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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:

- die wichtigsten Kenntnisse der Energiewirtschaft haben.
- vom Institut angebotene Lehrveranstaltungen 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. An analysis of the effects of different types of policies in the transport energy system (world-wide)

- **Motivation:** Several energy policies are implemented in transport in different countries: taxes, subsidies, standards.
- **Objective:** The core objective of this work is to analyse which major policies were implemented in major countries in the transport sector since the 1970s and what their effects were.
- **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 policies has to be developed in Excel. Some databases e.g. ODYSSEE are already available.
- **Supervisor:** Prof. Reinhard Haas

1.3. 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

2.4. Ein Vergleich verschiedener Ansätze zur Modellierung des Strompreises in day-ahead-Märkten

An analysis of different approaches for modelling electricity prices in day-ahead markets

- **Motivation:** Modelling future electricity prices is currently one of the most challenging tasks in energy economics and different methods of approach exist. In addition in recent years temporarily large quantities of renewable electricity have influenced the wholesale electricity market prices.
- **Objective:**
  - Comparison and analysis of different approaches for modelling electricity prices incl. the impact of Re- newable Energy Sources (RES-E) on prices in day-ahead electricity markets
  - To develop a simple own model for Austria
- **Method of approach:**
  - Conduct a comprehensive literature and internet survey
  - Data collection and putting together a database for Germany and Austria
  - Compare/use use a fundamental approach (Price=marginal costs) to model the price in the electricity market on an hourly basis based on scarcity (and an Econometric approach)
  - Creation of a simple model in MATLAB or EXCEL.
- **Supervisor:** Prof. Reinhard Haas

3. Energienachfrage / Energy demand models

3.1. Analyse des Einflusses von Energiepreisen und Einkommen (BIP) auf den Energieverbrauch ausgewählter Länder

Analysis of the impact of energy prices and income (GDP) on energy consumption in selected countries

- **Motivation:** Um den Einfluss von Preisen, Einkommen und anderen Parametern auf den Energieverbrauch zu bestimmen, kommen ökonometrische Analysen zum Einsatz. Allerdings kann es - möglicherweise - beträchtliche Unterschiede zwischen Regionen und Ländern geben.
- **Aufgabenstellung:** Im Rahmen dieser Arbeit ist ein geeignetes Statistikprogramm zu nutzen, um eine ökonometrische Analyse für den gesamten Energieverbrauch ausgewählter Länder weltweit durchzuführen. Dabei geht es eben neben den Effekten innerhalb eines Landes auch um Unterschiede zwischen den einzelnen Ländern. Das heißt, es geht darum, herauszufiltern, welche Effekte in den Ländern gleich sind und welche unterschiedlich. Ein spezifischer Aspekt ist, ob zwischen einzelnen Ländern signifikantere Einkommenselastizitäten ermittelt werden können als innerhalb einzelner Länder. Weiters ist das Modell auf Strukturbrüche zu testen.

- **Methode:** Die Daten sind weitgehend vorhanden, einige Zusatzrecherchen sind aber notwendig. Auswahl und Anwendung eines geeigneten Statistikprogramms ist eigenständig durchzuführen (Empfehlung: MICROFIT). Weiters wird die Durchführung der Pooled Data - Analyse anzuwenden.
- **Betreuer:** Prof. Reinhard Haas

3.2. Entwicklung einer Zeitreihe des Stromverbrauchs in österreichischen Haushalten nach Anwendungen

- **Motivation:** Um effiziente Energiesparstrategien setzen zu können ist die möglichst detaillierte Aufschlüsselung des Energieverbrauchs nach Anwendungen erforderlich.
- **Objective:** Ziel ist die Entwicklung einer Zeitreihe des Stromverbrauchs in österreichischen Haushalten nach Anwendungen von 1950 bis 2020. Eine Arbeit mit den Werten für 1950 bis 1995 liegt bereits vor
- **Method of approach:** Bottom-Analyse basierend auf Ausstattungsdaten von Statistik Österreich, . Creation of a database and a simple model in EXCEL.
- **Supervisor:** Prof. Reinhard Haas

4. Erneuerbare Energien / Renewable Energies

4.1. Comparative analysis of modelling strategies for decentral photovoltaic (& storage) in energy system models

- **Motivation:**
  - Solar photovoltaics (PV) is seen to be (besides wind energy) the main renewable energy technology to reach 100% renewable electricity generation in Austria in 2030 as outlined in the Renewable-Expansion-Act (“Erneuerbaren-Ausbau-Gesetz”) which came into force in July 2021. Especially in households, photovoltaics can be combined with decentral storage units to increase the self-consumption rate and, therefore, cost efficiency for the end-user. This – also in combination with increasing capacities of decentral storage – changes the electricity load profile of households. In energy system models, there are therefore two usual ways how to model decentral PV and storage: Either by considering this residual load profile assuming self-consumption or to model PV capacity aggregated and dispatched optimally from the system perspective.
- **Core objective/research question:**
  - What is the impact (error) of modelling decentral PV (+ storage) dispatch in energy system models either as system-optimal or as optimized in terms of self-consumption rates of the households? How does the impact change with an increasing share of decentral PV (+ storage) in the system? (What would be regulatory conditions to change the household's behaviour?)
- **Method of approach:**
  - Development of scenarios using the open-source energy system model Balmorel (GAMS) used and provided by the Energy Economics Group
  - Literature analysis of findings regarding impacts of methodological differences in energy system models on the results
  - Data research of possible scenarios regarding installed capacities of decentral (+ storage), development of energy communities
- **Expected results**
  - Analyse two scenarios for the year 2030: one with decentral PV generation + storage modelled from a system perspective, dispatching all generation from these units in a system-optimal way and another one with the underlying assumption of self-consumption optimization by households.
  - Conduct a sensitivity analysis regarding different shares of PV (+ storage) in the system.
  - Impact of generation behaviour of decentral PV and consumptions of households on energy system

modelling results, e.g. system costs, electricity prices, or GHG emissions

- **Supervisor:** Dr. Gustav Resch, Prof. Reinhard Haas

4.2. 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

4.3. 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

4.4. 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

4.5. The success of tendering/bidding strategies for Photovoltaics world-wide

- **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. This limits the maximum installed capacity.
Because PV has not been economically competitive with convent power plants financial promotion strategies had to be implemented .

- **Core objective/research question:**

The core objective is to analyze the success of tendering/bidding strategies for PV in various countries world-wide (especially the most successful ones). This success may also depend on the local insolation per year.

Derived research questions are: What were the costs for society? How long has PV to be promoted? What is the difference between central and decentral applications?)

- **Method of approach:**

Develop a model e.g. in Excel or Mathlab. The analysis should be conducted for different countries and a systematic comparison between the countries should be made. The methodical approach is to calculate the promotion costs per kWh and per year per country and the corresponding kWhs generated per capita.

- **Expected results**

The major expected result is an assessment of the success of PV. A cost comparison for 2020 should be conducted by country. Aside from the analysis of the bidding strategies the costs for investors and for society and the difference between central and decentral applications should be documented.

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

5.1. Analyse der empirischen Effizienz von Wärmepumpen mit unterschiedlichen Wärmequellen

Analysis of the empirical efficiency of heat pumps

- **Motivation:** Heat pumps are considered to be an efficient method for the reduction of CO2 emissions. Therefore both the European Union as well as local authorities seek further expansion of existing district heating systems or construct new ones in feasible areas..

- **Objective:**
  - Identify empirically monitored efficiencies (SPFs) of heat pumps depending on the heat source and evaluate their thresholds for the feasibility of a district heating system vs. local heat supply technologies.

- **Method of approach:**
  - Conduct a comprehensive literature and internet survey
  - Modelling on an hourly base per year of electricity generation from variable and other and heat demand based on hourly temperatures
  - Data collection and putting together a database for Germany and Austria
  - Compare/use use a fundamental approach (Price=marginal costs) to model the price in the electricity market on an hourly basis based on scarcity (and an Econometric approach)
  - Creation of a simple model in MATLAB or EXCEL.

- **Supervisor:** Prof. Reinhard Haas, Philipp Mascherbauer

5.2. Analysen zur Nutzung industrieller Abwärme

Analysis on the use of industrial excess heat

- **Motivation:** The use of industrial excess heat increases the efficiency of the overall energy system remarkably. However, many aspects of economic efficiency and potentials for its use still remain unclear. Within this topic different research questions can be worked on in course of the master thesis, some of them are stated in the following.

- **Objective:**
  - Analyse the influence of different load profiles and temperature levels of available/usable excess heat streams on the economic efficiency of excess heat projects on the basis of detailed technical modelling of excess heat systems
  - Derive comprehensive cost data for excess heat integration projects for different types of projects (internal vs. external, combination of heat sources and sinks) and show the sensi- tivity to various

influencing factors

- **Method of approach:**

Literature research, Technical modelling of excess heat systems on hourly basis including a storage tank, Techno-economic analysis, Sensitivity analysis

- **Supervisor:** Dr. Lukas Kranzl, Prof. Reinhard Haas

5.3. A rolling phase out 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

5.4. Analysis of economic district cooling potentials

- **Motivation:** Space cooling demand has been strongly increasing in the past years and is expected to further rise, last but not least due to climate change. District cooling may open opportunities for efficient and decarbonized supply of space cooling. On the other hand, district cooling requires
- **Objective:**

  The objective of this work is to assess the economic potential for district cooling under different technical assumptions, as well as climatic and demand related conditions for a few cases across Europe. In particular, the link between cooling and heating solutions through anergy networks should be analysed.

- **Method of approach:**
  - Conduct a scientific literature survey
  - Describe the current state of district cooling systems in Europe
  - Describe the state of technologies for district cooling and individual cooling technologies, including anergy grids
  - Set up a model for the economic comparison of different cooling solutions and identify main impact factors
  - Identify conditions for economic district cooling and assess the potential
  - Apply the model to one or several case studies across Europe
- **Supervisor:** Dr. Lukas Kranzl, Mostafa Fallahnejad, Prof. Reinhard Haas

5.5. Analysis of electricity demand of IT in Austria and the EU up to 2050

- **Motivation:** IT And digitalization are growing continuously and so does its electricity consumption and straightforward CO2-emissions
- **Objective:**
  - Identify scenarios for the electricity consumption of IT (PCs, Lap-Tops, servers, blockchain (?) in Austria and EU-wide up to 2050.
- **Method of approach:**
  - Conduct a comprehensive literature and internet survey
  - Setting up a bottom-up model for the market penetration of different IT appliances and the development of specific electricity demand per appliance in the EU countries
  - Data collection and putting together a database for the EU countries
  - Creation of a simple model in MATLAB or EXCEL.
- **Supervisor:** Prof.Dr. Amela Ajanovic, Prof. Reinhard Haas

6. Energieverbrauch im Verkehr / Energy Economics in Transport

6.1. Optimizing the interaction between a decentralized PV-system, a battery storage and an Electric vehicle

- **Motivation:** Electric vehicles as well as Photovoltaics electricity are considered to contribute to an environmentally benign future electricity system. However, it is not yet clear how these technologies could interact in an optimal way.
- **Objective:** The core objective of this work is to analyse for a single-family dwelling how the own consumption of a household of electricity from a PV system with a (stationary) battery including a Electric Vehicle can be economically optimized, considering with and without a stationary battery storage. Different sizes of the PV system are analysed. Finally the analysis has to be conducted in a dynamic framework taking into account possible Technological Learning effects of the EV, the (stationary) battery and the PV system.
- **Method of approach:** A combination of a static and a dynamic model has to be developed. The static model simulates on an hourly basis over a year the solar insolation, the corresponding electricity generation from the PV system, the charging demand from the EV and the possibilities of the stationary battery. The dynamic model considers the possible Technological Learning ef- fects of PV, the battery and the EV.

In addition, a comprehensive data collection and analysis has to be conducted as well as a literature review. The simple simulation market model (static and dynamic) has to be developed in Excel or MATLAB.

Supervisor: Prof. Amela Ajanovic, Prof. Reinhard Haas

6.2. On the effectiveness of policies for promoting alternative powertrains in Transport (world-wide)

- **Motivation:** Alternative Powertrains such as Fuel Cell vehicles, CNG vehicles or Battery Electric vehicles (BEVs) are considered to contribute to an environmentally benign future transport system. Targets for increasing their number exist in different countries and several policies for promoting these types of Vehicles are implemented in different countries.
- **Objective:** The core objective of this work is to analyse which monetary and non-monetary promotions systems for Alternative Powertrains exist in selected countries (world-wide) and what were their effects on the market penetration of these types of Vehicles.
- **Method of approach:** A comprehensive literature review as well as a data collection and analy- sis has to be conducted. The data collection should encompass the specific number of every vehicle category, GDP of the country, electricity price, types of subsides (or tax relief) and maybe some others. An econometric

model simulating the effects of policies has to be developed in MICROFIT, Excel or MATLAB.

- **Supervisor:** Prof. Amela Ajanovic

6.3. The prospects of hydrogen and fuel cells for large trucks

- **Motivation**

Currently, the transport sector is worst with respect to CO2 emissions. Especially, trucks are an increasing problem world-wide. Heading towards more environmental benign trucks is an important step in the currently discussed transition towards a sustainable energy system. Hydrogen powered fuel cell trucks are considered to be such a technology.

- **Core objective/research question:**

The core objective is to analyze the prospects of hydrogen and fuel cell powertrains for large trucks The economics and the CO2 emissions in comparison to conv diesel vehicles has to be analyzed. In addition, scenarios up to 2030/2050 should be developed.

- **Method of approach:**

First, the current state of investment costs as well as fuel costs of convent and alternative trucks, current energy consumption per ton and km, and the CO2 emissions (incl. embedded) has to be analyzed.. Develop a model e.g. in Excel. The analysis should be conducted for electricity and green hydrogen from RES. Which R&D projects exist and which empirically achieved pilot projects?Develop dynamic scenarios are developed up to 2050 based on Technological Learning.

- **Expected results**

The major expected result is an economic and environmental assessment of hydrogen powered fuel cell trucks for different types of vehicles. In addition, the future perspectives should be modelled, taking into account Technological Learning and possible efficiency improvements as well as the impact of policies e.g. CO2-taxes in a dynamic model up to 2050. .

- **Supervisor:** Prof. Amela Ajanovic

6.4. Perspectives for fuel cells powering locomotives

- **Motivation**

Currently, the transport sector is worst with respect to CO2 emissions. Regarding trains in remote areas still diesel locomotives are used. In these regions heading towards more environmentally benign trains is important. Hydrogen powered fuel cell locomotives could be a solution.

- **Core objective/research question:**

The core objective is to analyze the prospects of fuel cell powertrains for locomotives. The economics and the CO2 emissions in comparison to diesel locomotives has to be analyzed. Also the costs of electrification has to be analyzed. In addition, scenarios up to 2030/2050 due to Technological Learning should be developed.

- **Method of approach:**

Develop a model e.g. in Excel or Mathlab. The analysis should be conducted for electricity and green hydrogen from RES. Maybe an hourly model for the hydrogen production from RES could make sense. Develop dynamic scenarios are developed up to 2050 based on Technological Learning.

- **Expected results**

The major expected result is an economic and environmental assessment of hydrogen powered fuel cell trains compared to electric and diesel locomotives. In addition, a cost comparison for 2020 and in a dynamic model up to 2030/2050 should be conducted considering also Technological Learning and possible efficiency improvements.

- **Supervisor:** Prof. Amela Ajanovic, Prof. Reinhard Haas

6.5. The possible future role for fuel cells and/or electric motors as alternatives for powering airplanes

- **Motivation**

Currently, air transport is worst with respect to CO2 emissions per km travelled. Currently, it is almost solely based on fossil fuels. Heading towards more environmentally benign air transport drives is very important.

Electric or hydrogen powered fuel cell drives could be a solution.

- **Core objective/research question:**

The core objective is to analyze the prospects of electric and fuel cell powertrains for airplanes. The costs, the economics and the CO2 emissions in comparison to fossil fuel – based energy carriers has to be analyzed. In addition, scenarios up to 2030/2050 due to Technological Learning should be developed.

- **Method of approach:**

Develop a model e.g. in Excel or Mathlab. The analysis should be conducted for electricity and green hydrogen from RES. Maybe an hourly model for the hydrogen production from RES could make sense. Develop dynamic scenarios are developed up to 2050 based on Technological Learning.

- **Expected results**

The major expected result is an economic and environmental assessment of hydrogen powered fuel cell airplanes compared to electric and kerosin-based ones. In addition a cost comparison for 2020 and in a dynamic model up to 2030/2050 should be conducted considering also Technological Learning and possible efficiency improvements.

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