New Methodology for Financial and Technical Assessment of Energy Flexibility in Buildings

Summary

The global push towards sustainable development and energy efficiency has led to an increasing interest in flexible energy technologies in buildings. This PhD research aims to develop a robust methodology for the financial and technical assessment of energy flexibility in buildings, addressing the key barriers to implementation. The transition towards energy-efficient and flexible buildings is important in addressing climate changes and optimizing energy usage in urban environments. Energy flexibility in buildings refers to the ability of a building to adjust its energy consumption in response to external conditions, such as energy prices, grid demand, and renewable energy availability. The need for a systematic and data-driven methodology to assess the financial and technical viability of energy flexibility solutions has become increasingly relevant, particularly in smart grids and sustainable urban planning.

Research field:	Electrical power engineering and mechatronics
Supervisors:	Prof. Dr. Argo Rosin Vahur Maask
Availability:	This position is available.
Offered by:	School of Engineering Department of Electrical Power Engineering and Mechatronics
Application deadline:	Applications are accepted between June 01, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

The TEM-TA78 project at TalTech focuses on data-driven assessment of energy-saving and flexibility technologies in buildings, which aligns with this research topic. The project's goal is to support Estonian enterprises in developing and deploying new energy-saving and flexibility-based services. However, several challenges hinder the large-scale implementation of such technologies, including:

- The lack of standardized methods to evaluate the energy-saving potential and financial benefits.
- Issues related to data availability, quality, and integration for modeling and assessment.
- Need for reliable impact assessment methodologies for customers and policymakers.
- Limited skilled workforce in energy flexibility assessment and implementation.
- Low public awareness of available smart energy technologies.

The research
The PhD project aims to create a new, data-driven methodology that integrates financial and technical assessment frameworks for evaluating energy flexibility in buildings. The specific objectives include analyzing the assessment methodology's effectiveness and economic implications using datasets acquired from the TalTech campus and partner buildings. Ultimately, this research contributes to informed decision-making to provide flexibility with buildings and resource allocation in the face of evolving energy demands and generation profiles.
PhD project should address several key research questions to advance our understanding and improve financial and technical assessment of energy flexibility in buildings. Here are some relevant questions:

1. How can a standardized methodology be developed to evaluate the financial and technical feasibility of energy flexibility measures in buildings?
2. What are the key technical parameters and financial indicators that should be included in an assessment model for energy flexibility?
3. How can energy consumption data, predictive analytics, and AI-driven models enhance the accuracy of energy flexibility assessment?

4. What are the economic and environmental trade-offs associated with implementing energy flexibility technologies in different types of buildings?
5. How can energy flexibility assessment be integrated into smart grid frameworks to optimize energy management?
6. What role do policy incentives, market regulations, and stakeholder engagement play in adopting energy flexibility solutions in buildings?
7. How can the proposed assessment methodology be validated and scaled to accommodate various building typologies, climates, and energy market conditions?
   Research tasks involve combining quantitative and qualitative research methods, including data collection through measurements, simulations, and possibly field studies. Followed by data analysis using statistical and computational techniques.

Supervisors
Main supervisor: Researcher Vahur Maask
Co-supervisor: Prof. Dr Argo Rosin

Responsibilities and (foreseen) tasks

- **Development of a Comprehensive Assessment Model:**
  - Establishing a framework that integrates technical, economic, and environmental performance indicators.
  - Utilizing big data and AI-driven analytics to enhance assessment accuracy, such as XGBoost, CatBoost, long-short term memory or time series analysis tools.
  - Investigate the flexibility potential of various flexibility sources in buildings, such as smart HVAC systems, adaptive lighting, and energy storage.
- **Data Collection and Analysis:**
  - Gather extensive datasets from building management systems, smart meters, and other IoT devices to capture energy usage patterns, environmental conditions, and operational parameters.
  - Leveraging historical data from TalTech's campus buildings and industry partners to model energy flexibility potential.
  - Developing benchmark datasets for future research and industry applications.
  - Preprocess the data to handle missing values, outliers and ensure data integrity for accurate analysis.
- **Validation of Assessment Models:**
  - Testing and validating the methodology using real-world pilot projects or experimental results from TalTech's campus.
  - Identifying strategies for cost-effective deployment of energy flexibility measures.
- **Impact Evaluation and Decision Support:**
  - Designing a decision-support framework for policymakers, aggregators, and building owners.
  - Providing guidelines for smart building automation and classification frameworks.
- **Scalability and Policy Recommendations:**
  - Assessing the scalability of the methodology for different building types and urban settings.
  - Evidence-based policy recommendations to promote the adoption of energy flexibility technologies.

Applicants should fulfil the following requirements:

- master's degree in electrical engineering, computer science, or applied informatics from the last 5 years
- a clear interest in the topic of the position
- principal understanding of electric power systems
- strong programming skills (e.g., Python, MATLAB, C++)
- proficient English language user (at least CEFR level of C1)
- profound writing and analytical skills
- capacity to work both as an independent researcher and as part of an international team
- capacity and willingness to aid in relevant organizational tasks

The following experience is beneficial:

- (co-)authored published scientific papers

- practical experience in working with SQL database, Jupyter Notebook and/or MATLAB
- theoretical experience with energy flexibility assessment issues
- basic knowledge of machine learning

The candidate should submit a research plan for the topic, including the overall research and data collection strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

We offer:

- 4-year PhD position in the leading microgrids research group in the region with a large portfolio of pan-European and national research and development, and study projects, mainly concerned with renewable energy integration and digital and AI applications in electric power systems.
- The opportunity to carry out high-level research in the domain of microgrids and metrology.
- Access to state-of-the-art research facilities for microgrids, renewables integration and power system digitalization.
- Opportunities for student exchange through EuroTeQ and Erasmus+ programmes, visits to scientific conferences and laboratory facilities and networking with leading universities and research centres.

About the department

The Department of Electrical Power Engineering and Mechatronics of Tallinn University of Technology is an interdisciplinary research centre focusing on socially relevant and future-oriented research and teaching issues related to power engineering and mechatronics. The department's mission is to lead electrical engineering and technical studies and development projects in Estonia, which is known and valued in society and is a respected partner in national and international cooperation networks and organizations. The department has coordinated and partnered with several international projects, including Horizon 2020, INTERREG, 7FP, Nordic Energy Research etc.

The Department of Electrical Power Engineering and Mechatronics conducts research within seven research groups and operates state-of-the-art laboratories with high-end equipment, offering accredited services in lighting and different electrical measurements. The department's focus areas are domestic and global challenges related to increasing digitalization, decarbonization, and decentralization of electric power systems and the increasing use of renewable energy sources. The department carries out research in the following relevant areas:

- optimization of electric power systems and system analysis to find possibilities for electrification and decarbonization
- diagnostics and monitoring of equipment and systems
- cyber security, 5G data communications and artificial intelligence
- energy networks and research on green technology, including energy storage, renewable energy, hydrogen systems
- supply and demand-side management, IoT applications in energy systems
- implementation of smart industry, including industrial robotics, automation, 3D printing, computer vision, digital twins

Additional information

For further information, please get in touch with Researcher Vahur Maask, vahur.maask@taltech.ee or visit https://taltech.ee/en/department-electrical-power-engineering-mechatronics

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