

**ENERGEETIKATEADUSKOND
ELEKTROENERGEETIKA INSTITUUT
TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE 2012**

1. Instituudi struktuur

**Elektroenergeetika instituut, Department of Electrical Power Engineering
Instituudi direktor Heiki Tammoja**

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

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

(NB! punktid 2.1- 2.6 täidab struktuuriüksus)

2.1 struktuuriüksuse koosseisu kuuluvate uurimisgruppide

2.1.1 teadustöö kirjeldus *(inglise keeles)*;

The modern electric power systems, plants and networks, represent the largest and most expensive of man-made systems, are studied in the Department of Electrical Power Engineering. The main attention is paid to the development of general theory for optimal control and planning of modern power systems under probabilistic, uncertain and fuzzy information. But the very important practical value will have also the creation of the new mathematical models, methods and software systems for the optimization, modelling, monitoring and analyzing of power plants, networks and systems under electricity market conditions. This is very important not only for Estonia, but for the others countries too. In the list of actual topics are:

- High-voltage engineering and equipment, insulation materials;
- Power system economics and electricity trading (electricity markets);
- Energy planning and related environmental problems;
- Renewable energy sources and their utilization

and others.

In the research work take part the scientists with the long experience and PhD students (14 doctors and about 8 PhD students).

2.1.2 aruandeaastal saadud tähtsamad teadustulemused *(inglise keeles)*.

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

The thermal power plants (TPP) are the main producers of electricity as in the world, so in Estonia. At that the very important problem is optimization of operation in the TPP, optimal operation of the TPP.

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. 2012 was the second year of the

grant. In that year was studied the news references of vector-optimization and analysed the criterions of L. Hurwicz and V. Pareto. In addition some new forms of static and dynamic characteristics for thermal units are developed. The basic results of research will be published in 11th International Symposium "Topical problems in the field of electrical and power engineering" Pärnu, Estonia, January 16-21, 2012.

AR10126 „Optimization of the functioning of the Energy System to balance changeable loads”
(H. Tammoja)

On the direction of power systems cybernetics were continued the developing of theory, models, methods and computer programs for optimal control of power systems under electricity market conditions. The main attention was paid to the optimal unit commitment (OUC) and to the optimal load dispatch (OLD) problems between generating units or between different power plants. The new parts, added to the experimental program, are the follows:

- 1) optimal load dispatch between conventional hydro plants and pump hydro plants.
- 2) the taking into account the startup costs, depending upon outage time.

About the methods of optimization: the method of Lagrangian Relaxation (LR) was substituted to the decommitting strategy. The disadvantage of this method is that the dual function is generally infeasible, i.e. the once relaxed system-wide constraints are not satisfied. The new method is working very well. Now the program can work with the 168 time intervals. The developing of the new database for MS Visual FoxPro environment has been begun.

Lep12073 “Compilation of model in PSCAD software” (Ivo Palu)

Compilation of power plant model in PSCAD software. Model is needed to be supplied to Elering AS as part of connection agreement. Novelty was to compile fully functional model based on measured and estimated results. Model will be later validated based on real field measurements.

VFP408 „Intelligent coordination of operation and emergency control of EU and Russian Power Grids“ (H. Tammoja)

Recommendations for following tasks but also solutions for optimal data exchange are expected outcome. In the area of conflict of liberalized markets and transparency and secure operation data must be processed and transferred by proven principles in terms of reliability and security. These principles may be defined basing on review of current data exchange between control centres and results from simulations of data exchange by calculation and optimisation algorithms. In area of optimal control of power systems is worked out the improved method for optimal operation of interconnected power systems on the base of two mathematical method.

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. The demonstration will take place on the Danish island Bornholm with more than 50 % of electricity consumption from renewable energy production.

A real-time market concept will be developed to give small end-users of electricity and distributed renewable energy sources new options (and potential economic benefits) for offering TSOs additional balancing and ancillary services.

2.2 Uurimisgrupi kuni 5 olulisemat publikatsiooni läinud aastal.

- Kilter, J.; Dubbelman, E.; Palu, I.; Niitsoo, J. (2012). Wind Park and Transmission Network Cooperation Considering Grid Code Requirements. Navickas, A. (Editor-in-Chief); Sauhats, A.; Virbalis, A.; Ažubalis, M.; Galvanauskas, V.; Brazauska (Toim.). ELECTRICAL AND CONTROL TECHNOLOGIES. Proceedings of the The 7th International Conference on Electrical and Control Technologies ECT–2012 (183 - 188).Kaunas Technologija
- Niitsoo, J.; Palu, I. (2012). Investigation of Undesirable Consumption and Distorted Current. Drapela, J.; Machacek, J. (Toim.). Proceedings of the 13th International Scientific Conference Electric Power Engineering 2012 (287 - 291).IEEE
- Sarnet, T.; Kilter, J. (2012). Electric railway traction system modeling in Estonian transmission network and voltage unbalance analysis. In: Electrical And Control Technologies : Proceedings of the 7th International Conference on Electrical and Control Technologies ECT-2012: 7th International Conference on Electrical and Control Technologies, Kaunas, Lithuania, 3-4 May 2012. (Toim.) Navickas, A.; Sauhats, A.; Virbalis, A.; Ažubalis, M.; Galvanauskas, V.; Brazauskas, K.;
- Sarnet, T.; Kilter, J. (2012). Assessment of Synchronous Generator Influence on Transmission Network with Significant Level of Voltage Unbalance. Electronics and Electrical Engineering, 18(9), 11 - 14.
- Sarnet, T.; Kilter, J. (2012). Electric railway traction system modeling in Estonian transmission network and voltage unbalance analysis. In: Electrical And Control Technologies : Proceedings of the 7th International Conference on Electrical and Control Technologies ECT-2012: 7th International Conference on Electrical and Control Technologies, Kaunas, Lithuania, 3-4 May 2012. (Toim.) Navickas, A.; Sauhats, A.; Virbalis, A.; Ažubalis, M.; Galvanauskas, V.; Brazauskas, K.; Jonaitis, A. Technologija, 2012, 179 - 182.

2.3 Loetelu struktuuriüksuse töötajate rahvusvahelistest tunnustustest.

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

2.5 Aruandeaasta tähtsamad T&A finantseerimise allikad.

AR10126, Lep12183, Lep12073, VFN 573, VFP408 (kogu rahastamine oli lepingu algusaastal), Lep12084, Lep12105, VFP514 , ETF grandid G8550 ja G8760.

2.6 Soovi korral lisada aruandeaastal saadud T&A-ga seotud tunnustusi (va punktis 2.3 toodud tunnustused), ülevaate teaduskorralduslikust tegevusest, teadlasmobiilsusest ning anda hinnang oma teadustulemustele.

Professor H. Tammoja on Elering AS nõukogu ja Tallinna linna energeetika komisjoni liige.

Professor A. Hamburg on Eesti TA energeetikanõukogu esimees ja emeritprofessor M. Valdma ning akadeemik L. Krumm selle nõukogu liikmed.

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

Hinnang instituudi aruandeperioodi teadus- ja arendustegevuse kohta on hea.

2.7 Instituudi teadus- ja arendustegevuse teemade ja projektide nimetused (*Eesti Teadusinfosüsteemi, edaspidi ETIS, andmetel*)

- Haridus- ja Teadusministeerium

- sihtfinantseeritavad teemad:
- baasfinantseerimise toetusfondist rahastatud projektid (sh TTÜ tippkeskused):
- riiklikud programmid:

- Teiste ministeeriumide poolt rahastatavad riiklikud programmid:

- Uuriija-professori rahastamine:

- SA Eesti Teadusfond/Eesti Teadusagentuur

- grandid:

ETF8550, Tuuleelektrijaamade agregeeritud mudelite analüüs ja arendamine , Palu Ivo (2011 – 2012)

ETF8760, Soojuselektrijaama vektoroptimeerimine arvestades info mittetäielikkust, (Šuvalova Jelena (2011 – 2014)

- ühisgrandid välisriigiga:
- järel doktorite grandid (SA ETF ja Mobilitas):
- tippteadlase grandid (Mobilitas):

- Ettevõtluse Arendamise SA

- eeluuringud:
- arendustoetused:

- SA Archimedesega sõlmitud lepingud

- infrastruktuur (nn „mini-infra“, „asutuse infra“):
- Eesti tippkeskused:
- riiklikud programmid:

AR10126, Energiasüsteemi talitluse optimeerimine muutuvkoormuste tasakaalustamiseks, Toomas Rang, Tõnu Lehtla, Heiki Tammoja; Aadu Paist; Aleksander Kilk (1.11.2010 – 31.10.2013)

- muud T&A lepingud:

- SA Keskkonnainvesteeringute Keskusega sõlmitud lepingud:

- Siseriiklikud lepingud:

Lep11052, Eesti energeetika indeks, Valtin Juhan (1.08.2011 - 1.07.2012)

Lep12057, Harku alajaamas teostatud mõõtmised, Palu Ivo (9.02.2012 - 2.04.2012)

Lep12073, PSCAD mudeli koostamine, Palu Ivo (12.04.2012 - 22.05.2012)

Lep12084, Keskpingseseadme SM6 taluvuskatsed välguimpulsspingele, Taklaja Paul (1.03.2012 - 31.05.2012)

Lep12105, Keskpingseseadme taluvuskatsed välguimpulsspingele, Taklaja Paul (7.06.2012 - 22.06.2012)

Lep12160 - PSCAD mudeli koostamine Vão/Tallinna Elektriijaama II generaatorile, Palu Ivo (5.09.2012 - 17.10.2012)

Lep 12183 - Elektertransport ja selle mõju elektrisüsteemi talitlusele – I etapp, Palu Ivo, (18.11.2012 - 19.12.2012) – projekt jätkub 2013 aastal

Lisaks erinevad lepingulised tööd objekti SS299 kaudu.

- Helme koostootmisjaamas tehtud mõõtmiste aruanne
 - PSCAD mudeli koostamine Imavere Elekter OÜ generaatorile
 - Imavere koostootmisjaama PQ kõvera arvutamine
 - Konsultatsioon tuuleparkide Mäli ja Tamba elektrivõrku ühendamise küsimustes
- EL Raamprogrammi projektid:

VFP514, Targa võrgu suuremahuline demonstratsiooniprojekt ühendamaks reaalaja turu põhist hajutatud elektritootmist (DER) ja tarbijate juhtimist (DR), Palu Ivo(1.03.2011 - 28.02.2015)

VFP408, Euroopa Liidu ja Venemaa elektrivõrkude talitluse arukas koordineerimine ja avariide juhtimine, Tammoja Heiki (1.01.2009 - 31.12.2012)

VFN 573, Smart transmission grid operation and control (STRONgrid) – Ülekandevõrgu juhtimine ja kontroll, Palu Ivo (21.08.2012 – 31.10.15). Projekt koostöös KTH, NTNU ja AALTO ülikooliga

- Välisriiklikud lepingud:

2.8 Strukturiüksuse töötajate poolt avaldatud eelretsenseeritavad teaduspublikatsioonid (*ETIS klassifikaatori alusel 1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1 ja 5.1*).

1.1

Sarnet, T.; Kilter, J. (2012). Assessment of Synchronous Generator Influence on Transmission Network with Significant Level of Voltage Unbalance. *Electronics and Electrical Engineering*, 18(9), 11 - 14.

Drovtar, I.; Landsberg, M.; Kilter, J.; Rosin, A. (2012). Economic impact of renewable electricity generation on the Baltic region's electricity market. *Przeglad Elektrotechniczny*, 88(7b), 161 - 165.

Vaimann, T.; Niitsoo, J.; Kivipõld, T.; Lehtla, T. (2012). Power Quality Issues in Dispersed Generation and Smart Grids. *Electronics and Electrical Engineering*, 10(8), 23 - 26.

1.2

1.3

2.1

2.2

3.1

Taklaja, P.; Niitsoo, J.; Palu, I. (2012). Determining the Unknown Faults of the HV Overhead Lines. Drapela, J.; Machacek, J. (Toim.). *Proceedings of the 13th International Scientific Conference Electric Power Engineering 2012 (187 - 192).IEEE*

Niitsoo, J.; Palu, I. (2012). Investigation of Undesirable Consumption and Distorted Current. Drapela, J.; Machacek, J. (Toim.). *Proceedings of the 13th International Scientific Conference*

Kilter, J.; Dubbelman, E.; Palu, I.; Niitsoo, J. (2012). Wind Park and Transmission Network Cooperation Considering Grid Code Requirements. Navickas, A. (Editor-in-Chief); Sauhats, A.; Virbalis, A.; Ažubalis, M.; Galvanauskas, V.; Brazauska (Toim.). ELECTRICAL AND CONTROL TECHNOLOGIES. Proceedings of the The 7th International Conference on Electrical and Control Technologies ECT–2012 (183 - 188).Kaunas Technologija

Haas, A.; Niitsoo, J.; Taklaja, P.; Palu, I. (2012). Analysis of Electricity Meters under Distorted Load Conditions. In: Proceedings of 8th International Conference 2012 Electric Power Quality and Supply Reliability: 2012 Electric Power Quality and Supply Reliability, Tartu, June 11 - 13, 2012. (Toim.) Sakkos, T.. IEEE, 2012, 281 - 284.

Meyer, J.; Kilter, J.; Howe, B.; Zavoda, F.; Tenti, L.; Romero Gordon, J. M.; Milanović, J. V. (2012). Contemporary and Future Aspects of Cost Effective Power Quality Monitoring - Position paper of CIGRE WG C4.112. In: Proceedings of 8th International Conference 2012 Electric Power Quality and Supply Reliability: 2012 Electric Power Quality and Supply Reliability, Tartu, June 11 - 13, 2012. (Toim.) Sakkos, T.. IEEE, 2012.

Kilter, J.; Meyer, J.; Howe, B.; Zavoda, F.; Tenti, L.; Milanović, J. V.; Bollen, M.; Ribeiro, P. F.; Doyle, P.; Romero Gordon, J. M. (2012). Current Practice and Future Challenges for Power Quality Monitoring – CIGRE WG C4.112 Perspective . In: 15th International Conference on Harmonics and Quality of Power, Hong Kong, China, 17 – 20 June 2012: IEEE, 2012.

Rosin, A.; Palu, I.; Rosin, K.; Auväärt, A. (2012). Dimensioning of Electricity Storage according to Small Wind Turbine Power Generation and Household Load Patterns . In: IECON 2012 - 38th Annual Conference on IEEE Industrial Electronics Society: 38th Annual Conference on IEEE Industrial Electronics Society, Montreal, Canada, 25 - 28 October. IEEE, 2012, 5155 - 5160.

Sarnet, T.; Kilter, J. (2012). Electric railway traction system modeling in Estonian transmission network and voltage unbalance analysis. In: Electrical And Control Technologies : Proceedings of the 7th International Conference on Electrical and Control Technologies ECT-2012: 7th International Conference on Electrical and Control Technologies, Kaunas, Lithuania, 3-4 May 2012. (Toim.) Navickas, A.; Sauhats, A.; Virbalis, A.; Ažubalis, M.; Galvanauskas, V.; Brazauskas, K.; Jonaitis, A. Technologija, 2012, 179 - 182.

Drovtar, I.; Niitsoo, J.; Rosin, A.; Kilter, J.; Palu, I. (2012). Electricity Consumption Analysis and Power Quality Monitoring in Commercial Buildings. In: Proceedings of 8th International Conference 2012 Electric Power Quality and Supply Reliability: 2012 Electric Power Quality and Supply Reliability, Tartu, June 11 - 13, 2012. (Toim.) Sakkos, T.. IEEE, 2012, 107 - 112.

Kütt, L.; Järvi, J.; Vaimann, T.; Shafiq, M.; Lehtonen, M.; Kilter, J. (2012). High-Frequency Current Sensor for Power Network On-line Measurements. In: Proceedings of the 13th International Scientific Conference Electric Power Engineering 2012: EPE 2012, May 23-25, 2012, Brno, Czech Republic. Brno: IEEE, 2012, 367 - 371.

Drovtar, I.; Landsberg, M.; Kilter, J.; Rosin, A. (2012). Impacts of Large Scale Wind Integration on the Baltic Region's Thermal Power Plant Economics and Electricity Market in 2025. In: Power Electronics, Electrical Drives, Automation and Motion Symposium Proceedings: The 21st International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM 2012), June 20-22, 2012, Sorrento, ITALY. Sorrento, Italy: IEEE, 2012, 684 - 689.

Maripuu, R.; Tsernobrovkin, O.; Palu, I.; Kilter, J. (2012). Model verification for Analysis of Wind Power Impact to Transient Stability in Isolated Power System Using Combined Relay Protection and Dynamics Modelling Approach. In: Proceedings of 8th International Conference 2012 Electric Power Quality and Supply Reliability: 2012 Electric Power Quality and Supply Reliability, Tartu, June 11 - 13, 2012. (Toim.) Sakkos, T.. IEEE, 2012.

Taklaja, p.; Niitsoo, J.; Palu, I. (2012). Wet Test on Naturally Polluted Glass and Composite Insulators. In: Proceedings of 8th International Conference 2012 Electric Power Quality and Supply Reliability: 2012 Electric Power Quality and Supply Reliability, Tartu, June 11 - 13, 2012. (Toim.) Sakkos, T.. IEEE, 2012, 261 - 266.

Kilter, J.; Reinson, A. (2012). Wide-Area Applications for Enhancement of Estonian Power System Security . In: Proceedings of 8th International Conference 2012 Electric Power Quality and Supply Reliability: 2012 Electric Power Quality and Supply Reliability, Tartu, June 11 - 13, 2012. (Toim.) Sakkos, T.. IEEE, 2012.

3.2

Niitsoo, J.; Palu, I. (2012). Undesirable Usage of Energy in Residential House. J. Zakis (Toim.). 11th International Symposium “Topical Problems in the Field of Electrical and Power Engineering” and “Doctoral School of Energy and Geotechnology II” (126 - 128). Tallinn: Elekriajam

Astapov, V. (2012). Producing Electricity from Biogas: the New Possibilities for Farms. 12th International Symposium “Topical problems in the field of electrical and power engineering, Doctoral School of Energy and Geotechnology II”, Kuressaare, Estonia, June 11 - 16, 2012. Elekriajam, 2012, 110 - 112.

Astapov, V. (2012). Vector Optimization of Thermal Power Plants. In: 11th International Symposium “Topical problems in the field of electrical and power engineering” Pärnu, Estonia, January 16-21, 2012: Elekriajam, 2012, 213 - 215.

3.3

Treufeldt, Ü.; Metusala, T. (2012). Piksekaitse. Osa 1: Üldpõhimõtted.

4.1

5.1

2.9 Struktuuriüksuses kaitstud doktoriväitekirjade loetelu (*NB! struktuuriüksus lisab struktuuriüksuse töötaja juhendamisel mujal kaitstud doktoriväitekirjade loetelu*)

Paul Taklaja: elektroenergeetika instituut

Teema: *110 kV õhuliinide isolatsiooni töökindluse analüüs ja töökindluse tõstmise meetodid* (The Study of 110 kV Power Grid Reliability and the Measures to Decrease Insulation Failures)

Juhendajad: emeriitdotsent Rein Oidram ja dotsent Ivo Palu

Kaitses: 18.06.2012

Omistatud kraad: filosoofiadoktor (energia- ja geotehnika)

Reeli Kuhi-Thalfeldt, elektroenergeetika instituut

Teema: *Distributed Electricity Generation and its Possibilities for Meeting the Targets of Energy and Climate Policies* (Elektrienergia hajatootmine ja selle võimalused energia- ja kliimapoliitika

eesmärkide täitmiseks)

Juhendaja: prof Juhan Valtin

Kaitstes: 18.06.2012

Omistatud kraad: filosoofiadoktor (energia- ja geotehnika)

2.10 Struktuuriüksuses järeldoktorina T&A-s osalenud isikute loetelu (*ETIS-e kaudu esitatud taotluste alusel*)

2.11 Struktuuriüksuses loodud tööstusomandi loetelu

3 Struktuuriüksuse infrastruktuuri uuendamise loetelu