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Energy Economics Group (EEG)

# DIPLOMARBEITSTHEMEN

**Prof. Reinhard Haas**

**Dr. Lukas Kranzl**

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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 Assistant/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 CO<sub>2</sub>-taxes on the energy system in selected countries - Lessons learned

- **Motivation:** In the public discussion on fighting Global Warming CO<sub>2</sub>-taxes are considered as a very important mean. In many countries (such as Sweden, Switzerland, ) CO<sub>2</sub>-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 CO<sub>2</sub>-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 CO<sub>2</sub>-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 Germany

- **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 wind power potential in Austria including repowering in scenarios up to 2030 and 2050 based on technological progress.
- **Method of approach:**
  - Analysis of the development of the performance of wind power over time and the deployment in Austria (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)
  - 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 current state and future prospects for small modular nuclear reactors (world-wide) from a technical and economic point of view

- **Motivation:** SMRs (small modular nuclear reactors) are considered an important new solution for reducing GHG emissions and alleviating the problem of global warming. However, so far, they have not delivered, and it is not clear what the economics are and when they will be technically mature.
- **Objective:**
  - The core objective is to analyze the current state of SMRs from costs and deployment pov so far.
  - What are the most important countries right now?
  - What are the most important differences between SMRs and regular nuclear power plants, e.g., EPR as constructed in France and France?
  - How could a world-wide dynamic potential in scenarios could look like up to 2040 and 2050?
  - What is the environmental footprint of such SMRs?
- **Method of approach:**
  - Conduct a scientific literature survey including: (1) techno-economic aspects of different SMRs, (2) a comparison of the role of SMRS in different decarbonisation scenarios
  - First, a review of the literature has to be conducted regarding technical maturity, the number of SMRs so far produced respectively deployed and where and their construction times
  - Second, a cost analysis for now has to be done based on the literature
  - Third, own calculations based on Levelized cost analysis
  - Finally, scenarios for costs and potentials are to be derived
- **Supervisor:** [Prof. Reinhard Haas](#)

## 6. What is the maximum economically feasible potential of PV in Austria (depending on the development of electricity demand)?

### • Motivation:

- Photovoltaics is considered as an important renewable energy technology to reduce GHG emissions and alleviate the problem of Global warming. However, electricity generation from PV is variable, in summer considerably higher than in winter. Over a year, it is distributed quite unevenly. This limits the maximum installed capacity.

### • Core objective/research question:

- The major research question is: Analysis of the optimal (cost minimal) market penetration (level) of PV in different countries (Austria, Germany, Nordic, Italy, Africa . . . ) up to 2020, 2030, 2050 in a dynamic model? Derived questions are: How much PV has to be curtailed? What about decentral vs central? With and without storage? Analysis of the maximal/optimal market penetration of PV in different countries

### • Method of approach:

- Develop a model e.g. in Excel or Matlab. The analysis on an hourly base over a year (8760 hours) using demand profiles and solar insolation numbers. Creation of a database and a simple model in EXCEL should be conducted on an (yearly, monthly, daily and) hourly base for PV in different regions in Austria. Conduct the analysis depending on two different wind scenarios. Develop dynamic scenarios up to 2050 based on Technological Learning.

### • Expected results

- The major expected results are the potentials of PV electricity and the installed capacity (depending on three different wind scenarios). The analysis should also consider possible dynamic increases in the outputs of PV Systems considering further increases in efficiency and higher possible yields and higher full load hours in future. Is it necessary to curtail some peak power? (Consider also the age structure of today's PV plants)?
- In addition, a cost comparison for 2020 and in a dynamic model up to 2050 should be conducted considering also Technological Learning.

### • Supervisor: [Prof. Reinhard Haas](#)

## 7. Prospects for environmentally benign heating in AT up to 2040 – heat pumps vs biomass heating systems

• **Motivation:** Currently, electricity, mainly based on variable renewable energy technologies, is considered to also contribute to reducing GHG emissions and alleviating the problem of global warming. However, electrifying everything may lead to severe grid problems. Moreover, it is not clear how, in every hour of the year, the marginal electricity production could come from RES. Biomass-based heating systems can also be considered to be widely carbon-free.

### • Objective:

- The core objective is to analyze how much pellets or electricity for heat pumps in a single-family house and in an apartment building – for both good and poor thermal quality – will be used in 2040 in different countries, e.g., in Sweden, Austria, or Portugal.
- Another target is to estimate the marginal electricity emissions up to 2040 for selected European countries

### • Method of approach:

- Literature research peer-reviewed papers with the same two major focusses
- Define/Identify calculation method for heating energy demand (European-Norm?) → develop a small model in Excel
- Develop a small model for the SPF of new heat pumps depending on temperature levels
- Define the selected countries and collect climate parameters (heating degree days)
- Develop dynamic scenarios up to 2040 also based on technological progress.
- Creation of a database and a simple model in EXCEL

- **Expected results**

- The major expected results are the costs and the environmental performance of heat pumps (different heat sources) in comparison to different biomass-based heat systems by 2040.
- Analyze the CO<sub>2</sub> factors for the electricity generation mix on a yearly and on a monthly basis, as well as the marginal emissions on a monthly basis by country
- Conduct sensitivity analyses for every country and heating systems (e.g., +/- 10% for SPFs and ETA\_Biomass)
- Document/ Derive scenarios for electricity mixes and marginal carbon emissions from electricity by country up to 2030 and 2040
- In addition, a cost comparison for 2020 and a dynamic model up to 2040 should be developed, considering technological progress.

- **Supervisor:** Prof. Reinhard Haas, Marlene Sayer

## 8. 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)
- Analysis of other studies and development of own scenarios
- 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

## 9. 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

## 10. 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, Lukas Kranzl, Prof. Reinhard Haas

## 11. Assessing the impact of various locations of data centers on the energy system

- **Motivation:** The number and size of data centers is growing and so is their electricity demand and waste heat potential. In previous assessments, optimal locations of data centers were in particular derived from the need of data transfer in a specific location, the electricity prices and climatic conditions (i.e. the need for cooling). However, also the waste heat potential could play a considerable role in supplying heat to district heating grids. The question is, to which extent the consideration of the waste heat supply to district heating might impact the choice of data center locations.

- **Objective:**

Assess the optimal location of data centers considering different aspects and constraints, including the role of waste heat derived from the data centers.

- **Method of approach:**

- Conduct a scientific literature survey including: (1) techno-economic aspects of different data centers, (2) the role of data centers in supplying waste heat to district heating grids



- Carry out a comparative techno-economic analysis of existing large waste heat integration projects into district heating
- Develop a MILP model to identify ideal locations of data centers considering different infrastructure settings and constraints
- Derive conclusions for further work and for the further role of district heating for the energy system, in particular for the heating sector
- **Supervisor:** Ali Kök, Lukas Kranzl, Prof. Reinhard Haas

## 12. Economic assessment of the impact of district heating price structure on consumer behavior

- **Motivation:** District heating operators offer very different price structures to their consumers. The share of the base price to the consumption-dependent heat price differs, some operators provide incentives for a lower return temperature etc. A deep understanding how different district heating prices and price structures provide incentives for investing in grid connection and energy behavior is missing.
- **Objective:**  
Assess the impact of different district heating price structure on consumer behavior, both regarding investment decisions (i.e. to connect to district heating) and regarding the energy behavior (if being connected to district heating)
- **Method of approach:**
  - Conduct a scientific literature survey including: (1) review of existing district heating price structure within Austria and on an international level, (2) the role of more innovative price models, incentivizing energy saving measures and measures to contribute to reducing temperature levels
  - Carry out a comparative techno-economic analysis of different price models on various consumer types
  - Develop an economic model to understand the interaction between district heating operator, consumer types (including building construction companies) and suppliers of alternative heating system suppliers regarding choice and response to different price signals
  - Derive conclusions for further work and for the pricing strategy of district heating operators
- **Supervisor:** Ali Kök, Lukas Kranzl, Prof. Reinhard Haas