TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

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

8th Conference on Energy Economics and Technology

Energy Policies and Market Design in Europe

19th April 2013, TU Dresden

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ENERDAY

8th Conference on Energy Economics and Technology

Energy Policies and Market Design in Europe

Book of Abstracts

19th April 2013

Technische Universität Dresden, Faculty of Business and Economics
Münchner Platz 3, Schumann-Bau / Hülsse-Bau D-01069 Dresden, Faculty Assembly Hall

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Foreword

Dear participants of 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 8th Conference on Energy Economics and Technology focusing this year on Energy Policies and Market Design in Europe.

The objective of the ENERDAY is to address challenges for energy markets, policies and energy systems, in particular concerning the integration of renewable resources. Energy markets are more and more impacted by the continuous increase of energy, especially electricity, from renewable sources. This implies new challenges with respect to security of supply, cost efficiency, profitability of conventional technologies as well as sustainability. Up to now mainly conventional power plants are responsible for system services and security of supply. In the coming years system responsibility has to be taken more and more by technologies based on renewable resources. A harmonized sometimes so called "energy policy and market design 2.0" is necessary for a well-functioning power market. Therefore, the ENERDAY shall provide a platform for intensifying the dialogue between economic and technical issues.

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, the city's utility.

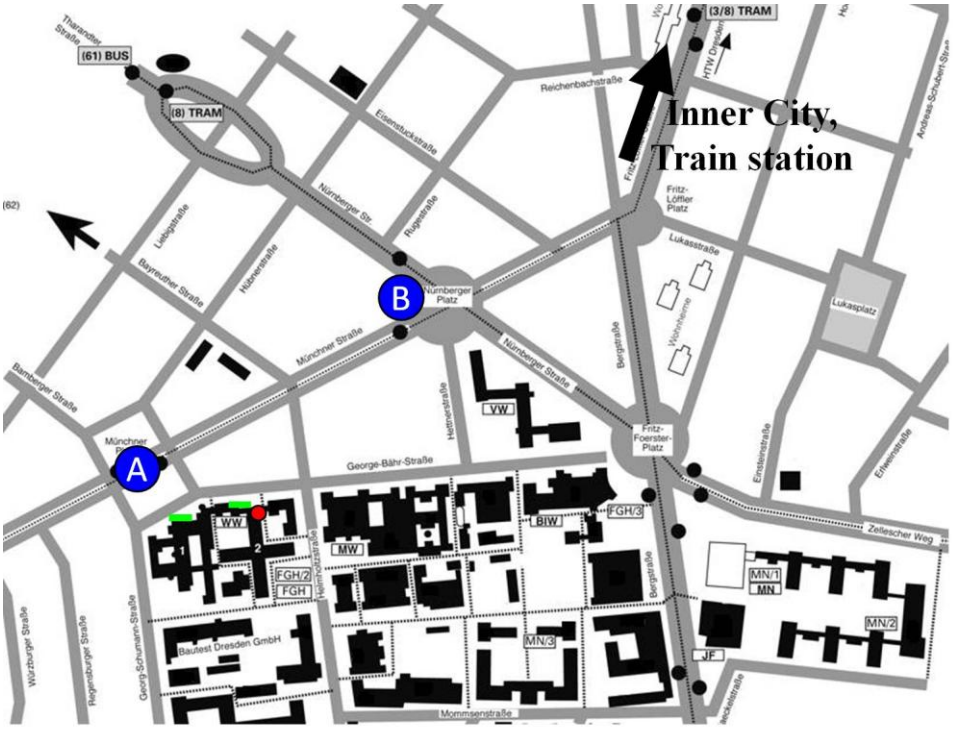
As the organizers of the conference, we were delighted with the very good attendance, which is reflected in the internationality and interdisciplinarity of the participants and the scope of the contributed talks. This year we were again surprised and encouraged by the amount of submitted contributions. More than twice as much submission in comparison to the available presentations slots has been submitted. Thus we were forced to a very stringent and strong selection of submissions based on scientific criteria's. We are pleased to be able to make a contribution to a fruitful exchange of scientific approaches and their practical application in the field of an "energy policy and market design 2.0". 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
Faculty of Business and Economics
Münchner Platz 3
Schumann-Bau / Hülsse-Bau
D-01069 Dresden,
Faculty Assembly Hall / Festsaal der Fakultät



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:

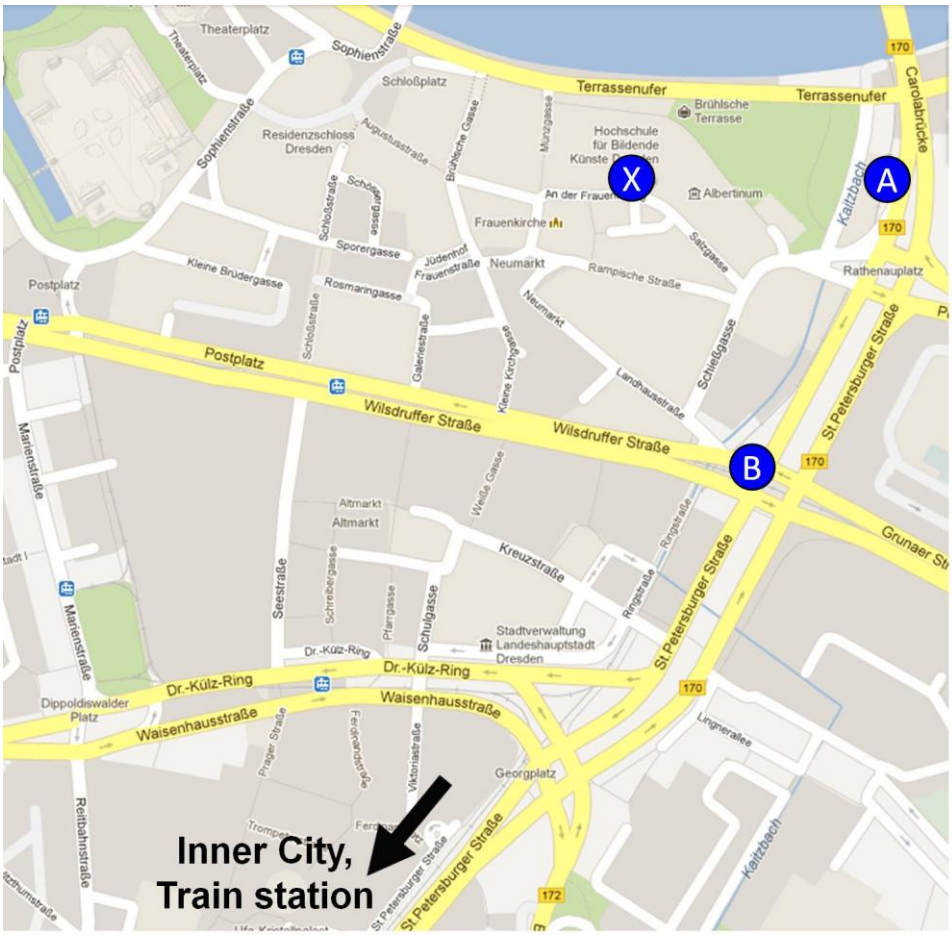
From the **airport** take the S-Bahn line S2 on the lower ground floor of the terminal building and drive up to the main train station ("Hauptbahnhof"). Then take the tram No. 3 (direction: Coschütz) and get off at "Münchner Platz".

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. 61 (direction: Weißig / Fernsehturm) up to "Nürnberger Platz".

From the **East** take the bus No. 61 (direction: Löbtau) up to "Nürnberger Platz".

Conference Dinner



Friday,
19th April 2013,
7 pm

Coselpalais
An der Frauenkirche 12
01067 Dresden
www.coselpalais-dresden.de

A Tram station:
Synagoge, Line 3

B Tram station:
Pirnaischer Platz, Line 3

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 "Pirnaischer Platz" turn left, then immediately turn right into "Landhausstraße" and then turn left into "Schiessgasse". Try to find a parking lot or basement garage around Neumarkt.

By tram / bus (about 20 minutes):

Tram Line 3 will take you directly from the University to the Conference Dinner (tram leaves every 10 minutes). Take the tram No. 3 (direction: Wilder Mann) and get off after seven stops at „Synagoge". Walk back and turn right into „Akademiestraße". Then turn right into „Salzgasse" and walk ahead. The Coselpalais is on the left-hand side (about 5 minutes to walk from the tram station „Synagoge").

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Conference program

Informal Get Together: Thursday, 18th April, 6 pm, Location: Paul Rackwitz, Plauenscher Ring 33, Dresden

Conference program, 19th April in the morning

8:15 h	Registration, Coffee & Tea (Room: Faculty Assembly Hall)		
8:45 h	**Opening Address (Room: Faculty Assembly Hall)** Prof. Dr. Udo Buscher, Vice-Dean of the Faculty of Business and Economics, TU Dresden Prof. Dr. Christian von Hirschhausen, TU Berlin WIP, and DIW Berlin Prof. Dr. Dominik Möst, TU Dresden, EE^2		
9:15 h	**Keynote Speech (Room: Faculty Assembly Hall)** Christian Dobelke, Tennet TSO GmbH: Old markets - new markets: an internal energy market beyond 2014? Chair: Prof. Dr. Dominik Möst, TU Dresden, EE^2		
10:00 h	Coffee & Tea		
10:30 h - 12:30 h	**Market design (Room: Faculty Assembly Hall)** Chair: Theresa Müller, TU Dresden	**Renewables and promotion schemes (Room: A 03)** Chair: Michael Zipf, TU Dresden	**System aspects in energy markets (Room: B 37)** Chair: Daniel Schubert, TU Dresden
10:30 h	**Disentangling the German discussion on capacity mechanisms** Jenny Winkler (Fraunhofer ISI), Dogan Keles (KIT), Lea Renz (KIT), Frank Sensfuß, Massimo Genoese, Wolf Fichtner	**The future of the EEG – small reform or revolution?** Christoph Gatzen (Frontier Economics)	**A new modelling tool to analyse challenges of the EU energy system** Leonidas Mantzos (European Commission Joint Research Centre), Peter Russ, Tobias Wiesenthal, Antonio Soria
10:50 h	**Auction design for a strategic reserve market for generation adequacy: on the incentives under different auction scoring rules** Gert Brunekreeft, Roland Meyer (Jacobs University Bremen), Margarethe Rammerstorfer (Vienna University of Economics and Business)	**Requirements of a Transformation to High Shares of Renewable Energy Sources - A Case Study for the Berlin-Brandenburg Region, Germany** Caroline Möller, Berit Müller, Markus Hlusiak, Jochen Twele (Reiner Lemoine Institut gGmbH)	**Exploring the functional organization of a fully renewable pan-European electricity system - let the weather decide** Martin Greiner, Gorm Andresen, Rolando Rodriguez (Aarhus University), Sarah Becker (Frankfurt Institute for Advanced Studies)
11:10 h	**Do we need an additional flexibility market in the electricity system? – A system-economic analysis for Europe –** Joachim Bertsch, Christian Growitsch, Stefan Lorenczik, Stephan Nagl (University of Cologne)	**Promoting renewable energy without hurting the poor when production costs are uncertain** Elisabetta Cornago, Antonio Estache (Université libre de Bruxelles), Renaud Foucart (Oxford University)	**Modeling the mid-term development of the energy system in Poland with the use of TIMES-PL model** Marcin Pluta, Artur Wyrwa, Janusz Zyśk (AGH University of Science and Technology)
11:30 h	**Structural versus Behavioral Remedies in the Deregulation of Electricity Markets: An Experimental Investigation Guided by Theory and Policy Concerns** Silvester van Koten (European University Institute), Andreas Ortmann (University of New South Wales)	**Potential imports of electricity from North Africa and policy implications** Christoph Kost (Fraunhofer ISE), Thomas Schlegl, Dominik Möst (TU Dresden)	**Combining Energy Networks: The Impact of Europe's Natural Gas Network on Electricity Markets till 2050** Hannes Weigt (University of Basel), Jan Abrell, Clemens Gerbaulet, Franziska Holz
11:50 h	**Economic Analysis of Capacity Remuneration Mechanism Design in Consideration of International Experiences** Thorsten Beckers, Albert Hoffrichter, Christian von Hirschhausen (Berlin Institute of Technology)	**Combining feed-in tariffs and tenders to support renewable electricity** Thilo Grau (DIW Berlin)	**Attitudes and Preferences towards for Electric Vehicles. What characteristics and policies do people value most?** Claudia Aravena, Eleanor Denny (Trinity College Dublin)
12:30 h	Lunch (Room: in front of the Faculty Assembly Hall)		

Conference program, 19th April in the afternoon

13:30 h	**Keynote Speech (Room: Faculty Assembly Hall)** Prof. Dr. Felix Müsgens, BTU Cottbus: Electricity Market Design – How (and When) can RES compete? Chair: Prof. Dr. Christian von Hirschhausen, TU Berlin WIP and DIW Berlin		
14:15 h - 15:45 h	**Control and balancing energy markets (Room: Faculty Assembly Hall)** Chair: Christoph Kost, Fraunhofer ISE	**Power Grids (Room: A 03)** Chair: David Gunkel, TU Dresden	**Security of supply (Room: B37)** Chair: Alexander von Selasinsky, TU Dresden
14:15 h	**Control Power and Variable Renewables: A Glimpse at German Data** Lion Hirth, Inka Ziegenhagen (Vattenfall GmbH)	**A prototypic implementation of an optimizing network expansion planning model considering the value perspective of the company and the effects of mono-poly regulation in the objective function.** Stefan Schnabel (Vattenfall Europe Distri-bution Berlin GmbH), Robert Kunze (KIT)	**The German 'Energiewende' and Security of Supply: An assessment of power interruption costs in Germany** Christian Growitsch, Raimund Malischek, Sebastian Nick, Heike Wetzel (University of Cologne)
14:35 h	**Reserve energy market integration in Germany and the northern alpine region** Clemens Gerbaulet, Alexander Weber (Berlin Institute of Technology)	**Cost Benefit Analysis of Transmission Grid Expansion in the Central and Eastern Europe Electricity Market** Günther Körbler, Georg Lettner,Hans Auer (Vienna University of Technology)	**The blackout in Munich: how do households value security of supply?** Daniel Schubert, Alexander von Selasinsky, Thomas Meyer, Dominik Möst (TU Dresden)
14:55 h	**Evaluation of hydrogen storage systems for surplus electricity in the German Energy Sector** Julia Michaelis, Fabio Genoese, Prof. Martin Wietschel (Fraunhofer ISI)	**European Electricity Grid Infrastructure Expansion in a 2050 Context** Jonas Egerer, Clemens Gerbaulet, Casimir Lorenz (Berlin University of Technology)	**Money on the right table – Hedging the risk of bottlenecks in the Nordic market** Mats Nilsson (Vattenfall AB), Tobias Johansson
15:15 h	**Optimizing the procurement of ancillary services; a market model proposal for electricity systems with large shares of renewables.** Timon Dubbeling (Sciences Po Paris)	**Renewable curtailment and its impact on grid and storage capacities in 2030** Theresa Müller, David Gunkel, Dominik Möst (TU Dresden)	**Merchant and Regulated Transmission Investment: The Case of the Baltic Sea Region** Alexander Weber, Clemens Gerbaulet (Berlin Institute of Technology)
15:45 h	Coffee & Tea		
16:30 h - 18:00 h	**Congestion management (Room: Faculty Assembly Hall)** Chair: Friedrich Kunz, DIW	**Renewables and smart grids (Room: A 03)** Chair: Hannes Hobbie, TU Dresden	**Fuel Markets (Room: B37)** Chair: Julia Michaelis, Fraunhofer ISI
16:30 h	**The Benefit of Coordinating Congestion Management in Germany** Friedrich Kunz, Alexander Zerrahn (DIW Berlin)	**Highly resolved simulation of feasible pathways to a renewable power system in Germany and Austria – Is storage really a limiting component?** Gerhard Totschnig, Johannes Radl, Andre Ortner (Vienna University of Technology)	**What Drives Natural Gas Prices? – A Structural VAR Approach** Sebastian Nick, Stefan Thoenes (University of Cologne)
16:50 h	**An integrated approach to model redispatch and assess potential benefits from Market Splitting in Germany** Katrin Schmitz, Michael Bucksteeg, Christoph Weber (University Duisburg-Essen)	**The mechanism of the "Grid signal light" as a part of the Smart Market/Grid System – the cooperation between Customers, Energy Logistics, Grid and Regulation** Holger Wiechmann (EnBW Vertrieb *GmbH*), Kai Hufendiek (EnBW AG)	**Testing Common Myths on Fuel Prices** Sebastian Kreuz, Felix Müsgens (Brandenburg University of Technology)
17:10 h	**Economic Potential of the "Power-to-Heat" Technology in the 50Hertz Control Area** Mario Götz, Diana Böttger, Hendrik Kondziella, Thomas Bruckner (University of Leipzig)	**Competition between different flexibility alternatives in electricity markets with a high share of intermittent renewable energy sources** Brunner, Christoph (EnBW AG)	**The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model** Franziska Holz, Philipp Richter (DIW Berlin), Ruud Egging (SINTEF Technology and Society)
17:30 h	**Management of a Medium Voltage Distribution Network with Distributed Generation** Michał Wierzbowski, Błażej Olek (Lodz University of Technology)	**Synergies between EE, RE and CO2 targets** Karsten Neuhoff (DIW Berlin)	**Central Asian Gas in Eurasian Power Game** Onur Cobanli (Humboldt–Universität zu Berlin)
19:00 h	Conference Dinner (Coselpalais, An der Frauenkirche 12, D-01067 Dresden)		

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Session 16.30 – 18.00

Congestion management

Renewables and smart grids

Fuel Markets

Keynotes

9.15 – 10.00

Old markets - new markets: an internal energy market beyond 2014?
Christian Dobelke (Tennet TSO GmbH)

13.30 – 14.15

Electricity Market Design – How (and When) can RES compete?
Prof. Dr. Felix Müsgens (BTU Cottbus)

Session 10.30 – 12.30
Market design

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

Disentangling the German discussion on capacity mechanisms
Jenny Winkler (Fraunhofer ISI), Dogan Keles (Karlsruhe Institute of Technology), Lea Renz (Karlsruhe Institute of Technology), Frank Sensfuß, Massimo Genoese, Wolf Fichtner

Auction design for a strategic reserve market for generation adequacy: on the incentives under different auction scoring rules
Gert Brunekreeft (Jacobs University Bremen), Roland Meyer (Jacobs University Bremen), Margarethe Rammerstorfer (Wirtschaftsuniversität Wien)

Do we need an additional flexibility market in the electricity system? - A system-economic analysis for Europe -
Joachim Bertsch (University of Cologne), Christian Growitsch (University of Cologne), Stefan Lorenczik (University of Cologne), Stephan Nagl (University of Cologne)

Structural versus Behavioral Remedies in the Deregulation of Electricity Markets: An Experimental Investigation Guided by Theory and Policy Concerns
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Economic Analysis of Capacity Remuneration Mechanism Design in Consideration of International Experiences
Prof. Dr. Thorsten Beckers, Albert Hoffrichter, Prof. Dr. Christian von Hirschhausen (Workgroup for Infrastructure Policy (WIP), TU Berlin)

Disentangling the German discussion on capacity mechanisms

Jenny Winkler (Fraunhofer ISI), Dogan Keles (Karlsruhe Institute of Technology), Lea Renz (Karlsruhe Institute of Technology), Frank Sensfuß, Massimo Genoese, Wolf Fichtner

In Germany, capacity mechanisms are currently discussed as an option to increase investment incentives for conventional power plants and other flexibility options and to guarantee the future security of electricity supply. Several concrete proposals for capacity market designs were published in the last two years (e.g. BET 2011, Consentec 2012 , ewi 2012, r2b 2012, WWF 2012). However, there is still considerable disagreement regarding the concrete design of the future electricity market:

1) The demand for additional conventional power plants capacities is still unclear. The current system margin highly depends on the capacity credits given to renewable electricity generation as well as international interconnectors and assumptions regarding the availability of balancing plants. Regarding the future need for capacities, expectations and modeling results deviate substantially subject to differing assumptions regarding the development of electricity demand, residual load, capacity credits and the realization of currently planned power plants as well as decommissioning of existing power plants
2) There are also some doubts about whether the current electricity market can deliver sufficient investment signals. The current low prices at the EPEX spot market cannot be taken as a proof for market failure, as they can also be explained by existing overcapacities due to the European market integration and increasing electricity generation from renewables as well as low emission certificate prices. An incremental adaptation of electricity markets in order to increase incentives for flexibility seems possible.
3) In order to design an efficient capacity mechanism, its objective must be clearly defined, which is not currently the case in the German discussion. In addition, future capacity demand must be precisely estimated in order to avoid overcapacities. Furthermore, there are several interdependencies between capacity mechanisms and the energy market which are not yet understood in detail. Maintaining a fair competition between several and partly still unknown options for flexibility in a capacity mechanism seems difficult. As a consequence of these challenges, the appropriate design of an efficient capacity mechanism is complicated. False parameterization can however lead to high additional costs.

The contribution will demonstrate in detail the need for additional research in the context of a future electricity market design. As a result, it will be shown that the introduction of a capacity mechanism at the moment is premature due to existing uncertainties and potential unwanted effects.

Auction design for a strategic reserve market for generation adequacy: on the incentives under different auction scoring rules

Gert Brunekreeft (Jacobs University Bremen), Roland Meyer (Jacobs University Bremen), Margarethe Rammerstorfer (Wirtschaftsuniversität Wien)

The challenge of large-scale integration of renewable energy sources into European electricity markets has raised the discussion on capacity mechanisms to ensure generation adequacy. One of the discussed mechanisms is a strategic reserve to be acquired through a central auction.

This article analyzes the welfare effects of different auction designs for a strategic reserve. Similar to operating reserves, the auction for a strategic reserve involves multi-part bidding, i.e. generators simultaneously hand in a capacity bid for withholding a certain amount of capacity from the regular electricity market, and an energy bid for the amount of energy that will actually be dispatched.

The focus is on two scoring mechanisms that can be used to determine the winning bids in the auction. In case of a simultaneous scoring rule, capacity and energy bids are weighted and combined to a single score based on which the cheapest bids are selected. Under sequential scoring rule the selection depends solely on capacity bids (at the first stage), while the energy bids are used (at the second stage) to determine the merit order for dispatch. An example for sequential scoring is the auction for minute reserves in the German market for operating reserves applied by the four transmission system operators.

The main difference between the simultaneous and sequential scoring mechanism is that under sequential scoring the bids are biased towards lower capacity bids and higher energy bids, since it is the capacity bid that "opens the door" to the reserve market irrespectively of the energy bid. By contrast, a simultaneous scoring rule incentivizes generators to balance their capacity and energy bid according to the weighting factor applied in the scoring rule.

We find that a simultaneous scoring is favorable from a welfare perspective, since it avoids the strategic incentives for excessive mark-ups on energy costs and limits the incentives for collusive behavior. This reduces the risk of inefficient selection and dispatch of reserve units compared to a sequential scoring mechanism.

Keywords: electricity market, market design, capacity mechanisms, auction design

Do we need an additional flexibility market in the electricity system? - A system-economic analysis for Europe -

Joachim Bertsch (University of Cologne), Christian Growitsch (University of Cologne), Stefan Lorenczik (University of Cologne), Stephan Nagl (University of Cologne)

The EU member states have declared to strongly increase the share of Renewable Energy Sources in the next decades. Given a large deployment of wind and solar capacities as well as limited cost-efficient storage technologies, this has two major impacts on electricity systems. First, the electricity system has to be flexible enough to cope with the volatile RES-E generation i.e. ramp up supply or ramp down demand on short notice. Second, sufficient back-up capacities are needed for times with low feed-in from wind and solar capacities. The provision of both back-up capacity has been intensively discussed in the previous literature of recent years (for instance Cramton and Stoft, 2008 and Joskow, 2008). In addition, Lamadrid et al (2011) argue that with increasing volatility, incentives to invest in flexible resources should be implemented in market design. However, they did not have a look at the dynamic view in an integrated analysis necessary to answer the questions of how an electricity system can adapt to an increasing share of renewables. This paper therefore analyses the flexibility requirements of the future European electricity system and the policy implications for market design with a system-economic dynamic approach. For this purpose, we simulate the development of the European electricity markets up to 2050 by using a linear investment and dispatch optimization model. Flexibility requirements are implemented in the model via constraints for ramping and provision of balancing power. We find that although an increase of fluctuating renewables has a tremendous impact on volatility and therefore flexibility requirements, the main trigger for investments into flexible conventional capacity are the achievable full load hours rather than ramping capabilities. Therefore any market design with investment incentives of achievable full load hours does not need additional incentives for flexibility.

Keywords: Electricity, market design, power plant fleet optimization, renewable energy, flexibility

Structural versus Behavioral Remedies in the Deregulation of Electricity Markets: An Experimental Investigation Guided by Theory and Policy Concerns

Silvester van Koten (European University Institute), Andreas Ortmann (University of New South Wales)

We experimentally study the effects of introducing a forward market and of increasing the number of competitors in a quantity-setting market. Our key interest was to better understand which of these two remedies enhances competition. Allaz and Vila (1993) theoretically showed that forward markets can have a pro-competitive effect. Le Coq and Orzen (2006) and Brandts, Pezanis-Christou and Schram (2008) experimentally investigated similar issues. All three experiments (including ours) support the prediction by Allaz and Vila (1993) – that introducing a forward market does indeed intensify competition. The results of the present study, however, differ from previous experimental results. In our experiment, the forward market is a more effective remedy than increasing the number of competitors. We argue that our results differ from Brandts et al.'s (2008) because they increased the number of competitors by entry, which thus increased the asset base and made production cheaper. In contrast, we increased the number of competitors by divestiture, which left the asset base constant. Our results address an important policy issue and provide tentative evidence on the competition-enhancing effect of forward markets, which are considered a behavioral remedy and are favored by the European Commission.

Keywords: European Electricity Markets, Economics Experiments, Remedies, Forward Markets, Competition Policy

Economic Analysis of Capacity Remuneration Mechanism Design in Consideration of International Experiences

Prof. Dr. Thorsten Beckers, Albert Hoffrichter, Prof. Dr. Christian von Hirschhausen (Workgroup for Infrastructure Policy (WIP), TU Berlin)

The question of choosing an effective and efficient form of financing electricity generating infrastructure has been broadly discussed in the sector over the last decades. In recent years the topic of applying capacity remuneration mechanisms (CRM) emerged to one of the major and most controversially discussed questions in energy debates across Europe. In Germany, there is an observable tendency that experts approve rationales for capacity based income streams in general, whilst the specific design of a capacity remuneration instrument is still vividly discussed. With this paper we try to contribute to the discussion on the latter by assessing international experiences with the usage of CRMs. Picking up on analyses on the functioning and characteristics of general basic forms of CRMs, we use an applied institutional economic approach and focus on the ability of diverging institutional settings to play a part in contributing to the achievement of the underlying objectives (i. e. mainly security of supply, cost from a welfare and a consumer perspective, environmental objectives). The empirical findings from the preselected five international markets support the conceptional work's suggestions that the basic models of a strategic reserve and capacity options might provide a reasonable framework in certain scenarios. Moreover they lead us to the conclusion that the choice of the 'correct' CRM itself does not yet guarantee a well performance of the institutional setup. Quite the contrary, all analysed systems require an in-depth planning to account for the specific circumstances of their environment. Especially those schemes which aim at creating a comprehensive competition by including a large variety of different technical options display a need of detailed planning to orchestrate this competition. Aiming at a design where 'market forces' do the greatest possible share of the work by themselves, seems to be an unrewarding strategy, whereas building up central know-how is likely to be a no-regret option when it comes to introducing a CRM, as the construction, parameterization, monitoring and adjustment poses a challenging task to the planner.

The paper is based on content derived from a TU Berlin-WIP research project and comprehensively picks up on findings from the ongoing BMU (German Federal Environment Ministry) funded project 'Weiterentwicklung des Sektor-/Marktdesigns im Rahmen der Transformation des Stromsystems'.

Keywords: applied institutional economics, electricity market design, capacity remuneration mechanisms, case study analyses

Session 10.30 – 12.30
Renewables and promotion schemes

Room: A 03
Chair: Michael Zipf (TU Dresden)

The future of the EEG – small reform or revolution?
Christoph Gatzen (Frontier Economics)

Requirements of a Transformation to High Shares of Renewable Energy Sources - A Case Study for the Berlin-Brandenburg Region, Germany
Caroline Möller, Berit Müller, Markus Hlusiak, Jochen Twele (Reiner Lemoine Institut gGmbH)

Promoting renewable energy without hurting the poor when production costs are uncertain
Elisabetta Cornago (Université libre de Bruxelles), Antonio Estache (Université libre de Bruxelles), Renaud Foucart (Oxford University)

Potential imports of electricity from North Africa and policy implications
Christoph Kost (Fraunhofer ISE), Thomas Schlegl (Fraunhofer ISE), Dominik Möst (TU Dresden)

Combining feed-in tariffs and tenders to support renewable electricity
Thilo Grau (DIW Berlin)

The future of the EEG – small reform or revolution?

Christoph Gatzen (Frontier Economics)

The German Renewable Support Act (EEG) has proven to be a very effective instrument to achieve the renewable electricity targets in Germany. However, the recent increase of the EEG levy from 3.6 €ct/kWh in 2012 to 5.3 €ct/kWh in 2013 has sparked the discussion about the future of design of the German renewable support scheme. Our simulations show that without reforms the EEG levy will further increase by 1.7 €ct/kWh until 2022. To reduce the costs while keeping the ambitious renewable targets we analyse two types of interventions: first, we consider reforms within the current EEG framework and second complete revision of the EEG. We find that significant savings can be achieved within in the current EEG framework. Our simulation results show that technology neutral feed-in tariffs can lower the EEG levy by 0.6€ct/kWh until 2022. We furthermore discuss the switch from feed-in tariffs to direct marketing of renewables in a quota or premium system. An efficient power market design requires that renewable generation face competition by conventional generation. At the same time, further savings of at least 0.1€ct/kWh can be obtained. In the long run, the question arises whether investment incentives into renewable generation will come from the European trading scheme (EU ETS).
All quantitative results in our study are derived by an intertemporal optimisation model which determines future capacity development of renewables in Germany until 2035.

Keywords: German Renewable Support Act, feed-in tariffs, direct marketing, European trading scheme

Requirements of a Transformation to High Shares of Renewable Energy Sources - A Case Study for the Berlin-Brandenburg Region, Germany

Caroline Möller, Berit Müller, Markus Hlusiak, Jochen Twele (Reiner Lemoine Institut gGmbH)

Germany's energy politics have made the decision to transform the electricity supply to very high shares of renewable energy sources. Opinions on what transformation steps are necessary to meet this target diverge significantly within politics and society. The major difference between opinions is to favour either the expansion of the electricity grid or decentralise the energy system. As a case study for possible future energy scenarios, we present an analysis on the distribution of different power plants and storage solutions in the Berlin-Brandenburg region in the northeast of Germany. This region comprises the capital city Berlin with high population density and high energy consumption and the surrounding Brandenburg with much lower population density and therefore more available space for setting up renewable energy installations. In addition, Brandenburg features significant lignite based electricity generation capacities, which, according to Brandenburg's "Energy Strategy 2030", should be maintained in the long term. Our study is based on combined simulations of the electricity supply and demand in both, Berlin and Brandenburg, considering economic aspects. Using the simulations, cost optimised scenarios were determined. Results for required installed capacities in an 80% renewables scenario in the year 2020 are: 8.8 GW wind energy, 4.8 MW photovoltaics, 0.4 GW bioenergy, 0.6 GW methanation and a gas storage capacity of 180 GWh. To cover the residual load a capacity of thermal power plants of around 3 GW is needed. To reach these figures energy policies must be prioritised. Suggestions are plenty and address decision makers in various fields of energy politics. They include the reduction of energy consumption, the increased installation of photovoltaics and wind turbines, the acceleration of the market launch of methanation systems and the exact design of the thermal backup generation system. One main outcome of our study is that installed capacities required for an 80 % renewable electricity supply are not significantly higher than currently planned by both federal state governments.

Keywords: Energy Transition, Energy Strategy, Energy System Simulation, Scenarios, Cost Optimisation

Promoting renewable energy without hurting the poor when production costs are uncertain

Elisabetta Cornago (Université libre de Bruxelles), Antonio Estache (Université libre de Bruxelles), Renaud Foucart (Oxford University)

We study the consequences of fostering green electricity while subsidizing the poor, in the presence of uncertainty on the production costs of renewable energy. We show how a price instrument and a quantity instrument are not equivalent when it comes to the impact of a wrong estimation. An identical error in the estimation of the costs of renewable energy leads to the opposite effect in terms of final pollution and cost of subsidies, depending of the policy tool being used.

We build up a partial equilibrium model of the electricity market assuming the market price of conventional electricity is constant, while the market price of renewable energy is marginally increasing and higher than the cost of conventional energy. We consider two different policies:

1. A *feed-in tariff*, whereby the production of renewable-based electricity receives a per-unit subsidy financed by a tax levied on non-poor consumers.
2. A *mandatory share of RES-E* the producers have to sell, either by producing it or by buying it on the secondary market at its marginal cost.

Choosing between these two policy options to promote renewables while committing to a low electricity price for the poor, a government needs to estimate production costs of green electricity. We simulate two opposite estimation mistakes and study their effect on market outcomes under a quantity-based scheme and under a price-based scheme. This translates into comparing alternative scenarios with respect to (i) the sales price of electricity, (ii) the overall quantity of produced electricity and its green vs. fossil component, (iii) the quantity of pollution generated by electricity production and (iv) the fiscal cost of subsidizing poor consumers as well as green energy producers.

Our results offer relevant policy recommendations for governments willing to protect the consumers on the verge of energy poverty while accelerating the transition towards a more sustainable energy mix.

Keywords: prices vs. quantities, renewables, equity, uncertainty

Potential imports of electricity from North Africa and policy implications

Christoph Kost (Fraunhofer ISE), Thomas Schlegl (Fraunhofer ISE), Dominik Möst (TU Dresden)

A two-step approach combining an optimized investment planning model for new plant capacities (conventional capacities and renewable energy sources) and an optimal operation dispatch especially was developed to cover the design of the existing power market in North Africa and the need for a future interconnected Mediterranean electricity exchange. As a key issue this modeling approach includes the existing conventional power plant system in the analysis and connects it with a high-resolution renewable energy generation. Also grid extensions between local areas via HVDC lines and the intercontinental transport via HVDC lines to Southern Europe have been linked with the investment model. To analyze the future hourly electricity generation for export and its costs the models use different strategies which optimize the electricity generation in North Africa which is exchanged with Europe: (1) surplus electricity is exported; (2) electricity generation below a certain generation price is exported; (3) demand loads of Europe are considered. Based on these results, policy strategies can be developed to fasten the deployment of an integrated electricity market between Europe and North Africa.

Keywords: Optimization model, electricity imports, renewable energies

Combining feed-in tariffs and tenders to support renewable electricity

Thilo Grau (DIW Berlin)

This paper analyzes the optimal framework for designing tender-based feed-in tariff schemes to support renewable electricity. While feed-in tariffs are the most common renewable energy policy used globally, auction mechanisms may be more suitable for large installations to improve control on costs to ratepayers. In recent years, European countries increasingly combined feed-in tariffs for small installations with tendering schemes for large-scale systems. However, the design of these policies and the differentiation of eligible project size categories vary across countries. What is the optimal threshold level between flexible feed-in tariff schemes and auction-based mechanisms across technologies? This paper develops an analytic model to simulate the deployment of renewable energy technologies based on project profitability, duration, and market uncertainty. The focus of the analysis is on solar photovoltaic plants with their dynamic cost trends. Flexible feed-in tariff schemes with frequent tariff adjustments are able to reach deployment targets effectively for small-scale photovoltaic systems due to their short project durations. However, large photovoltaic plants, with their long development lead times and high and diverse installation and connection costs, appear to be more suitable for auction mechanisms. To explore the optimal threshold level between feed-in tariffs and tenders, the analytic framework developed in this paper takes into account the different advantages and challenges of these policy schemes, including their risk implications. For large-scale renewable power plants, flexible feed-in tariff support implies uncertainty about tariff levels at project completion time, while auction mechanisms lead to higher project development risks as not all bids will be successful. Model results suggest that the optimal threshold level between feed-in tariffs and tendering schemes depends on a variety of policy design criteria with regard to technology, project size, location, financing costs and risks for investors.

Keywords: Feed-in tariff, auction, renewable energy

Session 10.30 – 12.30
System aspects in energy markets

Room: B37
Chair: Daniel Schubert (TU Dresden)

A new modelling tool to analyse challenges of the EU energy system
Leonidas Mantzos (European Commission Joint Research Center), Peter Russ, Tobias Wiesenthal, Antonio Soria

Exploring the functional organization of a fully renewable pan-European electricity system - let the weather decide
Martin Greiner, Gorm Andresen, Rolando Rodriguez (Aarhus University), Sarah Becker (Frankfurt Institute for Advanced Studies)

Modeling the mid-term development of the energy system in Poland with the use of TIMES-PL model
Artur Wyrwa, Marcin Pluta, Janusz Zyśk (AGH University of Science and Technology)

Combining Energy Networks: The Impact of Europe's Natural Gas Network on Electricity Markets till 2050
Hannes Weigt (University of Basel), Jan Abrell, Clemens Gerbaulet, Franziska Holz

Attitudes and Preferences towards for Electric Vehicles. What characteristics and policies do people value most?
Claudia Aravena, Eleanor Denny (Trinity College Dublin)

A new modelling tool to analyse challenges of the EU energy system

Leonidas Mantzos (European Commission Joint Research Center), Peter Russ, Tobias Wiesenthal, Antonio Soria

The European energy sector has entered a phase of drastic changes in terms of technologies, market structure and long-term environmental constraints. A tool suitable to analyse the impact of such changes will need to address the challenges arising from the transformation of the energy sector.
This paper describes the features of a new mathematical model designed to deal with EU energy and climate related policies with a high degree of detail. It follows a hybrid partial equilibrium approach combining behavioural decisions with detailed techno-economic data. The model runs on an annual basis with explicit vintage characteristics.
Decision-making is modelled at the level of representative economic agents which reflect the individual choices of the various decision makers. The number of representative agents is calculated by the model as a function of prevailing policy assumptions. Furthermore, the approach followed avoids the erroneous allocation of existing equipment to new agents; for example, a new household will need to invest in new heating capacities even if the overall energy demand of the residential sector decreases.
Different consumer categories are introduced in the model to account for different perceived risks and benefits. The definition of these categories is consistent across Europe through the linkage of their perceived risk factors to income levels (household) or size (industry).
A clear distinction is made between the investment decision and the use of the energy equipment. Hence, the utilisation rate is endogenous and stranded investments can be accounted for, thus the model can address the issue of premature replacement of equipment.
In power generation, the model attempts to mimic "real-life" decision-making. To this end, capacity planning is implemented under recursive (dynamic) foresight with imperfect information and is revisited on an annual basis. In addition, different unit plant sizes are implicitly considered, mimicking a mixed integer programming approach.

Keywords: Modelling, projection, energy policy assessments, energy efficiency, renewable energy

Exploring the functional organization of a fully renewable pan-European electricity system - let the weather decide

Martin Greiner, Gorm Andresen, Rolando Rodriguez (Aarhus University), Sarah Becker (Frankfurt Institute for Advanced Studies)

Todays overall macro energy system based on fossil and nuclear resources will transform into a future system dominantly relying on fluctuating renewable resources. At the moment it is not really clear what will be the best transitional pathway between the current and the future energy system. In this respect it makes sense to think backwards, which means in a first step to get a good functional understanding of fully renewable energy systems and then in a second step bridge from there to todays energy system. Based on state-of-the-art high-resolution meteorological and electrical load data, simple spatio-temporal modeling, and the physics of complex networks, fundamental properties of a fully renewable pan-European power system are determined. Amongst such characteristics are the optimal mix of wind and solar power generation, the optimal combination of storage and balancing, the optimal extension of the transmission network, as well as the optimal ramp down of fossil and nuclear power generation during the transitional phase. These results indicate that the pathways into future energy systems will be driven by an optimal systemic combination of technologies, and that economy and markets have to follow technology.

Keywords: energy systems, pan-European electricity system, wind energy, solar energy

Modeling the mid-term development of the energy system in Poland with the use of TIMES-PL model

Artur Wyrwa, Marcin Pluta, Janusz Zyśk (AGH University of Science and Technology)

The paper presents the results of the mid-term modelling of the development of the energy system in Poland. In particular, the impact of prices of CO_2 emission allowances (EUA) on the change in the structure of generating capacity and production is analysed. Two decarbonisation scenarios are built based on the EU Energy Roadmap 2050. The first one, Diversified Supply Technologies (DST) assumes that no technology is preferred and all energy sources can compete on a market basis with no specific support measures. The second scenario, NO_NUC_CCS is similar to the Diversified Supply Technologies but assumes lack of public acceptance for both: nuclear and Carbon Capture and Storage (CCS) technologies.

The main analytical tool used in the analysis is the TIMES model generator. The analysis is carried out with the use of TIMES-PL model for the period 2008 to 2035 with five-year time steps. The structure of the Reference Energy System and main modelling assumptions are presented. The latter include: (i) prices and potentials of primary energy sources, (ii) prices of CO_2 emission allowances, (iii) the demand for electricity and (iv) the technical and economic parameters of energy technologies. The results show significant changes in the structure of the fuel and technology mix by the year 2035 caused by the decarbonisation policy. Nuclear power plants and lignite-fired power plants equipped with CCS technology dominate in the DST scenario whereas renewables and gas-fired power plants in NO_NUC_CCS scenario.

Keywords: Modelling, energy system, TIMES-PL, CO_2 emission reduction

Combining Energy Networks: The Impact of Europe's Natural Gas Network on Electricity Markets till 2050

Hannes Weigt (University of Basel), Jan Abrell, Clemens Gerbaulet, Franziska Holz

The issue of electricity-natural gas interdependence is becoming a major energy policy and regulatory issue in all jurisdictions around the world. The increased role of gas fired plants in RES dominated electricity markets and the dependence on gas imports make this particular striking for the European energy market. In this paper we provide a first comprehensive combined analysis of electricity and natural gas infrastructure issues with an applied focus. We analyze different scenarios of the long-term European decarbonization pathways sketched out by the Energy Roadmap 2050. We identify criteria issues related to electricity and/or natural gas infrastructure in and the interrelation between both markets.

Keywords: Europe, electricity markets, natural gas markets, networks

Attitudes and Preferences towards for Electric Vehicles. What characteristics and policies do people value most?

Claudia Aravena, Eleanor Denny (Trinity College Dublin)

As a part of the policy for reducing CO2 emissions, the Irish Government has established a target of having 10% of the total transport vehicle fleet powered by electricity by 2020. This study uses a choice experiment methodology to investigate attitudes and preferences for different characteristics and policies related to the future deployment of electric vehicles in Ireland. We study what is the willingness-to-pay for different characteristics and policies associated to electric vehicles. In addition, we study how preferences differ in the presence and absence of a price attribute and therefore how this affects the marginal rates of substitution between attributes. The attributes considered were: i) range of driving in a full battery, ii) battery charging time, iii) battery life, iv) reduction in CO2 emissions, v) possibility of plug-in hybrid back-up, vi) size of the car, vii) top speed, viii) reduction in public parking charging fees and iv) purchase price. Results show that people are willing to pay more than €3000 extra for a larger vehicle, €350 for having the possibility to have a hybrid backup to electricity, €245 per extra year of battery life, €464 per hour they save when charging the car and €28 for each extra km/hr they could increase the speed of the car. Driving range showed to be one of the most important and considered attribute and individuals are willing to pay an extra €23 euro per kilometre they could drive further. Finally, there is a general concern for the reduction in CO2 emissions; this variable resulted to be significant and people are willing to pay €35 for each 1% of reduction in CO2 emission they could get by purchasing a new car. The effect of all attributes on the utility function of respondents was found to be robust to the introduction of the price vector except for the policy of provision of free or reduced public park fee, which was found to be non-significant when a price was attached to the different car alternatives. This is an interesting result showing that people seem to have a higher interest in the characteristics of the car itself rather than for the benefits of the policy associated with its acquisition. Finally, preferences seem to be stable to the introduction of a price vector, however marginal rates of substitution are lower when the price is considered in the choice experiment.

Keywords: Choice experiment; Electric vehicles; price vector; stable preferences.

Session 14.15 – 15.45
Control and balancing energy markets

Room: Faculty Assembly Hall
Chair: Christoph Kost (Fraunhofer ISE)

Control Power and Variable Renewables: A Glimpse at German Data
Lion Hirth, Inka Ziegenhagen (Vattenfall GmbH)

Reserve energy market integration in Germany and the northern alpine region
Clemens Gerbaulet, Alexander Weber (Workgroup for Infrastructure Policy (WIP), TU Berlin)

Evaluation of hydrogen storage systems for surplus electricity in the German Energy Sector
Julia Michaelis, Fabio Genoese, Prof. Martin Wietschel (Fraunhofer ISI)

Optimizing the procurement of ancillary services; a market model proposal for electricity systems with large shares of renewables.
Timon Dubbeling (Sciences Po Paris)

Control Power and Variable Renewables: A Glimpse at German Data
Lion Hirth, Inka Ziegenhagen (Vattenfall GmbH)

Control power (regulating power, balancing power) is used to quickly restore the supply-demand balance in power systems. Variable renewable energy sources (VRE) such as wind and solar power are often thought to increase the reserve requirement significantly. This paper provides a comprehensive overview of balancing systems in Europe, discusses the role of VRE, and presents empirical market data from Germany. Despite German VRE capacity doubled during the last five years and has surpassed 70% of peak load, contracted control power decreased by 20%, and procurement cost fell by 50%. Today, control power adds only 0.4% to household electricity prices. Nevertheless, we identify several sources of inefficiency in control power markets and imbalance settlement systems and propose a number of policy changes to stimulate the participation of VRE in control provision and to improve the incentives to forecast accurately.

Keywords:Balancing power,Control Power,Variable renewables,Wind and Solar power,Market design

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Reserve energy market integration in Germany and the northern alpine region
Clemens Gerbaulet, Alexander Weber (Workgroup for Infrastructure Policy (WIP), TU Berlin)

Given the increasing share of renewables in Europe, advanced coordination between countries on balancing energy could lead to significant improvements in terms of cost and power plant dispatch. Currently, an international cooperation on secondary balancing energy, the IGCC (International Grid Control Cooperation) is in place. It spans several European countries (Germany, Denmark, The Netherlands, Switzerland, The Czech Republic, and Belgium) and coordinates the activation of reserve energy in order to avoid counter-activation between control areas and even provides a common merit order list for reserve energy activation between some of the control areas. For the latter, a cross-border exchange of reserve energy is possible depending on intraday capacity available. In Germany, the procurement between all 4 control areas is coordinated as well and has led to significant cost reductions. We analyze the effect of a similar cooperation on the tertiary reserve energy markets of Germany, Austria and Switzerland – three countries that complement each other as the power plant and renewable portfolios differ significantly. The paper examines this option using a model implemented in GAMS and tests different levels of market integration using scenarios: i) A national scenario, bilateral scenarios in which the German reserve market is connected with the ii) Swiss or iii) Austrian market, respectively creating a common reserve market, and finally iv) a single-market scenario in which reserve energy procurement and activation is coordinated in the so-called "Germalpina" zone. The interplay of all players' objectives (cost minimizing procurement and activation of reserve energy of the TSOs, profit maximization of the power plant owners on the spot market and reserve energy markets) is modeled and analyzed. The current developments regarding the future consideration of capacity reservation mechanisms for cross-border lines are discussed as well. The results show that overall system costs are lower with higher levels of market integration, but at the same time the coordination requirements increase.

Keywords: balancing energy, market integration, cross-border coordination

Evaluation of hydrogen storage systems for surplus electricity in the German Energy Sector

Julia Michaelis, Fabio Genoese, Prof. Martin Wietschel (Fraunhofer ISI)

The increasing contribution of electricity generated from fluctuating renewable energies in Germany will likely lead to situations of oversupply, i.e. the supply of renewable electricity will exceed the system demand. Instead of limiting the output of wind turbines or solar parks, surplus electricity could potentially be used for water electrolysis to produce “green” hydrogen that is stored in the underground in salt caverns. Compared to the well-established pumped hydro electrical storage, hydrogen-based storage systems offer the benefit of a much higher volumetric energy density and are therefore more suitable to store large amounts of electricity for several weeks.

Three different options for further use and sale of hydrogen and their occurring synergetic effects are considered. First, hydrogen can serve as fuel for fuel cell electric vehicles and contribute substantially to the reduction of emissions in the transport sector in the future. Second, in times of high electricity prices, hydrogen could be reconverted into electricity to sell this electricity on a spot market like the European Energy Exchange (EEX). Third, the provision of balancing power is a possible option.

The present work examines if the operation of a hydrogen storage system is technically and economically reasonable in two different future energy scenarios. The model PowerACE is used for the simulation of the German electricity market, see [Sensfuss 2008] for a detailed description. The model is extended by splitting the German system into three zones with limited power exchange between those zones. The simulated time series of surplus electricity in each zone serve as input for a separate economic optimization model for the dispatch of the hydrogen storage system. The objective is to maximize the contribution margin of a single system considering its technical restrictions.

The simulations indicate that the amount of surplus electricity is the main influence factor on the profitability of the storage system. Depending on the assumed energy scenario, the amount in the northern part of Germany varies between 4.0 TWh and 14.3 TWh in 2030. Two different modes of operation are analyzed: a surplus driven case where only surplus electricity is used for the electrolysis and a price driven case where we also allow electricity that is partly generated by fossil fuels for the conversion into hydrogen when spot market prices are low. This case shows improved economic results.

Keywords: electricity market, hydrogen storage, fuel cell electric vehicles, optimization

Optimizing the procurement of ancillary services; a market model proposal for electricity systems with large shares of renewables.

Timon Dubbeling (Sciences Po Paris)

As the market share of variable renewables (RES) in European electricity systems rises, Transmission System Operators have to cope with an increasing discrepancy between the amount and quality of ancillary services that power systems need and the extent to which they are available. The energy-only remuneration model insufficiently rewards the provision of ancillary services. As a consequence, the integration of variables RES carries the risk of undermining the security of the power grid, this provoking increased curtailment of renewable production. With the end objective of further integration of RES in Europe, this paper discusses potential improvements concerning the procurement of ancillary services.

The paper starts with an overview of the technical challenges related to the integration of variable RES. It then analyses how ancillary services are procured and for which of these services new contractual and financial arrangements can be envisaged.

First, the paper finds that the relative weight of revenues from ancillary services as a part of total revenues for generators needs to increase. Doing so will make ancillary services a more important determinant in the operational and investment behavior of market players. Second, it concludes that there is room for improvement concerning the procurement of ancillary services: By switching from mandatory provision to market-based procurement methods where possible, those generators having the highest cost-effectiveness in delivering these services will be prioritized. The combined effect of these proposed changes is that the needs of the power system are aligned with the economic incentives that market players perceive. Therefore, they facilitate current and future market integration of variable renewables.

Session 14.15 – 15.45
Power Grids

Room: A 03
Chair: David Gunkel (TU Dresden)

A prototypic implementation of an optimizing network expansion planning model considering the value perspective of the company and the effects of monopoly regulation in the objective function
Stefan Schnabel (Vattenfall Europe Distribution Berlin GmbH), Robert Kunze, (Karlsruhe Institute of Technology)

Cost Benefit Analysis of Transmission Grid Expansion in the Central and Eastern Europe Electricity Market
Günther Körbler, Georg Lettner,Hans Auer (Vienna University of Technology)

European Electricity Grid Infrastructure Expansion in a 2050 Context
Jonas Egerer, Clemens Gerbaulet, Casimir Lorenz (Workgroup for Infrastructure Policy (WIP), TU Berlin)

Renewable curtailment and its impact on grid and storage capacities in 2030
Theresa Müller, David Gunkel, Dominik Möst (TU Dresden)

A prototypic implementation of an optimizing network expansion planning modell considering the value perspective of the company and the effects of monopoly regulation in the objective function

Stefan Schnabel (Vattenfall Europe Distribution Berlin GmbH), Robert Kunze, (Karlsruhe Institute of Technology)

In recent years several approaches for the electricity network expansion planning problem have been proposed. In the course of the increasing penetration of companies with information technologies first practical applications can be observed. Due to the extensive costs for infrastructure investments optimizations in this field have a substantial economic impact. The optimization problem can be stated as a large-scale, nonlinear, integer-mixed optimization problem. Derived mainly from operations research and engineering sciences most models aim at the minimization of the system costs.
However, in regulated natural monopolies the implication that minimizing costs leads to maximizing company value does not hold. This insight is confirmed by regulatory theory and studies and results basically from the fact that regulatory systems never can be perfect. For the German market many economical publications deal with the possibilities of regulatory optimization of investment strategies in terms of maximizing revenues or value. In practice investment evaluation methods as NPV calculations taking the regulatory system into account have been applied in recent years leading to an intensive discussion about the sufficiency of the regulatory system and it's implicated incentives to invest in network infrastructure.
Taken together the application of cost minimizing objective functions in network planning models exclude the economic calculation schemes that are practically applied in the electricity distribution companies for evaluation of investments and strategies. It can be supposed that this leads to suboptimal investment decisions.
The here proposed modell deals with this problem. It implements for the first time a value oriented economical calculus considering the effects of the German regulatory system in an optimizing modell for the grid expansion planning problem. The modell shows that a network expansion plan aiming at maximizing the Net Present Value of the investment program can significantly differ from a cost minimizing optimization depending on the expected regulatory framework. Secondly, under specific regulatory conditions the modell results equal the empirical investment behaviour under incentive regulation systems. Thirdly, it confirms that technical restrictions limit the possibilities of regulatory optimization.

Keywords: regulation of natural monopolies, distribution network expansion planning, shareholder value, metaheuristics, optimization

Cost Benefit Analysis of Transmission Grid Expansion in the Central and Eastern Europe Electricity Market

Günther Körbler, Georg Lettner, Hans Auer (Energie Economics Group EEG; Vienna University of Technology))

The distinctions of wholesale electricity prices in different European regions are the result of different power plant portfolios and from limited transmission capacities between the countries. The increase of side specific RES-E generation technologies can lead to intensified price differences if no further transmission extension will be implemented. To counteract ENTSO-E has published documents where the importance of transmission grid expansion is accounted in detail. This paper introduces a method for analysing the costs and benefits of future cross-border transmission capacity extension between different electricity price areas in central Europe. Based on a market coupling algorithm, an n-point model, where each point represents a defined market area, will be presented whereas the method does not take into account the power flows due to exchanges within the market zone. The methodology being implemented in MATLAB allows a detailed discussion on system benefits (e.g. like the increase of the social welfare, fossil fuel savings and the CO2 emission reduction). The congestion rent will be compared with the costs of the transmission grid extension. The market coupling algorithm is based on net export curves (NECs), which are defined as difference between local supplier and consumer bidding curves and represents the availability of import/export of electrical energy of a market zone. The market clearing price is equivalent to the NECs intersection with the vertical axis. The stepwise NEC is generated graphically by shifting the demand curve horizontally over the supply. Each intersection between supply and the shifted demand represents the NECs price level on the shifted volume. The NECs of different market zones are used for the calculation of the social welfare and the congestion rent, which are benchmarks for the economic analyses of future transmission grid extension. Empirical results will be derived in the next couple of weeks and presented at ENERDAY.

Keywords: Cost Benefit Analysis, Market Coupling, Net Export Curves, Transmission Grid Expansion

European Electricity Grid Infrastructure Expansion in a 2050 Context

Jonas Egerer, Clemens Gerbaulet, Casimir Lorenz (Workgroup for Infrastructure Policy (WIP), TU Berlin)

The European climate policy targets until 2050 require an adaption of the generation portfolio in terms of renewable and fossil based generation. Assumptions on the timeline of the targets and the availability and costs of generation technologies are used in energy system models to optimize the cost minimal system transformation. The results include investments in generation technologies and their national allocation. Yet, the models are limited to the national aggregation and lack the spatial resolution required to represent individual network investments and related costs.
In this paper, we analyze the impact the results of an energy system model have on the network demand in the European power grid in a line-sharp representation. A cost minimizing mixed-integer problem (MIP) model calculates where in the European electricity grid extension needs to take place for different time steps (2020/30/40/50) in order to obtain a cost minimizing power plant dispatch and grid expansion.
Scenarios based on the generation infrastructure options from the PRIMES EU-wide energy model scenarios invoke different expansion needs and a comparison is conducted for three scenarios with different renewable and CO_2 reduction targets. The model allows investments in the AC network and an overlay DC grid and resulting investment costs are compared to the numbers of the European Energy Roadmap 2050. The national character of the scenarios with the development of national generation portfolios is investigated by sensitivity runs with higher expansion costs on cross-border lines.

Keywords: Network investment, Europe, Mixed-Integer Modeling

Renewable Curtailment and its Impact on Grid and Storage Capacities in 2030

Theresa Müller, David Gunkel, Dominik Möst (TU Dresden)

Feed-in tariffs and feed-in priority are used in several European countries to promote renewable energy sources (RES). The example of Germany indicates this is an effective measure to facilitate investments in RES. On the other hand feed-in obligation can lead to several challenges due to the increasing share of RES. For example, in several hours the RES feed-in can exceed the demand. There are various options dealing with this challenge, e.g.

- Store the surplus of RES feed-in
- Export the (national) overproduction to neighboring countries
- Curtail renewable feed-in in times with low or negative residual load

Various researches indicate, additional storage facilities and transport capacities are necessary to integrate the increasing share of RES into the European electricity system [e.g. 1, 2, 3]. The higher the share of RES is the more investments in grid and storage capacities are needed. However, these studies consider an obligatory feed-in of RES into the electricity system. The question is obvious, whether the investments needed to integrate every unit of RES feed-in is reasonable.

Within this contribution the impact of RES feed-in obligation on grid and storage expansion in Europe by 2030 is analyzed. Two main scenarios are investigated: In the first one ("*RES feed-in obligation"*) the total feed-in of RES needs to be integrated into the energy system. The scenario "*RES curtailment"* considers the possibility of a temporary limitation of electricity generation from RES. The analyses are performed with ELTRAMOD, which is a European electricity transshipment market model. It represents the electricity market of the EU-27 states, Norway, Switzerland and Balkan region connected by net transfer capacities (NTC). Based on this linear optimization model, the cost-minimal generation dispatch and investments in storage and transmission capacities are identified. In order to adequately consider the intermittency of RES, the temporal resolution is determined by 8760 hours per year. The wind and PV feed-in time series are derived from a public data base.

First results show investments in grid infrastructure dominate the expansion of storage capacities in both scenarios. But the investments in the scenario "RES feed-in obligation" are much higher than in the scenario "*RES curtailment"*. Hence, the chosen feed-in scheme has got a strong impact on the required grid and storage capacities.

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Session 14.15 – 15.45
Security of supply

Room: B37
Chair: Alexander von Selasinsky (TU Dresden)

The German 'Energiewende' and Security of Supply: An assessment of power interruption costs in Germany
Christian Growitsch, Raimund Malischek, Sebastian Nick, Heike Wetzel (University of Cologne)

The blackout in Munich: how do households value security of supply?
Daniel Kurt Josef Schubert, Alexander von Selasinsky, Thomas Meyer, Dominik Möst (TU Dresden)

Money on the right table – Hedging the risk of bottlenecks in the Nordic market
Tobias Johansson, Mats Nilsson (Vattenfall AB)

Interaction between Energy and Agriculture via Biofuels and Future Social Impact
Yuri Yegorov (University of Vienna)

➔ Unfortunately the lecture will not take place. Instead Alexander Weber will give a lecture with the topic "Merchant and Regulated Transmission Investment: The Case of the Baltic Sea Region". We apologize for the change in the program.

Merchant and Regulated Transmission Investment: The Case of the Baltic Sea Region
Clemens Gerbaulet, Alexander Weber (Workgroup for Infrastructure Policy (WIP), TU Berlin)

The German 'Energiewende' and Security of Supply: An assessment of power interruption costs in Germany

Christian Growitsch, Raimund Malischek, Sebastian Nick, Heike Wetzel (University of Cologne)

The economic value of a secure supply with electricity has recently entered both scientific and political debates. However, empirical approaches investigating power outage costs are rather scarce. This paper contributes to research in this area as it analyses the economic costs imposed by potential power interruptions in Germany. Our disaggregated sectoral and regional analysis allows for conclusions for optimal load shedding in case of technical necessity and the economic efficiency of measures to improve security of supply. Following a macroeconomic approach, we estimate the economic costs of outages from losses in output with electricity being interpreted as an input factor. A rich data set on industry and households allows us to estimate both static and dynamic Values of Lost Load (VoLLs) for different German regions and sectors. We find that VoLLs vary significantly over time, between sectors and regions. On average, total national outage costs amount to approximately 430 Mio€ per hour. Our results further emphasise the prominent regional aspect of the German Energiewende as the areas with the highest estimated VoLLs, i.e. the southern and western part of Germany, coincide with the areas which face nuclear power plant shut downs in the near future and have less favourable sites for renewable electricity generation.

Keywords: Security of Supply, Value of Lost Load (VoLL), German Energiewende, Electricity outage costs

The blackout in Munich: how do households value security of supply?

Daniel Kurt Josef Schubert, Alexander von Selasinsky, Thomas Meyer, Dominik Möst (TU Dresden)

Germany has a consistently high level of security of electricity supply so that widespread power failures are rather rare events. In November 2012, almost 500,000 people in the southern half of Munich were affected by a power outage on a Tuesday morning. We took this occasion for an interdisciplinary study regarding the impact of power outages on opinions, attitudes and behavioural dispositions of consumers in Munich. Our contribution focuses on the valuation of security of electricity supply of affected and non-affected households.

For this purpose, we conducted a representative telephone survey (computer assisted telephone interviews) with a sample size of 514 randomly selected respondents about two months after the power outage in Munich occurred. The assessment of the valuation of security of supply was performed in two ways: qualitative (attitude) and quantitative (behavioural disposition). The qualitative validation consisted of a ranking of the three main energy policy objectives "security of supply", "environmental compatibility" and "economic efficiency". In order to perform the quantitative evaluation, we applied the contingent valuation method to reveal the interviewees' willingness to pay (WTP) and willing to accept (WTA) for a hypothetical power outage.

Our results show that consumers which were affected by the power outage in Munich have a significant higher WTP; they are willing to pay 32.32 € on average to avoid a power outage of four hours in their households whereas non-affected consumers are willing to pay 17.91 € on average. On the other side, we could not find evidence that there is a difference between affected and non-affected consumers with respect to their ranking of security of supply as one of the three energy policy objective in our qualitative assessment.

Keywords: security of supply, power outage, willingness to pay, willingness to accept, contingent valuation method, telephone survey

Money on the right table – Hedging the risk of bottlenecks in the Nordic market

Tobias Johansson, Mats Nilsson (Vattenfall AB)

The awareness of the European legislators that the regulated and deregulated parts of the electricity market are connected is slowly but steadily increasing. Thus the new EU legislation stipulates that the amount of transmission capacity should be present in either the financial markets or be ensured by selling physical transmission rights. There are few stakeholders of physical transmission rights as these are plagued with the uncertainties of knowing the actual direction of trade. More interesting is the foreseen use of auctioning of financially firm capacity.
In case transmission capacity is sold financially, it is in reality an auction of future congestion revenues collected in the day ahead market. These congestion rents occur when there is a bottleneck in the grid. The physical congestion is valued at the price differences between the two sides of the bottleneck when implicit auctioning such as Market Coupling or Market Splitting is used.
This paper elaborates upon a solution to the financial risk dilemma within the Nordic market design. The financial transmission right concept, as proposed in the continental markets, could be mirrored in the Nordic market, by requiring the Nordic TSOs to sell the underlying capacity or hedge the future congestion revenue in the Contracts for Difference (CfD) market. This would mean that the TSO use an already existing instrument. In addition this would mean that liquidity is accumulated around a fewer number of contracts compared to introducing FTRs on top of existing contracts. We put some empirical estimates on this market, values and revenues, and qualitatively discuss the issue framing transmission capacity risk with the owners and operators of the transmission grid.

Keywords: congestion, Risk, Financial hedging, Transmission

Interaction between Energy and Agriculture via Biofuels and Future Social Impact

Yuri Yegorov (University of Vienna)

The competition between agriculture and biofuels has important consequences for future security of supply of both food and energy. At this moment, practically all arable land is already used, and it has to be split between food production and substitutes of oil.
While there exist alternative solutions for the future global energy scarcity, that are related to use such sources and solar and wind energy, we are not aware about possible technologies to substitute oil by renewable energies in transportation (apart from rail transport driven by electricity that can be produced by renewables), especially in air transport. That is why our focus will be on future matching of demand and supply for food and transportation.
There exist also complementary problems, related to deforestation and future water scarcity (locally even for personal needs, but globally for agriculture). Since there exists a positive correlation between the global area covered by forest, on one hand, and global supply of fresh water, on the other, we assumed some functional dependence between both variables.
We will start our analysis with a simple model, where total arable land is fixed and is decomposed between land, used for agriculture, and for biofuel growing. As for oil supply, we assume a kind Hubbert-type curve, given by exogenous function with one peak (oil-peak). We also will assume both exponential population growth, along with exponential growth of agricultural productivity.

The equilibrium for a simple model consists from the dynamics of food and energy prices in the environment of growing population and agricultural productivity. Biofuels emerge before oil peak, when marginal cost of oil extraction starts to exceed the cost of agricultural production. Later we consider more complex model that also involves water, both for producing agriculture and biofuels, and for direct consumption. We also add forest and positive dependence between forested area and global water supply.

➔ Unfortunately the lecture will not take place. Instead Alexander Weber will give a lecture with the topic “Merchant and Regulated Transmission Investment: The Case of the Baltic Sea Region”. We apologize for the change in the program.

Merchant and Regulated Transmission Investment: The Case of the Baltic Sea Region

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

Most recent studies on the need for electricity grid expansion in Europe identify large investments into EHV (extra-high voltage) grids. Considering the past, one may have significant doubt that the investments will be delivered in time. European Regulation EC 714/2009, however, provides an option to push the construction of interconnectors: under certain circumstances, including an approval by the European Commission, interconnectors may be exempted from tariff regulation. In case an interconnector is granted an exemption, its only income is its congestion rent from price spreads between the markets connected. However, an exemption in the European context does generally not allow the merchant to withhold capacity. Recently, it could be observed that the Commission has become increasingly reluctant to approve exemptions. This leads to the question why such a potentially powerful instrument is decreasingly used, even in the light of large investment needs. The view of the literature on the desirability of merchant investments is heterogeneous and the debate is still on-going, with a tendency to deny the general significance of merchant transmission investments. We refer to this debate and analyse, based on a case study of the Baltic Sea region, what the effects of merchant transmission investments are under the current European Framework are, both from a total welfare and a consumer payments (rent extraction) perspective.

We set up a numeric game-theoretic model where a merchant investor acts as a Stackelberg leader and decides on its investments and on capacity withholding decisions to maximize its profit. The follower of the game is a fully coordinated planner who decides on cost-minimizing, regulated network expansion between price zones and conducts a cost-minimizing power plant dispatch. The problem is implemented as an MPEC (Mathematical Program with Equilibrium Constraints) and is solved using CPLEX. In order to do so, the MPEC is re-formulated as a mixed-integer linear program (MILP) by using a disjunctive constraints approach to the complementarity conditions of the problem of the follower. In order to increase solution speed, several additional constraints could be identified.

To assess the relative benefits of exempted investments, we compare both the total consumer payments and the social cost (i.e. taking a welfare perspective) to (i) a fully planned case, where a perfectly coordinated planner conducts all investment and dispatch decisions and (ii) a case where none of the potentially exempted lines are being built. We apply our model to the Baltic Sea region including the countries Denmark, Sweden, Estonia, Latvia, Lithuania, Poland and Germany. Our findings are that when having a merchant, exempted interconnector in place, although losses are low from a welfare perspective, consumer payments are nearly as high as having no interconnector at all. Additionally, we find that if capacity withholding (when scheduling the flows) was allowed, would not be much worse compared to the current ruling.

We conclude that allowing fully exempted merchant interconnectors should be considered carefully: a deeper investigation of why regulated investment is not delivered might be beneficial.

Keywords: network expansion, merchant lines, exemptions, MPEC, market integration

Session 16.30 – 18.00
Congestion Management

Room: Faculty Assembly Hall
Chair: Friedrich Kunz (DIW)

The Benefit of Coordinating Congestion Management in Germany
Alexander Zerrahn (DIW Berlin), Friedrich Kunz (DIW Berlin)

An integrated approach to model redispatch and assess potential benefits from Market Splitting in Germany
Katrin Schmitz, Michael Bucksteeg, Christoph Weber (University Duisburg-Essen)

Economic Potential of the "Power-to-Heat" Technology in the 50Hertz Control Area
Mario Götz, Diana Böttger, Hendrik Kondziella, Thomas Bruckner (University of Leipzig)

Management of a Medium Voltage Distribution Network with Distributed Generation
Michał Wierzbowski, Błażej Olek (Lodz University of Technology)

The Benefit of Coordinating Congestion Management in Germany

Alexander Zerrahn (DIW Berlin), Friedrich Kunz (DIW Berlin)

The German Energiewende is characterized by the phase-out of nuclear plants and an increasing share of renewable generation. As the high voltage transmission grid, however, had not been constructed to serve such needs, congestion is an issue in an increasing number of hours. A short-run curative relief consists in the redispatch of conventional generating units to re-establish network feasibility - a method that is employed by the transmission system operators (TSOs). As the operation of the German network is spatially divided into four control zones, each of which run by one TSO, the question arises whether coordinating redispatch measures among them can be beneficial.

To address this question, we formulate a generalized Nash model: in a first step, the spot market is cleared by equalizing supply and demand in a cost-minimizing fashion, without taking the power network into account. The dispatched quantities then become data for the actual model, in which the power grid comes into play: the objective function consists in the cost- minimal redispatch of conventional power plants in order to re-establish network feasibility. By lowering and increasing generation at certain nodes, power flows - captured with help of a PTDF-matrix - are changed such that line overflows can be eliminated. As a benchmark case, we model one single TSO responsible for the entire German system. In the model's restricted cases, for each zone there is one TSO solely eligible to access plants. Its actions, however, alter the set of feasible choices for the other TSOs as loop flows influence the constraints on network feasibility in the entire system. TSOs thus interact over a shared constraint. Mathematically, an underidentified system of equations emerges, which is a typical feature of generalized Nash problems. As a solution, we propose introducing an exogenous valuation parameter and thereby also establish different degrees of coordination: in a coordinated case, each TSO takes each line into account, in an uncoordinated case only lines within its own zone.

Applying the model to a detailed representation of the German electricity system with hourly data from 2011 reveals that total redispatching costs increase when coordination decreases: they are lowest in case there is one TSO across all zones, and intermediate if each TSO has access to resources solely located in its own zone but takes into account congestion on all lines in the system. Finally, costs are highest for the case each TSO has access only to own resources and only takes care of congestion within its own zone.

Keywords: Congestion Management, Redispatch, Generalized Nash Equilibrium

An integrated approach to model redispatch and assess potential benefits from Market Splitting in Germany

Katrin Schmitz, Michael Bucksteeg, Christoph Weber (University Duisburg-Essen)

An increasing RES-feed-in, especially from offshore wind farms, the nuclear phase-out and delays in transmission grid expansion challenge the German TSOs to ensure the security of supply. The load flows resulting from high variations in the geographical distribution of power generation (due to fluctuating RES-feed-in) amplify Germany's North-South congestion problem and increase redispatch measures and costs (see [1]). Congestion management becomes more and more also politically important (not only from a technical point of view). Germany's market design with uniform prices and the dealing of congestion by redispatch is obviously inefficient. Nevertheless, nodal pricing as first-best answer (see e.g. [2], [3]) doesn't seem to be a realistic alternative in the nearer future – especially due to the inevitably implementation of a European-wide (or even German-wide) ISO. However, welfare effects could also be achieved by the introduction of zonal prices as implemented already in the Scandinavian market.

Against this background we analyze the impact of zonal market splitting for Germany in 2015 especially with regard to remaining congestion and redispatch. As the European transmission grid is highly intermeshed, the impacts of the implementation of market zones in Germany will significantly affect imports and exports. Therefore we developed an integrated approach in which we model the European flows in a first stage linear power plant dispatch model and incorporate those import and export flows in a MIP power plant dispatch model for Germany. Due to the high complexity of the dispatch model (hourly resolution with rolling planning, MIP, modeling of each power plant unit with consideration of many technical restrictions) we approximate load flows by using PTDF calculated within a nodal DC load flow model to keep calculation times manageable. The German transmission grid is represented by 18 buses.

Our main findings are that market splitting can significantly reduce congestion and redispatch. However, its beneficial effects depend strongly on its 'adequate' design. In particular the main challenge is the delimitation of market zones and the determination of zonal transmission capacity. The authors are aware that market splitting cannot be expected to be the 'one and only' solution. A differentiated assessment between market splitting and grid extension is of course needed to mitigate security-of-supply risks.

Literature

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[2] Hogan, W. (1992), Contract Networks for Electric Power Transmission, Journal of Regulatory Economic (4), 211-242
[3] Neuhoff, K. et al. (2011): Renewable Electric Energy Integration: Quantifying the Value of Design of Markets for International Transmission Capacity, available at: http://climatepolicyinitiative.org/ wp-content/uploads/2011/12/Quantitative-Simulation-Paper.pdf

Keywords: Unit Commitment Model, Redispatch, Market Splitting, Case Study Germany

Economic Potential of the "Power-to-Heat" Technology in the 50Hertz Control Area

Mario Götz, Diana Böttger, Hendrik Kondziella, Thomas Bruckner (University of Leipzig)

Electricity generation through renewable energy sources (RES) in Germany has risen significantly in the last years. Specifically, the control area of "50Hertz Transmission GmbH" is confronted by a situation of high installed wind power capacities and simultaneously by a comparably low electricity demand. With already oversized conventional generation capacities with a high share of cogeneration plants, transfer capacities to neighbouring control areas are even today often congested. Therefore, the introduction of new electricity consumers like the Power-to-Heat technology (P2H) may be useful in integrating excessive amounts of RES and in supplementing system service provision. Furthermore, the tightening conflict between cogeneration and fluctuating RES could be defused through this technology. Compared to the often discussed Power-to-Gas technology, P2H is already available at comparably low costs.

In this paper, the economic potential of the application of P2H in combination with heat storages in district heating grids as an additional flexibility option for combined heat and power plants is assessed with the help of an energy-economic model. The model maximizes the possible profits of a district heating system consisting of combined heat and power plants, heating plants and heat storages on the day-ahead spot and balancing power market for a given heat demand on an hourly basis. In a case study, several existing district heating grids in the 50Hertz control area are analyzed for the years 2014 and 2020.

As the P2H technology is well-suited for the provision of balancing power, P2H-plants can pay back investment costs in less than one year by just providing negative secondary reserve. The energy price for P2H-plants is mainly determined by public associated charges for the electricity consumption. Therefore the cost efficient usage of P2H for heat provision needs negative spot market prices in a considerable size. Only with a total exemption of the additional costs P2H-plants would be used for heat production.

Keywords: Power-to-Heat, combined heat and power, heat storage, renewable energy, balancing power

Management of a Medium Voltage Distribution Network with Distributed Generation

Michał Wierzbowski, Błażej Olek (Lodz University of Technology)

Active management (AM) of electrical network is a key element for electricity supply system development proposed by the European Union. AM is essential part of the Smart Grid (SG) concept, strongly supported by many power industry corporations and scientific research institutes. Management allows to integrate larger number of Distribution Generation (DG) units in traditional network, facilitates its operation and makes its use more effective. It increases reliability, flexibility and stability of network operation, what increases security of the electricity supply. AM can be interesting tool in the face of future liberalization of a common EU electricity market. It brings many new features that can be used in the modern power system, beginning from technical services and ending with new electricity markets development.

The presentation describes analysis of power system and provides a new concept of the active management for distribution network operation, under market rules. It concentrates on optimization of distribution network operation, involving dispatch and balancing in both active and reactive powers, taking into account optimal power flows with reduction of power losses. The presentation provides essential assumptions for optimization and findings of the conducted simulations. Additionally, it proposes a new manner of power prices calculation for end-user, based on Power Flow Tracing methods.

Keywords: Smart Grid, network operation management, balancing, electricity market

Session 16.30 – 18.00
Renewables and Smart Grids

Room: A 03
Chair: Hannes Hobbie (TU Dresden)

Highly resolved simulation of feasible pathways to a renewable power system in Germany and Austria – Is storage really a limiting component?
Gerhard Totschnig (Vienna University of Technology), Johannes Radl, Andre Ortner

The mechanism of the "Grid signal light" as a part of the Smart Market/Grid System – the cooperation between Customers, Energy Logistics, Grid and Regulation
Holger Wiechmann (EnBW Vertrieb GmbH), Kai Hufendiek (EnBW AG)

Competition between different flexibility alternatives in electricity markets with a high share of intermittent renewable energy sources
Brunner, Christoph (EnBW AG)

Synergies between EE, RE and CO2 targets
Karsten Neuhoff (DIW Berlin)

Highly resolved simulation of feasible pathways to a renewable power system in Germany and Austria – Is storage really a limiting component?

Gerhard Totschnig (Vienna University of Technology), Johannes Radl, Andre Ortner

The highly resolved unit commitment and investment model HiREPS of the German and Austrian power system is used to economically evaluate different options for reaching a renewable energy share of more than 90% in Germany and Austria. The paper analyzes technically and economically feasible pathways. The hourly resolved model combines a very detailed model of the future options for the Austrian and German electricity system with a model of the heating sector and a modeling of the different storage and flexibility options.
In the paper economically and technically feasible pathways to reach a renewable energy share of more than 90% in Germany and Austria are analyzed. Different important aspects are analyzed. E.g: Electricity and heat sector investment analysis; the importance of hydropower, pumped storage and the economics of alternative storage technologies and power to gas; impact of fluctuating renewable energies on spot market prices; the role of heat storage systems; the impact of smart demand and flexibility options; combined heat and power; the optimal share of solar and wind power. Further the need and economic basis for new daily, weekly or monthly storage options are discussed. The analysis is performed for different scenarios of the Austrian and German power system.

Keywords: Electricity and heat sector investment analysis, economics of storage technologies and power to gas, impact of fluctuating renewable energies on spot market prices, role of heat storage systems, the impact of smart demand and flexibility options, combined heat an power, Portfolio management

The mechanism of the "Grid signal light" as a part of the Smart Market/Grid System – the cooperation between Customers, Energy Logistics, Grid and Regulation

Holger Wiechmann (EnBW Vertrieb GmbH), Kai Hufendiek (EnBW AG)

While advancing the German „Energiewende", the fluctuating generation will increase impressively. The integration of this type of generation is highly challenging. 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 an intelligent 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. Only some of the bottlenecks will be able to be cured by grid operator alone measures, e. g. controllable local substations. In other cases the interaction of all players, generators, customers, providers and grid operators is required. For an efficient and secure interaction it is important, that the responsibilities of 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 disturbed 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.

A way to interact in such a systematic way is described by the principle of the "grid signal lights" concept which is described in the presentation. The "grid signal light" defines three phases:

- Green phase: There is enough grid capacity available and the market can develop without grid restrictions – as long certain basic principles are obeyed.
- Yellow phase: The DSO observes defined threshold levels or forecasts such event. The DSO contracts defined system services by tender that are offered by players of the competitive market for this phase in advance. In case of the threshold will be transgressed, the DSO asks for this system service contracted from the respective market participant. The market participants deliver the service, i. e. regulated and competitive players interact.
- Red phase: The thresholds for the yellow phase are clearly transgressed and other defined thresholds are observed or forecasted to be observed, which lead to the estimation of the DSO, that stability of the grid (or a part of the grid) is endangered effectively soon. As last resort, the DSO takes mandatory measures, e. g. feed-in management, cut-off of sections of the grid or certain customer segments. The standard market rules are suspended during this phase (e. g. balancing rules), due to emergency actions by the DSO.

Examples derived from a research project will illustrate how this required interaction of regulated and competitive players operates. This set of roles and rules is our proposal for the basis of a smart energy system. They show at the same time the involvement of customers and their reactions. Without their acceptance and involvement, a smart system will not be able to operate.

Competition between different flexibility alternatives in electricity markets with a high share of intermittent renewable energy sources

Brunner, Christoph (EnBW AG)

The continuous expansion of electricity generation from intermittent renewable energy sources (RES) is changing the present generation structure considerably. In order to utilize a high share of supply-dependent RES, the future energy system needs to become more flexible than it is today. This presentation aims to contribute to the discussion about the adequate design of future electricity markets that ensures competition between different flexibility measures.

The presentation shortly outlines the flexibility requirements of RES dominated electricity system by examples of different coincidences of volatile demand and stochastic RES generation. Then, the various types of flexibility measures to balance RES deficits or surpluses that can be implemented at different parts of the electricity systems are introduced. To evaluate the suitability of these alternatives, their major characteristics and limitations are examined afterwards. By showing how these restrictions lead to partly contrary cost structures for the individual balancing measures, the shortcoming of the present electricity market design to attain competition between these different flexibility measures are finally emphasized.

Just increasing the flexibility on the generation side will be insufficient for electricity systems with a high share of fluctuating RES. Additional measures that raise the flexibility on the demand side are needed as well. Depending on the actual mismatch situation of RES supply and electricity demand the suitability of these different measures varies quite considerably, e.g. in terms of availability, potential, efficiency and cost structure. To meet the required level of flexibility at lowest cost future electricity markets need to achieve competition between these different balancing alternatives by a market design that reflects these restrictions.

Keywords: Storage, demand side management, substitution, flexibility, electricity market

Synergies between EE, RE and CO2 targets

Karsten Neuhoff (DIW Berlin)

The low price for CO2 allowances in the EU emission trading scheme has triggered a wide discussion on interactions between ETS, efficiency and renewable targets and policies. Behind this debate are concerns about what happens next, both under the existing targets and instruments and in the formulation of different targets for the period post 2020. The uncertainty around the nature of future targets increases risks around the return profile of new energy investments, and holds back investment strategies.

Policy targets can be seen as an interface between political objectives and specific policies and programs. This characterization underpins a clear analysis of targets. The paper first explores the link from political objectives to emission, renewable and efficiency targets, followed by a discussion how the targets can provide guidance for policy makers to implement and manage policies and programs and to provide visibility for companies to inform strategic and investment choices. The specific nature of EU ETS – as a target incorporated in a policy instrument, is subsequently discussed. At the end the analytic framework then provides the basis first for the discussion of implications for the possible formulation of energy and climate targets.

Session 16.30 – 18.00
Fuel Markets

Room: B37
Chair: Julia Michaelis (Fraunhofer ISI)

What Drives Natural Gas Prices? – A Structural VAR Approach
Sebastian Nick, Stefan Thoenes (University of Cologne)

Testing Common Myths on Fuel Prices
Sebastian Kreuz, Felix Müsgens (Brandenburg University of Technology)

The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model
Franziska Holz, Philipp M. Richter (DIW Berlin), Ruud Egging (SINTEF Technology and Society)

Central Asian Gas in Eurasian Power Game
Onur Cobanli (Humboldt–Universität zu Berlin)

What Drives Natural Gas Prices? – A Structural VAR Approach

Sebastian Nick, Stefan Thoenes (University of Cologne)

In this study, we develop a structural vector autoregressive model (VAR) for the German natural gas market. Our setup allows us to analyze the determinants of the natural gas price in a comprehensive framework. In particular, we illustrate the usefulness of our approach by disentangling the effects of different fundamental influences on gas prices during three recent supply interruptions: The Russian-Ukrainian gas dispute of January 2009, the Libyan civil war in 2011 and the withheld Russian exports in February 2012. Our results show that the natural gas price is affected by temperature, storage and supply shortfalls in the short term, while its long-term development is closely tied to both crude oil and coal prices. Interestingly, the influence of coal prices exhibits at least equal explanatory power for gas price variations than the oil price does. We attribute this empirical finding to the substitutive relationship within the electricity sector, where gas and coal compete for their positions in the merit order. Furthermore, our results of various fundamental drivers of gas prices question the exclusive focus on oil prices in previous gas market research as main determinant of gas prices. Hence, they provide valuable insights into the current debate of decoupling of oil and gas markets. Historical decomposition of fundamental price effects drawing upon our structural model suggests that the impact of supply shortfalls on German gas prices is rather limited. Thus, market power of strategic gas suppliers might have been overestimated historically.

Keywords: natural gas, structural vector autoregression, SVAR, supply interruption, security of supply

Testing Common Myths on Fuel Prices

Sebastian Kreuz, Felix Müsgens (Brandenburg University of Technology)

Transport is an essential good, nearly everybody consumes transportation services. Furthermore, an average household pays about 100€ per months for fuel. Therefore, fuel prices influence consumption and investment decisions. In addition, fuel prices have an essential impact on political discussions.
However, relatively little academic work on fuel prices exists. Most studies in the field research market power, e.g. symmetric and asymmetric price effects related to retail prices for fuel or oil ("Rockets and Feathers"). However, due to lacking publically available data, all published work has limitations in the data set. Most studies have only one data point per day – or less. In addition, fuel prices of different brands, e.g. to distinguish pricing behavior of different suppliers, rarely exists. Our data set comprises close to 13,000 data points for the period from January 1st to December 31st in the year 2011. The data set was gathered from an online platform where interested users can voluntarily report information on fuel prices via the internet, e.g. using mobile phone apps. In addition to the fuel price, every observation contains information on the time and date of the observation, the location and in most cases also the brand of the specific fuel station.
We use this data set as a starting-point for a bottom-up-analysis of the German fuel sector. In this paper, we test four wide spread public prejudices about fuel prices:

i. are fuel prices higher in the morning?
ii. are fuel prices higher on Fridays?
iii. are independent fuel stations cheaper than brands?
iv. are fuel prices more expensive at the beginning of public holidays?

Keywords: transportation sector, fuel prices

The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model

Franziska Holz, Philipp M. Richter (DIW Berlin), Ruud Egging (SINTEF Technology and Society)

In this paper, we use the Global Gas Model, a partial equilibrium model, to analyze the perspectives and infrastructure needs of the European natural gas market until 2050. It is written within the framework of the Energy Modeling Forum (EMF) no. 28, which particularly investigates GHG mitigation options for the European Union. Three pathways of natural gas consumption in a future low-carbon energy system in Europe are envisaged: i) a decreasing natural gas consumption, along the results of the PRIMES model for the EMF decarbonization scenarios; ii) a moderate increase of natural gas consumption, along the lines of the IEA (2012) World Energy Outlook's New Policy Scenario; and iii) a temporary increase of natural gas use as a bridge technology, followed by a strong decrease after 2030.

Our results show that import infrastructure and intra-European transit capacity currently in place or under construction are largely sufficient to accommodate the import needs of the EMF decarbonization scenarios, despite the reduction of domestic production and the increase of import dependency. However, due to strong demand in Asia which draws LNG and imports from Russia, Europe has to increasingly rely on pipeline exports from Africa and the Caspian region from where new pipelines are built. Moreover, pipeline investments open up new import and transit paths, including reverse flow capacity, which improves the diversification of supplies. In the high gas consumption scenario similar pipeline links are realized—though on a larger scale, doubling the costs of infrastructure expansion. In the bridge technology scenario, the utilization rates of (idle) LNG import capacity can be increased for the short period of temporary strong natural gas demand.

Keywords: natural gas, climate change, infrastructure, equilibrium modeling

Central Asian Gas in Eurasian Power Game

Onur Cobanli (Humboldt–Universität zu Berlin)

Holding huge natural gas reserves the Central Asian countries play a key role in Eurasian geopolitics. Following the dissolution of the Soviet Union, the major powers surrounding Central Asia have proposed several pipeline projects to build political cloud in Eurasia. Setting the major powers against each other the Central Asian countries seek to maximize their benefits from the pipeline projects. Using cooperative game theory I evaluate how the pipeline projects alter the power structure in the Eurasian gas trade. Gravitating eastwards to China benefits the Central Asian countries more than the western pipeline projects, but the Central Asian countries are heterogeneous in terms of their gas reserves and transit role. For Turkmenistan heading westwards to Turkey is more profitable. Carrying Turkoman gas further to European markets has marginal impact on the power of Turkmenistan and European consumers. Similarly, if Azerbaijan is linked to Europe, the leverage accruing to Europe from additional Central Asian supplies is insufficient for an European investment. Thanks to its transit position Turkey enjoys large benefits.

Keywords: Bargaining Power, Network, Trade links, Natural Gas, Caspian Sea,China

Faculty of Business and Economics

Chair of Energy Economics

Prof. Dr. Dominik Möst

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