

**ENERGEETIKATEADUSKOND
ELEKTROENERGEETIKA INSTITUUT
TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE 2014**

1. Struktuur

**Elektroenergeetika instituut, Department of Electrical Power Engineering
Instituudi direktor Ivo Palu**

- Energiasüsteemide õppetool, Chair of Power Systems, Heiki Tammoja
- Kõrgepingetehnika õppetool, Chair of High Voltage Engineering, Juhan Valtin

2. Teadus- ja arendustegevuse (edaspidi T&A) iseloomustus

2.1 Instituudi koosseisu kuuluvad uurimisgrupid

2.1.1 Energiasüsteemide uurimisgrupp

Power Systems research group, Heiki Tammoja.

2.1.1.1 Teadustöö kirjeldus

The tasks of the Power System research group are elaboration and assessment of energy sector development scenarios and analysis of activities needed for their realization. The research in energy system planning is done with energy planning models, as the studies are comprehensive and therefore require great number of input data and defining of variables. This modelling software are used for future electricity generation simulations, CO₂ emission prediction, electricity price or CO₂ cap price forecast, feasibility studies for a single power plant, market penetration of new technologies like carbon capture and storage (CCS), solar photovoltaic or different balancing options. One part of Researches is focused on developing methods and algorithms for advanced power system control implementing wide-area information (probabilistic, uncertainty and fuzzy). Key research directions include development of new applications for wide-area based control and protection of power system, implementation of FACTS and HVDC devices for system security enhancement, and development of real-time simulation approach to system control and protection. Other research activities are concentrated on the development and assessment of power quality mitigation methods in transmission and distribution systems considering the availability of modern compensation devices, and on developing modelling and analysing methods for power system optimal control considering data uncertainty and fuzzy information.

2.1.1.2 Aruandeaastal saadud **tähtsamad** teadustulemused

ETF8760 „Vector optimization of thermal power plants considering incompleteness of information“ (J. Šuvalova)

The scientific objective of the grant is to develop the new mathematical models and methods for the optimization of the TPP operation considering the possibilities of multi-objectives or vector-optimization and the different forms of information. The forms of information studied in the grant are deterministic, probabilistic, uncertain and fuzzy information. 2014 was the fourth and last year of the grant. The research focuses on one

of the alternatives of distributed electricity generation (DG) with condensing power plants and includes its comparison with common distribution structure with the account fuel-costs characteristics. The main results of the study are published in the paper and presented at a conference.

Lep14133 „Development of optimization methods and corresponding computer software system for optimization of VKG Energia OÜ thermal power plants“ (M. Keel). The goal is to maximize the electricity production of cogeneration heat and power plants (CHPP) of VKG Energia Company and by that way to increase the profit of company with taken into account prognosis of heat demand and residues of the oil factory. The oil factory is producing oil from oil shale. The problem consists of two subproblems: 1) unit commitment problem in CHPP, 2) optimal load distribution between boilers, turbines and CHPP. The main parts of the project are: 1) scientific research of the CHPP optimization problems, 2) developing the effective models and methods of optimization, 3) composing of algorithms and the computer software system, 4) software system testing and training. The new software system enables to increase the profit and reduce the environmental emissions.

The project began in September 2014. The first problem was to develop the suitable mathematical model for the VKG Energy thermal power plants optimization. The specific character of this problem consists of the plurality of different kinds of fuels (up to 5 kinds), of the common steam headers and of the different kinds of turbines. The first optimization subproblem is the unit commitment and the second subproblem – optimal load distribution. The first stage of the project will come to the end in April 2015.

2.1.1.3 Olulisemad publikatsioonid aruandeaastal

Astapov, V.; Shuvalova, J. (2014). Comparison of reducing losses and reducing generation costs during electricity production. The International Scientific Conference EPE 2014 (ELECTRIC POWER ENGINEERING), May 12-14, 2014, Brno, Czech Republic. IEEE, 2014, 49 - 52. 3.1.

2.1.2 Energiasüsteemide dünaamika ja juhtimise uurimisgrupp Power System Dynamics and Control group, Jako Kilter

Head of “Power System Dynamics and Control” research group is Dr. Kilter. his research is focused on analysing the power system dynamics and control using wide-area applications, HVDC and FACTS control applications, wind power connections, power quality, and load modelling. Dr. Kilter is a member of various international working groups in CIGRE and ENTSO-E where his work is mostly related to HVDC and wind park connections, and power quality related aspects. This research group has been involved in numerous international and national research projects. Teams’ work has resulted in more than 50 publications and various presentations at national and international conferences.

2.1.2.2 Aruandeaastal saadud **tähtsamad** teadustulemused

Lep13118 “Development and analysis of wide area measurement system (WAMPAC)”
(J. Kilter, I. Palu)

Purpose of this project is to investigate how to implement wide area measurements in Estonian 330 kV power system. Answer will be given, what are the differences in Estonian case and what can be developed onto existing measurement system (Elpros WaProtector) and how to integrate it into future version of SCADA.

B22 “Voltage unbalance mitigation methods in smart electrical networks” (J. Kilter)

The purpose of this scientific project is to examine and develop more efficient and flexible methods in order to mitigate voltage unbalance in modern electrical networks considering the constraints of optimality and system security. In general, modern power electronic based compensation devices are used for voltage unbalance mitigation. Possible control range of those devices depends directly on the implemented control algorithms. In this research project, the input information on network state variables is obtained from one certain network bus and also from various locations using wide-area measurement and control systems. The purpose is to develop robust control algorithms which enable more flexibility for securing required voltage quality. The results of this research are the control algorithms which consider the availability of data and enable more versatile control of the compensation devices. The results are applicable in actual electrical networks for the purpose on improving power quality and offer interest also in scientific and practical level.

2.1.2.3 Olulisemad publikatsioonid aruandeaastal

Tuttelberg, Kaur; Dufek, Jan (2014). Estimation of errors in the cumulative Monte Carlo fission source. *Annals of Nuclear Energy*, 72, 151 - 155. 1.1

Kilter, J.; Sarnet, T.; Kangro, T. (2014). Assessment of Transmission Network Voltage Unbalance in Connection of High-Speed Electrical Railway Connection. In: *Proceedings of 9th International Conference 2014 Electric Power Quality and Supply Reliability: 2014 Electric Power Quality and Supply Reliability*, Rakvere, June 11 - 13, 2014, 329-334. 3.1.

Uuema, P.; Puusepp, A.; Drovtar, I.; Kilter, J.; Vigants, H.; Blumberga, D. (2014). *Industrial CHP Optimal Management in the Energy Market under Incomplete*

Information. 2014 IEEE Innovative Smart Grid Technologies Conference - Asia (ISGT ASIA) - Electricity Market in Smart Grid, 20-23. May, 2014, Kuala Lumpur, Malaysia. IEEE, 2014, 407 - 411. 3.1.

Kilter, J.; Elphick, S.; Meyer, J.; Milanovic, J. V. (2014). Guidelines for Power Quality Monitoring – Results from CIGRE/CIREN JWG C4.112. In: Proceedings of 16th International Conference on Harmonics and Quality of Power: 16th International Conference on Harmonics and Quality of Power, Bucharest, Romania, 25-28.05.2014. IEEE, 2014. 3.1.

Uuemaa, P.; Puusepp, A.; Drovtar, I.; Kilter, J.; Rosin, A.; Valtin, J. (2014). Load Control Implementation in the Energy Intensive Industry. 17th IEEE Mediterranean Electrotechnical Conference - Power Electrical Systems (MELECON 2014), 13-16 April, Beirut, Lebanon. IEEE, 2014, 213 - 218. 3.1

2.1.3 Kõrgepinge uurimisgrupp

High-Voltage research group, Juhan Valtin

2.1.2.1 Teadustöö kirjeldus

Research of the High Voltage research group is focusing on the studies of the high voltage insulation and applications associated with the high voltages and strong electrical fields. Most research is related to the insulators and insulation used in power lines, both overhead and cable lines are studied. The evolution and deployment of the novel insulating materials increases notably the importance of research and need to understand all the different physical phenomena (high electrical field stresses, partial discharges, dielectric losses, temperature effects, etc.) distinctive to the power cables. Another scope of research is the effects to high voltage equipment (transformers, cable power lines etc.) due to high loading, nonlinear loads and power quality. Influence of power quality and dynamic power loading for the equipment, increased thermal and mechanical stress and aging are investigated. Research aims to provide indexes of reliability, considering different stresses to the power transmission networks during their lifetime, taking into account air pollution, weather, wildlife but also influences of characteristics of the future electric loads, materials etc.

2.1.3.2 Aruandeaastal saadud **tähtsamad** teadustulemused

PUT533 „Impact of new types of electricity generating patterns to high voltage equipment and cable insulations“ (I. Palu)

EU has agreed to increase the share of renewable energy sources to 20% by 2020. With a few exceptions, the main options for countries to do it is to use wind energy and biomass. All these new generating units will be installed to existing electricity grid, while there is notable difference, what type of load will be connected. The reason for this is that variable energy resources affects the load patterns and causes stress to high voltage equipment. The main purpose of this project is to investigate and explain what phenomena takes place in cable and other high voltage equipment insulation when variable power sources are connected to the grid. By knowing the structure and characteristics of stress to high voltage equipment, one can improve the planning and maintenance activities and will be able to evaluate the investment. Existence of this information could avoid over and under dimensioning.

Lep14124 “Partial discharge measurements of medium voltage underground power cables with XLPE insulation” (P. Taklaja)

Partial discharge measurements of medium voltage underground power cables with XLPE insulation.

Lep14072 “The cause of conflagration of highvoltage cables of power transformer” (P.Taklaja)

Expert opinion - The cause of conflagration of highvoltage cables of power transformer

VNF573 “Smart transmission grid operation and control (STRONgrid)” (I. Palu)

Purpose of the project is to address the challenges that the secure and reliable operation of the power grids will face in the future. One bachelor study level student is defended its bachelor thesis.

VFP514 „Large scale Smart Grids demonstration of real time market-based integration of DER and DR“ (I. Palu)

The key objective of the project is to demonstrate efficient operation of a distribution power system with high penetration of many and variable renewable energy resources. One bachelor study level student is defended its bachelor thesis.

Lep14071 “Objectives of investments into rural service reliability area of Elektrilevi OÜ, their realization methods and selection criteria” (J. Valtin)

Methodology for choice and soundness determination of network investments is developed considering development scenarios of an area, network residual life and investments timeliness. The methodology is applied to a pilot network area

2.1.3.3 Olulisemad publikatsioonid aruandeaastal

Hõbejõgi, T.; Reinberg, A.; Last, K.; Laanetu, M.; Mere, T.; Valtin, J.; Hamburg, A. (2014). Methodology for finding investment sites that can be refurbished from a nearby medium voltage line element instead of using the existing low voltage line corridor. *Przeład Elektrotechniczny*, 199 - 202. 1.1.

Taklaja, P.; Hyvönen, P.; Klüss, J.V.; Niitsoo, J.; Palu, I. (2014). Preventing Bird Streamer Outages Using Alternative Tower Configurations. *IEEE Transactions on Power Delivery*, 29(5), 2402 - 2409. 1.1.

Hyvönen, P; Taklaja, P; Klüss, J.V. (2014). AC-voltage performance of field aged glass insulator strings. *International Conference on High Voltage Engineering and Application*, Poznań, Poland, 8-11 September 2014. IEEE, 2014. [ilmumas] 3.1.

Hyvönen, P.; Klüss, J. (2014). Practical E-field sensors for EMP testing. *2014 International Conference on High Voltage Engineering and Application*, 8-11 September 2014 Poznan, Poland. IEEE, 2014. [ilmumas] 3.1.

2.2 Loetelu struktuuriüksuse töötajatest rahvusvahelistest tunnustustest

Kaur Tuttelberg; Sigvard Eklundi auhind parimale tuumatehnikaalasele magistritööle Rootsisis.

2.3 Loetelu struktuuriüksuse töötajatest, kes on välisakadeemiate või muude oluliste T&A- ga seotud välisorganisatsioonide liikmed:

Elektroenergeetika instituut on CIGRE liige.

Assistent Jaan Niitsoo on IEEE liige.

Assistent Paul Taklaja on IEEE ja NorKab liige.

Dotsent Jako Kilter on:

- POWERENG 2015 konverents, artiklite hindamiskomitee liige
- Power Quality and Supply Reliability Conference - Teaduskomitee liige
- CIGRE B4.62 liige (Connection of Wind Farms to Weak AC networks)
- CIGRE B4.64 liige (Impact of AC System Characteristics on the Performance of HVDC schemes)
- IEEE Power and Energy Society liige
- ENTSO-E EPS & CC DT HVDC AdHoc töögrupi liige
- CIGRE WG B4.55 liige (HVDC connection of offshore wind power plants)
- CIGRE WG C4.112 (Guidelines for Power quality monitoring – measurement locations, processing and presentation of data) liige
- ENTSO-E EPS & CC töögrupi liige
- ENTSO-E WG EPS Requirements for Generators töögrupi liige
- IEEE liige

Professor Petri Hyvönen on :

- Aalto Ülikooli Kõrgepinge labori juhataja
- NorKab liige

2.4 Mitme kodumaise tunnustuse osaliseks sai Kaur Tuttelberg:

- a) Eesti Teaduste Akadeemia üliõpilastööde auhind
- b) Mati Jostovi nimeline energeetikaalase doktoriõppe stipendium
- c) Riikliku üliõpilaste teadustööde konkursi II preemia magistriastmes

Ülevaade teaduskorralduslikust tegevusest:

Professor H. Tammoja:

- Elering AS nõukogu liige
- Elektrilevi OÜ kahjude erikomisjoni esimees
- Tallinna linna energeetika komisjoni liige
- TTÜ elektroenergeetika instituudi nõukogu esimees
- TTÜ energeetikateaduskonna nõukogu liige

Emeriitprofessor M. Valdma: Eesti Teaduste Akadeemia energeetikanõukogu liige.

Professor A. Hamburg:

- Eesti Inseneride Liidu president
- Eesti Teaduste Akadeemia energeetikanõukogu esimees
- Euroakadeemia professor

- Euroakademia ärijuhimise teaduskonna nõukogu liige
- EAS Energiatehnoloogia programmi nõukoja liige
- Eesti Inseneride Liidu president
- Elektroenergeetika Seltsi aseesimees
- Tallinna Polütehnikumi nõukogu esimees
- Tallinna Tehnikakõrgkooli nõukoja esimees
- Teadusagentuuri SA Archimedes TEAME programmi nõunike kogu liige
- Kolleegiumi liige ajakirjas INSENEERIA
- Kolleegiumi liige ajakirjas OIL SHALE
- Kehtna Majandus- ja tehnoloogiakooli nõukogu esimees
- WEC-Estonia juhatuse liige
- Majandus ja Kommunikatsiooniministri energeetikanõukogu liige
- Teadusaasta saadik

Dotsent Jako Kilter:

- Eesti Standardikeskuse Kõrgepingekomitee EVS/TK 19 esimees
- TTÜ elektroenergeetika instituudi nõukogu liige
- TTÜ energeetikateaduskonna nõukogu liige
- Elektroenergeetika Seltsi kutsekomisjoni liige
- Eesti Võrgueeskirja uuendamise töögrupi liige
- Elektroenergeetika magistriõppe kaitsmiskomisjoni liige
- ENTSO-E Võrgueeskirjade töögrupi liige

Dotsent Ivo Palu

- TTÜ elektroenergeetika instituudi nõukogu liige
- TTÜ energeetikateaduskonna nõukogu liige
- TTÜ elektroenergeetika instituudi direktor

Teaduse ja arendustegevuse eesmärgid on põhilises osas saavutatud ning püstitatud ülesanded täidetud.

Hinnang instituudi aruandeperioodi teadus- ja arendustegevuse kohta on hea.