



LAND OF THE CURIOUS




 14.12.2023

LABORATORY OF ELECTRICITY MARKETS AND POWER SYSTEM

Behnam Mohammadi Ivatloo

Behnam.ivatloo@lut.fi

AGENDA

- 
- »» Introduction
 - »» Ongoing Projects
 - »» Submitted Proposals
 - »» Supervision
 - »» Teachings
 - »» Publications
 - »» Next plans

INTRODUCTION

- 
- »» Behnam Mohammadi Ivatloo
 - »» Professor of Sector Integration in Power Systems
 - »» Previous Research Experiences: University of Tabriz, Aalborg University, MSKU University, University of Calgary
 - »» PI or Co-PI in more than 20 Research Projects
 - »» Supervisor or Advisor of 23 PhD thesis
 - »» Teaching experience of 7 B.Sc. level, 4 M.Sc. level and 4 PhD level courses.

 - »» Current Organization:
 - »» LUT University → School of Energy Systems → Department of Electrical Engineering
→ Laboratory of Electricity Markets and Power Systems

Laboratory of Electricity Market and Power Systems

Research staff 2023



Prof. Samuli Honkapuro



Prof. Behnam
Mohammadi-ivatloo



Prof. Jukka Lassila



Dr. Salla Annala



Dr. Gonçalo Mendes



Leticia Tomas Fillol



Jasmin Jaanto



Mohammad Ali
Norouzi



Dr. Juha Haakana



Dr. Jouni Haapaniemi



Ville Tikka



Otto Räisänen



Araavind Sridhar



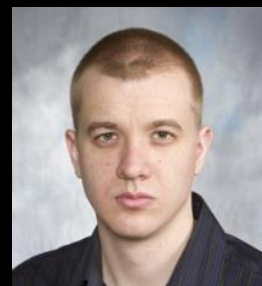
Mohammad Seyfi



Markus Salmelin



Hossein
Aghamohammadloo



Dr. Antti Pinomaa



Dr. Aleksi Mattsson



Dr. Aleksei Romanenko



Henock Dibaba



Ville Sihvonen



Narges Ghorbani



Anniina Sorvisto



Kuisma Saariaho

ONGOING PROJECTS

» Project Title: **Reliable 6G for Energy Vertical Applications (REEVA)**
Role: PI (LUT Side)

» Funder: **Business Finland**



Distribution grid protection

UC1: Virtual fault passage indication on edge–cloud continuum

UC2: Latency-critical intertrip and line differential protection

Microgrid control

UC3: Coordinated grid-forming and grid-following frequency converter control

UC4: Operation of electrified loads and storage units in microgrids based on local weather forecasts


Virtual power plant control

UC5: Event-triggered communication for control of space heating

UC6: Packetized energy management for electrified transportation considering spatial-temporal dynamics




ONGOING PROJECTS

- 
- **Project Title:** Joint Optimization of Data and Energy Networks for digitizing Sustainable Communities (COALESCE)
 - **Role:** Team member (LUT Side)
 - **Funder:** Horizon (Staff Exchange)
 - **Other Partners:** South East Technological University (IE), Trinity College Dublin (IE), University of Cyprus (CY), DHA Suffa University (PK), Millennium Institute of Technology (PK), Cleanwatts Digital (PT), CY.R.I.C (CY), Huawei Ireland Research Center (IE), Volve (FI)
 - **Objective:** COALESCE aims to develop a cross-optimization platform that enables integrated operation and interplay between the energy grids and the data and telecommunication networks. Telecommunication and data networks need energy, while energy grids need data to operate efficiently. This project will develop a framework that will optimize the interplay between energy grids and telecommunications and data networks in a way that both the infrastructure pillars (energy and telecommunications) are jointly sustainable and efficient. Through the Staff Exchange program, we will be able to exchange expertise and know-how between energy, data and telecommunications sectors across both academia and industry.

ONGOING PROJECTS

- 
- 
- Project Title: **Pathways out of Energy Crises to a Resilient and Just Energy System – PHOENIX**
 - Role: **Team member (LUT Side)**
 - Funder: **Academy of Finland (STN call)**
 - Other Partners: LUT University, University of Helsinki, VATT, University of Eastern Finland, University of Tampere
 - Project Summary: PHOENIX seeks to assess how the benefits and costs of the energy system are distributed in Finland and design solutions, actions and policies that would support a more equitable distribution. PHOENIX addresses resiliency of the energy system and the sectors of the society impacted by the green energy transition, such as manufacturing, rural areas, and energy end users. It explores new energy solutions that strengthen resiliency. PHOENIX focuses on energy justice and resilience from the perspectives of households and firms, and different industrial sectors and regions. It seeks to promote fundamental societal change in Finland that is needed to achieve a just green transition. Finland's transition will produce valuable global lessons on how a vital democratic society and a Nordic welfare state, with liberalized electricity markets and an energy-intensive goods export sector, can implement a just energy transition.

ONGOING PROJECTS

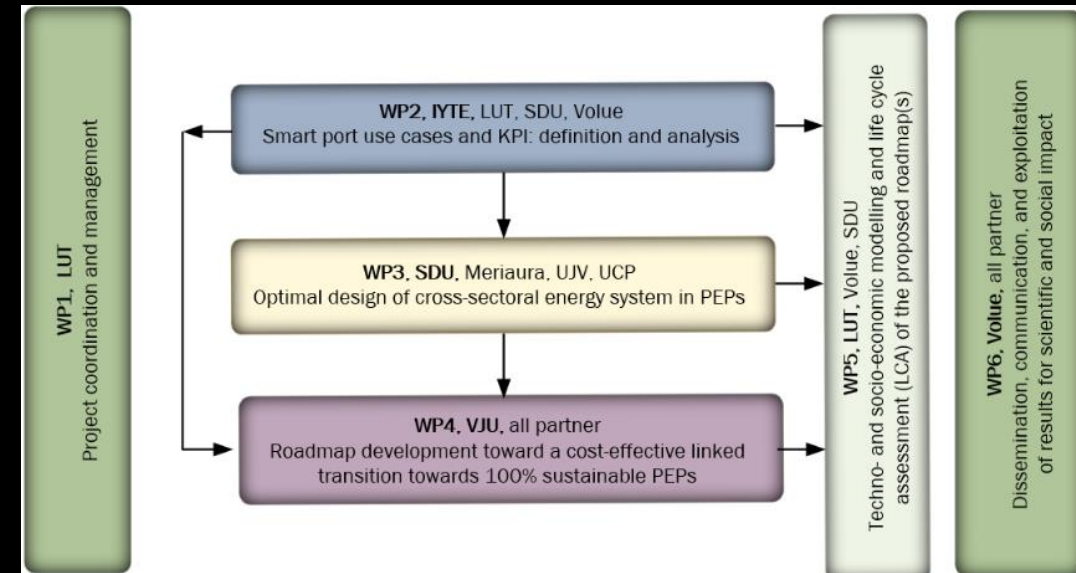
- 
- Project Title: **Optimal planning of hybrid energy storage systems in the renewable energy dominated power systems**
 - Role: **PI (LUT Side)**
 - Funder: **LUT Doctoral School Funding**
 - Partner: Leibniz University Hannover
 - **Summary:** Hybrid energy storage systems (HESS) are gaining attention in power systems development as they combine different ESS technologies to outperform each subsystem. The integration of HESSs is important for clean energy abundance. Optimization models are necessary to facilitate the participation of distributed energy resources in energy markets and power system operations. Tentatively, this project will consist of four work packages **1)** analysis of state of the art in energy storage technologies and different services that can provide by them, **2)** Identification of the required services by energy storage systems in the selected power system, **3)** Techno-Economic and Environmental analysis of the different hybrid EES technologies, and **4)** Optimal planning of the distributed HESS.

ONGOING PROJECTS

- 
- »» Project Title: Vetyä, virtaa Kaakkoon – mallinnuksesta markkinoille
 - »» Role: Collaborator (LUT Side)
 - »» Funder: REACT EU
 - »» Summary of the WP: This project aims to identify the requirements for modeling future energy systems, focusing on evaluating the current capabilities and shortcomings of existing modeling tools. The objective is to enhance our understanding of the evolving energy landscape, ensuring that modeling approaches align with the dynamic needs of the industry.

SUBMITTED PROPOSALS-UNDER REVIEW

- **Pre-Proposal Title:** Renewable Energy Integrated Positive Energy Ports: Linking Energy and Ship Transportation Sectors Transitions (RePort)
- **Role: Coordinator, Funder:** DUT call (EU+regional funding agencies)
- **Partners:** Izmir Institute of Technology (TR), UJV (CZ), Meriaura Energy Oy (FI), University of Southern Denmark (DK), ULUSOY CESME PORT (TR), Volue (FI)
- **Summary:** The RePort project advances Positive Energy Districts (PED) research by integrating port cities with the maritime sector, recognizing ports as crucial hubs in the transition to smart societies. It examines the sustainable transformation of port cities and the maritime sector, emphasizing smart and flexible energy systems, transitions in the maritime industry, and the interdependencies between port cities and the maritime sector.



SUBMITTED PROPOSALS-UNDER REVIEW

- Proposal Title: Energy jUstice in multi-fRame dEcentralized eNergy markets with the presence of distributEd eneRgy storaGe sYstems (EURENERGY)
- Role: Supervisor, Funder: EU-MSCA program
- Partner: Volue (FI)
- Objectives:
 - O1. Designing and modeling a multi-frame market framework for bilateral energy transactions, ancillary services to cover uncertainties, and flexibility market considering the real model of energy justice.
 - O2. Developing a risk-based market participation model and energy justice for energy storage system operators for multi-time market participation.
 - O3. Establishing regulatory policies for P2P energy transactions in the multi-time energy market to justify the share of clean energy for each sub-region.
 - O4. Forecasting error optimization module according to an online updating structure.
 - O5. Mathematical modeling of EJ for active consumers (small and large scale) and DESSs considering energy availability for each region and environmental pollution violations for each region.

SUBMITTED PROPOSALS-UNDER REVIEW

- 
- Proposal Title: Universal, open-source and cybersecure Digital Twin to provide investors in onshore wind farms valuable insights about current operations and future investments (TWINVEST)
 - Role: PI (LUT Side), Funder: EU-Horizon program
 - Partner: 14 Partners from BE, NO, IT, UK, GR, TR, and AT
 - Objectives:

TWINVEST intends to create the foundations of a universal, open-source and cybersecure Digital Twin (DT) to provide investors in onshore wind farms valuable insights about current operations and future investments. Guide investment decisions in wind energy is a complex as it involves various factors to monitor or assess such as energy production, maintenance, investment framework and characteristics of the wind farm.

SUBMITTED PROPOSALS-UNDER REVIEW

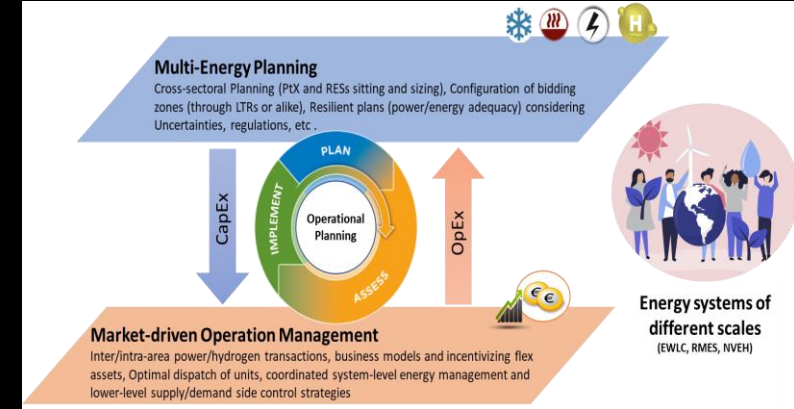
➤ Proposal Title: **Virtual Energy Nexus Uniting Nordic Efforts (VENUE)**

➤ Role: PI (LUT Side), Funder: NordForsk

➤ Partners: AAU, NTNU

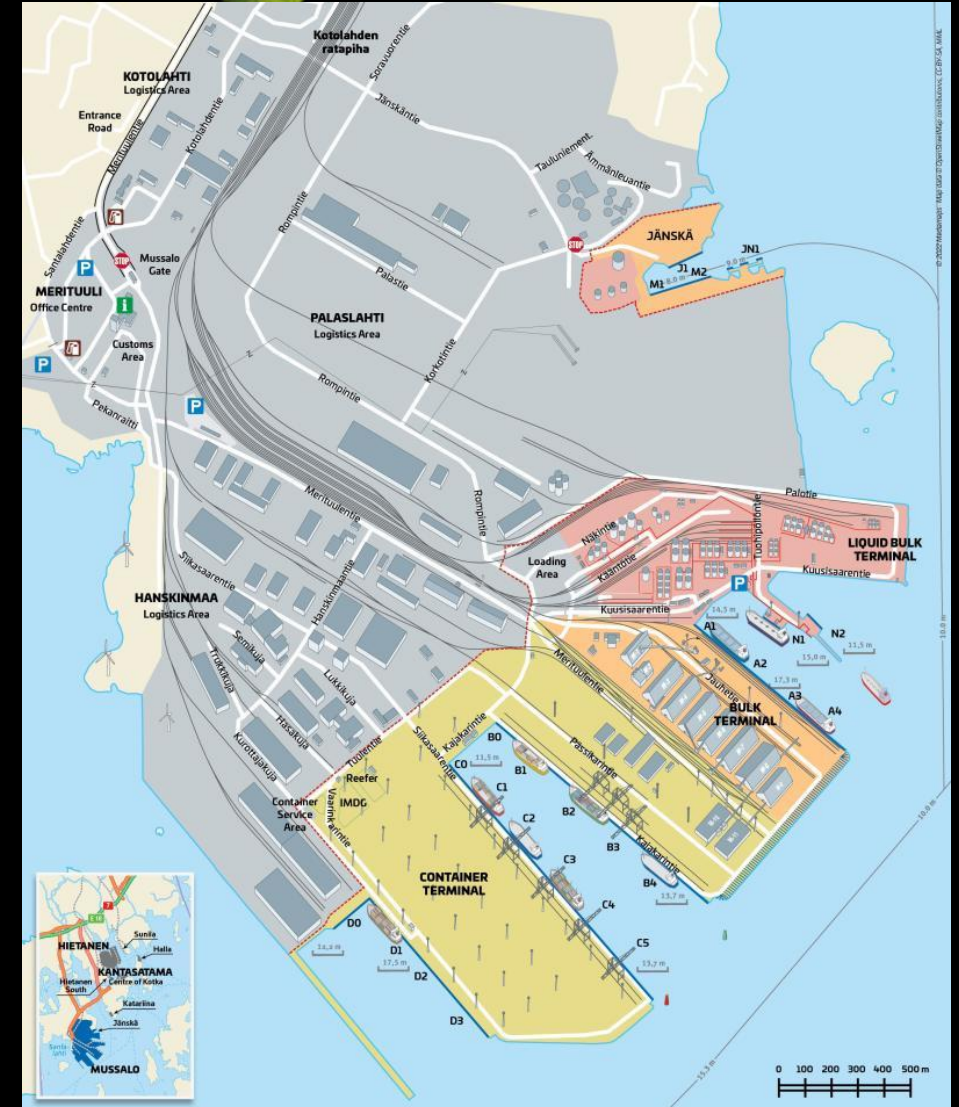
➤ Objectives:

- Cognitive and flexibility-oriented strategies for transitioning towards cooperative, resilient, scalable and greener regional energy systems in the Nordic.
- A cross-sectoral, multi-stakeholder, and multi-energy operational planning approach:
 - Planning phase: Optimal expansion planning of renewable sources and Power-to-X systems considering regional requirements for flexibility, resilience, power/energy adequacy, recommendations on green hydrogen and so on.
 - Operational phase: market-oriented approaches for inter-/intra-area Power/Hydrogen transactions, incentivizing flex assets, configuration of dynamic bidding zones, and so on.



SUBMITTED PROPOSALS-UNDER REVIEW

- Proposal Title: **Port of Mussalo Energy Community Pilot**
- Role: **Collaborator**
- Funder: **JTF**
- Objectives:
- The objective of the project is to improve the competitiveness of the local stakeholders by providing clean and affordable electricity to the participants and by helping them to meet their greenhouse gas reduction targets. The needs for regulatory changes are reported to the respective authorities and politicians.





PostDoc: Reliable 6G for Energy Vertical Applications (M. Norouzi)

PhD thesis: Peer to Peer market mechanism for multi-service trading of hybrid electric energy storage systems in power grids (H. Aghamohamamdloo)

PhD thesis: Deep reinforcement learning methods Applications in Sector Coupled Energy systems (M. Seyfi)

PhD thesis: Optimal planning of hybrid energy storage systems in the renewable energy dominated power systems (M. Safdar)

M.Sc thesis: Comparative study of the techno-economic performance of various energy storage solutions for fast-acting grid balancing applications (Y. Pourjamal-Aug. 2023)

M.Sc thesis: Economic analysis of P2X applications for the maritime sector (H. Kian-Aug. 2023)

M.Sc thesis: Standard Design Criteria for High Voltage Substations (R. Mustajärvi)

M.Sc thesis: Utilizing a novel technology arc suppression coil in US network (T. Matilainen)



Electric Power Transmission (5 credits, Autumn 2023)

59 Students are enrolled.

- Introduction of the course, Finnish power system, and Nordic market
- Modeling of transmission systems
- Active power and frequency control
- Reactive power and voltage control
- Power flow calculations
- Short circuit studies
- Stability analysis
- Protection of transmission network
- High voltage direct current transmission

»» ECTS: 4

»» Time: Winter 2024



»» Part 1

- »» 1.1. Introduction to optimization
- »» 1.2. Linear programming (geometric methods, simplex algorithm, and sensitivity) and duality theories (dual problem, weak duality theory, and strong duality theory)
- »» 1.3. Decomposition Techniques for LP (Dantzig Wolfe & Benders)

»» Part 2

- »» 2.1. Mixed integer linear programming
- »» 2.2. Nonlinear programming (KKT conditions, convexity, duality)
- »» 2.3. Application of Metaheuristic Algorithms

»» Part 3

- »» 3.1. Multi-objective optimization
- »» 3.2. Bi-level programming
- »» 3.3. Stochastic Optimization
- »» 3.4. Risk Modelling and Management



»» ECTS: 3

»» Time: Winter 2024

»» Part 1

- »» 1.1. Introduction to energy markets
- »» 1.2. Pricing and market clearing mechanisms
- »» 1.3. Competition and different type of markets
- »» 1.4. Market participants
- »» 1.5. Challenges of participation of renewable energy resources (RER) in markets

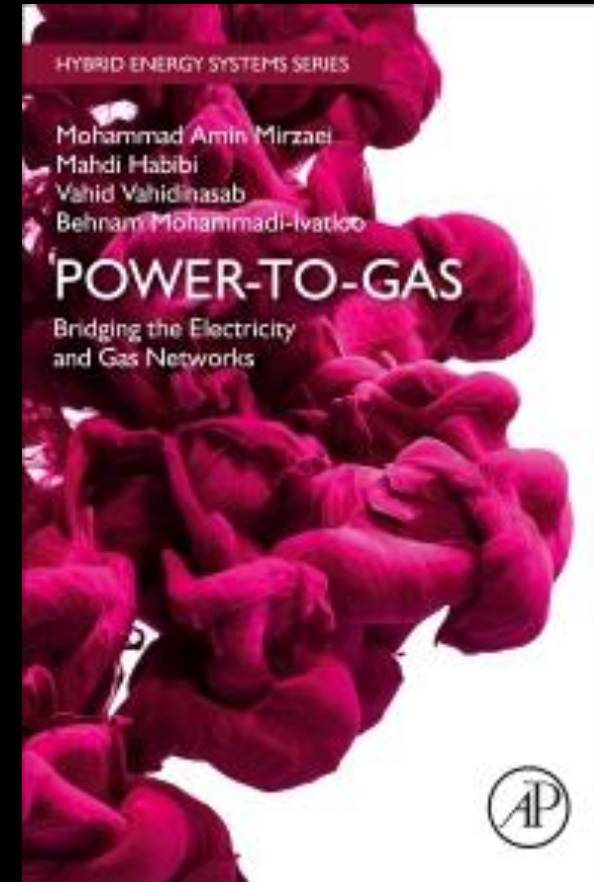
»» Part 2

- »» 2.1. Policies for integrating RERs in markets around the world
- »» 2.2. Impact of RERs on market clearing and market outputs
- »» 2.3. Demand side management for RERs integration in energy markets
- »» 2.4. Energy storage for RERs integration in energy markets
- »» 2.5. Impact of RER on balancing market

» Title: **Power-to-Gas: Bridging the Electricity and Gas Networks**

» Contents:

- » 1. Whole System Approach to Energy
- » 2. Interactions Across Electricity and Gas Networks
- » 3. Concepts, Environmental benefits and working mechanisms of P2G
- » 4. P2G Participation in multienergy and ancillary service markets
- » 5. P2G planning in the integrated Gas-Electricity Networks
- » 6. Integration of P2G Technologies in Operation of integrated Gas-Electricity Networks
- » 7. P2G integration in the Distribution Grids of Gas and Electricity
- » 8. Multiobjective framework for operation of integrated gas-electricity networks
- » 9. The role of P2G technologies in hydrogen/ electric-based refueling station
- » 10. Economic evaluation of P2G in gas-electricity-based virtual plants
- » 11. P2G application in managing network constraints
- » 12. P2G backup services for gas-fired CHP units



PUBLICATIONS-JOURNAL ARTICLES

- » "A resilience-oriented optimal planning of energy storage systems in high renewable energy penetrated systems." *Journal of Energy Storage* 67 (2023): 107500.
- » "Congestion management for coordinated electricity and gas grids in the presence of multi-energy hubs: A risk-based optimal scheduling." *Sustainable Energy, Grids and Networks* 36 (2023): 101153.
- » "A novel cyber-Resilient solar power forecasting model based on secure federated deep learning and data visualization." *Renewable Energy* 211 (2023): 697-705
- » "Risk-Oriented Operational Model for Fully Renewable Cooperative Prosumers in a Modern Water-Energy Nexus Structure." *IEEE Transactions on Sustainable Energy* (2023).
- » "A robust bi-level optimization framework for participation of multi-energy service providers in integrated power and natural gas markets." *Applied Energy* 340 (2023): 121047.
- » "Systematic review and cutting-edge applications of prominent heuristic optimizers in sustainable energies." *Journal of Cleaner Production* (2023): 137632

PUBLICATIONS-JOURNAL ARTICLES

- "Decomposition-Based Stacked Bagging Boosting Ensemble for Dynamic Line Rating Forecasting." *IEEE Transactions on Power Delivery* (2023)
- "GIS-assisted modeling of wind farm site selection based on support vector regression." *Journal of Cleaner Production* 390 (2023): 135993
- "An innovative transactive energy architecture for community microgrids in modern multi-carrier energy networks: a Chicago case study." *Scientific Reports* 13, no. 1 (2023): 1529.
- "Techno-economic, environmental and risk analysis of coordinated electricity distribution and district heating networks with flexible energy resources." *IET Renewable Power Generation* 17, no. 12 (2023): 2935-2949
- "Geographic information system-based prediction of solar power plant production using deep neural networks." *IET Renewable Power Generation* (2023).
- "Risk-Aware Stochastic Scheduling of Hybrid Integrated Energy Systems With 100% Renewables." *IEEE Transactions on Engineering Management* (2023).
- "Activating demand side flexibility market in a fully decentralized P2P transactive energy trading framework using ADMM algorithm." *Sustainable Cities and Society* 100 (2024): 105021

PLANS FOR SUBMISSION OF THE PROPOSALS



Academy of Finland Call (Research Project: Initial idea is about Energy Storages for Supporting Positive Energy Countries)

Horizon Calls-Smart Grid Ready Buildings

