DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

# PhD Public Defence

**Title:** Improved Observability for State Estimation in Active Distribution Grid Management

**Location**: Pontoppidanstræde 101, room 1.001

**Time**: Tuesday 1 October at 13.00

**PhD defendant**: Basanta Raj Pokhrel

**Supervisor:** Professor Birgitte Bak-Jensen

**Moderator:** Associate Professor Tamas Kerekes

**Opponents**: Associate Professor Tamas Kerekes, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Fabrizio Pilo, University of Cagliari, Italy
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**All are welcome. The defence will be in English.**

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**Abstract:**

Power system scenario is rapidly changing due to the increasing penetration of renewable based DGs at the distribution grid especially at LV and MV level. At the same time, conventional electricity meters are being replaced by smart meters, which can not only monitor energy consumption but also can record many other operating scenarios at the particular node. Also in transmission grid, big conventional generators are being phased out. However, the responsibility of overall grid balance is still with TSO. Consequences of this emerging scenario can be realized by both DSO and TSO owned grid and in their coordination. In LV grid, the availability of huge data due to smart meters at load points, new entities like BRPs, retailors etc. is a big challenge, which is evolving the issues of data security and handling together with processing of huge data for application in network operation and planning. On the other hand, utilities still operate on reduced observability specifically at MV level due to less number of measuring device in the network. PMUs and RTUs are the probable measuring devices but implementation of these devices at every nodes will be very expensive. However, in emerging scenario, DSOs are expected to handle an active network with flexible load, support local balancing, optimally utilize the distributed generation and set up active interaction with TSOs too.

In this PhD study, four issues from DSO perspective in the emerging scenario in electricity network such as huge data handling, network observability with minimum measurements, active network management and optimized operation, and TSO-DSO interoperability and coordination have been identified. These issues are further investigated, elaborated and solved by using mathematical models, dedicated network setups and case studies. Huge data handling issue is addressed by minimum measurement placement technique embedded with bus prioritization concept, which is then integrated with network observability and distribution state estimation procedure. Accuracy in estimated network parameters is assured by using improved forecasting procedure for pseudo measurement models. Models to evaluate tradeoff between network observability, estimation accuracy and used number of measurements have been proposed that can be useful for DSO to limit the investment in measurement devices. Active network management issue have been addressed by developing the prototype of ADMS model by integrating grid measurement, forecasting and state estimation modules with control algorithm in a close loop. As one of the key functionality of ADMS, loss optimization procedure and operation framework have been developed considering the availability of DSO owned storage facility, high penetration of DG and option of network reconfiguration. Also, proposed integrated algorithm of network observability for state estimation have been tested using real measurement data from selected network points of a Danish distribution LV and MV network. Analysis on observed network status and discussion on state estimation are presented. Finally, requirement of new coordination framework for TSO and DSO have been assessed. Role of network observability i.e. knowledge of each other's grid asset information in certain extent for the mutual benefit (for all utility operators) is highlighted. Assessment of current practice and need for revision specially on huge data handling, new market set up by involving DSO on market clearing process, use of DSO knowledge on network expansion planning etc. are investigated and way for future cooperation of TSO and DSO is recommended. Architecture for multi energy system for optimized operation is also proposed at the end.