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Energy Economics Group (EEG)

# DIPLOMARBEITSTHEMEN

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## Vorwort

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Dieses Dokument beinhaltet Diplomarbeitsthemen, die am EEG von Prof. Reinhard Haas angeboten werden. Die Hauptbetreuung der Arbeiten in diesem Katalog übernehmen jeweils Assistent/inn/en in Kombination mit Postdocs. Die Arbeiten sind im folgenden spezifischen Themengebieten zugeordnet.

Wenn Sie an einer Diplomarbeit interessiert sind sollten sie:

- vom Institut angebotene Lehrveranstaltungen – zumindest „Energieökonomie“ und „Energiesysteme ...“ absolviert und
- den Großteil Ihrer Prüfungen absolviert haben um eine rasche Bearbeitung Ihrer Diplomarbeit zu garantieren.

Falls Sie interessiert sind, schicken sie eine E-mail an eine/n der dem jeweiligen Thema zugeordneten Betreuer.

Beste Grüße,

Reinhard Haas

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## 1. The effects of CO2-taxes on the energy system in selected countries - Lessons learned

- **Motivation:** In the public discussion on fighting Global Warming CO2-taxes are considered as a very important mean. In many countries (such as Sweden, Switzerland, ) CO2-taxes are already implemented. Of interest is what are the lessons learned of these countries and what were their effects so far?
- **Objective:** The core objective of this work is to analyse in which countries CO2-taxes are already implemented, since when, in which design and what their effects were so far.
- **Method of approach:** A comprehensive literature review as well as a data collection and analysis has to be conducted. An economic model simulating the effects of CO2-taxes has to be developed in Excel. Some databases e.g. ODYSSEE are already available.
- **Supervisors:** Prof. Reinhard Haas, Marlene Sayer

## 2. The impact of taxation on the economics of energy efficiency measures

- **Motivation:** Energy taxes may have a considerable impact on the economic viability of energy efficiency measures like building retrofitting. However, also other taxes, in particular income taxes or taxes on different types of materials and resources have a strong impact. Thus, when carrying out cost-benefit analyses from a "socio-economic" perspective, it is not sufficient to exclude energy taxes. The same also needs to be done for other taxes.
- **Objective:** The objective of this work is to quantify the impact of different elements of taxation on the economic viability of energy efficiency measures for the case of building retrofitting.
- **Method of approach:**
  - Literature review
  - Data collection of taxation schemes for one or two countries within the EU
  - Assessment of the impact of different taxes for different measures in an xls-spreadsheet
  - Calculation of the economic viability of measures with and without taxes
  - Applying an existing optimization model for the cases with and without taxes
- **Supervisor:** Lukas Kranzl, Prof. Reinhard Haas

## 3. Design von Kapazitätsmärkten in Spotmärkten für Strom ausgewählter Länder (USA, Europa, Asien, Australien) – Lessons learned

An analysis of capacity markets design and major features in spot markets in selected countries world-wide (USA, Europe, Asia, Australia ...)

- **Motivation:** In recent years in many countries the idea of capacity payments for power generators in addition to revenues from the energy-only market, has gained attention, economic discussion, e.g. in Germany, USA, France and UK. The reason for this is that a significant number of market players claim that the long-term reliability of the electricity system is at risk, as long as there is no politically organized mechanism for capacity payments in place. Indeed, in many countries such CPs have been introduced.
- **Objective:** The goal is to document currently implemented capacity mechanisms world-wide in a systematic way and to analyse the lessons learned regarding costs, excess capacities and so on. This analysis should mainly be based on literature research.
- **Method of approach:** Systematic approach for analysing different features of CM, Analysis of historical data Econometric model, Regression analysis

- **Supervisor:** Prof. Reinhard Haas

#### 4. Repowering of wind power plants: Assessing future impacts and needs, exemplified for Austria and selected European countries

- **Motivation:** Wind power is considered as an important renewable energy technology to reduce GHG emissions and alleviate the problem of global warming. Yet, land areas are limited and technological progress has been achieved. Repowering of wind power plants may increase the yield significantly and hence may be an important strategy to contribute to a societally optimal development, and, possibly, to a reduction of subsidies.
- **Objective:**
  - The core objective is to analyze the dynamic potential of increasing wind energy generation due to repowering in Austria and selected other European countries up to 2030 and 2050.
  - Comparison of approaches / strategies for wind power repowering in Germany and other EU countries (where applicable)
- **Method of approach:**
  - Analysis of the development of the performance of wind power over time and the deployment in Austria and other selected EU countries (database on past installations available)
  - The analysis should be conducted on an (yearly, monthly, daily and) hourly base for wind in different regions in Austria (mainly NÖ and Bgld) and for selected EU countries (e.g. Denmark, Germany, Spain).
  - Develop dynamic scenarios up to 2050 based on technological progress.
  - Creation of a database and a simple model in MATLAB or EXCEL
- **Expected results**
  - The major expected results are the potential increases in wind plant outputs up to 2030 and 2050. The analysis should consider possible dynamic increases in the outputs of wind considering higher possible yields and higher full load hours in future.
  - In addition, a cost comparison for 2020 and in a dynamic model up to 2050 should be conducted considering also technological progress.
- **Supervisor:** Prof. Reinhard Haas, Marlene Sayer

#### 5. The role of offshore wind in decarbonizing the European electricity sector

- **Motivation:** Offshore wind power is gaining strong political attention at EU level and in selected European countries. Higher cost compared to onshore wind have however limited the uptake of this technology in the past. Has this recently changed? Do we need offshore developments due to limits in onshore potentials? How are the cost and market values of generating electricity in offshore wind plants in comparison to onshore today (and in future)?
- **Objective:**
  - Aim of this thesis is to conduct an up-to-date analysis on the possible role of offshore wind in decarbonizing the European electricity sector
  - Related objectives include to undertake a cost comparison to onshore wind, to assess recent political developments concerning offshore wind (support, project pipeline) and to undertake a comprehensive technology review (i.e. different technology solutions are under consideration, depending on water depth etc.)
- **Method of approach:**
  - Literature review concerning technology trends, cost trends (i.e. possibly project-specific), analyses of the potentials (building on own GIS-based data and results available at EEG) and the perspectives for offshore wind according to recent European studies.
  - Assessment of recent policy trends in supporting offshore wind (some data is available at EEG)
  - Model-based analysis of the market values of producing electricity via offshore wind power plants in

comparison to onshore wind, using the open-source energy system model Balmorel (available at EEG) for that purpose.

- **Expected results**

- Up-to-date assessment of the future role of offshore wind in Europe's electricity sector (country-specific)
- The assessment shall include own modelling of market values (offshore in comparison to onshore wind)

- **Supervisor:** [Prof. Reinhard Haas](#)

## 6. An analysis of the cost reductions of energy storage technologies employing the technological learning concept

- **Motivation:** Energy storage technologies are among the important technologies in the energy transition as a substitute for flexible fossil generation. However, storage capacity expansion, especially for long-term storage, is still associated with high costs. Nevertheless, it is expected that with a higher installed storage capacity worldwide, the specific investment costs of storage will decrease.

- **Objective:**

The future investment cost development of electrical, chemical and thermal energy storage systems shall be analyzed until 2050. Energy storage systems are differentiated by the cost of the power and the cost of the energy to be stored, which should be taken into account in the analysis.

- **Method of approach:**

- Literature - and market research and documentation of current and future energy storage costs as well as on the market diffusion per technology on the world market.
- Model to calculate the dynamic investment cost development until the year 2050
- Analysis of the investment cost development by means of scenarios (variation of learning rates)

- **Supervisor:** [Marlene Sayer](#), [Prof. Reinhard Haas](#)

## 7. Assessment of the future electricity storage demand of Germany by means of electricity system modeling

- **Motivation:** The question of whether the renewable expansion targets of neighboring countries have a negative impact on possible electricity balancing via import and export and the implied possible need for the expansion of additional electricity storage is prevalent. Within a project, a model that represents the Austrian electricity market is currently being developed. This linear optimization model can be used for the development of the model for Germany.

- **Objective:**

This work aims to develop a dynamic model of the German electricity system, which will be linked to an existing electricity model for Austria. The renewable expansion targets of Germany as well as the existing power plant capacities, shall be taken into account. The modeling will be based on the historical weather years 2015-2017 to consider the natural fluctuations in renewable energy generation.

- **Method of approach:**

- Research of the required data (power plant capacities, historical time series of generation, consumption profiles) and future renewable expansion plans of Germany
- Development of the hourly electricity market model for Germany in Python and linking of the model with the Austrian model
- Analysis of the import volumes from Austria available in the respective hours

- **Supervisor:** [Marlene Sayer](#), [Prof. Reinhard Haas](#)

## 8. Barriers and opportunities of large scale heat pumps in district heating

- **Motivation:** In various studies large scale heat pumps are considered as a key technology for decarbonizing district heating systems. However, some of these studies are not able to reflect carefully the local and system-wide constraints and implications. In particular, the potentials and barriers of different heat sources need to be better understood.
- **Objective:**

Improve the understanding of the possible role of large scale heat pumps and various heat sources for operating the heat pumps in future decarbonisation scenarios of district heating systems
- **Method of approach:**
  - Conduct a scientific literature survey including: (1) techno-economic aspects of different large scale heat pumps, (2) comparison of the role of heat pumps in different decarbonisation scenarios
  - Carry out a comparative techno-economic analysis of existing large scale heat pumps
  - Assess barriers of using heat pumps in different scales, with different heat sources, in different temperature levels based on literature and expert interviews
  - Based on an existing district heating supply dispatch model, integrate the results derived above into the model and estimate the quantitative impact of these new insights on future uptake of heat pumps in district heating grids
- **Supervisor:** Ali Kök, Lukas Kranzl, Prof. Reinhard Haas

## 9. The role of hybrid heat pumps: creating lock-in effects or a relevant transition technology?

- **Motivation:** Many studies and scenarios understand heat pumps as an important technology for the decarbonisation of the heating sector. Regarding the phase out of natural gas through heat pumps, there are different pathways under discussion: Either hybrid heat pumps (i.e. a combination of a heat pump with gas boilers), allowing for coverage of peak loads through gas boilers on cold winter days or rely on heat pumps only. The first approach could allow to respect the slower velocity of building retrofitting and to demolish the gas boiler after the building is retrofitted. However, there is also the risk of a lock-in effect, keeping gas longer in the system as it would be required.
- **Objective:**

Identify and quantify the advantages and disadvantages of hybrid heat pumps and identify building/district types where hybrid heat pumps might be a relevant transition technology.
- **Method of approach:**
  - Conduct a scientific literature survey including: (1) techno-economic aspects of hybrid heat pumps, (2) comparison of the role of hybrid heat pumps in different decarbonisation scenarios and studies
  - Define different options and technologies for implementing the hybrid heat pump approach
  - Define different generic district types and exogenous renovation steps/scenarios over the next years and decades
  - Compare the dynamic diffusion of hybrid heat pumps vs. purely electric heat pumps regarding costs and CO<sub>2</sub>-emissions. For this step, a cost-minimization MILP approach could be applied.
- **Supervisor:** Ece Özer, Iná Maia, Lukas Kranzl, Prof. Reinhard Haas

## 10. The economic value of waste heat potentials from data centers

- **Motivation:** Waste heat from data centers is a strongly growing heat supply potential for district heating systems. However, for exploiting these potentials, several conditions regarding temperature levels, scale

and suitable location (i.e. sufficiently close to district heating grids) need to be met. Moreover, the economic value of these waste heat potentials also strongly depends on the existing (and future) heat supply portfolio of the corresponding district heating system. Finally, district heating grid operators would like to have long-term investment security, which data center providers might not be willing to guarantee. This master thesis will be carried out in cooperation with (and financed by) a large data center operator in Austria.

- **Objective:**

Identify and quantify waste heat potentials from data centers of a large data center operator to be fed into district heating grids in Austria. Assess the economic potential of integrating these waste heat potentials in selected types of district heating grids.

- **Method of approach:**

- Conduct a scientific literature survey including: (1) techno-economic aspects of waste heat utilization from data centers, (2) potentials of waste heat from data centers in Austria and beyond, (3) expected growth of data centers in different regions across Europe
- Carry out a GIS based analysis of the matching between locations of data centers and heat demand in district heating grids. This will be done based on data regarding size and location of data centers from a large Austrian operator on the one hand and on (potential) district heating grids on the other hand from [www.austrian-heatmap.gv.at](http://www.austrian-heatmap.gv.at).
- Estimate investment costs for integrating waste heat from data centers in district heating grids
- Based on an existing district heating supply dispatch model, estimate the economic value of waste heat from data centers for different types of district heating supply portfolios

- **Supervisor:** Mostafa Fallahnejad, Ali Kök, Lukas Kranzl, Prof. Reinhard Haas