

Seminar im Sommersemester 2026

Seminar Energiewirtschaft VI: Bewertung und Modellierung von Wasserstoffprojekten und Energiesystemen unter Unsicherheit

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Kurzbeschreibung:

Das Seminar „*Bewertung und Modellierung von Wasserstoffprojekten und Energiesystemen unter Unsicherheit*“ beschäftigt sich mit der wissenschaftlichen Bewertung von Wasserstoff- und Energiesystemprojekten im Kontext der Energiewende. Im Fokus stehen unterschiedliche Modellierungsansätze zur techno-ökonomischen Analyse, die Untersuchung von Geschäftsmodellen sowie die Rolle von Datengrundlagen und deren Verarbeitung in der Literatur. Ein besonderer Schwerpunkt liegt auf der systematischen Analyse von Unsicherheiten in Energiesystemen sowie auf deren Einfluss auf Planung, Betrieb und Investitionsentscheidungen.

Darüber hinaus werden Methoden zur Bewertung der Versorgungssicherheit und Zuverlässigkeit in dekarbonisierten Energiesystemen untersucht und mit konventionellen Ansätzen verglichen. Ergänzend wird die Erweiterung klassischer Analysen um zusätzliche Umweltwirkungen über CO₂ hinaus betrachtet. Ziel des Seminars ist es, die Aussagekraft und Vergleichbarkeit wissenschaftlicher Studien kritisch zu bewerten sowie methodische Weiterentwicklungen für die Analyse zukünftiger Energiesysteme zu identifizieren.

Studierende erwerben vertiefte Kompetenzen in techno-ökonomischer Analyse, Datenaufbereitung, Modellierung und wissenschaftlicher Ergebnisaufbereitung. Das Seminar bietet damit eine forschungsnahe Auseinandersetzung mit aktuellen Fragen der industriellen Dekarbonisierung sowie der Planung zukünftiger Energiesysteme. Darüber hinaus ermöglicht das Seminar, die wissenschaftliche Arbeitsweise der Studierenden weiterzuentwickeln.

Folgende Seminarthemen stehen zur individuellen Bearbeitung zur Verfügung:

Thema 1: Scientific Evaluation of Hydrogen and Hydrogen Derivative Projects: Business Case, Data Basis, and Data Processing in the Literature (English/German)

Motivation

The increase in hydrogen demand leads to investments in the hydrogen economy. These facilities are subject to various uncertainties, such as regulatory uncertainties, economic uncertainties of investments, or weather-related uncertainties. Accordingly, various models have been developed in academia to analyze investments in the hydrogen sector.

Objective of the Study

Analysis and comparison of scientific models for evaluating hydrogen projects with respect to:

- Business Case (cost structures, revenue models, economic performance indicators)
- Data Basis (sources, assumptions, data quality)
- Approaches to Data Processing and Usage in the Literature, e.g.:
 - Use and selection of datasets
 - Aggregation and simplification of data
 - Derivation of scenarios from data
 - Handling of time series (e.g., electricity prices, weather data)
- Presentation and Interpretation of Results

Thema 2: Scientific Evaluation of Projects for the Production of Hydrogen and Hydrogen Derivatives: Methods (English/German)

Motivation

The increase in hydrogen demand leads to investments in the hydrogen economy. These facilities are subject to various uncertainties such as regulatory uncertainties, economic uncertainties of investments, or weather-related uncertainties. Accordingly, various models have been developed in academia to analyze investments in the hydrogen sector.

Objective of the Study

Analysis and comparison of scientific models for evaluating hydrogen projects with respect to:

- Modeling Approaches Used, e.g.:
 - Optimization models
 - Simulation models
 - Techno-economic models
 - Hybrid approaches
- Structure and Functionality of the Models, in particular:
 - Objective functions (e.g., cost minimization, profit maximization)
 - Decision variables
 - System boundaries and model scope
- Combination and Integration of Different Methods, e.g.:
 - Linking techno-economic and energy system models
 - Coupling of modules (production, transport, demand)
- Approaches to Handling Uncertainty, e.g.:
 - Scenario-based approaches
 - Sensitivity analyses
 - Stochastic modeling
 - Robust optimization
- Suitability of the Methods for Evaluating Investment Decisions, especially regarding:
 - Informative value of results
 - Transparency and reproducibility
 - Handling of complex real-world conditions

Thema 3: Scientific Evaluation of Hydrogen and Hydrogen Derivative Projects: Comparison, Classification, Informative Value of Results, and Result Presentation (English/German)

Motivation

The increase in hydrogen demand leads to investments in the hydrogen economy. These facilities are subject to various uncertainties such as regulatory uncertainties, economic uncertainties of investments, or weather-related uncertainties. Therefore, this study aims to analyze and compare scientific studies evaluating hydrogen projects.

Objective of the Study

To analyze and compare scientific studies on hydrogen projects, focusing on the comparability, robustness, and interpretability of their results and their implications for investment decisions.

- Key Results and Indicators, e.g.:
 - Production costs (e.g., LCOH – Levelized Cost of Hydrogen)
 - Profitability and break-even points
 - Competitiveness compared to alternatives
- Comparability of Results Between Studies, in particular:
 - Differences in assumptions and boundary conditions
 - Influence of location, technology, and system boundaries
 - Transferability of results
- Influence of Model Assumptions and Boundary Conditions on Results, e.g.:
 - Electricity prices
 - Capacity utilization
 - Regulatory frameworks
- Informative Value and Limitations of the Studies, especially regarding:
 - Uncertainty and robustness
 - Transparency and reproducibility
 - Potential biases due to assumptions

Thema 4: Uncertainty in Energy Systems Modeling

Motivation:

Future energy systems are subject to multiple sources of uncertainty, yet many models rely on simplified or deterministic assumptions.

Key question: How can uncertainty be systematically identified, classified, and incorporated into energy systems modeling?

Some of the questions that this seminar deals with:

- **Identification:** What are the relevant sources of uncertainty in future energy systems?
- **Classification:** How can these uncertainties be categorized? To what extent can they be quantified or assigned probabilities?
- **Implications:** What are the consequences of neglecting uncertainty in system planning, operation, and policy-making?
- **Methodology:** Which approaches exist to account for uncertainty in energy system models?
- **Limitations and outlook:** What are the key challenges of current approaches, and how might they be addressed?

Thema 5: Reliability Resources in Decarbonized Power Systems

Motivation:

The transition toward highly renewable power systems with increasing role of distributed energy resources (DERs) is reshaping the concept of reliability.

Key question: Can emerging and distributed flexibility options ensure reliable electricity supply in future decarbonized power systems, and how do they compare to the conventional solutions of dispatchable power plants?

Some of the questions that this seminar deals with:

- **Identification:** What are the relevant resources contributing to system reliability in future power systems?
- **Classification:** How do these resources differ in their characteristics, capabilities, and limitations?
- **Assessment:** How can their contribution to system reliability be evaluated and compared?
- **Methodology:** How should planning and operational frameworks be adapted to account for these changes?
- **Implications:** What are the consequences for system design, market structures, and policy?

Thema 6: Beyond CO₂: Environmental Impacts of Energy Systems

Motivation:

Energy system analysis often focuses primarily on CO₂ emissions, potentially overlooking other relevant environmental impacts.

Key question: How can energy system modeling exercises be extended to account for a broader set of environmental impacts?

Some of the questions that this seminar deals with:

- **Identification:** Which environmental impacts, beyond CO₂ emission, are relevant for energy systems?
- **Trade-offs:** What are the trade-offs involved in reducing the environmental impacts of the energy systems?
- **Methodology:** Which approaches exist to quantify and evaluate these impacts?
- **Integration:** To what extent are these aspects currently included in energy systems planning?
- **Limitations and outlook:** What challenges arise when integrating broader environmental metrics, and how can they be addressed?

Thema 7: Security of Supply and Backup Capacity Requirements in European Power Systems (English/German)

Motivation:

The transition toward renewable-based power systems raises critical questions regarding security of supply and the need for backup capacities. Various studies provide differing estimates depending on underlying assumptions and system configurations.

Key question: Can future European power systems ensure security of supply, and how do backup capacity requirements evolve under different assumptions?

Some of the questions that this seminar deals with:

- **Overview:** What are the projected backup capacity needs in selected studies and scenarios?
- **Comparison:** How do results differ across studies and what explains these differences?
- **Assumptions:** What are the key underlying assumptions, e.g.:
 - Electricity demand development
 - Expansion of renewable generation
 - Decommissioning and addition of dispatchable power plants
 - Role of flexibility options (e.g. storage, demand-side management, interconnections)
- **Methodology:** Which modeling approaches are used to assess adequacy and backup needs?
- **Implications:** What conclusions can be drawn for system planning, market design, and policy?

Thema 8: Impact of Data Center Electricity Demand on Future European Energy Systems (English/German)

Motivation:

The rapid growth of digitalization and artificial intelligence is driving a significant increase in electricity demand from data centers, posing new challenges for energy systems.

Key question: How will the growing electricity demand from data centers affect the development and operation of future European energy systems?

Some of the questions that this seminar deals with:

- **Demand Outlook:** What are the expected growth rates and drivers of data center electricity demand in Europe?
- **System Impacts:** What challenges arise for power systems, e.g.:
 - Grid connection and infrastructure constraints
 - Temporal and spatial concentration of demand
 - Integration of flexibility options
- **Comparison:** How does the European development compare to other major markets (e.g. North America, Asia)?
- **Solutions and Strategies:** What approaches are being discussed or implemented, e.g.:
 - Flexible operation and demand response
 - On-site generation or storage
 - Use of temporary solutions (e.g. mobile gas turbines in case of grid delays)
- **Risks and Implications:** What are the risks for system stability, infrastructure planning, and decarbonization targets?

Thema 9: CO₂ Pricing, EU ETS Reform, and Industrial Competitiveness in Europe (English/German)

Motivation:

The evolution of CO₂ pricing mechanisms in Europe plays a central role in achieving climate targets while maintaining industrial competitiveness. Recent reforms and policy instruments are intensively debated.

Key question: How do current and proposed CO₂ pricing mechanisms affect industrial competitiveness and investment incentives in Europe?

Some of the questions that this seminar deals with:

- **Overview:** What are the existing and planned mechanisms, e.g.:
EU ETS I (current emissions trading system)
EU ETS II (extension to additional sectors)
Carbon Border Adjustment Mechanism (CBAM)
- **Mechanisms:** How do these instruments function in terms of pricing, allocation, and coverage?
- **Reforms:** What changes and reform proposals are currently discussed?
- **Impacts:** What are the expected effects on:
CO₂ price development
Industrial competitiveness
Investment incentives and carbon leakage
- **Assessment:** How are these mechanisms evaluated in the literature with respect to effectiveness, efficiency, and fairness?

Termine:

Seminarauftritt:	Do., 16.04.2026, 11:00 bis 12:00 Uhr (vor Ort: Seminarraum 017, IIP)
Zwischenpräsentation:	Do., 28.05.2026, 10:00 bis 12:00 Uhr (vor Ort: Seminarraum 017, IIP)
Abschlusspräsentation:	Do., 09.07.2026, 09:00 bis 12:00 Uhr (vor Ort: Seminarraum 017, IIP)

Die Teilnahme an allen Terminen ist obligatorisch.

Die Online-Anmeldung muss vor dem **23.03.2026, 00.00 Uhr** auf der Seite <https://portal.wiwi.kit.edu> erfolgen.

Die Bestätigung des Seminarplatzes ist erst durch die verbindliche Anmeldung im Studierendenportal erfolgt (<https://campus.studium.kit.edu/exams/registration.php>).

WICHTIG: Bitte überprüfen Sie nach Ihrer Bewerbung regelmäßig Ihre E-Mails, um schnellstmöglich auf ein Seminarplatzangebot zu reagieren! Bei nicht fristgerechter Rückmeldung werden die Seminarplätze im Nachrückverfahren weitervergeben.

Bewerbungsunterlagen

- Aktueller Notenauszug (Bachelor **und** ggf. Master)
- Kurz-CV inkl. relevanter Vorkenntnisse (bitte kein Motivationsschreiben)

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