Advancing the Electric Distribution Systems for higher Flexibility and Reliability through Real-Time State Awareness Determination

Summary

Renewables have turned the tables in the electric distribution networks (DNs), where already today strict limitations are in effect to limit the actual renewable-produced energy infeed. Significant proportion of these limits are imposed due to classical approach to low-voltage distribution systems, where the network operates in a static, unobserved realm. This project aims to widen the DN actual performance characteristics through a more massive operating state observation leading through to impressive range of smarter-grid applications, such as enchanced true renewable hosting capacity, intra-community energy delivery provisions, greater and more effective flexibility of the grid etc. In this stage, emphasis will be put on aspects of general power delivery reliability and network topology identification thorugh operation characteristics modeling. The range of questions leading the path could be: how to implement measured data for network physical characteristics determination? where to set up the measurement systems and how many of units there would need to be? how to determine the actual loading and load carrying capability based on measured data?, and many others.

Research field:	Electrical power engineering and mechatronics
Supervisor:	Dr. Lauri Kütt
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 research

Distribution networks are under pressure to accommodate the high penetration of renewable energy produced, for example, by private household customers. All over Europe, last 5 – 7 years mark a drastic increase in the photo-voltaic (PV) installations regading both high and low power systems. The range of problems imposed by such high infeed of power at the time when load is at minimum, has led to multiple locations and areas to witness higher-than-standard-10% voltage elevation during sunny days. In order to limit the potential negative implications, and breach of contractual power delivery service terms, DN operators have already or are very close to cut down the´permitted power infeed levels. This is imposed without valid real-time data of the actual network state. In very many cases, the local overloading avoidance strategy is based on assumptions only, playing it double-safe.

Some assumptions on power delivery capability and capacity can be derived from planning-era data and load char-acterization. New and renewed infrastructure could be built to support perspective local-level planned power streams. However, with a planning span of 40 years, majority of the DN infrastructure could be struggling with present-day operating goals. Given that building up the actual power line imposes a huge price tag, there is a prominent perspec-tive to implement smart(er) grid methods and achieve higher power delivery capability without physical power lines' rebuilding. A huge perspective lies in providing the unobserved and unsupervised DN an added layer of capabilities through better self-awareness, helping to improve the local (individual connection based) response to power delivery cpacity demand.

While major DN flexibility provisions address full real-time data availability it is seldom so. The data gathered imposes a practically inefficient burden on the classical control system. With the address on data sampling, storing and trans-mitting efficiency from a supporting research project, the present project aims here to provide an appropriate set of methods to extract the real-time operating state definitions from the dataset. The state definitions would be developed based on trends recorded on actual power lines. In turn, the physical DN model can be derived, and this would help to serve the favourable operating conditons forecast, referring to any party in the grid supplying or loading.

The thesis should address the following questions:

1) Which aspects of measurement and quantification of the DN state variables monitoring from present best practices is appropriate to be used for electrical grids on-line monitoring?

2) Which limitations arise from the known proposed methods of measurement of electric power quality monitoring?

3) How to assess the potential loading and infeed consequences from customer connection points and disturbance sources from the grid using the monitoring data gathered?

Responsibilities and (foreseen) tasks

- Compile a critical practical case based listing of usable methods for distribution networks (DN) on-line / real-time measurements, addressing the opportunities, challenges and shortcomings;
- Extract practical data from the measurements done applying different signal processing and statistical processing methods;
- Configure the measurement setups, measurement devices and required auxiliary equipment for the on-line measurements of AC and DC power delivery systems:
- Formulate the proposals of methods in form of scientific publications, report on the applicability of the methods using the scientific expression;
- Contribute to the organization of research and practitioner workshops where project findings are presented.

(The following experience is beneficial:)

- Experimental and/or theoretical electromagnetic analysis, electromagnetic compatibility
- Programming in C / C++ / Python
- Working knowledge of statistics and signal processing
- Working knowledge of mathematical data analysis software, such as Matlab, NI Labview

The candidate should submit a research interest and motivation and motivation for the topic, including the expression of interest in the particular aspects of measurement, data processing of physical phenomenon research. 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 one of the largest, most internationalized and leading engineering science research centers in Estonia with a large portfolio of ongoing pan-European and national R&D projects in the field of electric engineering;
- The chance to do high-level research in one of the fast developing laboratories in the field of applied electromagnetics with direct hands-on approach;
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of electrical engineering.

About the department

The Department of Electrical Power Engineering and Mechatronics of Tallinn University of Technology is an interdisciplinary research center that focuses on socially relevant and future-oriented research and teaching issues related to power engineering and mechatronics. The mission of the Department is to be a leader in electrical engineering and technical studies and development projects in Estonia, known and valued in society, and a respected partner in both national and international cooperation networks and organizations.

The department educates future electrical and power engineering leaders and engineers at the bachelor's, master's and doctoral level. Through training courses, the department ensures lifelong learning and continuous development.

The department carries out large-scale interdisciplinary scientific research, development and professional projects, thanks to which the competence in the field of electrical energy and mechatronics continues to grow. With research, application and development services, the department increases the competitiveness of companies in both the domestic and international markets, keeping knowledge in Estonia. The department has coordinated or been a partner in numerous international projects, such as 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 also accredited services in the fields of lighting and different electrical measurements.

The departments' focus areas are related to both domestic and global developments, such as increasing digitalization and decarbonization, decentralization and decentralization of electricity generation, and the increasing use of renewable energy sources. The department conducts research in the following relevant areas tackling the energy transition:

- optimization of electrical 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 hydrogen technologies, including energy storage, renewable energy, low carbon technologies, consumption management, IoT applications in energy
- implementation of smart industry, including industrial robotics, automation, 3D printing, machine vision
- implementation of energy and resource efficiency, including digitization of supply chains, mapping of opportunities to optimize systems and reduce energy consumption
- development of smart city solutions, including environmentally friendly and self-driving vehicles / drones, digital twin applications.

(Additional information)

For further information, please feel free to contact Prof. Lauri Kütt at lauri.kutt@taltech.ee for further details on the subjects associated with this position offer.

To get more information or to apply online, visit https://taltech.glowbase.com/positions/980 or scan the the code on the left with your smartphone.