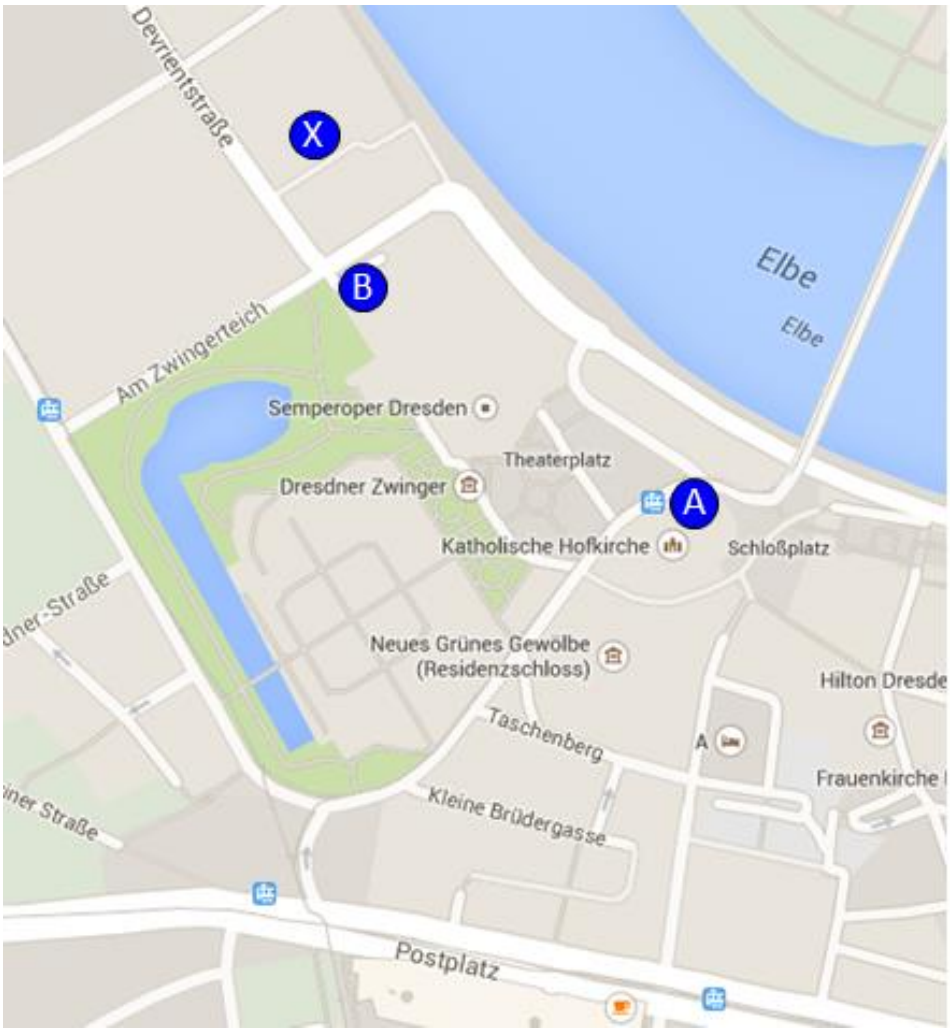
From the **West** (Leipzig, Chemnitz): At the motorway interchange 77b-Dreieck Dresden-West follow the signs A17 to "Prag". Leave the A17 at exit 3-Dresden Südvorstadt. Then drive on the B170 in direction Dresden and follow the signs to „Plauen". Drive on the "Nöthnitzer Straße", turn right into the "Georg-Schumann-Straße" and drive up to "Münchner Platz".
From the **East** (Bautzen, Berlin) leave the A4 at exit 81a-Dresden Hellerau and drive on the B170 in direction Dresden-Zentrum. After the main train station keep straight, following the tram (No.3). Turn right into the "Münchner Straße" and drive up to "Münchner Platz".
Try to find a parking lot around the "Münchner Platz" or within the university area.

By tram / bus:

From the **airport** take the S-Bahn line S2 on the lower ground floor of the terminal building and drive up to the main train station ("Hauptbahnhof"). Then take the tram No. 3 (direction: Coschütz) and get off at "Münchner Platz".
From the **North** or the **Inner City** take the tram No. 3 (direction: Coschütz) and get off at "Münchner Platz" or take the tram No. 8 (direction: Südvorstadt) up to "Nürnberger Platz".
From the **West** take the bus No. 62 (direction: Weißig / Fernsehturm) up to "Nürnberger Platz".
From the **East** take the bus No. 62 (direction: Löbtau) up to "Nürnberger Platz".

Conference Dinner

Chiaveri im Sächsischen Landtag
Bernhard-von-Lindenau-Platz 1
01067 Dresden, Dresden
www.chiaveri.de



Friday,
11 April 2014
7 pm

A Tram station: Theaterplatz, Line 8

B Basement garage Semperoper

X **Location Conference Dinner**

By car (about 15 minutes):

Drive along the "Münchner Straße" in direction Dresden-Zentrum. Keep left and follow the B170. At "Pillnitzer Straße" (before the bridge) turn right, then immediately turn left into "Steinstraße" and then turn left into "Terassenufer". Follow the street about 900 meters and try to find a parking lot or basement garage around Theaterplatz.

By tram / bus (about 25 minutes):

Tram Line 8 will take you directly from the University to the Conference Dinner (tram leaves every 10 minutes). The tram leaves at the corner of „Münchner Straße"/„Nürnberger Straße" (see map conference location). Take ram No. 8 (direction: Hellerau) and get off after seven stops at „Theaterplatz". Walk in the direction of the Semperopera along Terassenufer about 300 meters.

Conference program on Friday, 11th April 2014

Informal Get Together: Thursday, 10th April, 7pm in Paul Rackwitz, Plauenscher Ring 33, 01187 Dresden

8:15 h	Registration, Coffee & Tea (Room: Faculty Assembly Hall)		
8:45 h	**Opening Address (Room: Faculty Assembly Hall)** Prof. Dr. rer. pol. Susanne Strahringer, Vice-Rector for Academic and International Affairs, TU Dresden Prof. Dr. Udo Buscher, Dean of the Faculty of Business and Economics, TU Dresden Prof. Dr. Dominik Möst, TU Dresden, EE^2 Prof. Dr. Christian von Hirschhausen, TU Berlin WIP and DIW Berlin		
9:15 h	**Keynote Speech (Room: Faculty Assembly Hall)** Dr.-Ing. Ulf Kasper, Expert Control Reserve, TransnetBW GmbH: "Future development of the European market for system reserve" Chair: Prof. Dr. Christian von Hirschhausen, TU Berlin WIP and DIW Berlin		
10:00 h	Coffee & Tea		
10:30 h - 12:30 h	**Transmission Grids and Congestion Management** **(Room: Faculty Assembly Hall)** Chair: Theresa Müller	**Power Systems Modelling** **(Room: A 03)** Chair: Stefan Perras	**Energy Efficiency and Demand Side Measures** **(Room: B 37)** Chair: Christoph Brunner
10:30 h	**A long-term View on the German Transmission Grid Extension – What is the Impact of Renewable Integration?** David Gunkel (TU Dresden)	**Carpe diem: a novel approach to select representative days for power system models in order to better assess the costs of variable renewables** Paul Nahmmacher (Potsdam Institute for Climate Impact Research), Eva Schmid, Lion Hirth, Brigitte Knopf	**Analysing the impact of Eco-Design requirements on heating systems – A European case study** Rainer Elsland (Fraunhofer ISI), Harald Bradke, Martin Wietschel
10:50 h	**Available Transfer Capacity versus Flow Based: towards efficient market coupling** Lynn Gyselen (KU Leuven), Cedric De Jonghe, Ronnie Belmans	**The probability of long phases without wind power and their impact on an energy system with high share of renewable energies** Patrick Plötz, Julia Michaelis (Fraunhofer ISI)	**Increasing Efficient Appliance Purchases through Lifetime Monetary Consumption Information** James Caroll (Trinity College Dublin), Eleanor Denny, Seán Lyons
11:10 h	**Implication of non-harmonized regulatory regimes on cross-border electricity transmission investment** Diyun Huang (KU Leuven), Samson Hadush; Dirk Van Hertem; Ronnie Belmans	**Optimal Infrastructure investments for Renewable Energy Integration in Germany** Jonas Egerer (TU Berlin, Workgroup for Infrastructure Policy (WIP)), Wolf-Peter Schill	**Potential energy efficiency improvements in Swedish energy intensive industries using an Energy Efficiency Obligation Scheme** Maria Xylia (KTH Royal Institute of Technology), Semida Silveira
11:30 h	**Is there still a Case for Merchant Interconnectors? Insights from an Analysis of Welfare and Distributional Aspects of Options for Network Expansion in the Baltic Sea Region** Alexander Weber (Workgroup for Infrastructure Policy (WIP)), Clemens Gerbaulet	**Network Expansion and Welfare Effects in two-stage Cournot Model** Olga Spiridonova (Humboldt-Universität zu Berlin)	**Can heat pumps help to integrate fluctuating renewable generation?** Gerda Schubert (Fraunhofer ISI), Frank Sensfuß
11:50 h	**Network Expansion to Mitigate Market Power: How Increased Integration Fosters Welfare** Alexander Zerrahn (German Institute for Economic Research (DIW Berlin), Daniel Huppmann	**Storage placing in Germany in mid term context- Which site will be best?** Thomas Möbius, David Gunkel (TU Dresden)	**Report in an "Energiewende" Pilot Test – First Impressions, Proposals and Results** Holger Wiechmann (EnBW Vertrieb GmbH), Kai Hufendiek
12:30 h	Lunch (Room: in front of the Faculty Assembly Hall)		

13:30 h	**Keynote Speech (Room: Faculty Assembly Hall)** Prof. Dr. Yves Smeers, Universite Catholique de Louvain: **"**EU climate and energy policy and computational economic modeling" Chair: Prof. Dr. Dominik Möst, TU Dresden, EE^2		
14:15 h - 15:45 h	**European Policies and Strategies (Room: Faculty Assembly Hall)** Chair: Michael Zipf	**Capacity Mechanisms (Room: A 03)** Chair: Susanne Koschker	**Gas Market (Room: B 37)** Chair: Philipp Hauser
14:15 h	**Beyond 2020: Strategies and costs for transforming the European energy system** Brigitte Knopf (Potsdam Institute for Climate Impact Research, Y.-H. Henry Chen, E. De Cian, H. Förster, A. Kanudia, I. Karkatsouli, I. Keppo , T. Koljonen, K. Schumacher, D. P. van Vuuren	**Optimal level of remuneration for capacity to ensure generation adequacy** Hanspeter Höschle (KU Leuven), Cedric De Jonghe, Ronnie Belmans	**Assessing cross-border impacts of gas infrastructure investment expenditure across Europe with MRIO** Maaike C. Bouwmeester, Bert Scholtens (University of Groningen)
14:35 h	**EU climate and energy policy beyond 2020: How many targets and instruments are necessary?** Paul Lehmann (Helmholtz Centre for Environmental Research (UFZ)), Jos Sijm, Erik Gawel, Unnada Chewpreecha, Hector Pollitt, Sebastian Strunz	**Model-based analysis of design options for the German electricity market to ensure security of supply for increasing electricity generation from renewable energies** Dogan Keles (Karlsruhe Institute of Technology), Lea Renz, Massimo Genoese, Wolf Fichtner	**Pipeline Power: A Case Study of Strategic Network Investments** Onur Cobanli (Humboldt–Universität zu Berlin), Franz Hubert
14:55 h	**German Energiewende vs. European energy transition? On the alleged need to „Europeanize" the Energiewende** Sebastian Strunz (Helmholtz-Zentrum für Umweltforschung (UFZ)), Erik Gawel, Paul Lehmann	**A need for capacity markets** Wojciech Łyżwa (Lodz University of Technology)	**Investments in a Combined Energy Network Model: Substitution between Natural Gas And Electricity?** Hannes Weigt (Universität Basel), Jan Abrell
15:15 h	**Cost-minimal investments into conventional generation capacities under a Europe-wide renewables policy** Clemens Gerbaulet (TU Berlin and DIW Berlin), Casimir Lorenz, Friedrich Kunz, Christian von Hirschhausen, Benjamin Reinhard	**The forward premium in electricity markets: an experimental study** Silvester van Koten (University of Economics, Prague), Andreas Ortmann	**Valuing arbitrage opportunities for LNG suppliers across the Atlantic** Bert Scholtens (University of Groningen), Casper Kranenborg
15:45 h	Coffee & Tea		
16:30 h - 18:00 h	**National Policies and Developments (Room: Faculty Assembly Hall)** Chair: Hannes Hobbie	**Electricity Markets (Room: A 03)** Chair: Alexander von Selasinsky	**Industry and Energy Prices (Room: B 37)** Chair: Julia Michaelis
16:30 h	**The crucial role of infrastructure design in the German Energiewende: An analysis of possible branching points** Eva Schmid (Potsdam Institute for Climate Impact Research), Brigitte Knopf, Anna Pechan	**Analysis of Market Participants' Trading Behaviour on the Nordic Intraday Market** Richard Scharff (KTH Royal Institute of Technology), Mikael Amelin	**The Merit Order of Demand Response in Industry** Anna Gruber (Research Association for Energy Markets and Technologies, Munich), Serafin von Roon, Franziska Biedermann
16:50 h	**Facilitating variable generation of renewables by conventional power plant cycling: costs and benefits** Kenneth Van den Bergh, Erik Delarue (Energy Institute, KU Leuven)	**Optimization of Energy storage operation at competitive market** Błażej Olek (Lodz University of Technology)	**Development of transmission and distribution grid charges and of their regional differences in Germany** Fabian Hinz (TU Dresden)
17:10 h	**Optimal Incentives for Belgian Electricity Challenges** Ruben Laleman (Ghent University), Johan Albrecht	**Why wind is not coal: on the economics of electricity** Lion Hirth (Vattenfall GmbH), Falko Ueckerdt, Ottmar Edenhofer	**Social Effects in the Diffusion of Solar Photovoltaic Technology in the UK** Laura-Lucia Richter (University of Cambridge)
17:30 h	**Meeting EU energy and climate policy in Poland. Optimization of the energy mix** Michal Wierzbowski (Lodz University of Technology)	**The new Spanish electricity market design** Julian Barquin (Endesa, Regulatory Affairs)	**Assessment of industrial energy prices** Katharina Grave (Ecofys), Martin Pudlik
19:00 h	Conference Dinner (Chiaveri im Sächsischen Landtag, Bernhard-von-Lindenau-Platz 1 12, 01067 Dresden)		

Content

Session 10.30 – 12.30
Transmission Grids and Congestion Management

Room: Faculty Assembly Hall
Chair: Theresa Müller (TU Dresden)

A long-term View on the German Transmission Grid Extension – What is the Impact of Renewable Integration?
David Gunkel (TU Dresden)

Available Transfer Capacity versus Flow Based: towards efficient market coupling
Lynn Gyselen, Cedric De Jonghe, Ronnie Belmans (KU Leuven)

Implication of non-harmonized regulatory regimes on cross-border electricity transmission investment
Diyun Huang, Samson Hadush, Dirk Van Hertem, Ronnie Belmans (KU Leuven)

Is there still a Case for Merchant Interconnectors? Insights from an Analysis of Welfare and Distributional Aspects of Options for Network Expansion in the Baltic Sea Region
Clemens Gerbaulet, Alexander Weber (TU Berlin, Workgroup for Infrastructure Policy (WIP))

Network Expansion to Mitigate Market Power: How Increased Integration Fosters Welfare
Alexander Zerrahn, Daniel Huppmann (German Institute for Economic Research (DIW Berlin))

A long-term View on the German Transmission Grid Extension – What is the Impact of Renewable Integration?

David Gunkel (TU Dresden)

The German power sector will face a drastic change from conventional power generation to an energy system with a high share of intermittent renewable energy forms. The following analysis addresses the future transmission grid design for Germany in 2030 in a context of different renewable integration schemes. Therefore a DC load flow model is set-up, which deals with the trade-off between grid extension and regional renewable integration. Two scenarios concerning different renewable feed-in design options are considered: curtailment of renewables only at negative prices in the height of their individual levelized costs of electricity, and curtailment at marginal costs (tending to zero). To cope with the large-scale network capacity expansion problem, the Benders Decomposition and DC-load flow approximation is applied. The results show that the different renewable integration schemes have different effects on the AC grid extensions in contrast to High-Voltage-Direct-Current (HVDC) connections.

Available Transfer Capacity versus Flow Based: towards efficient market coupling

Lynn Gyselen, Cedric De Jonghe, Ronnie Belmans (KU Leuven)

The current European power exchange markets are undergoing major evolutions. On the one hand the market coupling evaluates from a trilateral coupling between Belgium, France and the Netherlands to a multi-lateral coupling. On the other hand the methodology used to couple markets changes from Available Transfer Capacity to Flow Based market coupling. This new market coupling methodology is said to improve economic efficiency and to contribute to the integration of different, originally nationally organized, electricity markets.

The purpose of this paper is to provide an overview of the current market evolutions in Europe: on the one hand the market coupling evolves from a trilateral coupling to a multi-lateral coupling, whereas on the other hand the methodology used to couple markets changes from Available Transfer Capacity to Flow Based market coupling. Since these evolutions have a significant impact on the trading behavior market operation, electricity prices, traded volumes and welfare, an overview of the evolutions is presented in this paper.
The first part of this paper is a literature study providing background. Important concepts in international trading are introduced and explained briefly, their advantages and disadvantages are discussed. The history of trading in Europe focuses on the conversion from trilateral to multi-lateral coupling. The paper concentrates on the evolution from Available Transfer Capacity to Flow Based market coupling. To provide a good understanding of the two methodologies, respectively the Available Transfer Capacity and Flow Based definitions are introduced. The difference between the Available Transfer Capacity methodology and the Flow Based methodology is explained by means of an example. Finally, in section 4, future steps are identified which could be proposed by European policy makers to continue the process towards efficient market coupling and market integrations.

It can be concluded that Europe is moving fast to a widely coupled market with more efficient methodologies. The Flow Based methodology is expected to improve market efficiency, energy policy makers should look further .This paper is able to identify alternative trajectories towards further market integration.

Keywords: Capacity Remuneration Mechanisms, Electricity Market, Generation Adequacy, Mixed Complementarity Problem

Implication of non-harmonized regulatory regimes on cross-border electricity transmission investment

Diyun Huang, Samson Hadush, Dirk Van Hertem, Ronnie Belmans (KU Leuven)

In general, there are two types of investment approach for interconnectors: the regulated and merchant investment. Regulated investment is usually conducted by TSOs and included in the regulated asset base to generate a stable rate of return, which is reimbursed by consumers. Merchant investment, which is run on a commercial base by independent developer or subsidiary project company of TSO, is designed to incentivize investment and competition. Intuitively, the question arises as how the linkage between these two regulatory regimes is set up with the existence of a connecting hub and what effect it will have on the network design.

In this paper, the strategic network planning of a country located in the interface between countries implementing merchant and regulated regime is investigated. A base case of the network planning is built based on a system implementing regulated regime with implicit assumption of a supranational planner in the region. In the case where merchant and regulated regimes co-exist, three types of planners with distinctive objectives could be observed. The first category is the planner from regulated regime who maximizes social welfare. The second one is the purely merchant, whose objective is to maximize congestion profit. The third type of planner, located in the interface of the two regimes, considers its welfare gain as the sum of social welfare change from the regulated investment and congestion profit from merchant investment. Its advantageous geographical position gives the planner bargaining power to exert influence of the capacity of lines connecting to this country.

The interaction of these three types of planners determines final outcome of interconnector network expansion in the whole region. More specifically, for each possible combination of expansion capacity from merchant and regulated lines, the sharing factor for investment cost and congestion rent of merchant line is iterated, in order to search the value which maximizes total welfare gain for the interface country, while respecting the boundary condition of non-negative welfare changes in the countries implementing only regulated or merchant regimes. The equilibrium option is obtained from possible combinations of merchant and regulated line capacity levels as a result of non-cooperative planning of the interface country. In the end, the equilibrium network expansion plan is used to compare with network planning outcome from the base case of fully regulated regional regime.

The expected implication is different investment level from the base case. In terms of global welfare offered by network expansion, in the existence of regulated and merchant regimes and in particular, strategic non-corporative planning behavior of the interface country, it could be weakened compared with fully regulated based case.

Keywords: merchant investment, regulated investment, transmission network expansion, strategic planning, investment cost sharing

Is there still a Case for Merchant Interconnectors? Insights from an Analysis of Welfare and Distributional Aspects of Options for Network Expansion in the Baltic Sea Region

Clemens Gerbaulet, Alexander Weber (TU Berlin, Workgroup for Infrastructure Policy (WIP))

Merchant vs. regulated transmission investment has been subject to intense research in the past, however, aspects of rent-distribution and high-dimensional investment decisions into grids have only been given little attention, and proponents of merchant transmission investment are still numerous.
We consider a two-level framework in which a profit-maximizing leader may invest into HVDC interconnectors. In the lower level, a fully-coordinated regulator minimizes system cost by conducting unit commitment and AC network expansion. The model takes into account the full EHV network of the region considered (using a DCLF approach), but at the same time follows the "European" principle of bidding-zone dispatch.

We apply the model to the Baltic Sea neighboring states. Network expansion uses a linear relaxation, yielding considerably better results than a transport model. Renewables, load, transmission network and conventional generation follow ENTSO-E's expected scenario for 2020. The model is solved by evaluating the lower-level linear program for a set of discrete DC-investment options. To classify the results, we compare them in terms of both welfare and distributive aspects to the result of a cost-minimizing planner investing into (i) both AC and DC lines, and (ii) AC lines only. For the sake of robustness, we take into account two different pricing schemes for electricity: (a) long-run marginal costs, including the cost of regulated network expansion and (b) short-run marginal costs, where the price is set by the most expensive plant dispatched.

Our results indicate that merchant investment leads to welfare gains which are only slightly lower than what can be achieved by a perfectly planned AC and DC network, however, most of the welfare gain is reaped by the merchant investor. Even more, analyzing all modeled potential choices of DC line investment shows that profit maximization does not only lead to overall reduced investment, but also to an investment which exhibits a lower welfare contribution than would have been possible with the same monetary investment, but another network configuration. All findings hold for both pricing schemes. As a result, distributional effects should be given careful attention besides the mere gains in welfare.

Keywords: DCLF network expansion, merchant lines, exemptions, MPEC, distributional vs welfare effects

Network Expansion to Mitigate Market Power: How Increased Integration Fosters Welfare

Alexander Zerrahn, Daniel Huppmann (German Institute for Economic Research (DIW Berlin))

Market Power and Network Expansion in Europe

Since the mid-nineties, the European Union has been aiming at establishing an internal electricity market to increase efficiency, welfare, and competition. Lack of sufficient interconnector capacities, however, prevents reaping the full benefits competition as markets are still not integrated (compare ACER/CEER, 2013) for an exposition of price spreads). In ten Member States, the largest generating company has a market share above 70% (data for 2010, European Commission, 2012). In our paper, we investigate to which extent costly expansion of the transmission grid can increase welfare by reducing the potential to exert market power.

Previous analyses of strategic behavior in constraining networks comprise Borenstein et al. (2000), who detect that even a thin line may be enough to foster competition although it may actually not be utilized. In the OR literature, Neuhoff et al. (2005) provide an overview of two-stage games: those, however, either do not feature firms' strategic behavior towards the transmission grid, or they rely on algorithmic solution techniques not allowing for an endogenous treatment of grid expansion.

Model and Results

We propose a three-stage model endogenizing the trade-off between costly network expansion and welfare benefits due to reduced market power, where on each stage the agents anticipate the impact of their decisions on subsequent players. On the third stage, an Independent System Operator (ISO) dispatches supply and elastic demand while assuring feasible network flows and assigning nodal prices, taking all upper level decisions as given. On the second stage, strategic firms interact in Cournot competition, anticipating their impact on network operation. By applying a reformulation with help of results from duality theory (Ruiz et al., 2012), we can explicitly derive the optimality conditions of this Equilibrium problem under Equilibrium Constraints (EPEC). As the set of KKT points is nonconvex, the first stage serves as selection device picking that solution which is optimal in terms of overall welfare. Incentive compatibility is ensured by ex-post checks.

Results for a three-node network indicate that grid expansion can indeed enhance overall welfare, and a higher level of network expansion shifts rents from producers to consumers.

Keywords: Market Power, Transmission Grid, Multistage Games, EPEC, European Integration

Session 10.30 – 12.30
Power Systems Modelling

Room: A 03
Chair: Stefan Perras (Siemens AG)

Carpe diem: a novel approach to select representative days for power system models in order to better assess the costs of variable renewables
Paul Nahmmacher, Eva Schmid (Potsdam Institute for Climate Impact Research), Lion Hirth (Potsdam Institute for Climate Impact Research and Vattenfall GmbH), Brigitte Knopf (Potsdam Institute for Climate Impact Research)

The probability of long phases without wind power and their impact on an energy system with high share of renewable energies
Patrick Plötz, Julia Michaelis (Fraunhofer Institute for Systems and Innovation Research ISI)

Optimal Infrastructure investments for Renewable Energy Integration in Germany
Jonas Egerer, Wolf-Peter Schill (German Institute for Economic Research (DIW Berlin) and TU Berlin, Workgroup for Infrastructure Policy (WIP))

Network Expansion and Welfare Effects in two-stage Cournot Model
Olga Spiridonova (Humboldt-Universität zu Berlin)

Storage placing in Germany in mid term context- Which site will be best?
Thomas Möbius, David Gunkel (TU Dresden)

Carpe diem: a novel approach to select representative days for power system models in order to better assess the costs of variable renewables

Paul Nahmmacher, Eva Schmid (Potsdam Institute for Climate Impact Research), Lion Hirth (Potsdam Institute for Climate Impact Research and Vattenfall GmbH), Brigitte Knopf (Potsdam Institute for Climate Impact Research)

Variable renewable energy sources (vRES) gain increasing significance in the European energy mix and are projected to become the dominant source of electricity. To appropriately reflect their variability in long-term power system models a high temporal resolution is desirable but seldom possible due to computational restrictions. Instead, most of these models rely on a limited amount of time-slices with representative load levels of demand and vRES electricity generation. However, the temporal and spatial variability of vRES is often poorly accounted for in existing time-slice approaches, which likely results in an underestimation of vRES integration costs. To fill this gap we present a novel time-slice approach that preserves pivotal features of the vRES feed-in patterns and apply this approach in the long-term European power system model LIMES-EU.

The newly developed approach uses a multi-dimensional hierarchical clustering algorithm based on historic national electricity demand data and a 30-year weather dataset. Amongst all candidate days it selects that set of days that best reflects (1) the average capacity factors of wind and solar power plants per region, (2) the load duration curves of the region-specific electricity demand and vRES feed-in patterns, and (3) the spatial correlation of vRES feed-in among regions. Ultimately, these conditions serve to correctly asses the needed storage and transboundary grid infrastructure as well as the optimal portfolio of the dispatchable power generation capacity required to integrate the increasing share of vRES into the European power system.

We show that by using this approach already a small number of time-slices is sufficient to cover the characteristic variability of the end-user electricity demand and the production from fluctuating RES. In this way the approach significantly decreases the need for computational resources while at the same time allowing for robust estimations of vRES integration costs in long-term power system models.

Keywords: Variable Renewable Energy Sources, Infrastructure Planning, Intertemporal Optimization, Mitigation

The probability of long phases without wind power and their impact on an energy system with high share of renewable energies

Patrick Plötz, Julia Michaelis (Fraunhofer Institute for Systems and Innovation Research ISI)

Long phases of no or little wind power are a potential thread to future energy systems with a high share of renewable energies. A frequently cited example observed in Germany was a whole week with very little wind power due to temperature inversion in January 2009. A frequent occurrence of these and similar situations would imply an increased need for energy storage or conventional power capacities in order to cover energy demand at any time in future energy systems.

Energy system research analyses the future effect of high renewable feed-in using mainly historical time series weather data. However, an understanding of the representativeness with respect to extreme weather events and long phases of low wind speeds or calms is still limited. Here, we study the frequency of occurrence of long calms in wind power feed-in and residual load as well as differences in their frequency of occurrence between different years. We analyse seven years of aggregated wind power feed-in in Germany on an hourly basis. We discuss the occurrence of extreme events in low wind and renewable power feed-in as observed historically for different threshold levels of low feed-in. In addition to this, we use extreme value statistics to obtain reliable estimates for extreme events such as hundred year calms.

We find the average duration of low wind power feed-in phase to grow linearly with the threshold: Phases with a wind power feed-in of less than three percent of installed power are typically three hours long and phases with less than eight percent feed-in are on average eight hours long. However, a period of wind power feed-in below eight percent of installed power that lasts one week occurs every two years and a period of more than ten days occurs every ten years.

Keywords: wind power, calm, extreme value statistics, energy storage

Optimal Infrastructure investments for Renewable Energy Integration in Germany

Jonas Egerer, Wolf-Peter Schill (German Institute for Economic Research (DIW Berlin) and TU Berlin, Workgroup for Infrastructure Policy (WIP))

We analyze optimal infrastructure investments for the integration of variable renewable generation in the German electricity system in 2024. The modeled German high voltage network reflects the state of the year 2012. The initial topology includes 326 network nodes and 743 transmission lines. In order to reduce numerical complexity, the topology has been aggregated such that only meshed elements are included. Using a combined dispatch, transmission and investment model, we compare four scenarios with different investment options on nodal network level, including gas-fired power plants at ten important network nodes, 13 different pumped hydro storage projects, AC transmission lines in the existing topology, and six possible HVDC lines. In a baseline scenario of the year 2024, geographically optimized investments into gas-fired power plants in southern Germany dominate compared to only punctual transmission investments. However, system costs are only slightly higher in scenarios with increased investments into networks and storage. In the scenario with costs for curtailment of renewable generation the model invests in additional AC and DC lines to provide transmission capacity for better wind integration. Considering additional system values of storage facilities that are not included in the optimization, we conclude that current plans for new pumped storage projects in Germany should be further developed.

Network Expansion and Welfare Effects in two-stage Cournot Model

Olga Spiridonova (Humboldt-Universität zu Berlin)

Integration of national electricity markets into a single European one should decrease the market power of local dominant players. However, existing transmission capacities may be insufficient to allow for vigorous competition.
This paper looks at the effects of grid expansion on competition in European electricity network given that system operators and some generating companies can act strategically. The goal is to find optimal, from the point of view of welfare maximization, level of transmission capacities of cross-border interconnectors using as an example data from Western European electricity market. Interactions in electricity market are modeled as a two-level model. First, a number of strategic generators choose their level of generation knowing that their choice can influence equilibrium prices and congestion. Next a welfare-maximizing system operator determines nodal prices given the bids of strategic generators and hence also determines the output of competitive fringe and network flows. Thus market interactions are programmed as a system of mathematical programs with equilibrium constraints (MPECs), i.e. as an equilibrium problem with equilibrium constraints (EPEC). Preliminary results on the data from Western European electricity market allow to determine the lines which will be congested in the equilibrium by strategic generators and indicate that network expansion results in welfare increase due to the reduction of market power.
The paper is work in progress.

Keywords: market power, Cournot competition, multistage games, transmission grid expansion, EPEC

Storage placing in Germany in mid term context- Which site will be best?

Thomas Möbius, David Gunkel (TU Dresden)

The electricity market in Germany is facing several significant structural changes. Renewable energy sources (RES), such as wind or solar power, highly depend on meteorological conditions. Hence, the availability of those generation capacities is uncertain and fluctuating. Furthermore, a physical separation of generation and demand of electricity can be observed. Investments in wind power predominantly take place in Northern Germany, while consumption hotspots remain in the south and west. An extension of energy storage capacity is a promising option to overcome upcoming challenges. This paper addresses the optimal locational planning problem of storage power plants within German electricity transmission system. Therefor the DC-load flow model ELMOD is applied. Using the nodal price approach gives incentives for an investment decision considering regional aspects and congestions within the transmission grid. The underlying network is based on the European high voltage grid by ENTSO-E (2011) with a focus on Germany covering a total of 661 DC lines and 457 substations. The model is formulated as a cost minimization problem. Based on the assumption that a Locational Marginal Price is applied in Germany, the calculations are performed for the year 2012 and 2020 considering the German nuclear phase-out and an increasing share of renewable energies. As a central result, the model calculations identify economically superior locations for storage plants. To achieve nontrivial outcomes, optimal locations for storage plants are identified by integrating a fixed extension target for storage plants. Furthermore, effects on total costs and nodal prices are analyzed and depicted within this contribution. The analysis show that especially congested transmission lines and a strong increase of wind power integration in Northern Germany, e.g. through the implementing of offshore capacities, have a significant impact on the optimal location planning. The model strongly tends to build storages at locations where wind curtailment can be prevented or a decline in congestion rents can be achieved. Moreover, storage extension influences the generation dispatch. It helps to increase the utilization of base load power plants and substitutes cost intensive peak load capacity with regard to minimize energy production costs. Consequently, optimal locations of energy storages could be identified regarding the year 2020 as temporal shifting of load by using energy storages eases network congestions.

Keywords: electricity market; energy storage; Germany; investment placing

Session 10.30 – 12.30
Energy Efficiency and Demand Side Measures

Room: B37
Chair: Christoph Brunner (EnBW Energie Baden-Württemberg AG)

Analysing the impact of Eco-Design requirements on heating systems – A European case study
Rainer Elsland, Harald Bradke, Martin Wietschel (Fraunhofer Institute for Systems and Innovation Research ISI)

Increasing Efficient Appliance Purchases through Lifetime Monetary Consumption Information
James Caroll, Eleanor Denny (Trinity College Dublin), Seán Lyons (The Economic and Social Research Institute, Dublin)

Potential energy efficiency improvements in Swedish energy intensive industries using an Energy Efficiency Obligation Scheme
Maria Xylia, Semida Silveira (KTH Royal Institute of Technology)

Can heat pumps help to integrate fluctuating renewable generation?
Gerda Schubert, Frank Sensfuß (Fraunhofer Institute for Systems and Innovation Research ISI)

Report in an "Energiewende" Pilot Test – First Impressions, Proposals and Results - A concept for the yellow phase of the "grid signal light" mechanism
Holger Wiechmann, Kai Hufendiek (EnBW Vertrieb GmbH)

Analysing the impact of Eco-Design requirements on heating systems – A European case study

Rainer Elsland, Harald Bradke, Martin Wietschel (Fraunhofer Institute for Systems and Innovation Research ISI)

Improving energy efficiency is seen as a key pillar in transforming the energy system. Residential heating systems can substantially contribute to reduce energy demand. The European residential sector ranks amongst the largest consumers in 2010 with a share of 26.7 % (12,814 PJ) of the total final energy demand in Europe (48,078 PJ). 10,327 PJ of this usage are attributed to residential space and sanitary water heating demand, which is equivalent to about 21.5 % of the overall European final energy demand. To exploit heating system related saving potentials the EU implemented the Eco-Design Directive to set minimum efficiency standards at the design phase. In terms of heating systems, Lots 1 and 2 were published in 2013 and Lots 15 and 20 are in the process of being developed. To evaluate the impact of these measures, a scenario analysis is conducted within the context of the Eco-Design preparation studies. The Eco-Design impact assessment is prepared over time horizons ending in 2025 and 2035, which is rather short compared to the lifetime of heating systems of 20 years or more. The technology specific assessments also neglect the interdependency between the heating systems.

This study aims to close this research gap by applying an impact assessment on a combination of all four Lots addressing heating systems in the period 2008-2050. The bottom-up model FORECAST-Residential* is used to analyse the EU27 residential building and heating stock on a country by country basis up to 2050. This methodological approach is designed as a vintage stock model, which allows stock turnover to be modelled in detail, taking into account regulatory requirements of the Eco-Design Directive explicitly.

The analysis reveals that the impact of heating system related Eco-Design Directives can lead to a reduction of final energy demand by 1376 PJ by 2050. By far the largest potential for savings are attributed to Lot 1, which is mainly related to the replacement of constant temperature and low temperature boilers through more efficient condensing boilers together with a strong diffusion of heat pumps (-1011 PJ until 2050). The second largest potentials are attributed to Lot 20 with the phasing out in some countries of electricity based heaters, such as radiant heaters and night storage heaters (-167 PJ until 2050). This reduction is also driven by targets given for primary energy usage in buildings. The third largest potential is related to Lot 15 (-120 PJ until 2050), closely followed by Lot 2 (-78 PJ until 2050). This is a result of a strong diffusion of solarthermics, especially in countries in the warm climate zone, and, due to replacing instantaneous water heaters through hot water storage, especially in Eastern European countries.

*FORECAST is a modelling platform that captures the final energy demand of the residential, industry, tertiary, transport and agriculture sectors for the EU 27+3 (3: Norway, Switzerland, Turkey) by country up to 2050 (http://www.forecast-model.eu).

Keywords: Bottom-up modelling, residential sector, heating energy demand, energy policy, impact assessment

Increasing Efficient Appliance Purchases through Lifetime Monetary Consumption Information

James Caroll, Eleanor Denny (Trinity College Dublin), Seán Lyons (The Economic and Social Research Institute, Dublin)

Household failure to minimize the total costs of their energy-consuming investments has led to the much cited ‘energy efficiency gap’. This paper proposes that this apparent misoptimization is partly the result of buyer inattention to, or miscalculation of, auxiliary costs. We test this hypothesis by adding five year consumption cost labels to the dryer line-up in four outlets of a large Irish electrical retailer (DID Electrical) . To our knowledge, this is the first paper to test the effect of monetary consumption information using a retail trial. Results show a significant improvement in the mean efficiency of dryers sold in trial stores. Specifically, the positive relationship between appliance efficiency and sales is significantly higher in the treatment group. This result highlights that some buyers are unaware or inattentive to the energy costs of prospective appliances, and that providing this information would increase likely the efficiency of the stock of appliances.

Keywords: The Energy Efficiency Gap, Efficiency Inattention, Lifetime Energy Costs

Potential energy efficiency improvements in Swedish energy intensive industries using an Energy Efficiency Obligation Scheme

Maria Xylia, Semida Silveira (KTH Royal Institute of Technology)

The impact assessment of the European Commission on the climate and energy policy framework states that the 2020 goal of 20% reduction of primary energy use will most likely not be reached, mainly because the energy efficiency target is not binding. The Energy Efficiency Directive (EED) is a response to this assessment. Although the EED also lacks binding targets, it has a number of binding measures, such as the obligation posed on the energy distributors or suppliers to save 1.5% of the final energy delivered annually, with exception of the transport sector.

Energy Efficiency Obligation Schemes (EEOS), as suggested in the Energy Efficiency Directive (EED), could help remove barriers to energy efficiency. However, despite the fact that such schemes have been successfully implemented and proven cost-effective in several Member States, not all countries are convinced of their potential benefits.

In this paper, we attempt to identify the problems associated with the implementation of the EEOS in Sweden, discussing how the scheme could be designed so as to remove barriers to energy efficiency. We focus our analysis on the industrial sector, where energy efficiency could be achieved together with production cost reductions, and thus also contribute to improved international competitiveness of energy-intensive industries.

The implications of an EEOS for the industries in Sweden are evaluated, together with insights from EEOS:s carried out in other Member States, and practices of industrial energy efficiency policies in Sweden. The objective is to identify pathways that could engage the industrial sector in energy saving measures while using the EEOS to remove non-economic and regulatory barriers to energy efficiency in the industrial sector.

Keywords: energy efficiency obligation scheme (EEOS), Energy Efficiency Directive (EED), Programme for Improving Energy Efficiency (PFE), industrial energy efficiency

Can heat pumps help to integrate fluctuating renewable generation?

Gerda Schubert, Frank Sensfuß (Fraunhofer Institute for Systems and Innovation Research ISI)

In Germany we see a remarkable change in the electricity system. An increasing electricity production from fluctuating renewable sources such as wind and photovoltaic cause a need of more flexibility. At the same time Germany aims at a decarbonisation of the heating market [1]. Heat pumps are one possible option to provide flexibility for the electricity sector together with low-emission heat for the heating market. A closer look into seasonal and daily patterns of heat demand is necessary to evaluate the effects of an increasing number of heat pumps.
Two scenarios [2] [3] combined with medium and ambitious increase of heat pump installations [4] [2] are investigated to analyze the impact of heat pumps on the German electricity and heating market. To consider characteristic load curve patterns of the heat pump and the interdependence with fluctuating RES generation a simulation of the German day-ahead market for a whole year in hourly resolution using the agent-based simulation model PowerACE is performed. Within these scenarios the effects of unrestrained and optimized heat pump operation as well as different heat storage sizes are compared.
The results show that heat pumps can contribute to integrate fluctuating RES generation and provide flexibility on the electricity market under certain conditions. One central precondition is an optimized operation based on market signals. CO_2 emission savings on the heating market are strongly correlated with the ability to integrate fluctuating RES generation on the electricity market.

Keywords: heat pump, flexibility, electricity market, heating market

Report in an "Energiewende" Pilot Test – First Impressions, Proposals and Results - A concept for the yellow phase of the "grid signal light" mechanism

Holger Wiechmann, Kai Hufendiek (EnBW Vertrieb GmbH)

While advancing the German „Energiewende", the fluctuating generation (wind, PV) will increase impressively. The integration of this type of generation is highly challenging. On one hand it requires entirely new approaches to energy logistics for dynamically balancing generation and demand on a regional or even local level. On the other hand, the existing grid capacities need to be operated in a smart way to tackle the challenges.

Especially on the distribution grid level, all actors face completely new challenges. Bottleneck situations used to be almost unknown on this grid level. For an efficient and secure interaction it is important, that the responsibilities of all the players are clearly defined in a role concept. Furthermore it is crucial, that each player is responsible for decisions it can control effectively and does not disturb relationships with other players in an uncontrollable way. For example leads a singular demand management activity of a DSO with a customer due to grid reasons at the same time to imbalances in the balance group of the supplier of this customer, though it is responsible to keep it in balance. Furthermore, it is important for an efficient development, to keep the system as open as possible allowing for innovation generated from competition of ideas.

A way to interact in such a systematic way is described by the principle of the "grid signal lights" presented last year. Based on this "grid signal light" principle we will present a detailed concept for the yellow phase. This concept includes an automated mechanism for the lower voltage levels based on leverage factors for smart applications like electric storage heating, heat pumps or smart charging of electric vehicles. At the same time it comprises an active approach with bidding elements for the higher voltage levels.

This approach is implemented in a pilot testing region by EnBW. Examples derived from that research project will illustrate how the required interaction of regulated DSO and competitive players operates in practice. This set of roles and rules is proposed as basis of a new smart energy system and therefore a key module for implementing the "Energiewende".

Keywords: Energiewende, "grid signal light" mechanism, detailed concept for the yellow phase, interaction between regulated DSO and competitive players

Session 14.15 – 15.45
European Policies and Strategies

Room: Faculty Assembly Hall
Chair: Michael Zipf (TU Dresden)

Beyond 2020: Strategies and costs for transforming the European energy system
Brigitte Knopf (Potsdam Institute for Climate Impact Research), Yen-Heng Henry Chen (Massachusetts Institute of Technology (MIT)), Enrica De Cian (Fondazione Eni Enrico Mattei (FEEM)) Hannah Förster (Öko-Institut, Germany), Amit Kanudia (KanORS-EMR), Ioanna Karkatsouli (Massachusetts Institute of Technology (MIT)), Ilkka Keppo (University College London), Tiina Koljonen (VTT Technical Research Centre of Finland), Katja Schumacher (Öko-Institut, Germany), Detlef P. van Vuuren (PBL Netherlands Environmental Assessment Agency and Utrecht University)

EU climate and energy policy beyond 2020: How many targets and instruments are necessary?
Paul Lehmann (Helmholtz Centre for Environmental Research (UFZ)), Jos Sijm (Energy Research Centre of the Netherlands (ECN)), Erik Gawel (Helmholtz-Zentrum für Umweltforschung (UFZ) and University of Leipzig), Unnada Chewpreecha, Hector Pollitt (Cambridge Econometrics), Sebastian Strunz (Helmholtz-Zentrum für Umweltforschung (UFZ))

German Energiewende vs. European energy transition? On the alleged need to „Europeanize“ the Energiewende
Sebastian Strunz, Paul Lehmann (Helmholtz-Zentrum für Umweltforschung (UFZ)), Erik Gawel (Helmholtz-Zentrum für Umweltforschung (UFZ) and University of Leipzig)

Cost-minimal investments into conventional generation capacities under a Europe-wide renewables policy
Clemens Gerbaulet, Casimir Lorenz (TU Berlin and DIW Berlin), Friedrich Kunz (DIW Berlin), Christian von Hirschhausen (TU Berlin and DIW Berlin), Benjamin Reinhard (TU Berlin)

Beyond 2020: Strategies and costs for transforming the European energy system

Brigitte Knopf (Potsdam Institute for Climate Impact Research), Yen-Heng Henry Chen (Massachusetts Institute of Technology (MIT)), Enrica De Cian (Fondazione Eni Enrico Mattei (FEEM)) Hannah Förster (Öko-Institut, Germany), Amit Kanudia (KanORS-EMR), Ioanna Karkatsouli (Massachusetts Institute of Technology (MIT)), Ilkka Keppo (University College London), Tiina Koljonen (VTT Technical Research Centre of Finland), Katja Schumacher (Öko-Institut, Germany), Detlef P. van Vuuren (PBL Netherlands Environmental Assessment Agency and Utrecht University)

The EU Commission has recently presented its strategy for a long-term vision of the European energy system in the EU Energy Roadmap and proposed a new framework for 2030. This includes setting a target for greenhouse-gas (GHG) emission reduction of 40% and an EU-wide target for renewables of 27% by 2030. Despite extensive modeling work, the analyses of the energy system were mainly based on one model, i.e. PRIMES. However, the single-model approach leaves several unanswered questions, particularly in terms of the modeling methodology, uncertainties related to input assumptions, and lack of transparency. To overcome this problem, a multi-model perspective is valuable for formulating robust and effective energy and climate policies.

The new study presented here is a systematic model comparison of 13 models of the European energy-economy system, including the PRIMES model and with it setting the Energy Roadmap into perspective. The Energy Modeling Forum 28 (EMF28) exercise systematically explores the energy system transition required to meet the European goal of reducing GHG emissions by 80% by 2050. The more comprehensive approach now allows for a more robust assessment of technologies, costs and infrastructure requirements. The paper investigates mitigation strategies beyond 2020 with a special focus on potential targets for 2030. We find that 40% GHG reduction until 2030 could be a cost-efficient milestone for reaching 80% GHG reduction in the long-term until 2050.

The 13 models present different technology pathways for the decarbonization of Europe, but a common finding across the scenarios and models is the prominent role of energy efficiency and renewable energy sources with renewables will become the most important source of electricity. The costs of achieving 40% reduction by 2030 are estimated to be moderate. However, the transformation becomes more challenging after 2040.

Keywords: European decarbonisation; mitigation scenarios; model comparison; climate change; EU Energy Roadmap 2050

EU climate and energy policy beyond 2020: How many targets and instruments are necessary?

Paul Lehmann (Helmholtz Centre for Environmental Research (UFZ)), Jos Sijm (Energy Research Centre of the Netherlands (ECN)), Erik Gawel (Helmholtz-Zentrum für Umweltforschung (UFZ) and University of Leipzig), Unnada Chewpreecha, Hector Pollitt (Cambridge Econometrics), Sebastian Strunz (Helmholtz-Zentrum für Umweltforschung (UFZ))

The European Commission has recently proposed to focus on a greenhouse gas (GHG) emissions reduction target for 2030 and to scrap binding targets for renewable energy sources (RES) at the Member State level. In this article, we are arguing that this proposal may be economically questionable.
We first point out economic rationales for implementing RES targets and instruments in addition to a GHG target and the EU Emissions Trading Scheme (ETS): (1) first-best arguments (technology market failures), (2) second-best arguments (imperfect internalization of GHG and other externalities), and (3) objectives beyond allocative efficiency which may nevertheless be relevant for practical policy-making (green jobs, distributional concerns).

Subsequently, we quantify the costs and some of the benefits of separate RES targets and instruments. For this purpose, we employ Cambridge Econometrics' 'E3MG-FTT:Power' model. It combines a top-down, global macro-economic model with a bottom-up, global electricity sector model. Modelling results suggest that the economic impact of an additional RES target hinges crucially on the question by which instruments it is attained:

a) In a least-cost scenario the RES target is attained by a uniform subsidy to RES electricity generation. Compared to a scenario with a GHG target and ETS only, power system costs increase only slightly while the effects are positive for GDP and insignificant for employment. The average carbon price for the period 2014-2030 declines from 40 to 28 Euro/ton CO_2.
b) Differentiating the RES subsidy by technologies impairs the economic performance of the policy mix across the board.
c) Attaining the RES target by the ETS alone (i.e. without a separate RES instrument) brings about severe economic distortions: GDP losses as well as power system costs rise tremendously, the average carbon price increases up to 200 Euro/ton CO_2.

Our analysis thus suggests that implementing a separate RES target may be economically reasonable as additional costs in terms of GDP losses and power system costs are only modest (if at all existent) and may compare with important societal benefits which are typically not captured by economic models. However, these welfare gains can only be realized by a policy mix including the ETS and a RES subsidy.

Keywords: EU climate and energy policy, EU emissions trading scheme, policy mix, renewables

German Energiewende vs. European energy transition? On the alleged need to „Europeanize“ the Energiewende

Sebastian Strunz, Paul Lehmann (Helmholtz-Zentrum für Umweltforschung (UFZ)), Erik Gawel (Helmholtz-Zentrum für Umweltforschung (UFZ) and University of Leipzig)

It is often argued that Germany’s energy transition (the so-called “Energiewende”) needs to be „Europeanized“, so as to make the transition process more efficient. In particular, the German system of feed-in tariffs for renewables is criticized for being an obstacle to efficient European energy supply. However, this view neglects i) the factual heterogeneity of European energy policies, ii) economic arguments in favor of decentralization and iii) political-economic obstacles against centralization of decision making. In this vain, we point out that a plea for a stronger role of the EU needs to be made with care and differentiation.

First, we show that the degree of centralization and homogeneity varies significantly across the diverse fields of energy policies in Europe (climate policy, technology policy, common single market, grids, security of supply). In particular, neither Germany’s feed-in tariff for renewables nor the planned nuclear phase-out represent singularities in Europe. Thus, the claim that Germany’s energy transition constitutes a “Sonderweg” is factually incorrect.

Second, following the economic theory of fiscal federalism, we show that full centralization of energy policy decisions on the EU-level would probably not be desirable from an economic point of view: Partly heterogeneous preferences and the laboratory function of decentralized government call for keeping major competences on energy policy with the Member States.

Third, there are strong obstacles towards full decentralization from a public choice point of view: Member States’ politicians are incentivized to reject the EU-wide allocation of energy production capacities around the EU in order to prevent potentially disruptive change in national industry structures and to serve rent-seeking pressure groups.

Against this background, we argue that bottom-up cooperation is far more conducive towards more “Europeanized” energy policies – as far as this would be desirable – than top-down harmonization pressure. Given the current heterogeneity of the European energy policy landscape, we identify priorities for fostering the European dimension of the Member States’ energy policies, such as strengthening EU climate policy and coordinating grid extensions and capacity markets.

Keywords: centralization, harmonization, energy transition, EU climate and energy policy, fiscal federalism, political economy

Cost-minimal investments into conventional generation capacities under a Europe-wide renewables policy

Clemens Gerbaulet, Casimir Lorenz (TU Berlin and DIW Berlin), Friedrich Kunz (DIW Berlin), Christian von Hirschhausen (TU Berlin and DIW Berlin), Benjamin Reinhard (TU Berlin)

The future development of the European power system is intensively discussed with respect to the electricity network as well as generation technologies. Renewable generation is assigned a dominant role with the underlying aim to reduce the carbon intensity of the entire electricity sector. This has direct implications for conventional generation capacities and their future development. Thus a closer investigation of the investments in conventional generation technologies is aimed taking into account the variability of an increasing share of renewable generation.
Given Europe-wide scenario assumptions regarding the development of renewables and prices for relevant input factors like fuel prices and power plant construction, the investments in storage and the power plant portfolio are an important indicator for future policy developments.

In our paper, we develop a dynamic electricity model which endogenously determines cost-minimizing investments in conventional generation capacities in ten year steps and model their dispatch for the entire European electricity system. Interactions between countries are modeled using a country-sharp power transfer distribution factor aggregation based on the actual underlying high-voltage transmission grid, which allows for a representation of loop-flows while reducing computational complexity. Taking the current generation portfolio and the expected decommissioning of power plants into account, certain investments in different forms of dispatchable generation and storage capacities are required at every ten-year step. This is necessary to compensate fluctuations in renewable generation while incorporating power plant ramping constraints and thus to ensure that load is met at every instant of time. The dispatch of generation is modeled for a full year in order to reflect the temporal and regional variations of renewable generation capacities, with an emphasis on wind generation. This methodology arrives at a cost-optimal power plant portfolio for every European country and provides an estimate for the costs associated with each scenario regarding investments into the electricity system.

Our initial model results indicate a lower capacity expansion for nuclear and carbon capture and storage technologies than indicated in the PRIMES scenarios which influence the current European policy developments. This also shows that cost assumptions are a crucial influence factor and the underlying sensitivities should be analyzed carefully.

Session 14.15 – 15.45
Capacity Mechanisms

Room: A 03
Chair: Susanne Koschker (TU Dresden)

Optimal level of remuneration for capacity to ensure generation adequacy
Hanspeter Höschle, Cedric De Jonghe, Ronnie Belmans (KU Leuven)

Model-based analysis of design options for the German electricity market to ensure security of supply for increasing electricity generation from renewable energies
Dogan Keles, Lea Renz, Massimo Genoese, Wolf Fichtner (Karlsruhe Institute of Technology)

A need for capacity markets
Wojciech Łyżwa (Lodz University of Technology)

The forward premium in electricity markets: an experimental study
Silvester van Koten (University of Economics, Prague), Andreas Ortmann (Australian School of Business)

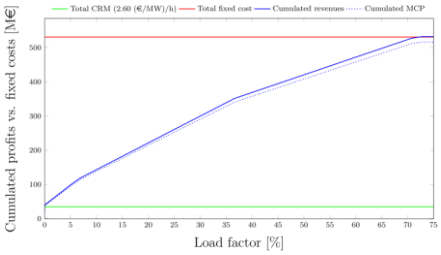
Optimal level of remuneration for capacity to ensure generation adequacy

Hanspeter Höschle, Cedric De Jonghe, Ronnie Belmans (KU Leuven)

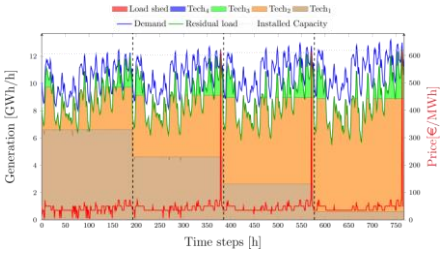
Large-scale integration of renewable energy sources (RES) and market distortion pose challenges to the profitability of existing power generators. Additional remuneration for capacity can origin from capacity remuneration mechanisms (CRMs) and supplement the revenues from electricity markets.

In a first step, a mixed complementarity problem (MCP) is formulated. It is used to obtain an optimal behavior of investors in generation units in a situation where the electricity price can reach any level. The problem is modeled with an hourly temporal resolution and calculates multiple investment periods. It is based on an economic dispatch taking into account variable and fixed costs of generation as well as external effects like intermittent generation from RES. In a second step, the obtained price profile is modulated to represent market distortions. The resulting behavior of investors is compared to the optimal behavior of the first step. The case of market distortion can be combined with supplementary payments per installed capacity expressed in €/MW to represent a CRM. Scenarios compare the results for different levels of (technology-specific) payments for capacity with the reference case. Enforced stepwise reduction of base load capacity analyzes the effect of a CRM in a system phasing out nuclear power.

The payment for capacity in addition to the revenues from selling electricity can ensure the profitability of power generators if markets are distorted. The model results give insights on the level of payment necessary per technology type to cover variable and fixed costs. The resulting additional costs through CRM to ensure security of supply are compared to the optimal costs under perfect competition. The difference can be understood as loss of social welfare. By adapting the payment to a sufficient level per technology, this loss can be minimized.



(a) Correlation of cost structure, operating hours and additional revenues from CRM (base technology)



(b) Generation schedule assuming stepwise phase out of base technology

Figure 1: Scenario with stepwise nuclear phase out: Results of the model

A model consisting of a MCP and LP is developed to analyze the effects of market distortions on the profitability of power generators. A supplementary payment which cans origin from a CRM is introduced. The level of payment is analyzed with respect to security of supply and minimal social welfare losses. A scenario with a stepwise reduction of base capacity is used to simulate the effects of a nuclear phase.

Keywords: Capacity Remuneration Mechanisms, Electricity Market, Generation Adequacy, Mixed Complementarity Problem

Model-based analysis of design options for the German electricity market to ensure security of supply for increasing electricity generation from renewable energies

Dogan Keles, Lea Renz, Massimo Genoese, Wolf Fichtner (Karlsruhe Institute of Technology)

Currently there is an intensive discussion in Germany about the early implementation of a capacity mechanism. The reason for that are doubts whether the current Energy-Only-Market (EOM) can provide sufficient investment incentives to ensure a long-term supply adequacy. Due to the increasing feed-in of electricity based on volatile renewable energies, the number of operating hours of conventional power plants is decreasing and thus their revenue situation is becoming worse. However, flexible conventional back-up capacities will be still necessary, especially when peak load times meet few wind and photovoltaic power production. This raises the question whether the marginal cost based energy-only market (EOM) provides enough incentives for investments in new power plant capacity or a capacity mechanism should be introduced as a new market segment for the product secured power.
To provide decision makers with new insights, the market design options that have been identified as relevant for Germany are implemented and analysed applying the agent-based simulation model PowerACE which simulates the German wholesale electricity market.

This study analyzes and evaluates those capacity mechanisms which are described in different design proposals and which are currently under consideration for Germany as well as those which are already internationally implemented. The evaluation of the selected capacity mechanisms is done by using the agent-based simulation model PowerACE which consists out of the four modules: markets, electricity supply, electricity demand and regulator. The model displays all the power plants in the German electricity market. Essential input parameters are the development of electricity demand, prices of carbon dioxide and fuels, imports and exports of electricity and the expansion of renewable energies. Investments occur in the model on the basis of calculation of profitability of the simulated power plant utilization of predetermined conventional technology options. Decision basis of the investment planning agents are the hourly prices of the spot and forward market simulated in the model and any additional revenues from the capacity mechanism. An important model extension is the implementation of capacity mechanisms. These are analyzed under various parameter settings on the investment behavior of the agents, the development of generation capacity, electricity prices, carbon dioxide emissions and costs. Furthermore it is possible to examine whether it comes to undersupply of demand in several scenarios or under certain parameterizations.

Simulation results for the EOM and for an energy market design with a centralized capacity market based on capacity options are briefly summarized and compared in the following. Figure 1 shows the development of installed power plant capacities in the EOM (left) and in case of an introduction of a centralized capacity market (right). The investment activity in the EOM is strongly influenced by cycles, which can be explained by a high level of prices on the wholesale market during scarcity periods. In the simulation with a centralized capacity market, however, the investments are carried out earlier and more evenly. The level of security of supply is thus significantly higher in the case of a capacity market than in the EOM. Besides, about 5 GW additional natural gas capacities are built, if a capacity market is introduced. This comes along with the need of restructuring of the power sector to more flexibility due to increasing electricity generation from renewable energies.

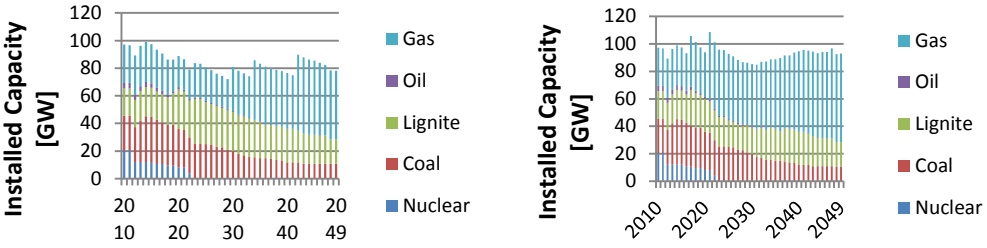


Figure 1: Development of installed conventional power plant capacity in EOM (left) and with centralized capacity market (right)

In this study additional capacity mechanisms, like a centralized capacity market, are implemented in PowerACE, whereby different adequate parameterizations for the mechanism are taken into account. However, other capacity mechanisms, such as a strategic reserve or a decentralized capacity market, will be analyzed in the next step to determine the most efficient mechanism and to deliver an overall contribution to the market design discussion in Germany and other European countries.

Keywords: market design, capacity market, energy-only-market, electricity prices, security of supply

A need for capacity markets

Wojciech Łyżwa (Lodz University of Technology)

The electricity markets were introduced in the European Union countries as "energy only" markets. After a few year of high electricity prices the wholesale prices are diminishing reaching in many cases the levels close to variable costs. Energy only markets can operate in two cases: (a) there is an excess of power generating capacity left after the monopoly era and (b) large price spikes are allowed in the market to cover fixed costs. In Europe the excess of generation capacities becomes smaller and large prices variations are dumped by various caps.

Facing the diminishing generation adequacy some European Union countries have started the introduction of the parallel markets called capacity or power markets. Various forms of such markets exist in Italy, Sweden and Spain. Other countries France, the UK and Poland are discussing the best options for capacity markets. Generally, there are two problems that have to be addressed: (a) missing money which means that the existing power plants withdraw from the market as they are not able to cover fixed costs and (b) missing capacity which relates to a lack of investment in new power generation assets as the results of poor economic incentives for investments. The former can be addressed by capacity markets while the latter can also be handle by capacity markets but the best tool for a lack of investment seems to be contracts for differences as proposed in the UK.

The reaction of European Commission to the uncoordinated development of power markets, which can have impact on the competitiveness of energy markets, was the publication of Staff Working paper on the 5th of November 2013 in which the EC formulated as few sets of criteria for power markets. The paper proposed deals with the review of various features of power markets proposed in Europe and operating in the US and discussed how they can fulfill the criteria formulated by European Commission. The paper also indicates fuzzy sets methodologies for the decision making when selecting the best power market solution.

Keywords: capacity market, generation adequacy, missing capacity, missing money

The forward premium in electricity markets: an experimental study

Silvester van Koten (University of Economics, Prague), Andreas Ortmann (Australian School of Business)

Economics experiments are designed to test the validity of the seminal theory of Equilibrium Electricity Forward Pricing by Bessembinder and Lemmon (2002) (BL) and the extent to which the theory is relevant for markets with less than perfect competition. The theory of Bessembinder and Lemmon plays a central role in the modeling of electricity prices in spot and forward markets. Financial markets are of eminent importance for producers and distributors to manage risk. Moreover, net electricity demand in the short term is highly variable and can be expected to become so even more in the near future. The role of financial markets for risk management in the electricity market will thus further gain in importance in the near future.

However, empirical tests of the Bessembinder and Lemmon theory of Equilibrium Electricity Forward Pricing have not been unequivocal. While empirical studies have provided some support, other papers have found weak or opposite effects. This may not be surprising, as the BL theory contains fundamentally unobservable variables and can therefore not be tested empirically with "field data". Economics experiments, taking place in the tightly controlled environment of an experimental laboratory, can control the variables that are usually unobservable in field data. An important factor is the specific experimental design and parameterization. A good experimental design and appropriate parameterization can greatly enhance the relevance of the experiment for the field of empirical (financial) energy economics. I therefore discuss different possible experimental designs and parameterizations. The main designs proposed are 1) "SIMPLE": parameters are close to the ones used in BL to test the model under the most favorable conditions possible, 2) "IMPERFECT COMPETITION": parameters reflect the more limited degree of competition typical in EU energy markets, and 3) "INTERMITTENT": parameters reflect a high variability of the residual demand due to a high penetration of intermittent (renewable) power generators.

Keywords: Decision making, economics experiments, forward premium, electricity markets, financial electricity markets.

Session 14.15 – 15.45
Gas Market

Room: B37
Chair: Philipp Hauser (TU Dresden)

Assessing cross-border impacts of gas infrastructure investment expenditure across Europe with MRIO
Maaike C. Bouwmeester, Bert Scholtens (University of Groningen)

Pipeline Power: A Case Study of Strategic Network Investments
Onur Cobanli, Franz Hubert (Humboldt–Universität zu Berlin)

Investments in a Combined Energy Network Model: Substitution between Natural Gas And Electricity?
Hannes Weigt (Universität Basel), Jan Abrell Swiss Federal Institute of Technology Zürich

Valuing arbitrage opportunities for LNG suppliers across the Atlantic
Bert Scholtens, Casper Kranenborg (University of Groningen)

Assessing cross-border impacts of gas infrastructure investment expenditure across Europe with MRIO

Maaike C. Bouwmeester, Bert Scholtens (University of Groningen)

At the European level, energy policies focus on stimulating market integration, security of supply and renewable energy. Market integration and security of supply are both dependent on the connectivity of energy infrastructure. In the current infrastructure, bottlenecks have been identified mainly at the borders of countries and for larger international projects. The EU is undertaken a major effect to resolve these bottlenecks and stimulates member states to invest in energy infrastructure. In the past, these national investment plans have been assessed at the national level. However, transmission investment projects aiming to increase the interconnectivity between European countries most likely entail large cross-border indirect effects. From a national perspective, these cross-border effects are recorded as leakages and are not further investigated. This needs to be reconsidered as the EU is updating its methodology for investment assessment following changes in the EU energy directive. The directive calls for assessing investment from an integrated perspective at the EU level. This paper contributes to the discussion on enlarging the scope of the analysis by showing the extent and distribution of the investment expenditure spill-overs. We analyze expected cross-border spill-overs related to the investment plans of five European countries by tracing their impact in a multi-regional input-output model. Value added coefficients and employment coefficients are used to translate the impacts into employment compensation, capital compensation and employment hours required. Our findings show that spill-overs are generally larger for employment compensation compared to capital compensation, that the spill-overs primarily flow to a limited set of countries, and that most employment hours are created for medium skilled-labor.

Keywords: multiregional input-output analysis; gas infrastructure; investment; international spillovers

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Pipeline Power: A Case Study of Strategic Network Investments

Onur Cobanli, Franz Hubert (Humboldt–Universität zu Berlin)

We use the Shapley value and the nucleolus to analyze the impact of three controversial pipeline projects on the power structure in the Eurasian trade of natural gas. Two pipelines, `Nord Stream' and `South Stream', allow Russian gas to bypass transit countries, Ukraine and Belarus. The third project, `Nabucco', aims at diversifying Europe's gas imports by accessing producers in Middle East and Central Asia. For the Shapley Value we obtain a clear ranking of the projects which corresponds to the observed investment patterns. Nord Stream's strategic value is huge, easily justifying the high investment cost for Germany and Russia. The additional leverage obtained through South Stream is much smaller and Nabucco is not viable. For the nucleolus in contrast, none of the pipelines has any strategic relevance at all, which appears to be at odds with the empirical evidence.

Keywords: Cooperative games, Networks, Strategic Investment, Natural Gas, Shapley Value, Nucleolus

Investments in a Combined Energy Network Model: Substitution between Natural Gas And Electricity?

Hannes Weigt (Universität Basel), Jan Abrell Swiss Federal Institute of Technology Zürich

Natural gas plays an important role in the future development of electricity markets as it is the least emission intensive fossil generation option while additionally providing the needed flexibility in plant operation to deal with intermittent renewable generation. As both the electricity and the natural gas market rely on networks, congestion on one market may lead to changes on another.. In addition, investments in one market have an impact in the other and may even become substitutes for one another. The objective of this paper is to develop a dynamic model representation of coupled natural gas and electricity network markets to test the potential interaction with respect to investments. The model is tested under simplified conditions as well as for a stylized European network setting. The results indicate that there is a potential for investment-substitution and significant market interactions that warrants the application of coupled models especially with regard to simulations of long term system developments.

Keywords: Electricity network, Natural gas network, Europe, MCP

Valuing arbitrage opportunities for LNG suppliers across the Atlantic

Bert Scholtens, Casper Kranenborg (University of Groningen)

Recent studies suggest that natural gas prices are decoupling from oil (e.g. Stern and Rogers, 2011). This decoupling may impact on the arbitrage opportunities for liquefied natural gas (LNG) suppliers in the Atlantic basin because a diminishing oil-link could have an effect on gas pricing differentials across the Atlantic. Brown and Yücel (2008) argue that long-term movements in natural gas prices occur due to changes in crude oil prices, but that in the short-term natural gas prices are mainly driven by other factors such as weather, seasonality and natural gas storage. In contrast, Vásquez Josse and Neumann (2006) find no evidence for a stochastic trend between natural gas and Brent or WTI crude oil prices in the US in the period 1999 to 2005 and conclude that the US market is determined by gas-to-gas based prices. As such, there are two alternative perspectives on the market interrelatedness of oil and gas. The first is that oil and gas prices remain coupled because (1) high volatility of gas prices make producers insist on oil-linked contracts, (2) LNG contracts are oil-linked, (3) energy customers substitute towards cheaper energy sources and, (4) fear of manipulation of gas prices. Alternatively, the two markets are separated or start to move independently because (1) nowadays more alternative energy inputs exist for electricity production, leading to a reduction of pricing weight of oil in gas prices, (2) increased gas-to-gas prices lead to gas prices linked to spot gas prices, and (3) increased liquidity of gas markets reduce the need for an oil link. We try to answer the question whether the natural gas price is still (as strongly) pegged to the oil price in the second half of the 2000s, compared to the period before, for the US and the UK market. Our main hypothesis is that the market separation perspective holds; natural gas is shifting away from oil-pegged prices to gas-to-gas prices.

Yepes Rodríquez (2008) argues that there are arbitrage opportunities in the Atlantic for LNG suppliers. But this is disputed by e.g. Dehnavi and Yegorov (2012). Combined with the observations of Neumann (2009) and Stern and Rogers (2011), this leads to our 'arbitrage value hypothesis': When a global gas market is realized, it is not possible to make significant profits by selling gas in one market for a higher price than in another market. This is because market reactions diminish the price spread and thus reduce arbitrage profits. However, because the literature suggests cointegration of the UK and US gas markets is limited, it seems that exploiting these price spreads is possible. Hence, we investigate the prospect of arbitrage opportunities in the Atlantic gas market.

We establish that the arbitrage opportunities for LNG suppliers trying to exploit arbitrage opportunities in the US diminished significantly in the period 2008-2012 in comparison with the period 1997-2008. Our second finding is that cointegration relationships are changing over time. Furthermore, we establish that the natural gas and LNG prices across the Atlantic show no signs of cointegration from 2008 to 2012, which suggests that there is still no true global gas market.

Keywords: LNG trade, oil, natural gas, arbitrage, US, UK

Session 16.30 – 18.00
National Policies and Developments

Room: Faculty Assembly Hall
Chair: Hannes Hobbie (TU Dresden)

The crucial role of infrastructure design in the German Energiewende: An analysis of possible branching points
Eva Schmid, Brigitte Knopf (Potsdam Institute for Climate Impact Research), Anna Pechan (Carl von Ossietzky Universität Oldenburg)

Facilitating variable generation of renewables by conventional power plant cycling: costs and benefits
Kenneth Van den Bergh, Erik Delarue (Energy Institute, KU Leuven)

Optimal Incentives for Belgian Electricity Challenges
Ruben Laleman, Johan Albrecht (Ghent University)

Meeting EU energy and climate policy in Poland. Optimization of the energy mix
Michal Wierzbowski (Lodz University of Technology)

The crucial role of infrastructure design in the German Energiewende: An analysis of possible branching points

Eva Schmid, Brigitte Knopf (Potsdam Institute for Climate Impact Research), Anna Pechan (Carl von Ossietzky Universität Oldenburg)

Profound changes have occurred in the German energy system over the past decades. Several policy changes resulted in branching points that opened windows of opportunities for new actors as well as new activities in the energy system. A prominent example is the Renewable Energy Sources Act: From 2000 onwards, the feed-in tariff led to the entrance of a large amount of small-scale and individual actors generating electricity with distributed, renewable resources feeding into the distribution grid. If this development was to be intensified, the infrastructure backbone of such a "decentralized" Energiewende would be the lower-voltage local and regional distribution grid, redesigned to allow for smart solutions under the paradigm of "produce and consume locally". On the other hand, big utilities and corporations favor a type of "centralized Energiewende" that envisions large-scale solutions. Here, the infrastructure backbone would be the long-distance transmission grid designed to distribute renewable electricity from sites with most favorable resource potential to demand centers, likely situated elsewhere. Currently, the two camps pursue a fierce debate on how the Energiewende should continue in the long-run.

This paper argues that policy choices determining the design of future electricity grid infrastructure will be decisive for the degree to which the Energiewende will develop more under the "decentralized" or the "centralized" paradigm. In order to substantiate the discussion, we identify and characterize possible branching points regarding the design of infrastructure for the German electricity sector. These are completing the north-south HVDC connections, particularly "Suedlink", reforming the regulation for distribution grid operators, the degree to which IT/smart solutions become legally and economically marketable, decisions regarding the European interconnected grid and the development of storage. It turns out that considerable reform requirements regarding institutional/legal issues as well as technology development and deployment are necessary for either infrastructure future.

Keywords: Energy transition, transformation pathways, energy policy, decentralization, transmission grid

Facilitating variable generation of renewables by conventional power plant cycling: costs and benefits

Kenneth Van den Bergh, Erik Delarue (Energy Institute, KU Leuven)

Renewable electricity generation from wind and sun is variable, meaning that it fluctuates in time in a largely uncontrollable way. The variable character of wind and sun requires operational flexibility in the power system. An important source of operational flexibility is conventional power plant cycling, i.e., changing the power output of conventional units by means of ramping and switching (starting up and shutting down). This paper assesses the operational costs and benefits of variable wind and solar generation with respect to conventional power plant cycling, based on a case study of the German 2013 power system. The presented results follow from a detailed unit commitment model. The study shows that total production cost decreases considerably due to fossil fuel savings (about 40 % decrease in production cost at 25 % wind and solar share). Wind and sun lead to more partial load operation of conventional units, but the decline in operating efficiency during partial load has a limited impact on production costs (partial load cost is about 0-3 % of production cost). The total cycling cost, i.e., the cost related to ramping and starting power plants, increases with wind and solar injections. The increase in cycling cost is however one order of magnitude smaller than the decrease in production cost, even if all types of cycling cost are considered (fuel costs during start-up, capital and maintenance costs, forced outage costs, reduced efficiency costs and ramping costs). The study shows that, under the assumptions made, wind and solar injections decrease the total operational costs due to a strong decline in fuel and CO_2 emission costs which outweigh the increase in cycling costs.

Keywords: Variable generation, wind power, solar power, power plant cycling.

Optimal Incentives for Belgian Electricity Challenges

Ruben Laleman, Johan Albrecht (Ghent University)

The Belgian electricity market is under stress. Belgium wants to phase out nuclear production capacity in a liberalized European electricity market which is strongly impacted by climate and renewable energy policies. In this report we evaluate the impact of the nuclear phase out on the security of supply in Belgium, combined with a decrease in old fossil capacity and an increase in renewables. In the market context of today, incentive schemes only stimulate investments in renewable energy sources (RES) which are sheltered from market dynamics. By consequence, investments in controllable, non-intermittent assets are very limited, biomass being the only exception.

In a baseline scenario we find that Belgium is likely to become strongly dependant on electricity imports in the near future. This dependency can eventually increase to a black out risk. We assume that this risk is unacceptable for policymakers and put forward some scenarios to guarantee a reserve margin of at least 5%. Incentives for capacity additions, system flexibility and reliability are compared. For these scenarios we estimate subsidy costs and overall system costs and other related issues such as surplus problems. We compare two ways to handle the variability of renewables. The first scenario is similar to the current situation and assumes that renewables have grid priority. The second scenario assumes that renewables are forced to participate in the market to a certain extent. These two options are then combined with demand side management and an option to use older thermal plants as back-up assets. Finally, we combine all scenarios to estimate the costs of a balanced approach.

The goal of this report is to show the implications of various policy choices and to provide some insight in the often complex tradeoffs in electricity policy.

Keywords: Energy Policy, Electricity Markets, Renewable Energy, Nuclear Phase out, Subsidies

Meeting EU energy and climate policy in Poland. Optimization of the energy mix

Michal Wierzbowski (Lodz University of Technology)

The term of "*energy mix"* means a structure of units generating the energy in relation to the primary energy use. The term covers wide range of energy type, however in the paper proposed it refers only to the mix of the energy technologies used for the electricity generation.
The issue of right *energy mix* is relevant for the electricity sector, because the proper structure of the energy sources in the power systems determines the security of electricity supply and local energy security in general. The shape of the *energy mix* also defines a possibility to meet the European energy and climate requirements. The *energy mix* should be able to provide power and energy balance in the power system.

In all countries *energy mix* has to be planned in long term horizon. It has to meet specific requirements and be possibly the least expensive. Additionally the mix cannot be frequently modified due to the inertia in the power system investments. Therefore, it is extremely important to develop the energy policy providing the most optimal *energy mix* in long-term horizon.

The paper proposed refers to the optimization tool that can provide an invaluable help in energy policy development, leading to the right *energy mix*. It includes the analysis of the model of *energy mix* optimization developed at the Department for Strategic Analyses at the Chancellery of the Prime Minister of the Republic of Poland. As an addition the paper provides the description of modifications and upgrades, developed by the author, that make the model more useful for simulations of assumptions of energy policy. In the end the paper presents a set of simulations scenarios for *energy mix* in Poland, relating to the European energy and climate policy.

Keywords: electricity generation, energy mix, energy system modelling, optimization

Session 16.30 – 18.00
Electricity Markets

Room: A 03
Chair: Alexander von Selasinsky (TU Dresden)

Analysis of Market Participants' Trading Behaviour on the Nordic Intraday Market
Richard Scharff, Mikael Amelin (KTH Royal Institute of Technology)

Optimization of energy storage operation at competitive market
Błażej Olek (Lodz University of Technology)

Why wind is not coal: on the economics of electricity
Lion Hirth (Potsdam Institute for Climate Impact Research and Vattenfall GmbH), Falko Ueckerdt (Potsdam Institute for Climate Impact Research), Ottmar Edenhofer (Potsdam Institute for Climate Impact Research, TU Berlin and Mercator Research Institute on Global Commons and Climate Change)

The new Spanish electricity market design
Julian Barquin (Endesa, Regulatory Affairs)

Analysis of Market Participants' Trading Behaviour on the Nordic Intraday Market

Richard Scharff, Mikael Amelin (KTH Royal Institute of Technology)

Trading possibilities after closure of the day-ahead electricity market are expected to be of vital importance for an efficient integration of variable renewable energy sources. Today, there is a variety of different designs for intraday markets. In Europe, two basic layouts can be distinguished: double-sided intraday auctions like in Spain and Portugal and platforms for continuous trading as, for example, in Germany, France or the Nordic countries. Understanding trading behaviour on intraday markets can reveal shortcomings not only in their design, but also in the market rules of the whole electricity market. Both can hamper a more efficient integration of wind power.

In this work, trading activities on *Elbas*, the Nordic intraday market, are analysed. The analysis includes all trades that have been successfully settled between 1st March 2012 and 28th February 2013. In order to explain the observed trading behaviour, data is collected that is supposed to be relevant to market participants when taking their intraday trading decisions. Information that is not published by the market participants, e.g. wind power forecasts of individual power generating companies, is approximated by data from the Swedish transmission system operator.

The work focuses on explaining the trading behaviour of market participants in the four Swedish bidding areas. Data from the other seven bidding areas that constitute the synchronous Nordic power system are considered in detail while all trades outside this area, i.e. trades in the Baltic countries, the German, Dutch or Belgian bidding areas as well as the Western Danish bidding area, are aggregated and represented as one external area.

Starting from a list of intuitively expected elements of a bidding strategy for intraday trading, it is investigated whether such a bidding strategy can be observed in practice using descriptive statistical methods as well as explaining important examples in detail.

Keywords: intraday market, adjustment market, balancing expected deviations, observed trading behaviour, Nordic electricity market

Optimization of energy storage operation at competitive market

Błażej Olek (Lodz University of Technology)

Renewable energy sources (RES) and distributed generation (DG) becomes more and more common. Especially it refers to a small scale wind and photovoltaic (PV) power units which are installed by the end users and connected to low voltage networks. Their stochastic generation profile makes wide variety of local electricity production, leading to uncontrolled power flows and voltage fluctuations. In addition, PV peak generation often occurs during an off-peak hours demand and when consumption goes up. It results with local difficulties in distribution network operation but also with power system management. These problems can be solved by coordinated operation of energy storages connected to LV networks. Due to accumulation ability it can reduce generation peaks and adjust local energy production to demand profile, improving network reliability and preserving power quality standards. Additionally storages have large potential of ancillary services.

Two operation methods of energy storages can be distinguished regarding to ownership and common coupling point (CCP): storage operating as a single unit and storage cooperating with the DG. While the first method is relatively simple, the second one should be implemented preserving market and legal rules of power industry. Especially that energy is traded via power exchange and that operation should be carried out in accordance with unbundling and TPA rule.

The paper presents the method of optimal energy storage management including primary legal and market rules. The results presented refers to the study on the energy storage operation at local (decentralized) balancing market. Additionally the energy storage provides the set of ancillary services in field of power quality, such as: reactive power compensation, asymmetry reduction and harmonics reduction.

Why wind is not coal: on the economics of electricity

Lion Hirth (Potsdam Institute for Climate Impact Research and Vattenfall GmbH), Falko Ueckerdt (Potsdam Institute for Climate Impact Research), Ottmar Edenhofer (Potsdam Institute for Climate Impact Research, TU Berlin and Mercator Research Institute on Global Commons and Climate Change)

The economics of electricity is shaped by its physics. A well know example is the non-storability of electricity that cause its price to fluctuate widely. More generally, physical constraints cause electricity to be a heterogeneous good along three dimensions - time, space, and lead-time. Consequently, different generation technologies, such as coal and wind power, produce different economic goods that have a different marginal economic value. Welfare max-imization or competitiveness analyses that ignore heterogeneity deliver biased estimates. This paper provides an analytical welfare-economic framework that accounts for heterogeneity for unbiased assessments of power generators. The framework offers a rigorous interpretation of commonly used cost indicators such as ‘levelized electricity costs’ and ‘grid parity’. Heteroge-neity is relevant for all generators, but especially for variable renewables such as wind and solar power. We propose a definition of ‘variability’, derive the opportunity costs of variability, and link that concept to the ‘integration cost’ literature. A literature review shows that variability can reduce the value of wind power by 20-50%. Thus it is crucial that economic analysis ac-counts for the physics of electricity.

Keywords: power generation, electricity sector, integrated assessment modeling, variable re-newables, integration costs, welfare economics, power economics, levelized electricity cost, grid parity

The new Spanish electricity market design

Julian Barquin (Endesa, Regulatory Affairs)

As of July 2013 the Spanish government published extensive draft legislation (more than 700 pages) that substantially change the current power system regulation. The draft legislation mainly covers the regulated grid activities, the non-mainland systems regulation and, importantly, the renewables support scheme design as well as distributed generation regulation. It also touches on the capacity reliability mechanisms, and mandates the Spanish TSO and MO to prepare further reforms of the wholesale market. The draft legislation is expected to be approved by the Congress before March 2014.

The Reform is actually a radical turnover of the Spanish regulation. The paper main objectives are to describe the Reform so far as it impacts on the electricity market, to roughly evaluate the economic impact, to assess the likely behaviour of the affected stakeholders in the new market environment, and the consistency or otherwise with the wider European regulation and targets. Specifically, the main Reform points to be addressed are:

- The Reform supersedes the current RES support scheme by Feed-in-Tariff system by a new system based on benchmark competition against reference facilities. The support scheme is intended to be based on investment (MW) rather than operational (MW-h) aid, although it also considers operational aid in the case of biomass or CHP facilities.
- The Reform introduces changes in the access tariff and the introduction of a new backup tariff that impacts on the economics of distributed generation, and specially PV-DG.
- The Reform modifies the Capacity Reliability Mechanisms. It considers both a firmness and an adequacy payment. It allows for auctions in order to guaranty the system reliability. It also considers a novel auction mechanism to mothball CCGT stations under the current circumstances of depressed demand.
- The Reform also touches on Transmission and Distribution remuneration, establishing a return on the implied Regulatory Asset Basis linked to the yield of the Spanish Treasury Bill.
- Finally, the Reform addresses the isolated Balearic and Canary islands systems that uniquely in Europe are open to competition for the market whereas they are operated by the ISO and remunerated according a standard cost methodology.

The paper concludes that the Reform might be an appropriate blueprint. Furthermore, the Reform clearly distinguishes between “rules” (e.g. benchmark competition for RES) and “parameters” (e.g. reference RES facilities specification). The Reform success will critically depend on these “parameters” being defined in a predictable, consistent and fair manner.

Session 16.30 – 18.00
Industry and Energy Prices

Room: B37
Chair: Julia Michaelis (Fraunhofer ISI)

The Merit Order of Demand Response in Industry
Anna Gruber, Serafin von Roon, Franziska Biedermann (Research Association for Energy Markets and Technologies)

Development of transmission and distribution grid charges and of their regional differences in Germany
Fabian Hinz (TU Dresden)

Social Effects in the Diffusion of Solar Photovoltaic Technology in the UK
Laura-Lucia Richter (University of Cambridge)

Assessment of industrial energy prices
Katharina Grave (Ecofys), Martin Pudlik (Fraunhofer ISI)

The Merit Order of Demand Response in Industry

Anna Gruber, Serafin von Roon, Franziska Biedermann (Research Association for Energy Markets and Technologies)

The ambitious objectives of the German "Energiewende" can be achieved by different measures, such as grid expansion or installation of storages. Another possibility is the matching of power demand with supply, which is also referred to as Demand Response.
Flexibilization of load can be achieved by on- and off-switching respectively in- or decrease the load of electrical units. Also the generation of companies' own electricity generation plants can be varied. The technical potential of these flexible loads is - compared to other sectors - relatively high. In general, there are two different types of flexible loads. On the one hand there are energy-intensive processes, which can vary their load, on the other hand also cross-sectional technologies like ventilation systems or refrigerating machines are suitable for offering flexible loads. The technical potential is about 2.000 MW for energy-intensive processes /FFE-01 14/ and about 800 to 1.400 MW for cross-sectional technologies /DIW-02 13/ (in each case: for a duration of one hour).
In order to quantify the economic potential the analysis of costs for Demand Response is necessary. The occurring costs can be divided into initial costs (investments), fixed operating costs and variable costs. The results of a survey show that the costs for Demand Response of cross-sectional technologies are dominated by the initial costs whereas the variable costs are almost negligible. These findings will be validated.
Additionally, the costs for energy-intensive processes will be quantified. Usually, for these branches the initial costs are very low so that they do not influence the profitability for Demand Response of energy-intensive processes. On the other hand, variable costs play an important role in case a loss of production occurs. With an increasing number of activation the variable costs are increasing, therefore there is a need to also quantify the opportunity costs. Input values are for instance prices of raw materials as well as world market prices for commodities.
By matching the costs of cross-sectional technologies and energy-intensive processes with the technical potentials, the Merit Order for Demand Response in industry can be determined. On this basis, a comparison with other functional energy storages is possible.

Keywords: Demand Response, flexibilization of load, energy-intensive processes, cross-sectional technologies, cost analysis

Development of transmission and distribution grid charges and of their regional differences in Germany

Fabian Hinz (TU Dresden)

Final electricity prices in Germany contain grid charges, which depend on the location the customer is connected to the grid. Grid charges vary for household customers in the range between 4 and 9.5 Cent/kWh. For industry customers charges also depend on the voltage level they are connected to and range between 1 and 3 Cent/kWh on average. The charge depends on the specific transmission and distribution grid structure. Strong regional differences in grid charges can be observed throughout Germany. In the Eastern part, grid charges for household customers are on average about 1.5 Cent/kWh higher than in the West. This has two main causes: First, strong investments in transmission and distribution infrastructure were necessary after the reunification in the 1990s, which in accordance with German regulations are being recovered by means of grid charges. Second, the Eastern part of Germany is less densely populated and shows a lower electricity consumption density, which leads to higher grid cost per kWh consumed.

The integration of (increasing amounts of) renewables necessitates extensions of transmission and distribution grids. In areas with high amounts of renewables this could lead to an increase of grid fees above average and thus to an additional effort for customers in these areas. The research question is: how will grid charges for transmission and distribution grids develop in the next years and will regional differences of grid charges continue to increase? For this purpose a model, considering investments in transmission and distribution grids as well as demographic trends, is developed. The model predicts grid charges for household and industry customers on district (“NUTS3 – Nomenclature of Territorial Units for Statistics 3”) level.

The projections show that differences in transmission grid charges (of the four transmission system operators) are getting smaller, whereas distribution grid costs grow more apart. Besides, an asymmetry in regional grid charges can be observed, with a relatively small share of customers paying disproportionately high charges.

Keywords: grid charge, electricity price, grid extension cost, renewable integration, demography

Social Effects in the Diffusion of Solar Photovoltaic Technology in the UK

Laura-Lucia Richter (University of Cambridge)

The main research question in this paper is whether the installation rate of solar PV technology is affected by social spillovers from spatially close households. The installed base, defined as the cumulative number of solar PV installations within a neighbourhood by the end of a particular month, serves as a measure for the social effects of interest. Motivated by the technology-specific time lag between the decision to adopt a solar PV panel and the completion of the installation, the third lag of the installed base serves as main regressor of interest in the panel data model employed. The results suggest small, but positive and significant social effects that can be exploited to promote adoption: at the average installation rate of 0.7 installations per 1,000 owner-occupied households, one more solar PV panel in the postcode district increases the installation rate three months later by one percent. At the average number of 6,629 owner-occupied households within a postcode district, this implies an increase in the number of new installations in the neighbourhood by 0.05. Projects involving a high number of installations could hence promote diffusion. A major limitation of the model is that social spillovers are assumed to spread within defined neighbourhoods, only. Spatial econometric methods could allow for social effects across these borders.

Keywords : social effects, installed base, diffusion, solar PV technology, micro-generation

Assessment of industrial energy prices

Katharina Grave (Ecofys), Martin Pudlik (Fraunhofer ISI)

In the context of the German renewable energy law (EEG), there is a highly controversial debate about distributional effects of payments. In 2014, consumers pay more than six Cents per kilowatt-hour to finance the deployment of renewable energy sources. Energy intensive industrial consumers can apply for reduced surcharges. If specific criteria are met, they pay less than 1% of the full levy. At the same time they profit from decreasing wholesale electricity prices. These are lower than in neighbouring countries, partly because of increasing infeed from renewable energy sources (merit order effect). In this context Germany is accused by the European Commission for illegal subsidies. Also, full paying consumers in Germany protest, because they have to bear a higher burden. The industrial consumers themselves protest and point to their "real" power prices – because of long term contracts they do not profit from the spot market as fast as the politicians suggest.

We would like to base the discussion on sound numbers and analyse the acquisition strategies of industrial power consumers. From the results of questionnaires, we sketch a generic acquisition strategy for big energy intensive customers. The strategy combines payments for long term and short term contracts. Future prices at stock exchanges are assumed to reflect prices paid for long-term contracts of up to two years. For the short term power acquisition, day ahead prices are taken into account. Data from the stock exchanges EEX and EPEX are used to calculate average prices that are paid by industries in Germany. A time series analysis shows developments since 2006. In comparison to wholesale market prices, a diversified acquisition strategy balances out price differences. The drop in average electricity prices on wholesale markets is not directly lowering prices for industrial customers, but decreasing forward prices reduce payments by customers also in the future.

Keywords: energy-intensive industry, electricity prices, wholesale prices

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Prof. Dr. Dominik Möst

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Postal address
TU Dresden
01062 Dresden

Visiting adress
Münchner Platz 3
Georg-Schumann-Bau,
A 404

Internet
http://www.ee2.biz