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Institut für Energiesysteme und Elektrische Antriebe
Energy Economics Group (EEG)

DIPLOMARBEITSTHEMEN

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Vorwort

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 „Energiemodelle …“ 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.

Herzlichst,

Reinhard Haas

Inhaltsverzeichnis

1. Energiepolitik / Energy policies

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

- **Motivation:** In the public discussion on fighting against 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 analy- sis 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, Jasmine Ramsebner

1.2. 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

2. Strommärkte und -preise sowie Strommarktmodellierung / Electricity markets and prices as well as power system modelling

2.1. The role of Demand Response in decarbonizing the European electricity sector.

- **Motivation:**
  - In the course of the energy transition, the need for flexibility in the European electricity system is increasing strongly. Mainly this is caused by an increased infeed of intermittent renewable electricity on the one hand and a reduction of dispatchable (conventional) power plants on the other. Demand Response (DR), i.e. the consumer-side adjustment of the demand to the existing supply, is one instrument to provide the required flexibility.
  - Today, economically feasible demand response potentials can essentially be located within the

industrial (process) technologies. However due to various market barriers, actual application of Demand Response is limited. Considerable uncertainty therefore remains, as regards to its future contribution to decarbonizing the electricity sector until 2050.

- **Core objective/research question:**
  - What are the European potentials for demand response in the industry (and trade and businesses).
  - What are plausible scenarios for the future application of those potentials in Europe until 2050.
- **Method of approach:**
  - Research the existing literature to gather Demand Response potentials in Europe.
  - Develop scenarios and quantify them using the open-source energy system model Balmorel (GAMS) provided by the Energy Economics Group.
  - Apply (and extend) an existing Demand Response Add-On.
  - Conduct sensitivity analysis regarding varying degrees of DR implementation and intermittent renewable infeed.
- **Expected results**
  - Create a database on potentials for Demand Response in Europe based on the literature research. In case of data scarcity, this task is limited to some relevant European countries.
  - Develop two consistent scenarios of how Demand Response could develop until 2050.
  - Implementation of those scenarios in Balmorel.
  - Quantitative and qualitative impact assessment of varying degrees of Demand Response on energy system modelling results, e.g. system costs, electricity prices, or GHG emissions
- **Supervisor:** Dr. Gustav Resch, Prof. Reinhard Haas

2.2. Modelling industry auto-consumption in energy system models – A Comparative analysis of different approaches

- **Motivation:**
  - Today, industrial electricity consumption in Europe constitutes more than one third of the total electricity consumption. While electricity is commonly sourced from the grid, some industrial actors generate electricity (and heat) directly on-site for their own consumption. These (cogeneration) power plants are used to satisfy the own demand (auto-consumption) but also to profit from price peaks on the spot market by exporting the electricity to the grid.
  - From a modelling perspective, this auto-consumption can be implemented in two different ways:
    1. By incorporating both power plant and the total industrial consumption in the model. Here the industrial plant dispatch is based on the optimization of the overall electricity sector.
    2. By considering solely the residual demand (total on-site consumption - auto-consumption) of the industrial consumer. Auto-consumption would thus be seen as an energy efficiency measure in the model. Here, the plant dispatch is optimized by the industrial consumer itself and not the system.
  - Both approaches have different benefits and drawbacks that shall be explored in this master thesis.
  - To add to the dilemma: There remains considerable uncertainty regarding the impact of the energy transition on the amount of on-site generation by the industry. Increasing degrees of electrification as well as grid parity might strongly increase the amount of on-site generation in the future and thereby shift the recommendation towards using one of the two modelling approaches.
- **Core objective/research question:**
  - What is the difference of modelling the industries' power plant dispatch either as system-optimal or optimized in terms of auto-consumption rates? What is the influence of the energy transition on the use of on-site generation?
- **Method of approach:**
  - Literature analysis of methodological differences in energy system models on the topic
  - Data research of possible scenarios regarding installed capacities of industry capacities and demand profiles of important industry processes

- Development and quantification of scenarios using the open-source energy system model Balmorel (GAMS) used and provided by the Energy Economics Group
- Extension of the existing model

- **Expected results**
  - Assessment of scenarios to show the differences in the system optimal and auto-consumption optimal approach
  - Conduction of sensitivity analyses with varying degrees of auto consumption in the industry.
  - Impact of generation behaviour of industry on-site capacities on energy system modelling results, e.g. system costs, electricity prices, or GHG emissions on system and industry complex level
- **Supervisor:** Dr. Gustav Resch, Prof. Reinhard Haas

2.3. Design von Kapazitätsmärkten in Spotmärkten 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 signi ficant 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 an. 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

3. Erneuerbare Energien / Renewable Energies

3.1. The impact of high raw material and energy prices on the competitiveness and future uptake of renewables

- **Motivation:** Within 2021, initially driven by the COVID pandemic but recently overshadowed by the Ukraine crisis, raw material and energy prices have increased substantially within Austria, Europe and world-wide. This may affect the future uptake of renewable energies where, on the one hand, high raw material and energy prices, lead to an increase of capital cost for various renewable energy technologies, and, on the other hand, high energy prices as currently applicable in the gas and electricity sector improve the competitiveness of alternative solutions to fossil energy carriers/technologies.

- **Objective:**
  - Aim of this thesis is to shed light of the impacts arising from those market turbulences on the competitiveness of renewable energies.
  - We suggest to take a narrow focus sector-wise, i.e. on the electricity sector, and, geographically, on Austria and/or Europe.

- **Method of approach:**
  - Data gathering concerning price trends for relevant raw material and energy prices as well as associated indicators (e.g. inflation, construction cost/price indices, etc.) that impact the capital cost of wind, solar, hydro and bioenergy technologies at present (and possibly in future).
  - Literature review concerning methodological approaches how to incorporate the impact of high energy and raw material prices in technological learning (as commonly applied to derive future cost projections for energy technologies)

  - Development of a methodology to incorporate above sketched price and market turbulences in future cost projections for key renewable energy technologies in the electricity sector.
  - Data-base preparation and/or development of an (MS excel or Matlab) model to derive a limited set of different future scenarios for assessing the competitiveness of renewables in the electricity sector (e.g. within Austria until 2030, or for selected other European countries or the EU as a whole). Details on that can be discussed at the kick-off stage.
  - (Model-based) Analysis and reporting of derived results and findings.
- **Expected results**
  - Up-to-date assessment of the impacts arising from (currently) high energy and raw material prices on the competitiveness of renewables in the Austrian/European electricity sector. Results may include LCOE comparisons, an analysis of support expenditures (if required) to finance the planned future uptake of renewables, etc.
  - As stated above, results may include the development of a sound methodology to incorporate above sketched price and market turbulences in future cost projections for key renewable energy technologies in the electricity sector.
- **Supervisor:** Dr. Gustav Resch, Prof. Reinhard Haas

3.2. 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:** Dr. Gustav Resch , Prof. Reinhard Haas

3.3. 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-data 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:** Dr. Gustav Resch , Prof. Reinhard Haas

3.4. An analysis of the optimal market penetration of PV in different countries

- **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 uneven. This limits the maximum installed capacity.
- **Core objective/research question:**
  - The major research question is: What is the optimal (cost minimal) level of PV installation in Austria in 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 (Austria, Germany, Nordic, Italy, Africa . . .)
- **Method of approach:**
  - Develop a model e.g. in Excel or Mathlab. 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 three 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 capapcity (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 todays 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

4. Energieverbrauch für Heizen, Warmwasser, Kühlen / Energy demand for Space, Water Heating & Cooling

4.1. A rolling investment approach for implementing district heating grids

- **Motivation:** District heating is a capital investment asset. Therefore, implementation of DH system should be planned carefully in advance. The DH grid is built and extended over time and in different phases. Once the grid is built in a district and the DH system became operational there, the DH system owner can count on the profits made in that district to further extend the grid to other zones. Therefore, it is crucial to have an estimation of potential profit that can be made in each zone and create a step-by-step plan for extension of grid.
  - **Objective:**

    Given a preliminary plan of the transmission and distribution grid, the master thesis should elaborate development phases for implementation of grid under the assumption of maximizing profits (or other objective functions)
  - **Method of approach:**
    - Conduct a scientific literature survey
    - Based on an existing model, the identified district heating areas are broken to smaller zones. The parameters such as grid costs and annual heat sale associated to each zone are calculated. Under consideration of construction limits and constraints related to supply of heat by transmission lines, the most profitable steps for extending DH grid should be calculated in a Python script.
    - Applying the model to one or several case studies
  - **Supervisor:** Dr. Lukas Kranzl, Mostafa Fallahnejad, Prof. Reinhard Haas