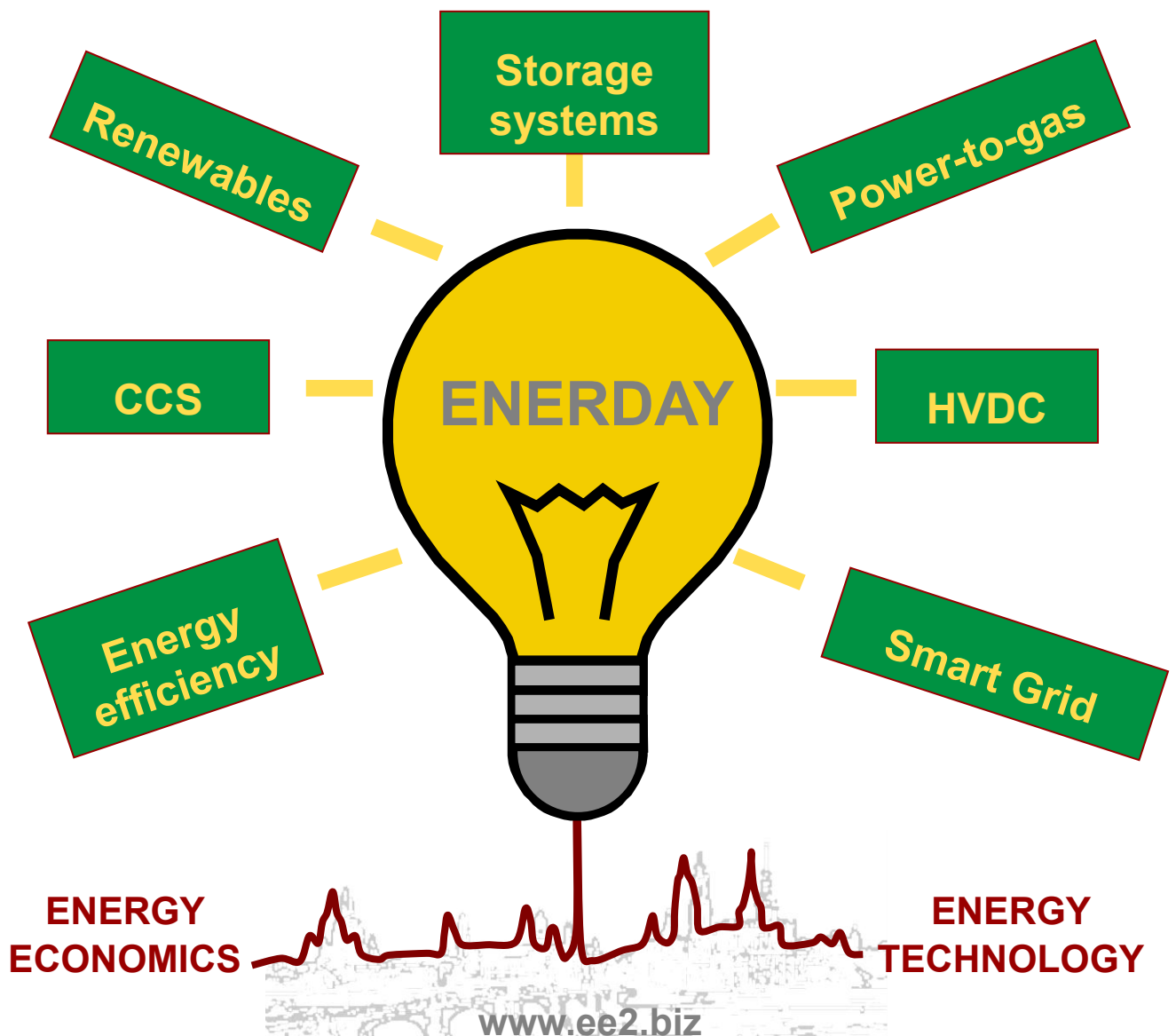


# 7<sup>th</sup> Conference on Energy Economics and Technology

*“Infrastructure for the Energy Turnaround”*



27 April 2012, TU Dresden

Supporting Organizations



Scientific Partners





# **ENERDAY**

## **7<sup>th</sup> Conference on Energy Economics and Technology**

*Infrastructure for the energy turnaround*

## **Book of Abstracts**

**27 April, 2012**

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

Contact / Registration:

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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 7<sup>th</sup> Conference on Energy Economics and Technology focusing this year on the infrastructure for the energy turnaround (“die Energiewende”).

The objective of the ENERDAY is to address challenges for energy systems, energy markets and policies, in particular concerning the relevance of the energy transformation for the infrastructure. Mastering the challenges associated with this transformation is of highest importance for the national economy and necessitates well educated energy economists and engineers. 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 good attendance, which is reflected in the internationality and interdisciplinarity of the participants and the scope of the contributed talks. This year we were surprised and encouraged by the amount of submitted contributions, which induced us to set-up an additional poster session as well as a strict selection process. 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 the on-going energy turnaround. We would like to thank all the speakers 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, Michael Zipf  
& EE<sup>2</sup> organizing committee

## Conference Location

Technische Universität Dresden

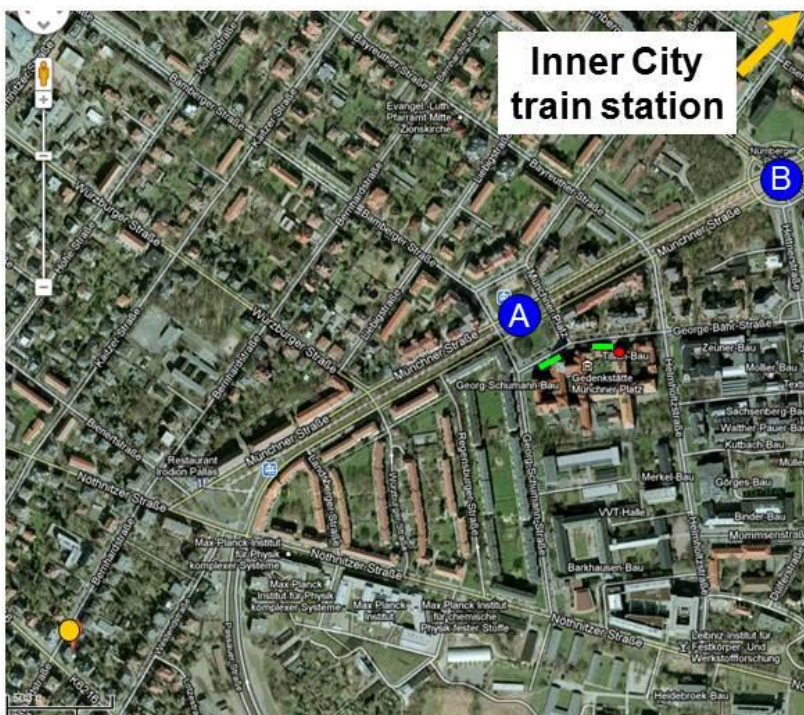
Faculty of Business and Economics

Münchner Platz 3

Schumann-Bau / Hülse-Bau

D-01069 Dresden,

Faculty Assembly Hall/Festsaal der Fakultät



- **ENERDAY** registration
- Building entrances
- Paul Rackwitz (pre-conference Dinner)
- A** Tram station: Münchner Platz Line 3
- B** Tram/Bus station: Nürnberger Platz Line 8, Bus Line 61

- From the **Inner City** or the **North** take the tram No. 3 (direction "Coschütz") and get off at "Münchner Platz" or tram No. 8 (direction "Südvorstadt") up to "Nürnberger Platz".
- From the **West** (Hotel Am Bonhoefferplatz) or the **East** take the tram No. 8 and get off at "Nürnberger Platz".
- From the **airport** take the train (airport shuttle) to the main train station and take the tram No. 3.

- By car:**
- From the **West** (Leipzig, Chemnitz) leave the A4 at Dresden-Altstadt and follow the signs to "Prag" (E55).
  - At the "Nürnberger Platz" turn right into the "Münchner Strasse"

- From the **East** (Bautzen, Berlin) leave the A4 at Dresden-Hellerau and follow the signs to "Prag" (E55).
- After the main train station keep straight, following the tram (No. 3) to "Nürnberger Platz" into the "Münchner Strasse"

Try to find a parking lot around the "Münchner Platz" or within the university area



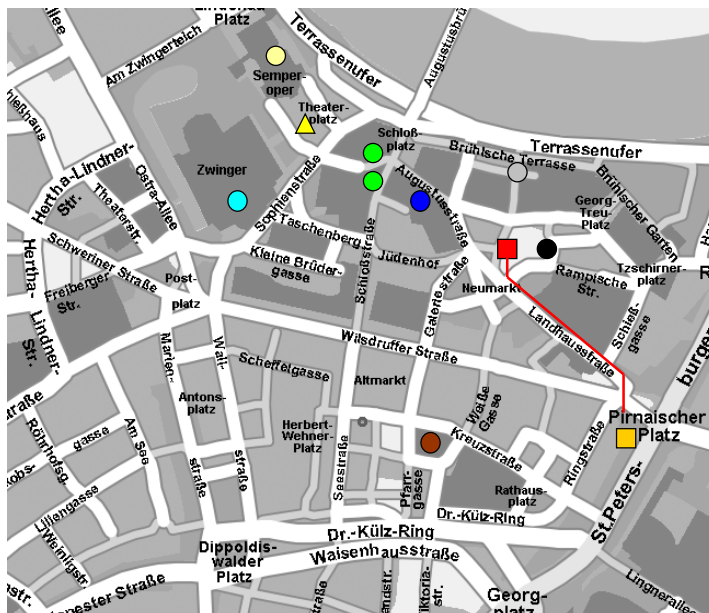
## Conference Dinner at Friday, 27<sup>th</sup> April

Augustiner an der Frauenkirche

An der Frauenkirche 16/17

01067 Dresden

[www.augustiner-dresden.de](http://www.augustiner-dresden.de)



■ Tram station "Pirnaischer Platz", Line 3

■ Conference Dinner "Augustiner"  
(Start: 7pm) An der Frauenkirche 16/17  
Tel: +49-(0)351-482897-0

### How to get to the Conference Dinner:

Tram Line 3 will take you directly from the University to the tram station at the "Pirnaischer Platz" (tram leaves every 10 minutes). Get off the tram (6 stops) and turn left into the Landhausstraße (Walk straight ahead about 400m until you reach the "Neumarkt" (an historic market place). The "Augustiner" is located vis a vis the Church of our Lady.

### Saturday

▲ Meeting Point for Historical Tour, 9.30am

Meeting Point for Hiking: 9.00am Central Station

### Further Points of interest (only a selection):

- "Zwinger": baroque complex of pavilions and galleries commissioned by Augustus the Strong, elector of Saxony
- Semper Opera House: built between 1838 and 1841 by Gottfried Semper, home to the "Sächsische Staatsoper"
- Catholic "Hofkirche" (Church of the Court) and "Residenzschloss" (Royal Palace): former seat of Government of the Saxon rulers
- "Frauenkirche": Church of our Lady designed by George Bähr, completed in 1734, destroyed in 1945 and rebuilt in the last years
- Procession of Princes: a 102 meter long mural
- "Kreuzkirche": a 18th century church in neoclassicist style
- Brühl Terrace: terraced promenade with beautiful architecture

## Program

**Informal Get Together: Thursday, 26 April, 7 pm, Location: Paul Rackwitz, Plauenscher Ring 33, Dresden**

### Conference program, 27 April in the morning

8.30 h	Registration, Coffee & Tea (Room: Faculty Assembly Hall)		
9.00 h	<b>Opening Address (Room: Faculty Assembly Hall)</b> Prof. Dr. Susanne Strahinger, 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 <sup>2</sup>		
9.30 h	<b>Keynote Session (Room: Faculty Assembly Hall)</b> Dr. Jürgen Neubarth, DII GmbH : Bringing the Desertec vision into reality – The power transmission challenges Chair: Prof. Dr. Dominik Möst, TU Dresden, EE <sup>2</sup>		
10.15 h	Coffee & Tea		
10.45 h - 12.30 h	<b>Transmission Networks (Room: Faculty Assembly Hall)</b> Chair: Jonas Egerer, TU Berlin  <i>Cost allocation across borders in the European Transmission grid</i> Mats Nilsson, Kristian Gustafsson (Vattenfall AB)  <i>From Nodal to Zonal Pricing: A Bottom-Up Approach to the Second-Best</i> Barbara Burstedde (EWI University of Cologne)  <i>The transition to future transmission networks – How to regulate grid investments under uncertainty</i> Mike Huggins, Anton Burger, Aria Rodgarkia-Dara (Frontier Economics)  <i>Does a Welfare Maximizing Quality Regulation Guarantee Timely Network Replacement Investments? – Theoretical Model and Experiment</i> Volker Wannack (Jacobs University Bremen)  <i>Optimal investments for renewable energy integration in Germany</i> Jonas Egerer (TU Berlin)	<b>Renewables (Room: A 03)</b> Chair: Massimo Genoese, Karlsruhe Institute of Technology (KIT)  <i>Local Energy Autarky vs. Pan-European Network – 100% Renewable Energies Scenarios by 2050</i> Mark Nowakowski (Umweltbundesamt)  <i>Remuneration and capital costs of renewable energy projects on Green Certificate markets – the Polish example</i> Markus Reichel, Stephan Wegert (DREBERIS GmbH)  <i>A new model for analyzing renewable energy integration in Germany</i> Wolf-Peter Schill (DIW Berlin)  <i>Electricity Investment: An Evaluation of the New British Energy Policy</i> Chiara Del Bo, Massimo Florio (University of Milano)  <i>Analysis of drivers affecting the use of market premium for renewables</i> Massimo Genoese et al. (Karlsruhe Institute of Technology)	<b>Emissions (Room: B37)</b> Chair: Hannes Weigt, University of Basel  <i>Do Emission Trading Schemes Facilitate Efficient Abatement Investments? An Experimental Study</i> Silvester van Koten (European University Institute)  <i>Redistribution Effects of Energy and Climate Policy</i> Lion Hirth, Falko Ueckerdt (Vattenfall AB)  <i>The effect of policy uncertainty on energy infrastructure deployment: A real option approach for CCTS network development</i> Joris Morbee (European Commission)  <i>Investigating a CO<sub>2</sub> Tax and a Nuclear Phase Out with a Multi-Fuel Market Equilibrium Model</i> Daniel Huppmann (DIW Berlin), Ruud Egging (NTNU Trondheim)  <i>CO<sub>2</sub> Abatement from RES Injections in the German Electricity Sector: Does a CO<sub>2</sub> Price Help?</i> Hannes Weigt et al. (University of Basel)



## ENERDAY

### Afternoon

12.30 h	Lunch (Room: in front of the Faculty Assembly Hall)		
13.30 h	<b>Keynote Speech (Room: Faculty Assembly Hall)</b> Gregor Zoettl, University of Munich: Challenges in Market Design: Addressing Generation and Network Issues Chair: Christian von Hirschhausen, TU Berlin WIP, and DIW Berlin		
14.15 h - 15.45 h	<b>Smart Grids</b> <b>(Room: Faculty Assembly Hall)</b> Chair: David Gunkel, TU Dresden  <i>Market Roles and a System Structure for Smart Market/Grid – Design and Experiences from Test Region</i> Holger Wiechmann, Kai Hufendiek (EnBW)  <i>Quantitative effects of decentralized storage options in a smart grid infrastructure</i> Matthias Koch, Christoph Heinemann, Dierk Bauknecht (Öko-Institut)  <i>Increasing the use of renewable energy: the MeRegio project – first results</i> Hellmuth Frey (EnBW)  <i>A free ride on demand response? – A scenario based analysis of cross-national externalities and supply side effects in Europe</i> Katharina Grave et al. (EWI University of Cologne)	<b>Acceptance</b> <b>(Room: A 03)</b> Chair: Stefan Perras, TU Dresden  <i>Consumer Valuation of Changes in Alternative Fuel Vehicles' Driving Range: A Meta-analysis</i> Alexandros Dimitropoulos et al. (VU University Amsterdam)  <i>Social Acceptance of Renewable Energy Innovation: An interdisciplinary case-based approach to the study of deployment practices</i> Abdelfattah Triki (ISG Tunis)  <i>Energy-economic Analysis of CCS in Climate Change Mitigation Scenarios under a Nuclear Phase-out in Switzerland</i> Nicolas Weidmann, Hal Turton (PSI)  <i>Electricity transmission line planning: How Transmission System Operators can avoid public opposition</i> Stefan Perras (TU Dresden/Siemens Management Consulting)	<b>Natural Gas</b> <b>(Room: B37)</b> Chair: Friedrich Kunz, TU Dresden  <i>Design of auctions for short-term allocation of gas network services in virtual hubs markets</i> Miguel Vazquez, Michelle Hallack (European University Institute)  <i>The Supply Curve for Gas Supply Security with Application to Bulgaria</i> Florent Silve (University of Cambridge)  <i>Overall simulation of German natural gas transmission systems – potential of gas grid for energy transformation</i> Bo Li (TU Clausthal)  <i>Pipeline Power</i> Franz Hubert, Onur Cobanli (HU Berlin)
15.45 h – 16.30 h	<b>Coffee &amp; Tea</b> <b>+ Poster Session (topics see next page)</b>		
16.30 h - 18.00 h	<b>Generation</b> <b>(Room: Faculty Assembly Hall)</b> Chair: Rainhard Madlener, RWTH Aachen  <i>Economic analysis of electricity storage applications in the German spot market for 2020 and 2030</i> Hendrik Kondziella, T. Bruckner (University of Leipzig)  <i>Techno-economic evaluation of energy technologies under uncertainty</i> Dogan Keles (Karlsruhe Institute of Technology)  <i>Is a capacity market the best possible solution in a fast energy turnaround?</i> Lukas Schuffelen and Dominic Nailis (BET Aachen GmbH)  <i>Evaluation of different strategies to hedge the commodity price risk of industrial combined-heat-and-power plants</i> Reinhard Madlener, Andreas Palzer (RWTH Aachen), Günther Westner (E.ON Energy Projects GmbH)	<b>Electric Mobility</b> <b>(Room: A 03)</b> Chair: Alexandra Paetz, Karlsruher Institute of Technology (KIT)  <i>Sustainable Mobility: Analyzing the Supply Chain for TUM's Electric Vehicle MUTE</i> Christian Kandler et al. (TU Munich)  <i>Range limits of electric vehicles: Invest in charging infrastructure or buy larger batteries? A techno-economic comparison</i> Till Gnann et al. (Fraunhofer ISI)  <i>Total Ownership Cost Projection for the German Electric Vehicle Market with Implications for its Future Power and Electricity Demand</i> Patrick Plötz et al. (Fraunhofer ISI)  <i>Feasibility of Battery Switch Stations for Local Emission Free Public Transport</i> Alexandra Paetz (Karlsruhe Institute of Technology)	<b>Desertec</b> <b>(Room: B37)</b> Chair: Christoph Kost, Fraunhofer ISE  <i>The DESERTEC University Network and the socio-economic development of the MENA region</i> Mouldi Miled (DUN)  <i>Comparative Study of Public Acceptance of DESERTEC-related Renewable Energy Plants</i> Dina Abdel-Fattah et al. (DESERTEC Foundation)  <i>Solar power plants operating under market prices</i> Christoph Kost (Fraunhofer ISE), Christoph Flath (IISM Karlsruhe)
Evening, 19.00 h	Reception, Conference Dinner, Augustiner, An der Frauenkirche, D-01067 Dresden		

## ENERDAY Postersession

### 7<sup>th</sup> Conference on Energy Economics and Technology

*Infrastructure for the Energy Transformation*

**Topics Postersession - within Coffee break in the afternoon, 15.45 h – 16.30 h**

**(Room: Above Faculty Assembly Hall)**

<b>Topic 1</b>	Matthias Popp (Poppware)	<i>Storage demand for a macroeconomic beneficial transformation of power supply</i>
<b>Topic 2</b>	Ivan Benes (Cityplan)	<i>Resilient Power Pilot Project</i>
<b>Topic 3</b>	Philipp Richter (DIW Berlin)	<i>Trade and the Environment: The Role of Firm Heterogeneity</i>
<b>Topic 4</b>	Hikaru Yamada (Sprint Capital Japan Ltd.)	<i>Smart Distribution for Post Disaster Management</i>
<b>Topic 5</b>	Jing Xu (Florence School of Regulation)	<i>Adoption of netback pricing regime in Chinese gas industry is a step towards a single price market?</i>
<b>Topic 6</b>	Ariadna Cruz Velis (TU Delft)	<i>Large-scale offshore wind power integration from a technical interoperability</i>
<b>Topic 7</b>	Zbigniew Krysa (Wroclaw University of Technology)	<i>Changes in the energy production from the combustion fuel based on spread analysis in the Polish energy market</i>
<b>Topic 8</b>	Moritz Riede (IAPP)	<i>Status and Potential of Organic Solar Cells</i>

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# Content

## Session 10.45 – 12.30

Transmission Network

Renewables

Emissions

## Session 14.15 – 15.45

Smart Grids

Acceptance

Natural Gas

## Session 16.30 – 18.00

Generation

Electric Mobility

Desertec

## Postersession 15.45 – 16.30

## Keynotes

**9.30 – 10.15**

*Bringing the Desertec vision into reality – The power transmission challenges*

Jürgen Neubarth, DII GmbH

**13.30 – 14.15**

*Challenges in Market Design: Addressing Generation and Network Issues*

Gregor Zoettl, University of Munich

**Session 10.45 – 12.30****Transmission Networks**  
**Room: Faculty Assembly Hall**  
**Chair: Jonas Egerer (TU Berlin)**

*Cost allocation across borders in the European Transmission grid*  
Mats Nilsson, Kristian Gustafsson (Vattenfall AB)

*From Nodal to Zonal Pricing: A Bottom-Up Approach to the Second-Best*  
Barbara Burstedde (EWI University of Cologne)

*The transition to future transmission networks*  
*– How to regulate grid investments under uncertainty*  
Mike Huggins, Anton Burger, Aria Rodgarkia-Dara (Frontier Economics)

*Does a Welfare Maximizing Quality Regulation Guarantee Timely Network Replacement Investments? – Theoretical Model and Experiment*  
Volker Wannack (Jacobs University Bremen)

*Optimal investments for renewable energy integration in Germany*  
Jonas Egerer (TU Berlin)

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*Signals and cost allocation in transmission investment*

Mats Nilsson (Vattenfall AB)

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Where should capacity increases in the European transmission grid occur? How should costs for these transmission investments be allocated? In a smart grid, how does demand react, and how can market signals affect long run political decision making? The interaction between long run investors, regulators and the transmission grid operator is to say the least dynamic. To move from an electricity market that is based on geography to one that is based on the underlying physical infrastructure requires legislation that allows for the use of markets outside the national scope. Often the beneficiaries of an investment are outside of the area in which the investment is done. The financing of these often in absolute numbers large projects is an important part of the project ever being realized. Thus, who benefits and who pays are generally important questions in a policy discussion. This paper elaborates upon these questions from three different aspects. First, must there be a top-down legislative action to make investments that benefits stakeholders outside the transmission control area to happen? What could be the role of national regulators? And finally, what kind of signals must reach market participants to trigger long run reactions?

Keywords: Market information, cost allocation, transmission

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*From Nodal to Zonal Pricing: A Bottom-Up Approach to the Second-Best*

Barbara Burstedde (Institute of Energy Economics at the University of Cologne)

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Congestion management schemes have taken a prominent place in current electricity market design discussions. In this paper, the implications of establishing zonal pricing in Central Western Europe, Switzerland and Austria are analyzed with regard to potential zonal delimitations and associated effects on total system costs. Thereby, a nodal model sets the benchmark for efficiency and provides high-resolution input data for a cluster analysis based on Ward's minimum variance method. The proposed zonal configurations are tested for sensitivity to the number of zones and structural changes in the electricity market. Furthermore, dispatch and redispatch costs are computed to assess the costs of electricity generation and transmission. The results highlight that suitable bidding zones are not bound to national borders and that losses in static efficiency resulting from the aggregation of nodes into zones are relatively small. Nonetheless, nodes with extreme characteristics do exist and are worth identifying.

Keywords: Cluster Analysis, Electricity Market Modelling, Nodal Pricing, Redispatch, Zonal Pricing

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*The transition to future transmission networks – How to regulate grid investments under uncertainty*  
Mike Huggins, Anton Burger, Aria Rodgarkia-Dara (Frontier Economics)

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The demands we place on transmission grids are evolving rapidly, as we install ever increasing quantities of renewable generation in locations where there has traditionally been no generation, and as conventional generation begins to retire. These changes are having a significant impact on power flows, requiring major new investment in transmission capacity. There is no doubt that these trends will continue and accelerate, but there is often little clarity over exactly what will be built where and exactly when existing stations might retire. Consequently the job of the transmission planner has become more difficult than ever. In this paper we discuss the sources of this uncertainty and its consequences for transmission planning and hence regulation.

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*Does a Welfare Maximizing Quality Regulation Guarantee Timely Network Replacement Investments?*  
– Theoretical Model and Experiment

Volker Wannack (Jacobs University Bremen)

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This paper shows by using a theoretical model that under an ideal welfare maximizing quality regulation the wage maximizing asset manager of a typical electricity distribution system operator (DSO) avoids the necessary replacement investments near the end of his labor contract in line with the industry standard. Therefore, an alternative labor contract that is deviating from the industry standard is proposed which encourages the asset manager to act in the interest of the overall welfare maximization and implicitly in the interest of the owner of the DSO. Following, an experiment reveals that not every asset manager behaves according to the theoretical model. This can be explained by the fact that the experiment participants showed different behavioral types, such as indirect reciprocity, conformity, guilt aversion or forward induction, of which some influenced the investment behavior. As opposed to this, individual distribution preferences showed no influence on investment behavior. Interestingly, no participant within the experiment did the necessary replacement investments near the end of the standard labor contract. Given the new contract format, 9,5% of the respondents have performed necessary investments on time. Consequently, the results of the experiment seem to confirm the recommendation to implement the new labor contract.

Keywords: electricity network investment, quality regulation, experiment, moral hazard, bounded rationality

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*Optimal investments for renewable energy integration in Germany*

Jonas Egerer (TU Berlin), Wolf-Peter Schill (DIW Berlin)

In recent years, Germany has experienced substantial growth in renewable energy. According to the National Renewable Energy Action Plan, variable renewable electricity generation from wind and solar power will continue to increase significantly over the next decade. Integrating these variable renewables into the electricity grid is a major challenge. Several strategies are currently being discussed. These include power storage, transmission grid expansion, demand-side measures (DSM), conventional backup power plants, and feed-in management of variable renewables. In this study, we employ a technical-economic analysis to determine a cost-minimizing combination of investments into such integration measures. We focus on the year 2022, in which the remaining nuclear capacity in Germany will be phased out.

We use a combined dispatch and network model with a DC load flow approach. The German high voltage transmission network is represented with over 300 nodes and more than 500 lines. A mixed integer unit commitment formulation allows representing start-up constraints and related costs of nearly 500 thermal plants in a more realistic way compared to a linear approach. We use an hourly time resolution, covering all subsequent hours of the year 2022. Exogenous model parameters include nodal power demand, thermal and renewable generation capacity, renewable feed-in patterns, and baseline transmission capacity. As for these parameters, changes compared to the status quo are estimated according to governmental and semi-official projections.

In a first model run, we determine nodal market outcomes for all hours of the year 2022 under the assumption that no additional investments into renewable integration measures have taken place. We are particularly interested in the frequency, duration, and location of (i) renewable surplus generation and (ii) critical shortages of power supply. In a second model run, we allow endogenous investments into storage, transmission expansion, demand-side management, and conventional backup power plants, and determine a cost-minimizing combination of these investments. In addition, wind and solar power may be curtailed.

Importantly, the modeled integration measures “compete” for dispatch in periods of shortage and/or excess renewable supply. We are interested in analyzing their interrelation. For example, we expect significant investments into gas power plants due to their low investment cost; however, new power plants will change the dispatch regime and thus the viability of all other modeled integration measures. The same is true for storage, DSM, and transmission investment. Our analysis will shed some light on these interactions.

**Session 10.45 – 12.30****Renewables****Room A 03****Chair: Massimo Genoese (Karlsruhe Institute of Technology)**

*Local Energy Autarky vs. Pan-European Network –  
100% Renewable Energies Scenarios by 2050*

Mark Nowakowski (Umweltbundesamt)

*Remuneration and capital costs of renewable energy projects on Green Certificate markets –  
the Polish example*

Markus Reichel, Stephan Wegert (DREBERIS GmbH)

*A new model for analyzing renewable energy integration in Germany*

Wolf-Peter Schill (DIW Berlin)

*Electricity Investment: An Evaluation of the New British Energy Policy*

Chiara Del Bo, Massimo Florio (University of Milano)

*Analysis of drivers affecting the use of market premium for renewables*

Massimo Genoese et al. (Karlsruhe Institute of Technology)

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*Local Energy Autarky vs. Pan-European Network – 100% Renewable Energies Scenarios by 2050*

Mark Nowakowski, Federal Environment Agency (Umweltbundesamt)

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The Federal Environment Agency has developed three radically different scenarios to study the technical and ecological feasibility of Germany switching to an electricity supply based entirely on renewable sources by 2050. The studies assume different generation structures and degrees of connection between individual regions in Germany and between Germany and other countries within a pan-European network: In the “Local Energy Autarky” scenario, small-scale decentralized energy systems use locally available renewable energy sources to satisfy their own power demand without being connected with each other or with outside suppliers, i.e. without electricity imports to Germany. In the “Regions Network” scenario, electricity is exchanged throughout Germany and only a small part of the load is covered by electricity imports from neighbouring countries. In the “International Large Scale” scenario, Germany’s electricity supply is based on all renewable-energy potentials in Germany, Europe and its vicinity which can readily be tapped by large-scale technology projects and storage power plants. In this scenario, Germany imports much of its electricity demand via a well-developed intercontinental transmission grid. The studies presented here suggest that expanding the European electricity grid might offer significant potential for optimizing the security of energy supply. This is true not just for Germany, but even more for a Europe increasingly focused on renewable energy sources.

Keywords: Renewable Energies, Scenarios, Grid Extension, Power Supply, Energy Security

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*Remuneration and capital costs of renewable energy projects on Green Certificate markets – the Polish example*

Stephan Wegert, Dr. Markus Reichel (DREBERIS GmbH)

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Poland is one of the European countries, which chose to implement a renewable energy promotion scheme based on quotas and green certificates instead of feed-in tariffs. The 2020 target for green energy production is set at 15% of final energy consumption, respectively 19% for electricity generation. In order to improve the efficiency of the system, the Polish government prepared a draft law on Renewable Energies which was published on 22 December 2011. It has made clear, that Poland will keep the certificate system. However, several changes have been announced, such as the introduction of technology specific allocations of certificates or the restriction of the period, for which producers are entitled to receive certificates, to 15 years starting with commissioning date.

In our paper we investigate the effects of the current structure and planned changes of the Polish certificate market on the behavior of green energy investors and resulting price levels for green certificates. In order to appraise renewable energies projects, two main parameters have to be understood well. The first one concerns the future remuneration of electricity from renewable energy, the second one are the capital costs that are related to the risks associated with this remuneration. We show that the proposed changes in stabilize the market and mitigate investment risks.

We conclude that certificate systems tend to higher investment risks and thus higher capital costs, which must be reflected in higher overall remuneration. By a more appropriate design of the certificate promotion scheme, this adverse effect can be partially compensated.

Keywords: renewable energy, green certificates, investment risks, valuation, capital costs

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*A new model for analyzing renewable energy integration in Germany*

Wolf-Peter Schill (DIW Berlin)

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Electricity generation from renewable sources like wind and solar power has increased substantially in recent years in Germany, and is projected to grow further in the future. Integrating these variable renewables into the electricity grid is both a technical and an economic challenge. Importantly, the build-up of both variable renewable generation capacity and of the technologies for integrating these into the grid (e.g. power storage, grid expansion, and demand-side measures) has intricate effects on power market outcomes, among them changes in the patterns of residual load and spot market prices. In addition, thermal generators face higher ramping requirements and a lower number of yearly full-load hours, which reduces their profitability.

In this context, a range of research questions needs to be answered. For example, it has to be determined which capacities of storage and other technologies are required for integrating variable renewables cost-efficiently into the German grid. Moreover, the effect of both additional renewables and their integration strategies on market outcomes is of great interest. In particular, it has to be seen if renewable energy integration technologies like storage can generate sufficient revenues to cover their capital costs. In order to answer such questions, solid power market modeling is indispensable. Most importantly, the limited flexibility of the current thermal generation systems has to be represented in order to generate useful insights. In addition, the provision of control reserves has to be included in order to cope with stochastic renewable feed-in.

Against this background, we introduce a new power market model. It is formulated as a mixed-integer unit commitment problem, which allows representing thermal generators in a sufficiently realistic way. Depending on the problem size, it is possible to include special features like efficiency losses of thermal generators in part-load mode or downtime-dependent start-up costs. In addition, the model includes a representation of primary, secondary and tertiary reserve provisions as well as stylized must-run restrictions related to combined heat and power generation. We use a cost-minimizing approach, assuming perfectly inelastic short-term power demand. In doing so, we avoid the problem of most market models, according to which renewable integration problems are strongly diminished by demand reactions. After determining the cost-minimal dispatch, we use an innovative heuristic in order to find prices that make the cost-minimizing dispatch incentive compatible for every generator in the market. In this way, it is possible to interpret the model result as market outcomes, although its general character is rather cost-based than price-based.

In this paper, we present the model formulation, discuss some main features, and provide some exemplary applications. As for the latter, we start with the calibration of the model for the year 2010. Subsequently, we demonstrate the effect of the German nuclear phase-out after the Fukushima accident in order to assess the model's robustness to major supply-side shocks. Finally, we present a model run for the year 2020, assuming stylized expansion of renewable power generation and additional investments into power storage. We are interested in the changes in full-load hours, price patterns, and profitability of different technologies compared to the base year 2010. The paper concludes with a discussion of shortcomings and the need for future model extensions.

Keywords: Power market model; Unit commitment; Renewable energy integration

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*Electricity Investment: An Evaluation of the New British Energy Policy and its Implications for the European Union*

Chiara Del Bo, Massimo Florio (University of Milan)

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Traditionally, the electricity market has been characterized by vertically integrated monopolies due to the special features of this commodity, such as non-storability in the longer term, the physical laws requiring instant equation of supply and demand and the need for a complex and integrated network, controlled by a system operator. Despite these features, however, a wave of reforms promoting competition has been initiated in most markets, including the US and Europe, accompanied by regulation. In this paper we offer an overview of the current electricity policy debate taking place in the UK, which may pose the basis for a rethinking of the dominant policy paradigm. We review the technological and economic features of electricity markets, focusing on the rationales underlying the reforms put in place in the European Union and highlighting the impacts and potentially problematic consequences of liberalization in terms of investment and infrastructure, related to overarching economic, social and policy goals, focusing on the implications of environmental and climate-change mitigation policies as well as poverty reduction issues. The paper analyses the possible consequences, in terms of reforms and regulation of the electricity industry, of these new goals, suggesting that they may be relevant for the electricity industry in the EU.

Keywords: Electricity market; Energy policy; Investment

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*Analysis of drivers affecting the use of market premium for renewables*

Dr. Massimo Genoese, Viktor Slednev, Prof. Dr. Wolf Fichtner (Karlsruhe Institute of Technology)

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In order to provide an incentive for market and system integration of renewable energies, the new German renewable energy support act (EEG) offers a market premium for renewables, giving all operators of renewable energy installations the opportunity to market their electricity on their own. The aim of this paper is to identify parameters that determine the profitability of wind power operators in the market premium model. Therefore the two components of the market premium, (i) a premium (PM) to cover the costs of the direct marketing and (ii) a term that fills the gap between the feed in tariff and the actual market value of the renewable generation are analyzed and evaluated based on data of the four German grid operators from the years 2007-2011. The chosen approach is to divide the components (i) and (ii) into a bias- and a covariance. Besides the result that the current parameterization gives market participants an incentive for direct marketing, the incentive for a minimization of the forecast deviation is found to be varying among the analyzed portfolios. Especially the generation profile of the TransnetBW control zone is found to show an above average performance.

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**Session 10.45 – 12.30****Emissions****Room: B37****Chair: Hannes Weigt (University of Basel)**

*Do Emission Trading Schemes Facilitate Efficient Abatement Investments?  
An Experimental Study*

Silvester van Koten (European University Institute)

*Redistribution Effects of Energy and Climate Policy*

Lion Hirth, Falko Ueckerdt (Vattenfall AB)

*The effect of policy uncertainty on energy infrastructure deployment:*

*A real option approach for CCTS network development*

Joris Morbee (European Commission)

*Investigating a CO<sub>2</sub> Tax and a Nuclear Phase Out with a Multi-Fuel Market Equilibrium Model*

Daniel Huppmann (DIW Berlin), Ruud Egging (NTNU Trondheim)

*CO<sub>2</sub> Abatement from RES Injections in the German Electricity Sector:*

*Does a CO<sub>2</sub> Price Help?*

Hannes Weigt et al. (University of Basel)

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*Do Emission Trading Schemes Facilitate Efficient Abatement Investments? An Experimental Study*  
Silvester van Koten (European University Institute)

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The main policy objective of a cap-and-trade program is the cost-efficient abatement of pollutants or emissions. Whether a cap-and-trade program will realize cost-efficient abatement in practice is an open question. Earlier experiments on abatement-by-switching suggest that experimental participants make highly inefficient abatement choices and that permit allocation methods bias participants to over or under-abatement. These results are surprising, as experiments on abatement-by-reduction, a different but similar form of abatement, suggest that participants can quickly learn to make efficient choices and that allocation has little or no effect (Wråke et al. 2010, Van Koten 2012). Examination of the earlier experiments reveals that participants had little opportunity for unbiased learning, price was set in relatively small groups, and that there was uncontrolled price uncertainty. Running experiments that incorporate opportunities for unbiased learning, exogenous price setting and controlled uncertainty, participants quickly learn to make accurate decisions and allocation has no effect on decision-making, not even for relatively inexperienced participants. Uncertainty, while lowering the accuracy of decision-making, does not bias participants towards over or under-abatement. These results suggest that policy-makers may enjoy the industry support that free allocation buys without paying the cost of a decreased efficiency of abatement. The learning effect found in this experiment cautions against relying on the results of experiments where participants have little opportunity for unbiased learning or where prices are determined by a small group.

Keywords: Abatement, Cap-and-Trade, Experimental Economics, Emission Trading System, Carbon Permits

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*Redistribution Effects of Energy and Climate Policy*

Lion Hirth (Vattenfall AB), Falko Ueckerdt (Potsdam-Institute for Climate Impact Research)

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While usually designed for a different purpose, energy and climate policies also redistribute wealth between producers, consumers, and the government. This paper compares the redistribution effects of CO<sub>2</sub> pricing and renewable deployment support schemes. An analytical model is developed to show that rents exist and change due to these policies. Qualitative findings are then quantified using a numerical model of the European electricity market. While CO<sub>2</sub> pricing increases the rents of low-carbon conventional generators and decreases those of carbon-intensive producers, wind deployment reduces rents of all generators. Redistribution is often large relative to welfare effects. These findings imply that a society with a preference for avoiding large redistribution might prefer a mix of policies, as opposed to the classical finding that CO<sub>2</sub> pricing alone is the first best climate policy.

Keywords: Carbon tax, Environmental economics, Power generation economics, Profitability, Rents, Redistribution, Wind power generation, Optimization, Electricity market, Welfare

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*The effect of policy uncertainty on energy infrastructure deployment - A real option approach for CCTS network development*

Joris Morbee (European Commission, DG JRC, Institute for Energy and Transport)

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The EU's commitment to reduce greenhouse gas emissions by 80% to 95% by 2050 compared to 1990 levels will require a major transformation of the energy system. Since this transformation is largely policy-driven, the required infrastructure investments are subject to significant policy uncertainty. This paper assesses the effect of policy uncertainty on the structure and investment costs of energy infrastructure, by studying the optimality of a European CO<sub>2</sub> transport network for carbon capture, transport and sequestration (CCTS) under policy uncertainty. We modify the JRC's *InfraCCS* CO<sub>2</sub> pipeline network optimisation model so as to take into account an uncertain level of capture plant deployment. The annual amount of CO<sub>2</sub> captured by 2050 is considered a stochastic variable ranging from 210 Mt/y to 981 Mt/y. Uncertainty is assumed to be resolved over time in a binomial lattice with 4 time steps from 2020 to 2050. In a real option framework, the *InfraCCS* model is run to find the optimal adaptive network investment strategy that minimises expected pipeline investment cost. The results show that, as a result of uncertainty, the resulting pipeline network is less efficient than the optimal network: network investment costs increase by up to 3.5 billion euro compared to a deterministic scenario.

Keywords: carbon capture, transport and storage (CCTS); pipeline networks; real options; option pricing; policy uncertainty

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*Investigating a CO<sub>2</sub> Tax and a Nuclear Phase Out with a Multi-Fuel Market Equilibrium Model*

R. Egging (NTNU Trondheim), D. Huppmann (DIW Berlin)

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We present an energy market equilibrium model that captures climate aspects, infrastructure constraints, fuel substitution, and market power à la Cournot in a single framework. The model represents the supply and transportation infrastructure, fuel transformation, power generation, and several demand sectors of fossil fuels, renewables and nuclear energy.

We calibrate the model to market data from the year 2010, with a detailed representation of Europe and the rest of the world represented by continent. We analyze the impact of various regional and global CO<sub>2</sub> tax levels and the consequences of a nuclear phase out in Germany.

Our results illustrate that positive effects of regional CO<sub>2</sub> taxes can be largely undone through carbon leakage and that global CO<sub>2</sub> tax levels affect countries differently, dependent on factors such as the fuel mix and idle capacity in power generation. The regional fuel mix in Europe is affected less by a global than a local tax. Finally, Germany is well-connected to surrounding countries, and its potential to increase the use of renewables and import gas and electricity is high enough to compensate for a nuclear phase out.

Keywords: Fuel substitution, environmental policy, market power, mixed complementarity problem

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*CO<sub>2</sub> Abatement from RES Injections in the German Electricity  
Sector: Does a CO<sub>2</sub> Price Help?*

Hannes Weigt (University of Basel), Erik Delarue (KULeuven), Denny Ellerman (MIT)

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The overlapping impact of the Emission Trading System (ETS) and renewable energy (RE) deployment targets creates a classic case of interaction effects. Whereas the price interaction is widely recognized and has been thoroughly discussed, the effect of an overlapping instrument on the abatement attributable to an instrument has gained little attention. This paper estimates the actual reduction in demand for European Union Allowances that has occurred due to RE deployment focusing on the German electricity sector, for the five years 2006 through 2010. Based on a unit commitment model we estimate that CO<sub>2</sub> emissions from the electricity sector are reduced by 33 to 57 Mtons, or 10% to 16% of what estimated emissions would have been without any RE policy. Furthermore, we find that the abatement attributable to RE injections is greater in the presence of an allowance price than otherwise. The same holds for the ETS effect in presence of RE injection. This interaction effect is consistently positive for the German electricity system, at least for these years, and on the order of 0.5% to 1.5% of emissions.

Keywords: ETS, RE policy, interaction, emission abatement, Germany

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**Session 14.15 – 15.45****Smart Grid****Room: Faculty Assembly Hall****Chair: David Gunkel (TU Dresden)**

*Market Roles and a System Structure for Smart Market/Grid –  
Design and Experiences from Test Region*  
Holger Wiechmann, Kai Hufendiek (EnBW)

*Quantitative effects of decentralized storage options in a smart grid infrastructure*  
Matthias Koch, Christoph Heinemann, Dierk Bauknecht (Öko-Institut)

*Increasing the use of renewable energy: the MeRegio project – first results*  
Hellmuth Frey (EnBW)

*A free ride on demand response? – A scenario based analysis of cross-national externalities  
and supply side effects in Europe*  
Katharina Grave et al. (EWI University of Cologne)

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*Market Roles and System Structure for Smart Market/Grid –  
Design and Experiences from Test Region*

Holger Wiechmann, Kai Hufendiek (EnBW Vertrieb GmbH)

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Everybody is talking about the “Energiewende”, the “Smart Energy World” and about “Smart Grids”, but almost no one knows, what it exactly means.

Not only the growth in fluctuating power generation from renewable energy sources like wind power and photovoltaic but also their locally distributed characteristics in the expanding decentralized generation market are calling for new ways of decentralised managing energy. All these upcoming challenges will be managed by new intelligent systems exchanging and processing all kinds of information only. In combination with the consumption being as well locally distributed and expecting growth as well e. g. for electric vehicles or electric heat pump systems, new processes and methods have to be developed to manage and link especially decentralised energy generation and consumption on a local basis as well as linked with the central system.

The interaction of all stakeholders (customers, market players, grid operators, authorities) in a Smart Grid/Smart Market environment is required to successfully implement an efficient “Energiewende”. Derived from the different interest of these stakeholders, the paper describes a system and roles within this system. It shows how Smart Grid and Smart Market can be interact corresponding to the guidelines of German Regulator recently published.

As such a system was already implemented for a research project with real customers, the experiences are reported. Especially the issue whether load shifting will really take place and to what extent it happens is critical for the success of Smart Energy systems. Insights to be provided from the research project.

Keywords: smart grid, smart market, demand side management, fluctuating power, market roles

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*Quantitative effects of decentralized storage options in a smart grid infrastructure*  
Dr. Matthias Koch, Christoph Heinemann, Dr. Dierk Bauknecht (Öko-Institut e.V.)

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Decentralized storage options are a relevant part of a smart grid infrastructure in order to provide flexibility at distribution grid level for the system integration of renewable and intermittent energy sources. These storage options relax the constraints for operating small scale power plants, like gas storages for gas engines or turbines fired with biogas or sewage gas or heat storages for combined heat and power plants. On the demand side cooling storages of electrical cooling appliances in households and food retailing as well as electricity consumption shifted in time (virtual storages) help to move electricity demand towards times of variable generation.

The effects of decentralized storage options in a smart grid infrastructure are quantified with the electricity system model PowerFlex, developed by Öko-Institut within the E-Energy1 project eTelligenz2. The PowerFlex model is based on a linear optimisation problem in hourly resolution and covers various generation and supply side technologies as well as different flexibility and storage options. As the result of a scenario analysis, the integrated amount of renewable energy, the CO<sub>2</sub>-



emissions of the thermal power plant fleet, the annual generation costs and the hourly marginal electricity prices are determined.

The scenario analysis for Germany presented in this paper consists of the years 2010, 2020 and 2030 and includes different variations of the development of renewable energy sources (e.g. BMU-Leitstudie 20103) and pump storage power plant capacities (e.g. SRU Sondergutachten 20114), which compete with decentralized storage options. First results show, that the operation profiles of decentralized storage options correspond quite well with the marginal electricity price in the model.

In the 2030 scenario, about 6 % of the available variable energy sources from wind and solar power could not be included into the electricity system. Finally the effects from the use of decentralized storage options as well as additional pump storage power plant capacities to reduce the amount of wasted renewable energy are quantified.

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*Increasing the use of renewable energy: the MeRegio project – first results*

Hellmuth Frey (EnBW Energie Baden-Württemberg AG, Karlsruhe)

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A strongly centralized structure of energy generation is the basis for a reliable energy supply. Nevertheless, distributed and renewable energy generation will significantly increase in the next years. This has an impact on the energy generation of conventional power plants as well as on planning and operation of the grid which has additionally to take over a higher share of customer generation. Smart metering and the use of modern information and communication technologies offer the chance to efficiently combine these two structures. Smart metering and smart grids have the potential to strongly change the future energy industry.

The presentation gives an overview over the current situation in the German energy system which is influenced by the political order to increase the share of renewable energy significantly. A government funded competition called “E-Energy” has been started to demonstrate these effects in different model regions. An overview will be given on first results of the project “MeRegio”.

Within MeRegio 1000 private customers are already equipped with smart meters. Since end of 2009 they are connected to a smart grid system. These customers are provided with price signals. The idea of this project is to learn about the price elasticity of private and industrial customers. A first analysis of their change of behavior will be given.

Keywords: E-Energy, MeRegio, smart grid, price signal, price elasticity

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*A free ride on demand response? A scenario based analysis of cross-national externalities and supply side effects in Europe*

Katharina Grave, Joachim Bertsch, Christina Elberg, Christian Tode, (Institute of Energy Economics, Cologne)

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Flexibility is one of the major challenges in transforming the European electricity systems. Demand response seems to be one option to integrate renewable energy sources (RES-E) into the system. This paper analyzes the externalities of selected national systems with assumed developed demand response on neighboring countries in Europe and the effects on the supply side. A linear, inter-temporal, European optimization model with 14 regions is used to simulate an hourly dispatch. Demand response potential for three European countries with different supply structures and RES-E integration levels, namely France, the Iberian Peninsula and Germany, is quantified. An integrated scenario analysis with no or full availability of demand response in the respective countries is performed.

Results show that in systems with demand response the share of base-load generation increases, while mid-load and peak-load generation declines. Formerly curtailed RES-E generation is integrated. While France, the Iberian Peninsula and Germany benefit from their assumed demand response rollout, neighboring countries take a free ride on the positive externalities like reduced marginal costs and lower price volatility. This sheds new light on the question, whether policies of demand response should be implemented at a European level.

Keywords: Demand Side Management, Demand Response, linear modelling, European electricity systems

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**Session 14.15 – 15.45****Acceptance****Room: A 03****Chair: Stefan Perras (TU Dresden)**

*Consumer Valuation of Changes in Alternative Fuel Vehicles' Driving Range: A Meta-analysis*  
Alexandros Dimitropoulos et al. (VU University Amsterdam)

*Social Acceptance of Renewable Energy Innovation: An interdisciplinary case-based approach to the study of deployment practices*  
Abdelfattah Triki (ISG Tunis)

*Energy-economic Analysis of CCS in Climate Change Mitigation Scenarios under a Nuclear Phase-out in Switzerland*  
Nicolas Weidmann, Hal Turton (PSI)

*Electricity transmission line planning: How Transmission System Operators can avoid public opposition*  
Stefan Perras (TU Dresden/Siemens Management Consulting)

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*Consumer Valuation of Changes in Driving Range: A Meta-analysis*

Alexandros Dimitropoulos, Piet Rietveld, and Jos N. van Ommeren (VU University Amsterdam)

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We perform a meta-analysis of studies investigating consumer preferences for electric and other alternative fuel vehicles (AFVs) to provide insights into the way driving range is traded off for capital costs. We find that consumers are willing to pay, on average, between 67 and 75 US\$ for a one-mile increase in driving range. Ceteris paribus, 100-mile-range cars have to be priced about 48-61% less than their conventional counterparts to become competitive. In line with intuition, but in contrast to most specifications employed in primary studies, we find that consumers' marginal willingness to pay (WTP) decreases non-linearly with increases in driving range. The variation in the WTP and compensating variation estimates among examined studies can be attributed to differences in the levels of driving range considered, in other elements of the study design and in the country of study. Provided that a large scale introduction of electric vehicles is a policy aim, our findings support the continuation of R&D efforts directed towards the reduction of battery costs and the development of battery technologies permitting longer driving ranges. We further propose that consumer valuation of driving range should not be examined in isolation from other attributes related to refuelling activities, such as refuelling duration and the coverage of refuelling infrastructure.

**Keywords:** Meta-analysis; Driving range; Willingness to pay; Electric vehicle; Alternative fuel vehicle.

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*Renewable Energy Innovations: An interdisciplinary case-based approach to the study of deployment experiences and social acceptance*

Abdelfattah Triki (Graduate Institute of Management -Tunis University)

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Social acceptance is crucial for the successful development of renewable energy projects. Nonetheless social acceptance, as part of renewable energy implementation, is believed to have largely been neglected despite the importance and the variety of features that are related to it and that may bring new aspects to the debate. The project in hand tries to fill in this gap and to provide conceptual contributions as well as in-depth empirical data based on case-based research drawing upon various sources from deployment experiences around the world. The proposed research proposes the constitution of an interdisciplinary research team from the EUMENA region. The members of the team will review different deployment experiences of renewable energy technologies plants and will conduct field research using Rolf et al's (2007) triangle of social acceptance, community acceptance and market acceptance of renewable energies innovations as a framework and Schinke & Klawitter's (2010) suggestions as strategic key elements of sustainability principles for the implementation of the DESERTEC concept.

**Keywords:** social acceptance, renewable energy innovation, DESERTEC concept, sustainable human development, deployment experiences

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*Energy-economic Analysis of CCS in Climate Change Mitigation Scenarios under a Nuclear Phase-out in Switzerland*

Nicolas Weidmann, Hal Turton (Paul Scherrer Institute (PSI), Villigen, Switzerland)

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After the nuclear accident in Fukushima in 2011, Switzerland reconsidered the role of nuclear power in its energy system and decided to phase-out nuclear energy over the lifetime of existing power plants. This change in nuclear policy is likely to have a significant impact on the Swiss energy system and could intensify the need for alternative low-carbon electricity generation technologies in climate change mitigation scenarios given that Switzerland intends to keep its historical close balance between annual electricity imports and exports. Carbon capture and storage (CCS) being an almost abundant low-carbon electricity source could possibly contribute to the replacement of declining nuclear based electricity. However, the potential future role of CCS is highly dependent on a number of uncertainties affecting the future Swiss energy system such as (climate) policy decisions, availability of CCS and alternative climate change mitigation technologies in supply and end-use sectors and so on. The aim of this work is to analyse a set of scenarios representing some of the main uncertainties related to the future energy system and identify conditions under which CCS could become an attractive technology. The results of this analysis show that CCS could significantly contribute to the realization of an energy system satisfying climate constraints and substantially reduce energy system costs associated with nuclear phase-out.

Keywords: Carbon capture and storage, nuclear phase-out, bottom-up energy system model, climate change mitigation, scenario analysis

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*Electricity transmission line planning: How Transmission System Operators can avoid public opposition*

Stefan Perras (Technische Universität Dresden)

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Power transmission lines are urgently needed to foster the liberalization of the European energy markets, increase security of supply and support the integration of renewable energies. Unfortunately the implementation of new lines is stumbling. Project delays in the planning phase of more than 10 years are not rare. Main reasons are insufficient and lengthy authorization procedures and lack of social acceptance. Whereas the former has just recently been addressed by several legislative proposals comparably little attention has been paid to dealing with social opposition. Motives for opposition are mainly the fear of electromagnetic fields, visual impact, loss of property value, insufficient compensations and a lack of participation and transparency. To identify success factors for transmission system operators (TSO) in dealing with social opposition, more than 60 interviews have been conducted with action groups, NGOs and other energy experts across Europe. Further ideas have been derived from analogue large infrastructure projects (e.g. CCS). Collected ideas have been transformed into a structural equation model and are currently being tested through a questionnaire with almost all European TSOs. Preliminary results show that communication, participation, organizational readiness, trust, technical design and economic benefits turn out to be success factors for TSOs.

Keywords: Social acceptance, public opposition, transmission line planning, success factors, structural equation model

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**Session 14.15 – 15.45****Natural Gas****Room: B37****Chair: Friedrich Kunz (TU Dresden)**

*Design of auctions for short-term allocation of gas network services in virtual hubs markets*  
Miguel Vazquez, Michelle Hallack (European University Institute)

*The Supply Curve for Gas Supply Security with Application to Bulgaria*  
Florent Silve (University of Cambridge)

*Overall simulation of German natural gas transmission systems – potential of gas grid for energy transformation*  
Bo Li (TU Clausthal)

*Pipeline Power*  
Franz Hubert, Onur Cobanli (HU Berlin)

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*Design of auctions for short-term allocation in gas markets based on virtual hubs*

Miguel Vazquez and Michelle Hallack (Florence School of Regulation and Loyola de Palacio Chair, RSCAS, European University Institute)

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Gas markets based on virtual hubs has been the preferred EU design. Such market designs are based on socializing network flexibility services. Nonetheless, shippers have different preferences about the network flexibility, which are not reflected in current allocation models. Consequently, two scenarios are possible: free flexibility or absence of flexibility. We propose the introduction of auction mechanisms to deal with network service allocation in the short term. The auction aims to represent simultaneously the diversity of players' preferences and the trade-offs implied by network constraints. Two sealed-bid auctions are proposed. On the one hand, an auction with one product allocates network services through the minimization of gas price differences. On the other, a multi-product (gas and line-pack storage) auction is designed to facilitate the revelation of preferences on line-pack storage.

Keywords: auction design, gas markets, gas balancing, entry/exit allocation, iterative and combinatorial auctions)

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*The Supply Curve for Gas Supply Security with Application to Bulgaria*

Florent Silve (University of Cambridge)

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We evaluate the cost-effectiveness of various policy options and infrastructure investment proposals to improve the security of gas supply in Bulgaria, one of the most gas insecure countries in the European Union. We do this by computing 'security of supply cost curve' for different gas supply disruption scenarios. The curves show the cumulative amount of security of supply on the horizontal axis and the unit cost of security on the vertical axis. Measures should be implemented by order or rising unit cost until the public authorities' preferred level of security is achieved.

Our results show that a cost-effective gas supply security policy for Bulgaria would concentrate on two measures: (1) allowing reverse-flow transactions on the transit pipelines to Greece and Turkey to access the LNG terminals in these countries in case of disruption in Russian gas supplies and, (2) ensuring effective dual-fuel capability for Bulgaria's heat generation plants. The infrastructure options actually considered by the Bulgarian authorities and gas industry (expanding the withdrawal rate of the Chiren underground gas storage and building a new gas interconnector pipeline with Greece) appear to be much more costly.

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## *Overall simulation of German natural gas transmission systems – potential of gas grid for energy transformation*

Bo Li, Joachim Müller-Kirchenbauer, Anatoly Gorshkov (Clausthal University of Technology)

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The legal framework of liberalization of the energy markets requires gas network operators to publish flow capacities at their entry and exit points. In combination with publicly available knowledge about the gas transportation infrastructures, an overall simulation of the hydraulic gas flow over Germany becomes possible. The ITE-GS model is able to simulate the major gas transmission systems in Germany, with consideration of the storage facilities. Through the analysis of gas demand behaviours in different areas and market regions over the year, various scenarios can be defined and simulated by the model. Both nationwide networks and individual entry/exit points can be analyzed via those simulations. Through the simulations, the potential of Germany's existing and also future extended gas transmission grids is shown, for natural gas as well as for other energy gases. The investigation also integrates several case studies, for example, the influences on the national gas grid by introducing new energy transformation technologies (e.g. bio-methane, hydrogen and synthetic methane from "Power-to-Gas" projects) and the study on the gas grid's transport capability for the replacement of nuclear power plants by gas fired power plants in southern Germany. Some bottleneck areas in the existing gas transmission system under such new energy transformation conditions are shown in the model, which could provide good reference information for future pipeline grid extension and facilities enhancement.

Keywords: gas grid, transport capacity, grid potential, new gas sources integrated, Nuclear Moratorium

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### *Pipeline Power*

Franz Hubert, Onur Cobanli (Humboldt–Universität Berlin)

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We use cooperative game theory to analyze the strategic impact of three controversial pipeline projects. Two of them, Nord Stream and South Stream, allow Russian gas to bypass transit countries, Ukraine and Belarus. Nord Stream's strategic value turns out to be huge, justifying the high investment cost for Germany and Russia. The additional leverage obtained through South Stream, in contrast, appears small. The third project, Nabucco, aims at diversifying Europe's gas imports by accessing producers in Middle East and Central Asia. The project has a large potential to curtail Russia's power, but the benefits accrue mainly to Turkey, while the gains for the EU are negligible.

Keywords: Bargaining Power, Transport Network, Natural Gas

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**Session 16.30 – 18.00****Generation****Room: Faculty Assembly Hall****Chair: Reinhard Madlener (RWTH Aachen)**

*Economic analysis of electricity storage applications  
in the German spot market for 2020 and 2030*

Hendrik Kondziella, T. Bruckner (University of Leipzig)

*Techno-economic evaluation of energy technologies under uncertainty,*  
Dogan Keles (Karlsruhe Institute of Technology)

*Is a capacity market the best possible solution in a fast energy turnaround?*  
Lukas Schuffelen and Dominic Nailis (BET Aachen GmbH)

*Evaluation of different strategies to hedge the commodity price risk of industrial combined-  
heat-and-power plants*  
Reinhard Madlener, Andreas Palzer (RWTH Aachen), Günther Westner (E.ON Energy  
Projects GmbH)

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*Economic analysis of electricity storage applications in the German spot market for 2020 and 2030*

Hendrik Kondziella, Thomas Bruckner (University of Leipzig)

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It is well accepted that renewable electricity generation in Germany is expected to make up for a large share of the future electricity mix. Many scientists and policy makers argue that appropriate storage capacity could compensate for the fluctuating generation patterns of wind and solar power. However, there is no evidence if the required storage capacity would be induced by future energy markets.

In this paper, we present the economic ramifications of a growing storage market share on the spot market. The basic analysis is done by applying the power plant dispatch model MICOES for the years 2020 and 2030. Moreover, a load levelling algorithm adjusts the original hourly demand curve to simulate a storage market penetration up to a capacity of 40 GWh that equals today's pumped hydro storage installations.

The scenario without additional storages in operation shows increasing daily price spreads due to higher penetrations of fluctuating renewable energies in 2030. When introducing storage capacity into the market, the initial price spread declines and thus deteriorates potential revenues per kilowatt-hour installed storage capacity. On the other hand, enlarged storage capacity reduces peak demand significantly. Hence, investment in less utilized peak-load power plants could be deferred.

Keywords: electricity storage, spot market, power plant dispatch, renewable energy, scenario analysis

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*Techno-economic evaluation of energy technologies under uncertainty*

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

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Since the liberalization of electricity markets power generation companies are facing many uncertainties, such as uncertain energy prices or fluctuant generation of renewable electricity. Therefore energy utilities are exposed to different risks in combination with huge and largely irreversible investments. In this context, we present some basic approaches how to use stochastic programming in energy economics and apply a stochastic dynamic program (SDP) to carry out a techno-economic evaluation for energy technologies under uncertainty. We apply the stochastic dynamic optimization model for the evaluation of energy storage technologies.

The annual return of energy storage power plants can be significantly increased applying an SDP model compared to the results of a simple strategy under uncertainty. In the simple strategy the energy storage is charged during offpeak hours and discharged to produce again electricity if prices are high, i.e. in peak hours. Contrarily, the SDP model optimizes the storage level at the end of each day and the dispatch of power plant components (i.e. turbine and pump) in each hour, considering uncertain electricity prices via a stochastic tree. Comparing the results of the SDP model with that of a deterministic optimization model with perfect price foresight, it can be noted that the annual return reaches more than 90% of the annual return of the perfect price foresight method, which can be seen as a hypothetical upper limit.

Keywords: energy storage, uncertainty, stochastic dynamic programming, electricity prices, fluctuant renewable resources

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*Is a capacity market the best possible solution in a fast energy turnaround?*

Lukas Schuffelen, Dominic Nailis (BET Aachen GmbH)

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The owners of existing assets value the conditions differently than potential investors. Long construction times of new power plants, uncertain progress in the growth of renewables, the grid extension and demand side management give the need for a master plan. With the given renewables compensation system the market based energy price and market signals shrink. In this context some important questions pop up:

- Is it possible for the existing energy only market to maintain security of supply – even with a high impact of renewable energies - without regulatory changes?
- Are there adequate incentives to invest in new assets?
- Do we need a capacity market? How could its design look like? What are alternatives?
- How could one estimate the windfall profits in an energy only market?

The different opinions of the market participants regarding a capacity market sometimes mirror only their expectation of their possible proceeds potential and refer not necessarily to an objective attitude. This work is trying to draw the outline of an objective comparison between different ways into a decarbonized future.

Keywords: capacity market, future energy market design, future energy system, generation expansion planning, investment incentives

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*Evaluation of Different Strategies to Hedge the Commodity Price Risk of Industrial CHP Plants*

Andreas Palzer (Fraunhofer Institute for Solar Energy Systems, Freiburg), Günther Westner (E.ON Energy Projects GmbH, Munich), Reinhard Madlener (Institute for Future Energy Consumer Needs and Behavior (FCN), School of Business and Economics / E.ON Energy Research Center, RWTH Aachen University)

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In this paper we design and evaluate eight different strategies for hedging commodity price risks of industrial cogeneration plants. Price developments are parameterized based on EEX data from 2008-2011. The probability distributions derived are used to feed a model based on Monte Carlo simulation with the aim to determine the value-at-risk of the individual strategies. In a final step, the values-at-risk obtained are combined in a mean-variance portfolio analysis in order to determine the most efficient hedging strategy. We find that the strategy adopted can have a marked influence on the price risk. Quarterly futures are found to be particularly well suited for reducing market price risk. In contrast, spot trading of CO<sub>2</sub> certificates is found to be preferable compared to forward market trading. Finally, portfolio optimization shows that a strategy mix can improve the profitability also of heat-based cogeneration plants, on top of the benefit of choosing the optimal strategy combination that reflects the risk preferences of the plant operator.

Keywords: commodity price risk, cogeneration, hedging, Monte Carlo simulation, mean-variance portfolio optimization





**Session 16.30 – 18.00****Electric Mobility****Room: A 03****Chair: Alexandra Paetz (Karlsruher Institut of Technology)**

*Sustainable Mobility: Analyzing the Supply Chain for  
TUM's Electric Vehicle MUTE*  
Christian Kandler et al. (TU Munich)

*Range limits of electric vehicles: Invest in charging infrastructure or buy larger batteries?  
A techno-economic comparison*  
Till Gnann et al. (Fraunhofer ISI)

*Total Ownership Cost Projection for the German Electric Vehicle Market with Implications for  
its Future Power and Electricity Demand*  
Patrick Plötz et al. (Fraunhofer ISI)

*Feasibility of Battery Switch Stations for Local Emission Free Public Transport*  
Thomas Kaschub et al. (Karlsruhe Institute of Technology)

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*Sustainable Mobility: Analyzing the Supply Chain for TUM's Electric Vehicle MUTE*

Christian Kandler (Technische Universität München, IfE)

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Mobility is a key challenge for sustainable development and can be blamed for an increasing world-wide oil demand, poor air quality in cities and accelerated CO<sub>2</sub> emissions. Electric vehicles seem to offer a way out of these problems, if electricity can be supplied in a sustainable fashion. TUM's electric vehicle MUTE can be considered as a prime example for a series of highly efficient electric vehicles designated by some OEMs for the next coming years. The purpose of this paper is therefore to analyze the primary supply chain for different methods of charging electric vehicles focusing on their specific CO<sub>2</sub> emissions and resulting charging costs. The paper will deal with three charging options in more detail, focusing on charging methodology, simulation results analysis and a comparison to a conventional vehicle with ICE. In conclusion the paper shows that sustainable mobility on the basis of highly efficient EVs such as MUTE in combination with renewable energy charging is the cleanest and most affordable option in Germany up to date. Additional EV investment incentives such as in France or the USA are therefore not necessary in Germany: With the help of the EEG, very cheap charging costs and thus EV operation costs arise. Hence coupling EVs and renewable energies provides a double benefit for society: clean energy generation combined with next generation mobility.

Keywords: electric vehicles, primary energy supply chain, specific carbon emissions, charging costs, renewables

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*Range limits of electric vehicles: Invest in charging infrastructure or buy larger batteries? A techno-economic comparison*

Till Gnann, Patrick Plötz, Martin Wietschel (Fraunhofer ISI)

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Battery electric vehicles are critically reviewed in terms of their limited driving range. There are different possible ways to increase their range, e. g. developing charging infrastructure or using larger batteries. Both options require investments which a user of a battery electric vehicle will have to bear, either directly or indirectly. Thus in this paper we want to determine which investment is lower per capita: an investment in infrastructure or battery size.

We simulate battery states of charge for a large set of driving profiles to obtain the minimal battery capacity necessary per user to replace his or her car with a battery electric vehicle. A distinction between the payers of infrastructure investment leads to the main results: if all users had the same battery smaller than 25 kWh and those who needed additional infrastructure to cope with their trips had to carry the additional investment, it would always be cheaper to invest in additional battery size. This could be the case if infrastructure was built by a company. If the additional cost for infrastructure was borne by all BEV-users with same battery sizes, which could be the case if the government built it, and the battery size was larger than 10 kWh, it would be less expensive to invest in infrastructure.

Keywords: battery electric vehicles, charging infrastructure, battery size, driving profiles, driving range

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## *Total Ownership Cost Projection for the German Electric Vehicle Market with Implications for its Future Power and Electricity Demand*

Patrick Plötz, Till Gnann, Martin Wietschel (Fraunhofer ISI)

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Electric vehicles have a high potential to reduce greenhouse gas emissions in the transportation sector, but their large-scale introduction would also have a significant impact on power grids and electricity demand. The future market shares of electric vehicles are difficult to predict, but purchase price and fuel costs are generally acknowledged as highly relevant factors. However, the latter are heavily dependent on the vehicle kilometres travelled which require a detailed analysis. In this paper, we examine the total cost of ownership (TCO) for a distribution of annual vehicle kilometres travelled rather than the 'average driver', which is a commonly used but misleading entity. Such TCO estimates are an integral part of buying decisions and we compare the TCO for conventional, plug-in hybrid, and battery electric vehicles. We look at three different vehicle size classes to model customer purchase decisions and to derive the future market shares of the three propulsion technologies. The resulting projections are combined with a vehicle fleet stock model to obtain projections of the German electric vehicle fleet. The associated increased energy demand is then computed for different fuel price scenarios. Implications for electricity consumption and power demand are derived and discussed.

Keywords: Electric vehicles, TCO, stock model, electricity demand, Plug-in Hybrid electric vehicles

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## *Feasibility of Battery Switch Stations for Local Emission Free Public Transport*

Thomas Kaschub, Alexandra-Gwyn Paetz, Patrick Jochem, Wolf Fichtner (Karlsruhe Institute of Technology (KIT), Chair of Energy Economics)

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Electric Mobility is one key technology for increased energy efficiency and local zero emissions for vehicles – especially in cities. Urban bus public transportation has not only in developing countries significant shares and is therefore a relevant research issue. Different technologies that seem suitable to meet these two targets have been introduced to several field tests. However, little attention has been given to battery electric busses (BEB) in combination with battery switch stations – although both range limitation and long charging times, could be solved. Furthermore, power load peaks in the evening hours could be prevented.

First we give an overview of different systems for urban bus transport with respect to characteristics such as emission reductions and technological challenges. In the following we introduce several battery switch systems and analyze one example battery switch station for BEB and its economic feasibility. The business case is based on empiric data for the Karlsruhe public transportation system and includes e. g. a dynamic economics calculation, sensitivity analyses and possible system extension steps.

Even though there are various influencing factors, we show that both, a cost-efficient operation of a battery switch station in a current public bus fleet operation and a reduction of local air pollution are possible.

Keywords: electric mobility, urban public road transport, battery switch stations

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**Session 16.30 – 18.00****Desertec****Room: B37****Chair: Christoph Kost (Fraunhofer ISE)**

*The DESERTEC University Network and  
the socio-economic development of the MENA region*  
Mouldi Miled (DUN)

*Comparative Study of Public Acceptance of DESERTEC-related Renewable Energy Plants*  
Dina Abdel-Fattah et al. (DESERTEC Foundation)

*Solar power plants operating under market prices*  
Christoph Kost (Fraunhofer ISE), Christoph Flath (IISM Karlsruhe)

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*The DESERTEC University Network and the socio-economic development of the MENA region*  
Mouldi Miled (DUN)

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Employment and socio-economic development are now key for development of the populations and the societies in the rapidly growing and politically transforming MENA region. A huge challenge for this region is the production of basics for life like water, food and energy, for the expanding population and the creation of new opportunities for progress.

By exploiting the energy of deserts, the DESERTEC concept is also a source of employment and socio-economic development. It can help to master the transition to a sustainable and democratic society. To this end stakeholders in public authorities, private sector and civil society need knowledge, in particular on technology, societal development and ways to create employment. However, there is not much institutional competence in this region for producing such knowledge.

Key words: Rebound effect; SOEP; fixed effects; energy efficiency; Germany

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*Comparative Study of Public Acceptance of DESERTEC-related Renewable Energy Plants*  
Dina Abdel-Fattah, Nagi Siam, Franziska Dormann (DESERTEC Foundation)

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Research and academic literature have shown that NIMBYism and other indicators of low public support have an effect on the sustainability and longevity of renewable energy (RE) power plants. Research has been generally conducted on the public acceptance of renewable energy power stations in the context of developed countries, in which linkages have been found between low public acceptance and controversies regarding renewable energy power plants. However, a large gap still exists in the discourse regarding developing countries, in which there is little literature available on the variations in public acceptance, not only towards RE power plants, but also regarding the transmission infrastructure of these power stations. The DESERTEC Concept, the concept which the DESERTEC Foundation promotes, focuses on the buildup of large-scale RE plants worldwide and therefore also on the promulgation of RE in developing countries. Since RE is a fairly new and budding sector, gaining public acceptance is key in ensuring that renewable energy projects are not only properly backed but also sustained. This paper is thus a comparative case study of the current status quo of public acceptance of RE power stations in the EU-MENA region and the Sub-Saharan African region, two regions with fairly large RE potential. More specifically, this paper delves into the public acceptance of both constructed and planned renewable energy projects in Egypt, Turkey, and South Africa. Combining the work of various DESERTEC-related research projects in each of the aforementioned countries, the general finding is that public acceptance is more than vital in ensuring that RE projects move from conceptualisation to implementation.

Keywords: renewable energy, public acceptance, DESERTEC, EUMENA, South Africa

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*Solar power plants operating under market prices*

Christoph Kost (Fraunhofer Institute for Solar Energy Systems ISE),

Christoph Flath (Karlsruher Institut für Technologie (KIT))

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Using an economic valuation approach for renewable energy technologies we show that design and operation of concentrated solar power plants should be primarily based on market mechanisms instead of support schemes. Unlike other renewable energy technologies (e.g. photovoltaics and wind), concentrating solar power (CSP) offers the possibility to optimally dispatch electricity output depending on market demand and market prices. With the potential to store thermal energy for several hours and days, the operation of such a power plant can be aligned to the market conditions.

The control opportunities provided by storage-enhanced CSP plants have direct implications on the investment decisions. Not only nameplate capacity but also the solar field multiple and storage size plays a crucial role for the viability of the plant investment. Hence, investment incentives for CSP plants with thermal storage need to appropriately account for this interdependency. Two inefficient outcomes of an ill-designed scheme can arise from strategic behavior of plant investors / operators:

- (1) Inefficient storage-sizing to strategically leverage the incentive scheme
- (2) Operation mode selection not aligned with general market conditions

This strategic behavior is analyzed by an energy modeling at locations in Spain under the respective electricity market prices of Spain in the year 2010. Plant valuation is then adapted to different price characteristics of two other countries. Based on these findings, alternative support schema for CSP power plants should be developed to incentivize proper power plant sizing and operation from a market based perspective.

Keywords: Concentrating Solar Power, storage, optimization model, economic valuation, incentive scheme

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## **ENERDAY Postersession**

**Topics Postersession - within Coffee break in the afternoon, 15.45 h – 16.30 h**

**(Room: Above Faculty Assembly Hall)**

<b>Topic 1</b>	<i>Matthias Popp (Poppware)</i>	Storage demand for a macroeconomic beneficial transformation of power supply
<b>Topic 2</b>	<i>Ivan Benes (Cityplan)</i>	Resilient Power Pilot Project
<b>Topic 3</b>	<i>Philipp Richter (DIW Berlin)</i>	Trade and the Environment: The Role of Firm Heterogeneity
<b>Topic 4</b>	<i>Hikaru Yamada (Sprint Capital Japan Ltd.)</i>	Smart Distribution for Post Disaster Management
<b>Topic 5</b>	<i>Jing Xu (Florence School of Regulation)</i>	Adoption of netback pricing regime in Chinese gas industry is a step towards a single price market?
<b>Topic 6</b>	<i>Ariadna Cruz Velis (TU Delft)</i>	Large-scale offshore wind power integration from a technical interoperability
<b>Topic 7</b>	<i>Zbigniew Krysa (Wroclaw University of Technology)</i>	Changes in the energy production from the combustion fuel based on spread analysis in the Polish energy market
<b>Topic 8</b>	<i>Moritz Riede (IAPP)</i>	Status and Potential of Organic Solar Cells

*Storage demand for a macroeconomic beneficial transformation of power supply*  
Matthias Popp (Pooware)

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There are a lot of technical possibilities to transform the existing power supply system into a sustainable functioning renewable power supply system. The task today is not so much finding technical solutions for this challenge, but rather to find favourable ways to do this.

The physical foundation for a power supply is always the exact balance between electricity production and consumption. Traditionally the production followed precisely the demand. With an increasing share of the volatile power sources wind and sun, the question is, what methods of keeping this balance are available and where are the corridors of interaction between these methods. This should lead to macroeconomic favourable conditions, acceptability in society as well as with consumers and operators, protection of nature, responsible use of resources and security of power supply.

A significant indicator for this analysis is the storage demand for a power supply system, based on the most important renewable power sources wind and sun, with the aim to keep the same comfortable electric power supply conditions as nowadays.

These conditions were researched using real wind data over 39 years, real solar data over 13 years and power consumption data of three current years for all European countries. Therewith the European weather characteristic of a long period of time is considered in relation to the power consumption behaviour of nowadays. This is helpful for transformation plans to a renewable power supply.

The results allow the evaluation of the different proposals for the future development of the electric power production system as well as for the balancing between production and consumption, with an increasing share of volatile power sources.

Based on this knowledge, the role of the following topics can be evaluated:

- a powerful transmission grid,
- demand site management,
- self-supply concepts,
- new mobility concepts,
- interaction of electricity system with heat storage systems,
- a contingent of regenerative firm capacity (base load, e.g. hydro, biomass, ...)

can play and

- what amount of balance capacity will remain

in dependence of the future production and consumption structure.

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**RESILIENT POWER PILOT PROJECT**

Ivan Benes (CITYPLAN, Praha)

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Poster presents research pilot project in the field of smart grid. The research project N°2A-1TP1/065 „Increasing the resilience of the distribution system against long-term transmission grid blackout in

order to enhance public safety” was partly supported by the Czech Ministry of Industry and Trade in the framework of “Sustainable prosperity” program.

Goal of five-year project with a budget of 2 million EUR was to improve security of citizens, protect environment and decrease the damages caused by long-term power failures.

If we consider that 30% of power production is connected into distribution networks (e.g. municipal district heating plants and independent power producers), it seems to be attractive option ensure emergency power supply with utilization of distributed power generation. The lost system services of transmission grid could be replaced by special function of smart grids that will provide crisis demand side management on the distribution level. Project demonstrates possibility of crisis demand side management that enables to provide necessary electricity for residents and critical infrastructure through adaptive distribution grid islanding. In 2011 project team has implemented the pilot project on the local micro-grid.

Keywords: power supply security, smart grid, island operation, crisis demand side management

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*Trade and the Environment: The Role of Firm Heterogeneity*

Udo Kreickemeier (University of Tübingen) and Philipp Richter (DIW Berlin)

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The traditional literature on trade and the environment derives three principal channels through which trade liberalization affects the environment: an emission increasing scale effect due to an augmentation of economic activity, an emission reducing technique effect arising from decreasing average emission intensity, and a composition effect, whose sign and strength depends on comparative advantages of the considered country. This paper theoretically derives a new effect of trade liberalization on environmental quality in a trade model of monopolistic competition with heterogeneous firms for a small economy. We show that in the presence of heterogeneous firms the aggregate volume of emissions is influenced not only by the long-established scale effect, but also by a *reallocation effect* resulting from an increase in the relative size of more productive firms. We show how the relative size of these effects, and hence the overall effect of trade liberalization on the environment, is affected by the emission intensity at the firm level. We show that aggregate emissions decrease with more liberal trade if and only if firm-specific emission intensity decreases strongly with increasing firm productivity. Notably, the *reallocation effect* can be interpreted as an intra-sectoral composition effect and as a technique effect for the aggregate sector.

Keywords: trade and the environment, environmental effects, emission intensity, monopolistic competition, heterogeneous firms

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*Smart Distribution for Post-disaster Management*

Hikaru Yamada, President, Sprint Capital Japan Ltd.

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Japan suffered from massive earthquake and Tsunami disaster in March last year, which caused wide-spread damages in energy supply system and infrastructure. Tokyo areas had rotation blackouts suddenly for 10 days in March and then power shortages in summer. In these rotation blackouts, some traffic lights went off and train schedule was heavily cut back. Of course hospitals ran emergency back-up generators but bulk energy supply was in chaos.

The lessons learned after the blackout included increased unfairness, increased sense of danger and risk of lives, mainly as a result of problems of current electricity distribution system, which distribute power by substation coverage down to end-points.

With the advent of smart distribution technologies, we could avoid such chaos. Application of smart metering system should include functions to “selectively” supply power with priority in reduced load situation such as traffic lights and hospitals. Also it should not switch off power supply but, rather, lower the capacity from, for example, 60 amps to 10 amps, by which consumers will maintain minimum use of power to medical devices and refrigerator, and would avoid risk of restart of power supply out of sudden.

Keywords: smart distribution, disaster management, end-point control, selective power supply, lowering capacity

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*The challenges of adopting a netback pricing regime in Chinese gas market*

XU Jing, Michelle Hallack, Miguel Vazquez (Florence School of Regulation, European University Institute)

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The Chinese market is characterized by a few integrated firms, which are in charge both of the supply and the transmission of the gas from fields to cities. In December 2011, Chinese gas market took the first step toward a market-oriented reform. It switched from cost-plus pricing to netback pricing in two pilot provinces. Under this new scheme, gas-to-gas competition is encouraged to determine city-gate wholesale prices. In addition, regulatory authorities have set price cap on every city gates. We show that such measures face a lack of incentives for the efficient use of the network, because: (1) Demand heterogeneity should drive the use of the pipeline. But pipeline owners sometimes earn the price cap instead of the congestion price. Therefore, there are no incentives of dealing with congestion when the price is at the cap. (2) When the price cap is higher than the supply cost of high-cost gas, there is no incentive to sell pipeline rights to transport low-cost gas that will eventually lower the gas price. To solve the two limitations together, we suggest compensation mechanism that reallocates congestion rents to pipeline owners, instead of having fixed transmission tariffs. This can be understood as regulated versions of the transmission contracts that redefine the incentives for resource allocation.

Keywords: Chinese gas market, netback pricing, pipeline, compensation mechanism

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*Large-scale offshore wind power integration from a technical interoperability perspective*

Ariadna Cruz Velis (TU Delft)

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This paper explores the integration of large-scale offshore wind power in the electricity grid from a technical interoperability perspective. The offshore wind grid is analyzed as part of a network industry (i.e. an industry where products or services are provided on the basis of an infrastructure where different components need to work together and be coordinated).

The liberalization of the electricity markets was performed from a market-oriented point of view only, largely neglecting the systemic and technical nature of the industries involved, supposing the technical characteristics would remain unchanged by the reforms. This last has proven not to be the case, and consequently, there has been an increasing awareness of the importance of reconciling the technical and institutional components of infrastructures. Two elements have been identified: critical assets (i.e. fundamental for the functioning of a technical system) and specific functions essential to the functioning of a technical system (i.e. interoperability, interconnection, capacity management, and system management (ibid)).

The document focuses only on interoperability and combines the concept proposed by Finger, Groenewegen, and Künneke (2005) which is defined as “technical and institutional conditions under which infrastructure networks can be utilized” and a second one, “the ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable to operate effectively together”. The reason to use the ideas of this second group of authors is the fact that a lot of research has been carried out on the concept of interoperability and a methodology to systematize it for the information and communication sciences, but not so much as applied to the concepts of infrastructures.

Understanding the broad concept of interoperability helps to identify the technical challenges and requirements for the integration of wind energy. In general terms, the major obstacles identified for its integration are the its intermittency and the uncertain reliability of the grid; nevertheless the European Wind Energy Association argues that electricity systems are inherently variable and that these challenges do not belong particularly to the wind industry.

Keywords: Offshore wind power, technical interoperability, integration

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*Changes in the energy production from the combustion fuel based on spread analysis in the Polish energy market*

Zbigniew Krysa, Wrocław University of Technology

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Clean dark spread formation on the Polish energy market in the years 2013-2020 based on EU ETS Amending Directive and national application for derogation created by the Polish government has been shown. Substitution of coal for natural gas and therefore achieve greater efficiency in MWh per unit of emissions in the next few years in the Polish energy industry is for technical reasons not possible. Relative situation of energy companies which produce energy only from coal in an open energy market will continue to worsen. Stability of the structure of energy production in Poland will not



allow in the short term to change the fuel burned for energy production and the probable lack of capacity in the energy system reduces the response to price signals from the market. The results of calculation price of energy providing positive CDS for different price levels of purchase emission rights, taking into account changing power plants efficiency at a given cost of fuel compared to current energy prices are presented. Based on Climate Spread was determined coal price to gas price ratio for Polish energy market providing the profitability of energy production from coal will exceed the profitability of the production from gas.

Keywords: Clean Dark Spread, Polish energy market, energy from coal

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### *Status and Potential of Organic Solar Cells*

Moritz Riede (Institut für Angewandte Photophysik, Technische Universität Dresden)

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Organic solar cells (OSC) have attracted increasing attention in recent years from science and industry. The number of groups working on OSC has rapidly increased and development has reached a stage at which several companies are preparing to make them commercially available. Although OSC have lower power conversion efficiencies than most of their inorganic counterparts, they have possible cost advantages, due to low material consumption, simple processing methods as well as the possibility for flexible and light-weight devices. This presentation summarises important recent developments and describes how the synthesis of new organic semiconductors with tailored properties, optimisation of the active layers, adoption of inorganic device concepts like tandem devices, and enhanced light incoupling have led to major improvements. It further outlines the current research strategies for improving the basic physical understanding and obtaining higher device efficiencies and lifetimes. Finally, based on the investigated large area production technologies it is shown that the cost can potentially be very low and organic solar cells could address large markets.

Keywords: photovoltaics, organic solar cells, flexible solar cells

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