Fraunhofer Institute for Applied Information Technology (FIT)

No more Evolution! Revolutionizing Tomorrow's Electricity-Market Design

Fraunhofer FIT

Speeding up the energy transition and rapidly reducing greenhouse gas emissions is imperative for achieving climate goals in Germany and Europe. Electricity market design plays a crucial role in the decarbonization of the German energy system, driving the expansion of both Renewable Energy Sources (RES) and highly needed flexibility on demand side (e.g., by incentivizing consumers to adapt to the temporal and spatial availability of RES). However, current electricity market design in Germany is not well suited to deal with increasing shares of RES and does not embrace demand-side flexibility. Market outcomes may not be physically feasible, as grid constraints are not considered in the market design. This leads to an inefficient dispatch together with costly redispatch as well as excessive feed-in management. Hence, the current electricity market design must be substantially revised, which is also high on the political agenda of the German government.

One promising approach for a future-proof electricity market design is locational marginal pricing (LMP). In an LMP system, electricity prices reflect electricity supply and demand taking available transmission capacities and local scarcity of electricity into account. This implies that each individual node in the electricity network possibly features an individual electricity price. LMPs may become an essential building block in the transition of our electricity system, economy, and society towards a low-carbon world, while maintaining companies' economic competitiveness. However, a transition to LMP requires a thorough consideration of all the relevant effects and specifications involved in such a market design transition. With this project study, we are looking for motivated students that are eager to analyze the impact of introducing LMP on investment decisions in energy flexibility and possible industrial (re)location in Germany as well as to capture associated distributional effects.

Your Challenge

- Modeling an LMP-based market design in Germany
- Processing real-world data on electricity consumption, generation, and transmission capacity
- Analyzing interdependencies between market design and investment as well as (re)location decisions
- Analyzing distributional effects and conceptualizing counteractive policy measures
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

- Start date: anytime
- Duration: 3-6 months
- Team size: 2-4 students
- Supervision: **Prof. Dr. Sebastian Schwenen**
- Co-supervision: **Fraunhofer FIT**
  (Prof. Dr. Jens Strüker, Dr. Martin Weibelzahl)

Your Profile

- Strong interest in digital energy and electricity market design
- Analytical and problem-solving capabilities
- Open-mined attitude with a proactive and collaborative working style
- Excellent written and verbal communication skills

Who we are & what we offer

- **Fraunhofer FIT is part of the world's leading applied research organization** | Fraunhofer FIT is a trailblazer in innovation and research excellence with a key focus on actively shaping the future of our energy system
- **Impact** | Accelerate the energy transition firsthand by working on topics that are timely and most relevant for achieving our energy and climate policy goals in Germany and Europe
- **Interdisciplinary teamwork** | Work in an interdisciplinary team with experienced research experts (doctoral candidates, post-doctoral researchers and/or professors)
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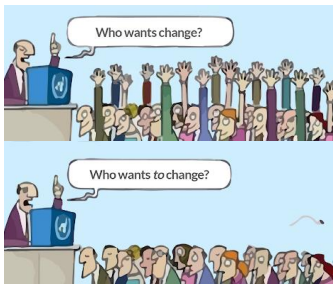
Who wants (to) Change? Participatory Systems for Electricity-Market Design

Fraunhofer FIT

Speeding up the energy transition and rapidly reducing greenhouse gas emissions is imperative for achieving climate goals in Germany and the Europe. Electricity market design (i.e., "rules" defining how electricity prices are formed) plays a crucial role in the decarbonization of the German energy system, driving the expansion of both Renewable Energy Sources (RES) and highly needed flexibility on demand side (e.g., by incentivizing consumers to adapt to the temporal and spatial availability of RES). However, current electricity market design is not well suited to deal with increasing levels of renewable RES, and it does not embrace demand-side flexibility. Although there are promising avenues towards a revised market design, acceptance of a new market design is rather low: Change significantly affects different stakeholders, with concrete implications of a revised market design often being perceived as "unclear" or "abstract".

With this project study, we are looking for motivated students that are eager to build a prototype that provides adaptive and persuasive decision support to different stakeholder groups (e.g., political decision makers or corporate representatives) regarding different electricity market design specifications and possible effects. The prototype – which could take the form of a web application – should allow stakeholders to cognitively process and learn about the multidimensional implications associated with different market design options in a "participatory way". The overarching objective is allowing key stakeholders to form well-informed preferences and ultimately increase the acceptance for revising our current electricity market design.



Source: https://knowyourmeme.com/memes/who-wants-change-who-wants-to-change#fn

Your Challenge

- Developing a prototype that illustrates multidimensional implications of different electricity market designs in Germany (e.g., overall system costs, distributional effects, self-sufficiency)
- Prototype testing in collaboration with corporate representative and political decision makers
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

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- Co-supervision: **Fraunhofer FIT**
  (Prof. Dr. Jens Strüker, Dr. Martin Weibelzahl)

Your Profile

- Strong interest in digital approaches to decarbonization, market design, and participation
- Analytical and problem-solving capabilities
- Open-mined attitude with a proactive and collaborative working style
- Excellent written and verbal communication skills

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Is it a Match?
CO_2 Reduction vs. Electricity-Cost Reduction

Fraunhofer FIT

Electricity generation from Renewable Energy Sources (RES) is becoming increasingly important for an effective energy transition in Germany. However, RES are subject to weather-dependent fluctuations. In this vein, flexibility in energy-intensive industrial processes can be one promising approach to reduce CO_2 emissions by means of aligning electricity consumption with renewable generation. Thus, companies may reduce their overall carbon footprint by means of energy flexibility. Besides aligning electricity consumption with renewable generation, companies could also use their flexibility to react to the fluctuation of electricity prices at the day-ahead or intraday market with the aim of reducing electricity costs. As a consequence, the question arises, how electricity prices and renewable fluctuations are correlated on different markets and how companies can achieve both: Reducing their carbon footprint and electricity costs with the help of energy flexibility.

With this project study, we are looking for motivated students eager to analyze the connection between renewable electricity generation and electricity prices in general and derive a first prototype of a production control system that considers CO_2 reductions and electricity bill reductions in an integrated manner – fostering decarbonization and ensuring competitiveness of the energy intensive industry.

Illustration by Alexandre Magnin - Sustainabilityillustrated.com

Your Challenge

- Processing real-world data on electricity generation and electricity prices
- Developing a prototype / optimization that considers CO_2 reductions as well as electricity bill reductions considering flexible electricity consumption
- Prototype testing in collaboration with corporate representative and political decision makers
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

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Your Profile

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Let's Participate! Economic Incentives to Integrate Decentralized Electric Assets

Traditionally, the German electricity system was characterized by conventional power plants and top-down electricity flows: Electricity was generated by few large fossil fuel or nuclear power plants, which were sited close to the centers of electricity demand. To foster decarbonization, the electricity system is now characterized by drastic changes. Decentralized wind and photovoltaic parks are spread all over the country. Furthermore, the provision of heat using electricity as well as mobility in form of electric vehicles are on the rise. However, these decentralized assets are – at the moment – not fully utilized to provide, e.g., flexibility to the electricity system.

With this project study, we are looking for motivated students to investigate, how economic incentive models must be designed to foster the integration of decentralized assets into the electricity system. For this purpose, a multitude of incentives for the provision of, e.g., ancillary services or local congestion management, must be considered and coordinated. In a second step, these incentive models must be evaluated in a quantitative manner. Therefore, a simulation model shall be developed, which allows the assessment of different economic incentive schemes for the integration of decentralized electrical assets.

Your Challenge

- Get to know the electricity system and the underlying markets & services
- Identify the relevant stakeholders and design dimensions for economic incentive models
- Use an iterative process to design economic incentive models
- Develop a tool to quantitively evaluate the designed incentive models
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

- Start date: anytime
- Duration: 3-6 months
- Team size: 2-4 students
- Supervision: **Prof. Dr. Sebastian Schwenen**
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Innovative Business Models Based on Zero-Knowledge Proofs

Fraunhofer FIT

In recent years, there have been rapid advances in the practicality of technologies that transparently show the correctness or compliance of computations without having to give up the confidentiality of the underlying data. Probably the best known and currently most focused example of this are so-called zero-knowledge proofs. With these, the correctness of a calculation can be proven in a short statement without having to make the underlying data transparent. A current obstacle to their application lies essentially in their complexity and technology maturity, but past rapid advances suggest that meaningful practical applications can be expected in near future. An example of this might be the following problem: A company wants to order products with certain characteristics and would need to search a vendor's "catalog" to find the best fit. However, the vendor may not want to disclose their complete product line. On the other hand, the company does not want to disclose their search query to the supplier, as the supplier might otherwise still be able to change its offer or prices. With privacy preserving computing technologies, such a "matching" of offers and queries could happen without the provider having to disclose their catalog and the company their query to each other (and to any third party).

With this project study, we are looking for motivated students eager to analyze different technologies in the area of zero-knowledge proofs and/or the possible applications in enterprises or public administration.

Your Challenge

- Get to know the concept and the capabilities of zero-knowledge proofs
- Use an iterative process to design (and implement) innovative business models based on privacy-preserving technologies
- Prototype testing in collaboration with corporate representative and politicians via FIM-network
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

- Start date: anytime
- Duration: 3-6 months
- Team size: 2-4 students
- Supervision: **Prof. Dr. Sebastian Schwenen**
- Co-supervision: **Fraunhofer FIT**
  (Prof. Dr. Jens Strüker, Dr. Marc-Fabian Körner)

Your Profile

- Strong interest in innovative and applied advanced technology
- Analytical and problem-solving capabilities
- Open-mined attitude with a proactive and collaborative working style
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Digital CO_2 Proofs for Harmonizing Corporate Carbon Standards & Legislation

Fraunhofer FIT

The significance of sustainability and decarbonization substantially have increased for companies over the recent years. This becomes also evident from the fact that Germany as well as the European Union increasingly enact or draft up political instruments to reduce CO_2 emissions. One building block of these instruments is the mandatory reporting of CO_2 information, e.g., due to requirements in annual reports or due to the mandatory participation in emission trading systems. In addition, voluntary standards on corporate carbon accounting have emerged. For companies in particular, the multiplicity of different reports, standards, and the resulting key figures is associated with increasing effort and expenses. Consequentially, there is a strong need for harmonization of corporate reporting obligations and standards (see, e.g., Klaaßen, L., Stoll, C. Harmonizing corporate carbon footprints. Nat Commun 12, 6149 (2021)). Digital technologies may represent efficient tools to improve the current reporting processes while supporting the harmonization of corporate accounting processes.

For this project study, we are looking for motivated students that analyze and compare the currently existing reporting and accounting standards. The objective of the project study is to identify the potential of different digital technologies to harmonize the current reporting processes from a company perspective. For this purpose, multiple key factors where harmonization is most beneficial should be considered and set into relation to the characteristics of specific digital technologies. The findings from this analysis should, then, be incorporated into a prototype tool that allows companies to identify suitable digital technologies for improving their carbon reporting and accounting processes.

Your Challenge

- Get to know carbon accounting standards and legislative carbon reporting
- Identification of the required harmonization between the existing standards and legislation
- Derive and compare the potential of digital technologies for the harmonization
- Development of an evaluation tool of the potential of digital technologies from a corporate perspective
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

- Start date: anytime
- Duration: 3-6 months
- Team size: 2-4 students
- Supervision: **Prof. Dr. Sebastian Schwenen**
- Co-supervision: **Fraunhofer FIT**
  (Prof. Dr. Jens Strüker, Dr. Marc-Fabian Körner)

Your Profile

- Strong interest in analyzing digital approaches and carbon standards
- Analytical and problem-solving capabilities
- Open-mined attitude with a proactive and collaborative working style
- Excellent written and verbal communication skills

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Towards Transparency in the Energy Transition: New Business Models based on Emission Data

Due to an increasing importance of emission data for consumers, e.g., demand for sustainable products and product carbon footprints, companies aim at collecting and utilizing emission data of their products. In this context, companies seek to create new profits from providing information about the degree of product sustainability. Therefore, there is a particular need for innovative and sustainable business models that build on high-quality emission data that can be communicated in a transparent and immutable way.

For this project study, we are looking for motivated students that want to develop innovative business models that address the increasing importance of emission data for consumers. The objective is to develop a hybrid business model that combines a physical product with a service component based on information systems and utilizing emission data. Thereby, students may decide on one of the following focus areas:

- Battery storage: Due to changes in European legislation (RED II, RED III), guarantees of origin for the electricity that is charged as well as discharged by a battery storage may have a great influence on the business models of storage operators.
- Green hydrogen: As one of the key elements of a decarbonized industry, the importance for verifiable data on the origin of the electricity used in hydrogen production increases and may have influence on the business models of power-to-X plant operators.
- Green steel: As the steel industry is the second largest emitter of greenhouse gases, steel companies have to radically transform towards the production and marketing of green steel by the use of renewable sources and green hydrogen.

Your Challenge

- Get to know business model canvas as well as current corporate sustainability developments
- Development of a hybrid business model for a specific industry/product (i.e., battery storage, green hydrogen, or green steel)
- Economic comparison of various approaches to process, evaluate, and communicate emission data
- Presentation and visualization of results (optional: publication of results in a scientific journal)

Organizational Scope

- Start date: anytime
- Duration: 3-6 months
- Team size: 2-4 students
- Supervision: **Prof. Dr. Sebastian Schwenen**
- Co-supervision: **Fraunhofer FIT**
  (Prof. Dr. Jens Strüker, Dr. Marc-Fabian Körner)

Your Profile

- Strong interest in business model development and corporate decarbonization efforts
- Analytical and problem-solving capabilities
- Open-mined attitude with a proactive and collaborative working style
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Leading the Way to Decarbonization?! Providing Emission Data Through Emerging Technologies

Due to the expanding demand for sustainable and green products, companies seek to create new profits from providing information about the degree of product sustainability. In this context, there is a particular need for better, high-quality data that can be communicated in a transparent and immutable way. With data security and the issue of data ownership playing a crucial role, new technologies such as blockchain technology or self-sovereign digital identities lend themselves to such implementations, offering new opportunities for comprehensible and user-oriented implementations.

For this project study, we are looking for motivated students who want to evaluate the usage of emerging digital technologies in a tracking system for emission data by implementing a prototype. This system should focus on new areas for emission tracing for which no scalable solutions are currently available. To evaluate specific emerging technologies, students may decide on one of the following focus areas that may serve as an intriguing use case :

- Battery storage: Due to changes in European legislation (RED II, RED III), guarantees of origin for the electricity that is charged as well as discharged by a battery storage become more relevant for storage operators.
- Green hydrogen: As one of the key elements of a decarbonized industry, the relevance of verifiable data on the origin of the electricity used in hydrogen production increases.
- Green steel: As the steel industry is the second largest emitter of greenhouse gases, the production and marketing of green steel using renewable sources and green hydrogen becomes increasingly important for steel companies.

Your Challenge

- Dive into the concepts of relevant emerging technologies, e.g., blockchain or digital identities
- Use an iterative process to design and implement a scalable and user-centric solution for providing emission data
- Prototype testing in collaboration with corporate representative and politicians via Fraunhofer-network
- Presentation and visualization of results (optional: publication of results in a scientific journal)

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