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LABORATORY OF ELECTRICITY MARKETS AND POWER SYSTEM

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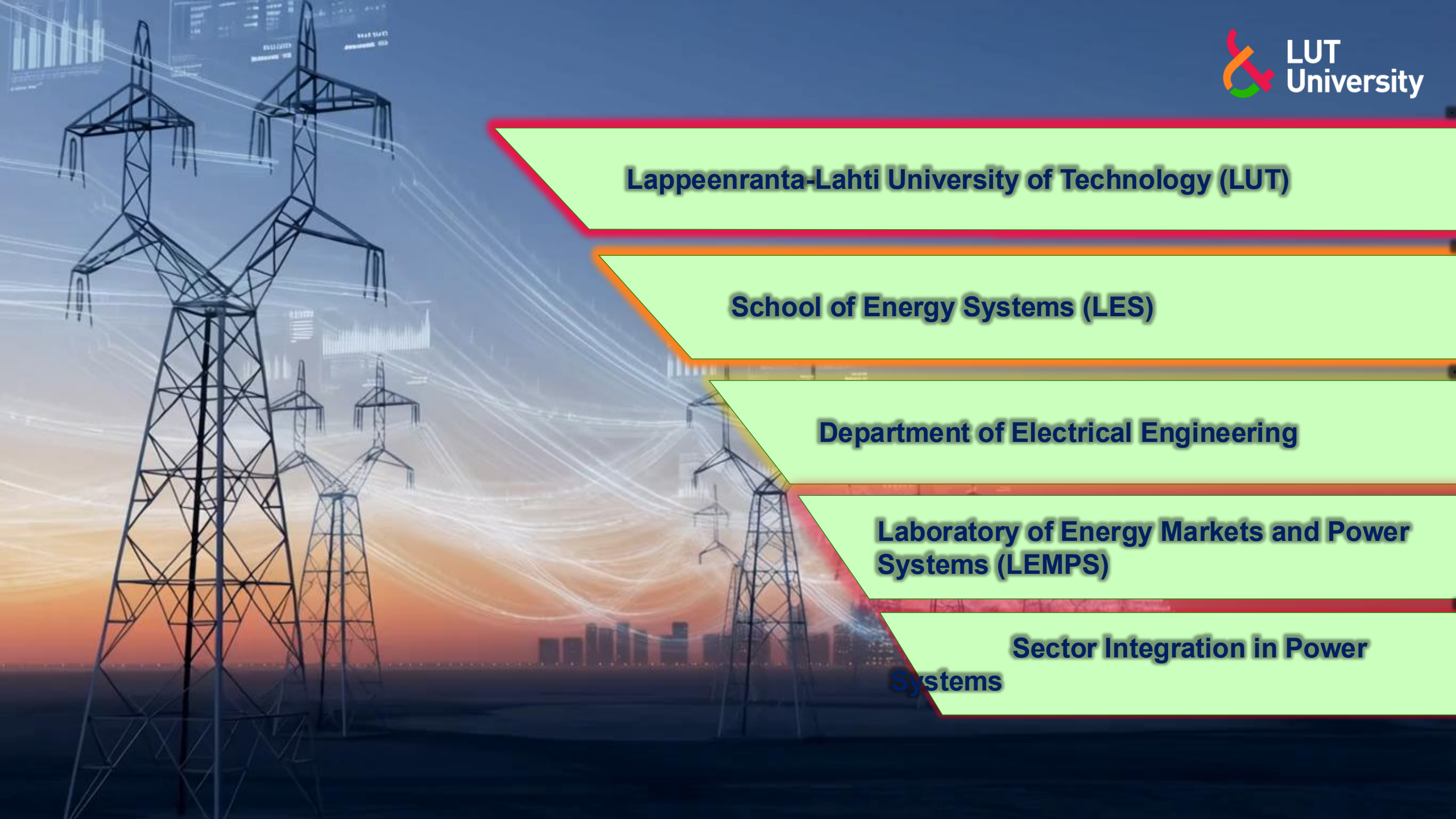
AGENDA

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



LUT University

Lappeenranta-Lahti University of Technology (LUT)

School of Energy Systems (LES)

Department of Electrical Engineering

Laboratory of Energy Markets and Power Systems (LEMPS)

Sector Integration in Power Systems

COMPLETED PROJECTS

- Project Title: **Reliable 6G for Energy Vertical Applications (REEVA)**
  Role: PI (LUT Side)
- **Funder: Business Finland (Extended by end of 2026)**

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

VTT

LUT University

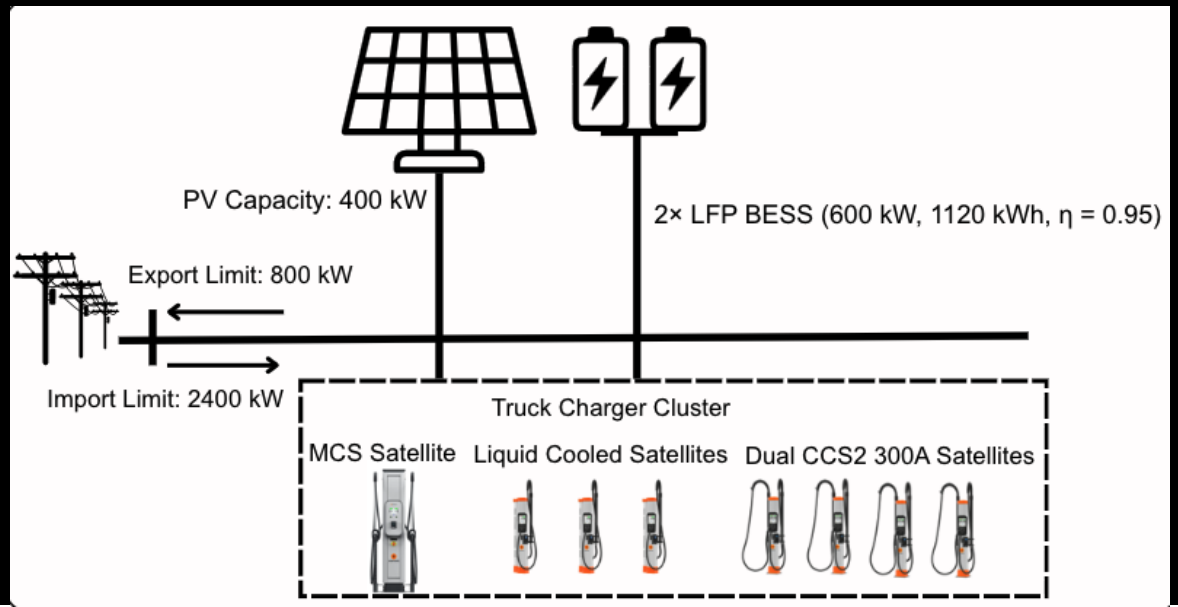
UNIVERSITY OF OULU

FINALIZED PROJECTS

- Project Title: **Vetyä, virtaa Kaakkoon – mallinnuksesta markkinoille**
- **Role: Collaborator (LUT Side)**
- **Funder: REACT EU**
- **Summary of the Work:** 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.

FINALIZED PROJECTS

- Project Title: **Charging Station participiation in Frequency Markets**
- **Role: Collaborator (LUT Side)**
- **Funder: EMRC**
- **Summary of the Work:** This project developed a multi-market optimization framework for electric vehicle charging depots integrating battery energy storage, photovoltaic generation, and charger flexibility.



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

- 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.

ONGOING PROJECTS

- Proposal Title: **Port of Mussalo Energy Community Pilot**
- **Role: Collaborator (leading task related to energy storage planning)**
- **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.

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), Volue (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: Flexible electric boilers as part of the energy system of the future
- **Role: Team member**
- **Funder:** Euroopan aluekehitysrahasto (EAKR)
- **Project Summary:** The project aims to strengthen the competitiveness and sustainability of the South Karelia heating sector by assessing how flexible electric boilers and thermal energy storage can be integrated into district heating systems. As Finland transitions toward carbon neutrality and increasingly relies on weather-dependent renewable electricity, the project examines how these technologies can reduce emissions, lower operating costs, and provide essential flexibility for the power system.

ACCEPTED PROPOSAL

- Proposal Title: *AI-Driven Framework for Bottom-up Expansion of Integrated Power and Green Hydrogen Supply Chains*
- **Role: Coordinator**
- **Funder: European Commission** under the **Horizon Europe programme** (Pillar I – Excellent Science)
- **Summary:** The project aims to develop a data-driven planning toolchain to support the expansion of sector-coupled electricity–hydrogen (SCEH) systems, which are essential for fully renewable energy communities. Because historical hydrogen consumption data is limited, the work combines distributed planning algorithms with deep learning-based forecasting to optimize the location, sizing, and investment decisions of SCEH components while addressing flexibility challenges and hydrogen demand variability.

LUT'S FIRST ACCEPTED MSCA-PF PROPOSAL

SUPERVISION-POSTDOC AND PHD STUDENTS

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)

PhD thesis: Developing Forecasting Tools for Wind Power Investment (R. Akhtar)

PhD thesis: Local Energy Markets, a Nascent Market driven by Business Model Innovation and the search of a Dominant Design (Luisa Matos)

PhD thesis: AI-Driven Energy Flexibility as a Service (Amin Hasanzadeh)







SUPERVISION-MASTER STUDENTS

Graduated 2025

M.Sc. thesis: Pre-charge resistor protection in STATCOM (M. Gheiasvandi)(To graduate in Dec. 2025)

Ongoing 2025

M.Sc. thesis: Renewable Integration Strategies for Data Centers: Opportunities and Challenges for Efficiency and Scalability (U. Sutapa)

M.Sc. thesis: Hybrid classical and quantum optimization for energy flow in integrated energy systems (S. Ur Rehman)

M.Sc. thesis: Continuous-time Scheduling of EV Charging with Service Quality Constraints (F. Saeed)

M.Sc. thesis: Solar PV Frequency Support via Synthetic Inertia: Technical and Economic Perspectives (M. Ars)

TEACHING

Electric Power Transmission (5 credits, Autumn 2025)

53 Students are enrolled.

- Intorduction 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

PhD Courses

- Total ECTS: 10

- Time: Winter 2025

1) **PhD course: Energy Markets and Analytics (Organizer and Co-instructor) (25 Participants)**

- Time: Spring 2025

1) **Digital Infrastructure and Innovation Strategy (Organizer) (20 Participants)**
2) **Applied Optimization in Engineering (Organizer and Co-instructor) (50 Participants)**

PUBLICATIONS-JOURNAL ARTICLES

Enhancing the Risk-Oriented Participation of Wind Power Plants in Day-Ahead, Balancing, and Hydrogen Markets with Shared Multi-Energy Storage Systems	Journal of Energy Storage
EXPLORING GEOTHERMAL ENERGY-BASED SYSTEMS: FROM BASICS TO SMART SYSTEMS	Renewable and Sustainable Energy Reviews
Lyapunov-Based Real-Time Optimization Method in Microgrids: A Comprehensive Review	Renewable and Sustainable Energy Reviews
Overview of Energy Modeling Requirements and Tools for Future Smart Energy Systems	Renewable and Sustainable Energy Reviews
Aggregator decision analysis in residential demand response under uncertain consumer behavior	journal of Clenaer production
Coordinated bidirectional charging of multiple types of electric vehicles: A risk-based model	Intenational Journal of Electrcial Power and Energy Systems
Smart contract-based peer-to-peer energy token trading for self-decisive retailers and prosumers with flexible loads	IEEE Transactions on Industry Applications
Chance-constrained dynamic thermal line rating of power system for enhancing stochastic renewable penetration	Renewable Energy
Three-layer resilience-aware scheduling framework in a hydrogen-integrated distribution network considering fuel cell electric vehicles	Energy
A robust framework for peer-to-peer energy trading with transmission costs consideration: A fuzzy possibilistic programming model	Applied Energy
Communities for Clean Energy Justice and Equity in Grid Modernization	John wiley and sons
Deep Reinforcement Learning-Based Real-Time Controller for Energy-Efficient Buildings	IET Generation, Transmission and Distribution
Real-time peer-to-peer energy trading of multi-carrier energy buildings: A multi-agent deep reinforcement learning solution	Energy and Buildings
A Cyber-Resilient Model for Online Wind Power Forecasting Based on Lifelong Learning	IET Renewable Power Generation
Multi-Market Revenue Optimization for Integrated Wind and Hybrid Energy Storage Systems	Applied Energy
Innovative defense strategies: Fusion deep learning approach to counter false data injection attacks in power systems	Reliability Engineering & System Safety

Services to the community

1) Editorial **Board of Journals: IEEE Transactions in Power Systems, IEEE Transactions on Transportation Electrification, IET Smart Grid, ….**
2) **Invited Talks: 6th International Energy Storage Conference, 19th Symposium on Microgrids, ISGT ME 2025, …**
3) **Examiner of PhD thesis: Finland, Czech, UK, UAE, India, …**
4) **Evaluation of Proposals in different** EU countries

PLANS FOR SUBMISSION OF THE PROPOSALS

HORIZON-CL5-2026-03-D3-21: Hybrid AI-Control Framework for a next-generation grid-scale energy storage and system integration.

HORIZON-CL5-2026-02-D3-07: Improved reliability and optimised operations and maintenance for wind energy systems

HORIZON-CL5-2025-05-D4-06: Phase out fossil fuel in energy intensive industries, through the integration of renewable energy sources (IA)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