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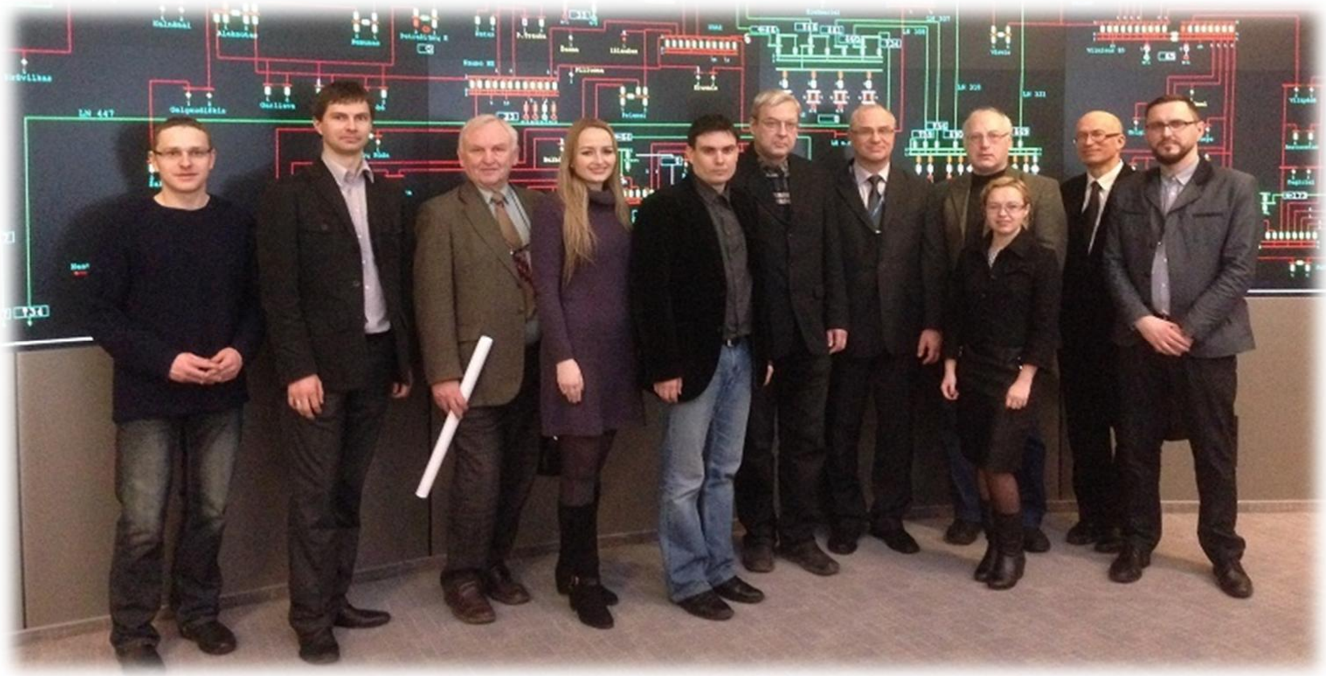
NATIONAL OPEN ACCESS SCIENTIFIC CENTRE FOR FUTURE ENERGY TECHNOLOGIES

OPEN R & D LITHUANIA

Laboratory of Systems Control and Automation: Profile and Opportunities to Contribute



EERA ESI meeting, November 2016, DTU

LABORATORY’S PROFILE

Laboratory of Systems Control and Automation

Major research directions

✓ *mathematical modelling of power systems and networks, investigation of their control issues;*

✓*modelling and optimisation research of ICT-based control systems of power systems.*

Vision

To become one of the major excellence centre in science and technology carrying out the research related to mathematical modelling of power systems and solution of control problems relevant for the sustainable operation and development of power sector.

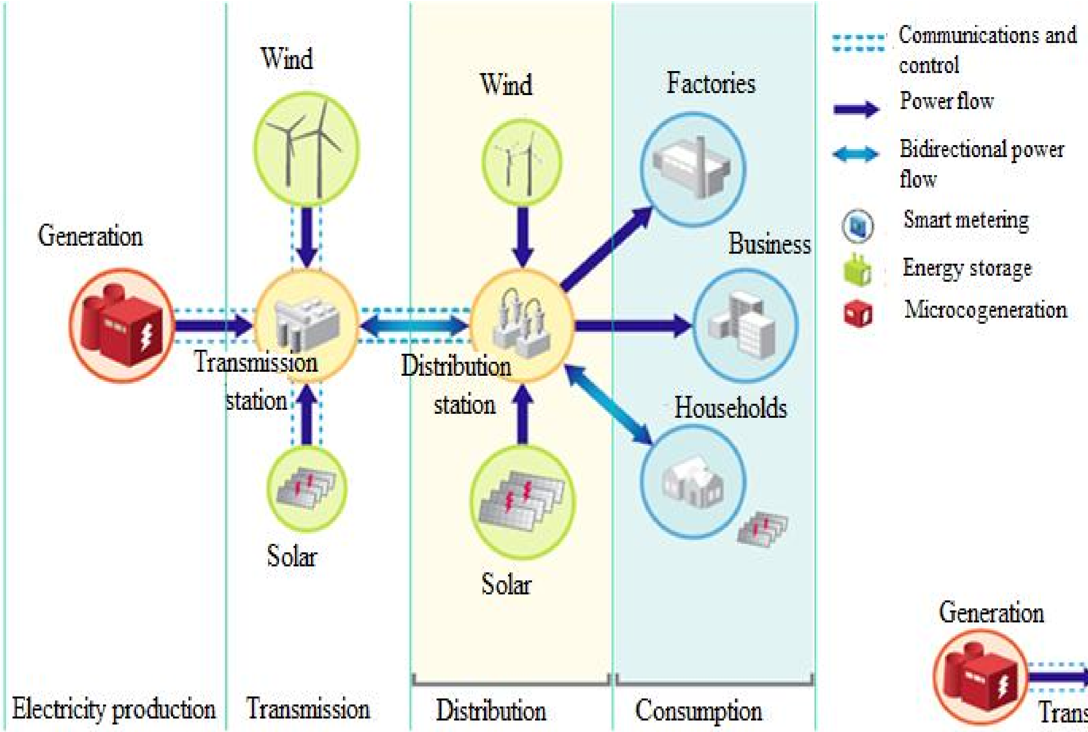
Mission

✓*To carry out theoretical and applied research;*

✓*To provide consultancies and problem solutions for power sector delivering them to public institutions and industry/business companies;*

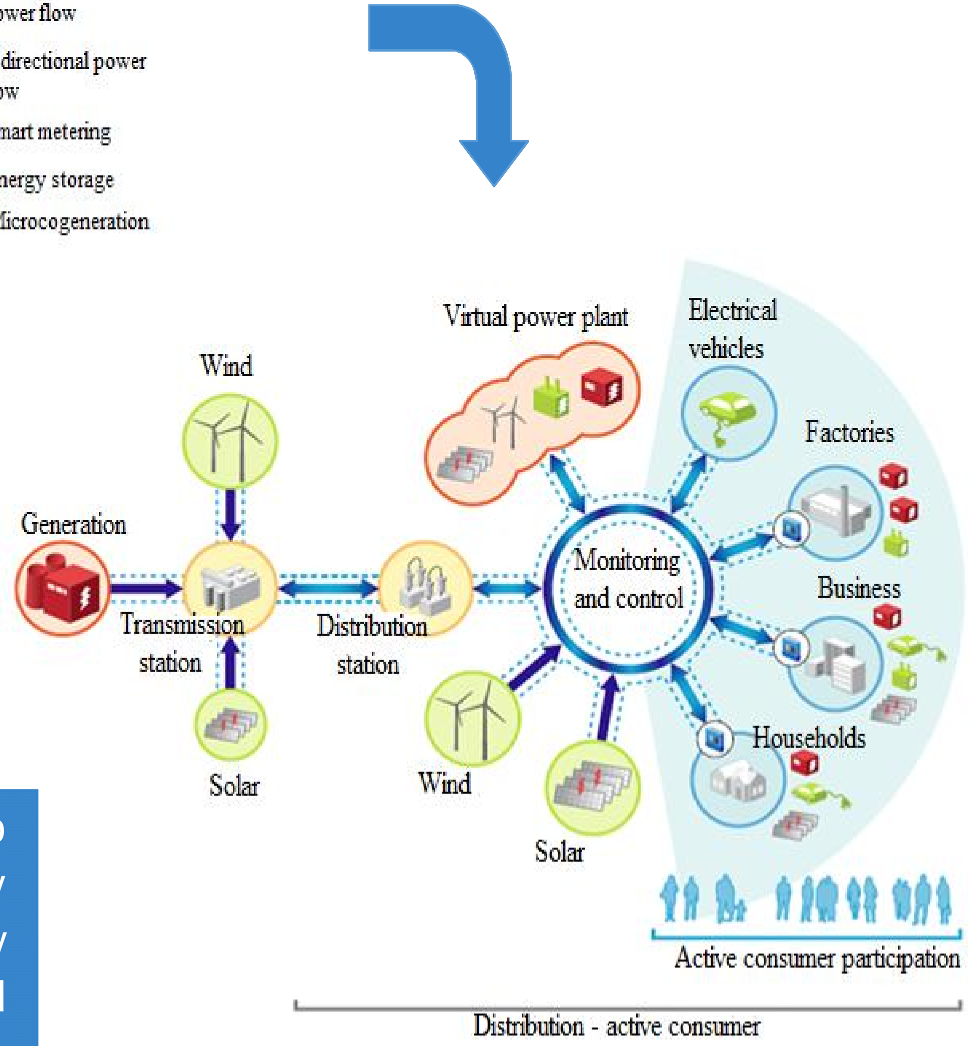
✓*To cooperate with Lithuanian higher education institutions contributing to the education of specialists for Lithuanian industry and research sectors.*

OUR VIEWS ON GRIDS' FUTURE



Conventional power grid

Future Electric Power Systems



Smart grid

Smart technologies will be embedded into electrical power networks, pursuing efficiency and reliability targets, including high quality power supply to customers at acceptable and competitive prices.

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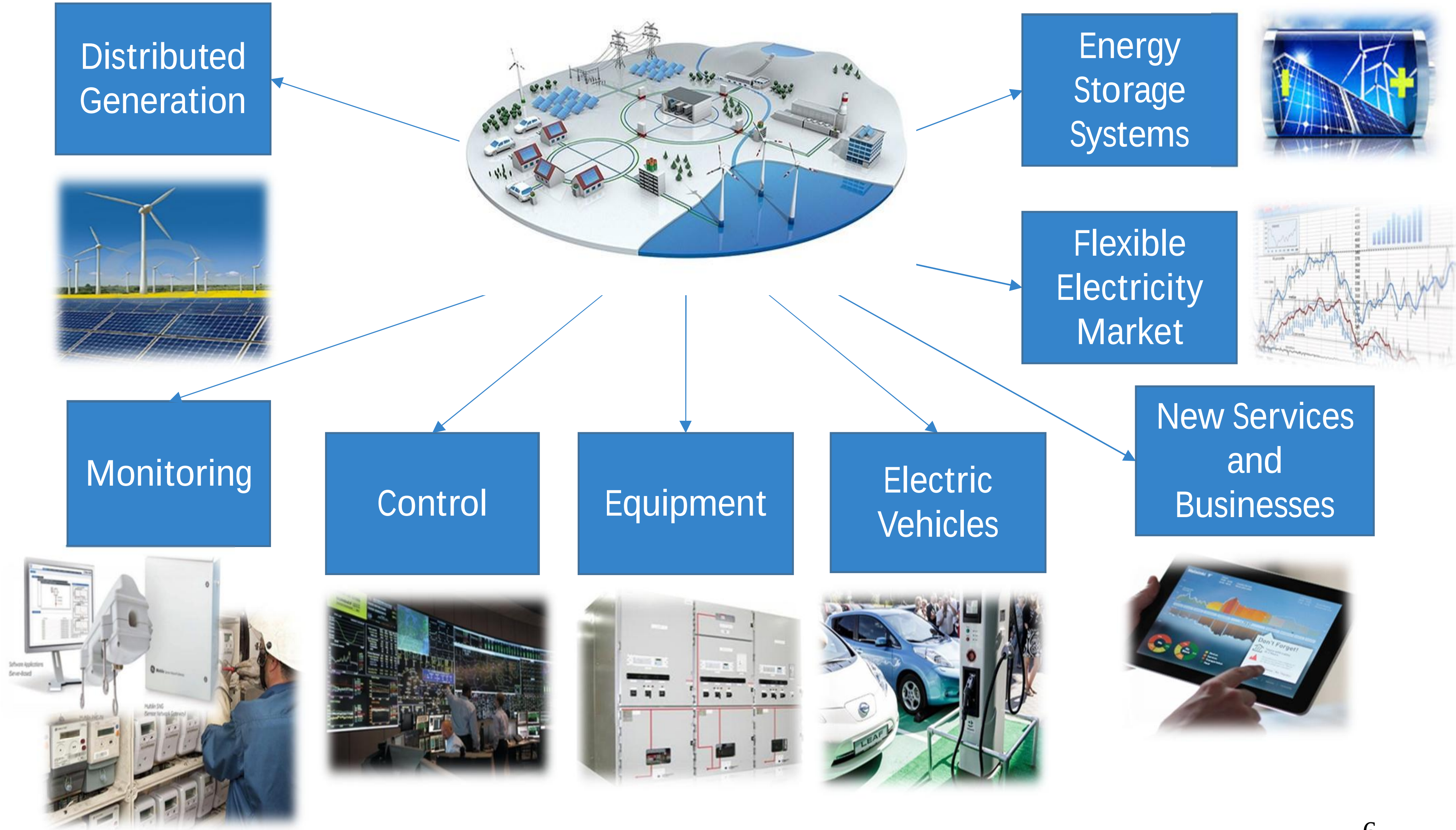
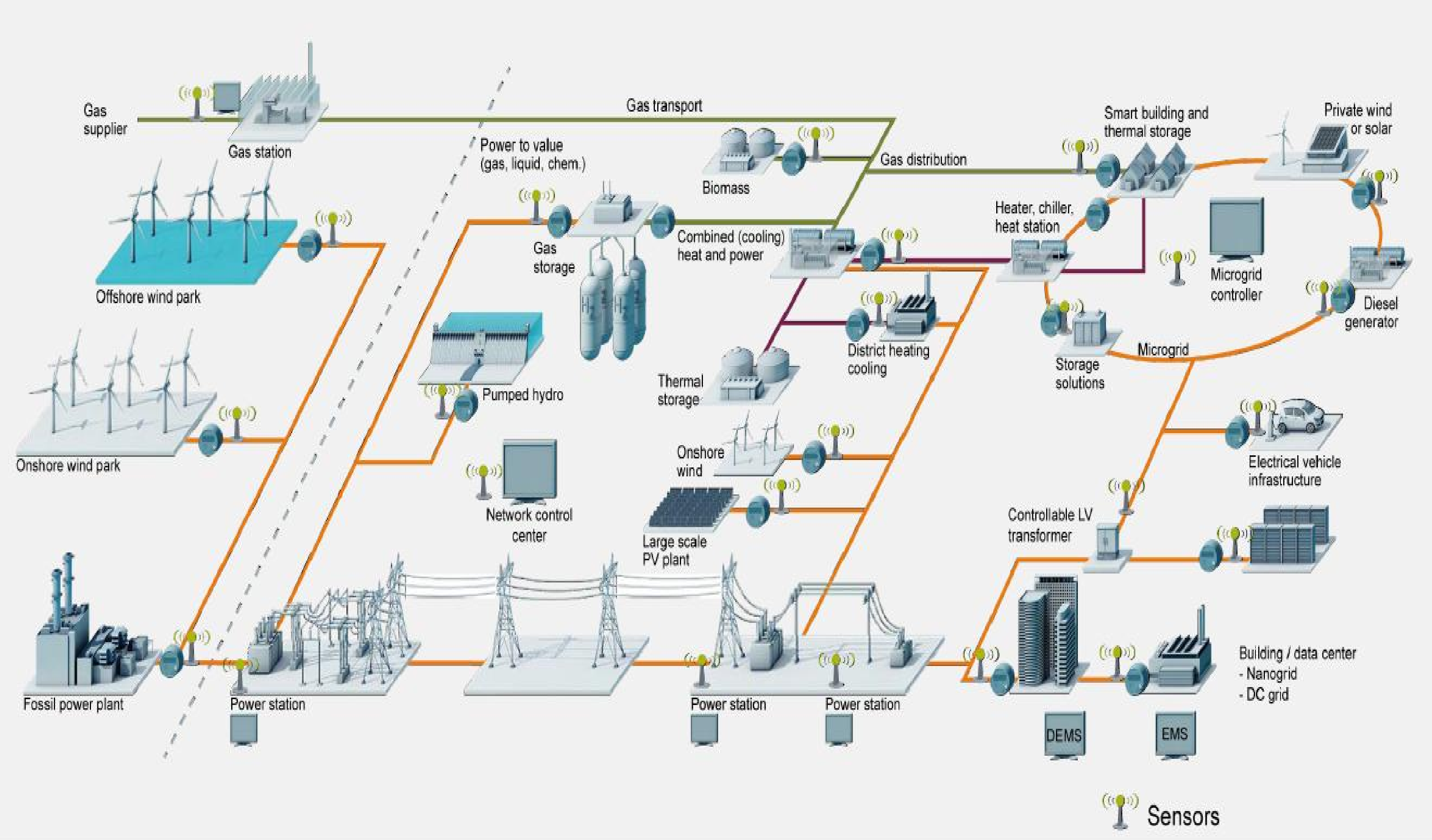
Enhanced Functions of Smart Grid



Smart Grid Structure



POWER SYSTEM STABILITY AND RELIABILITY

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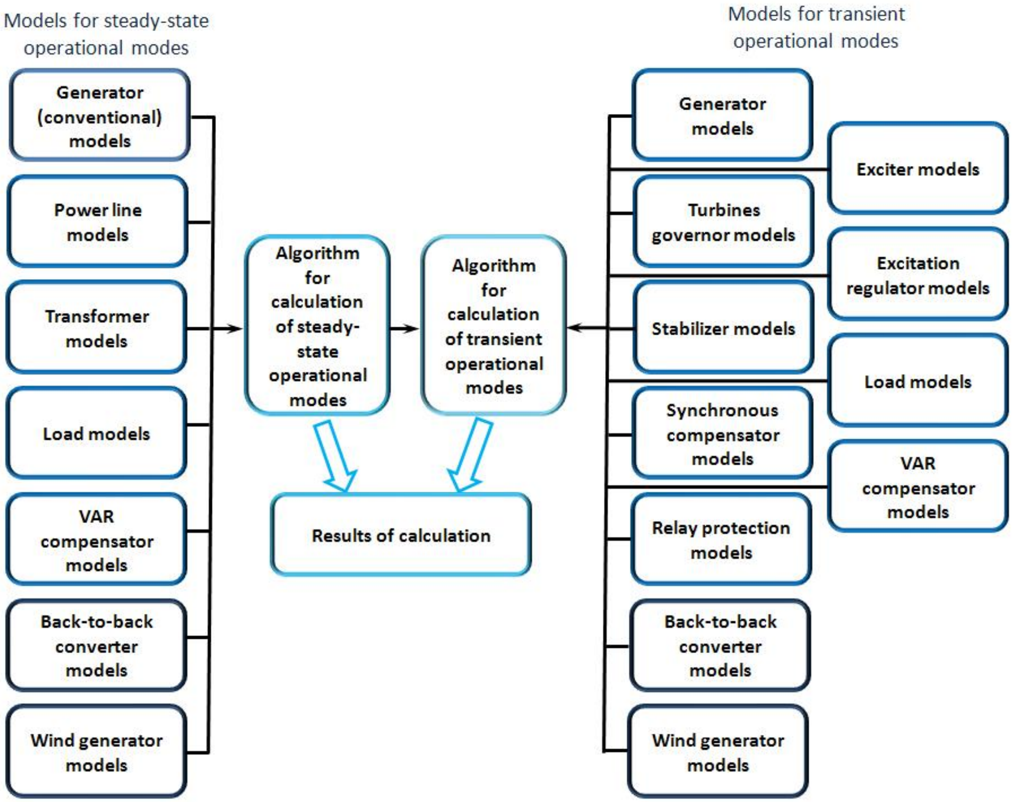
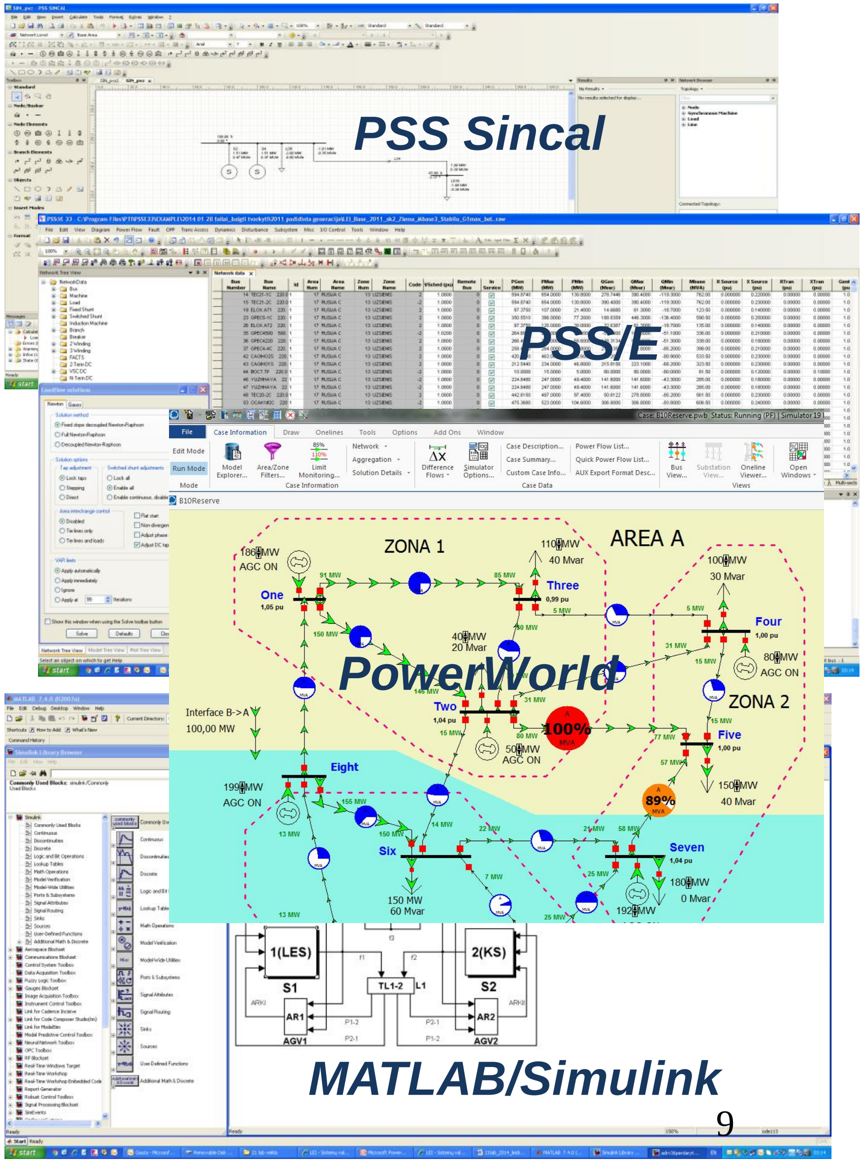
Mathematical modelling of electric power systems, analysis and estimation of parameters





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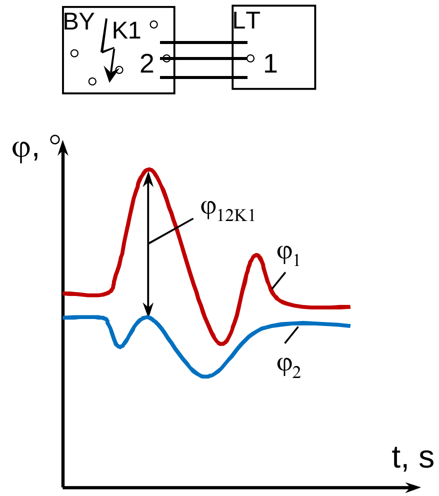
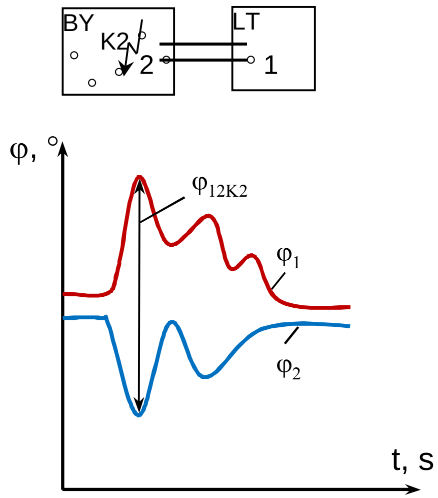
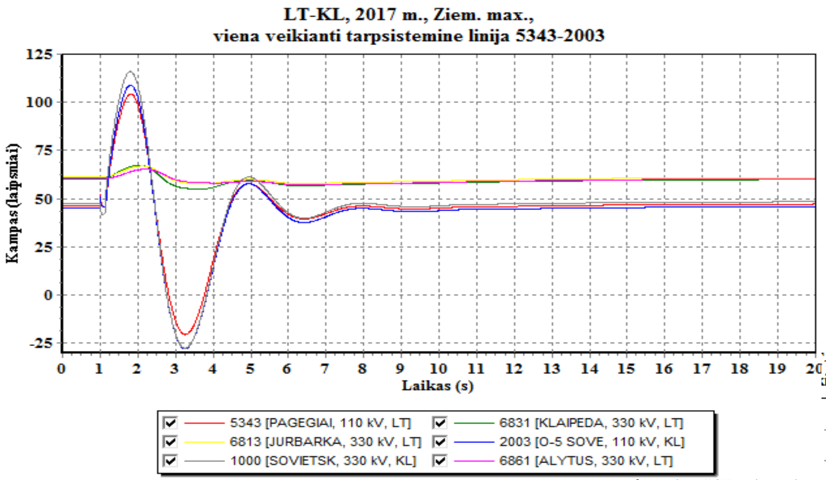
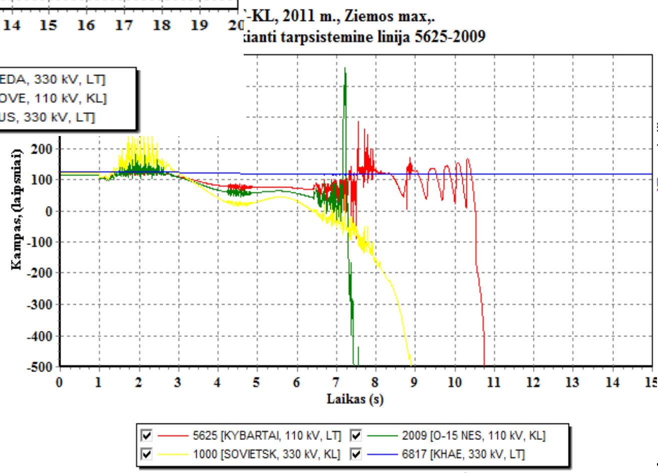
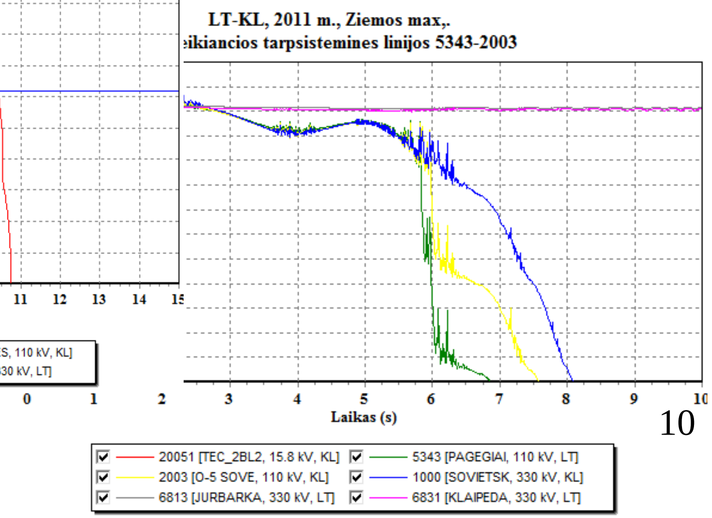
Stability research of electric power systems (PSS/E): phase angle oscillations



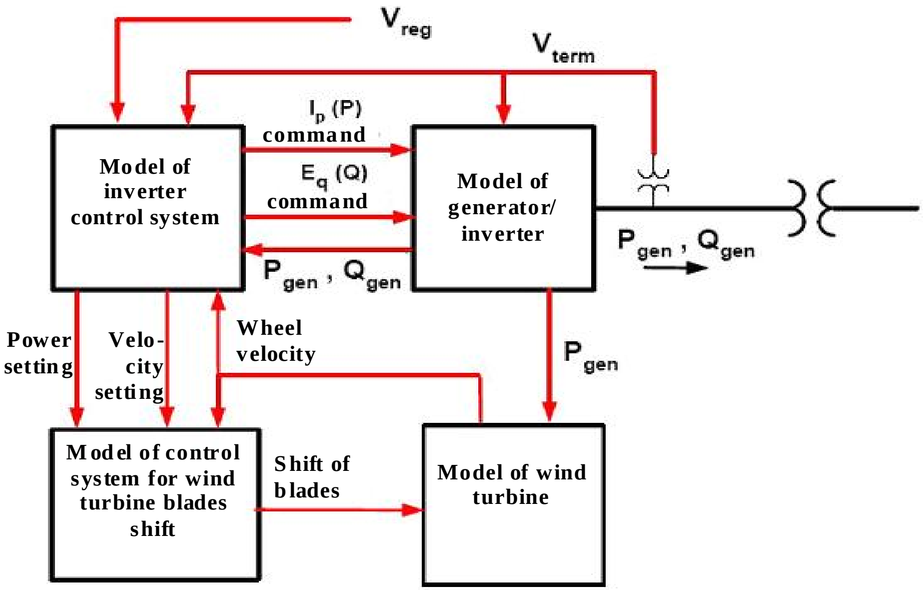


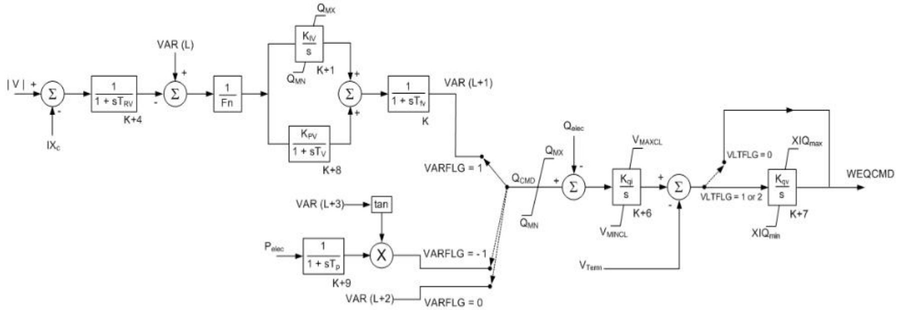


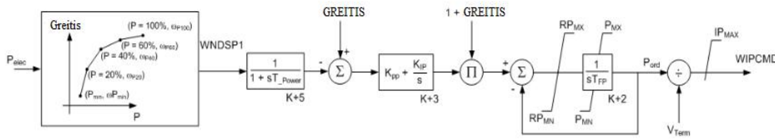


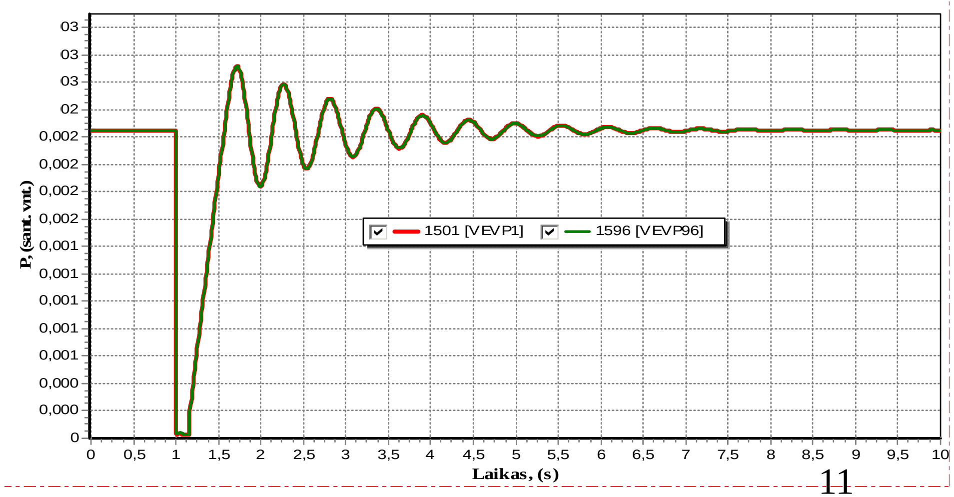


Wind power plant control systems (PSS/E)









LOAD-FREQUENCY CONTROL

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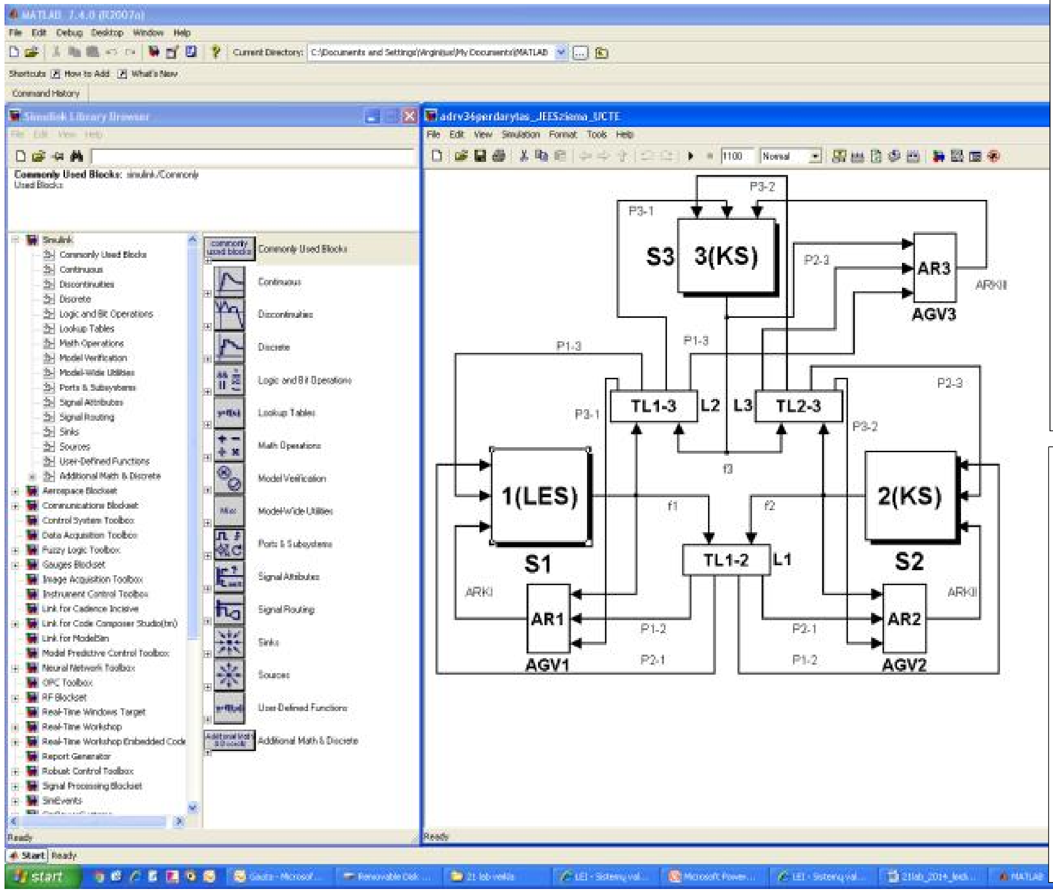
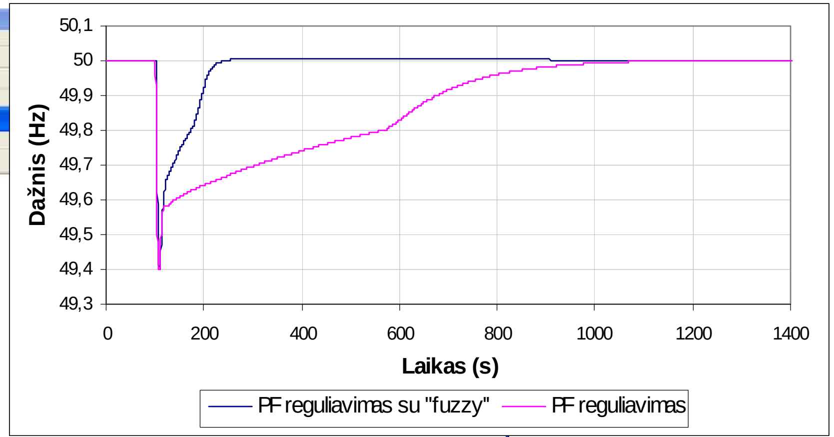
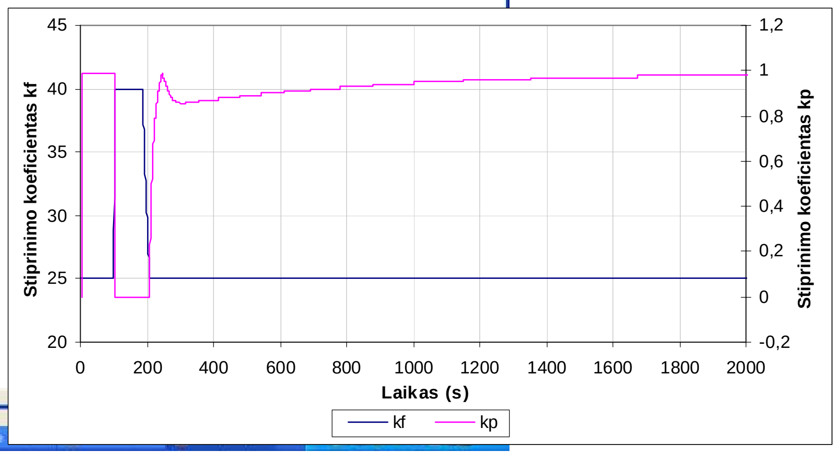
✓*Analysis of power system control problems;*

✓*Development of control algorithms for load- frequency control, voltage control.*







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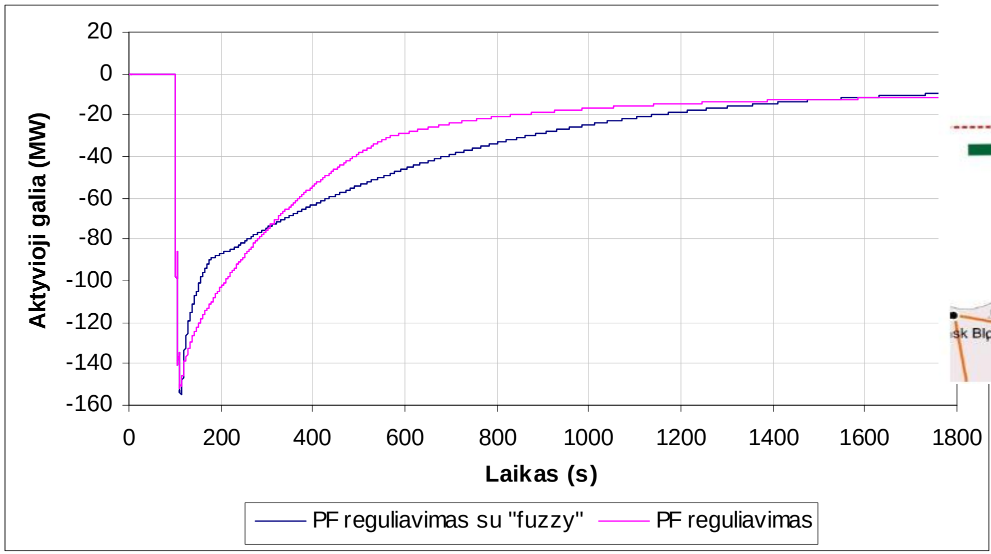
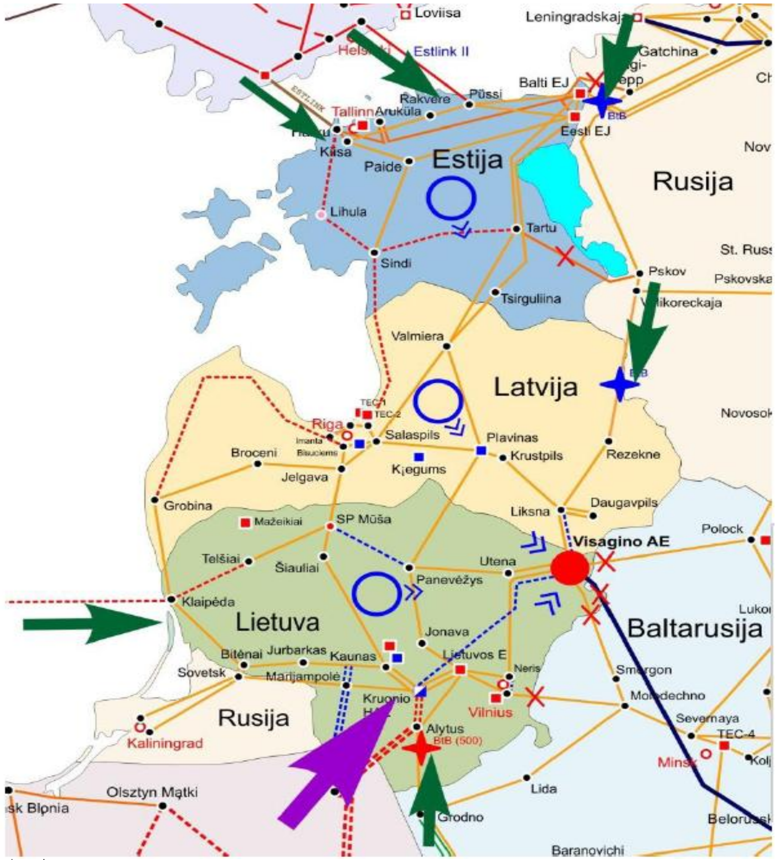
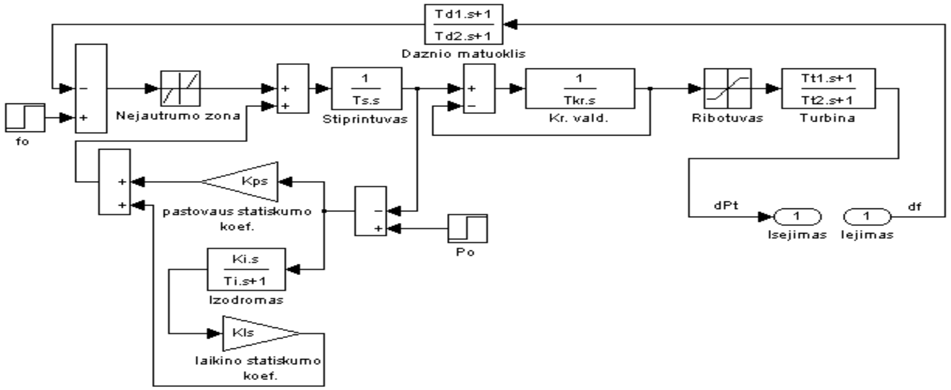
Load – frequency control of electric power system

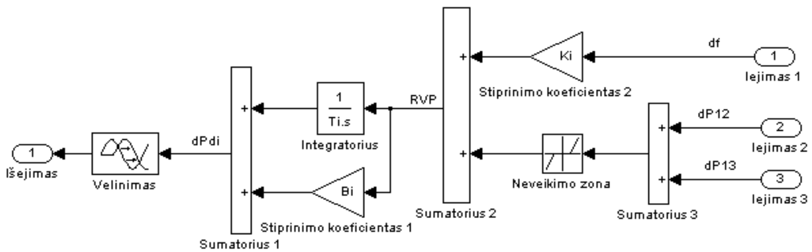




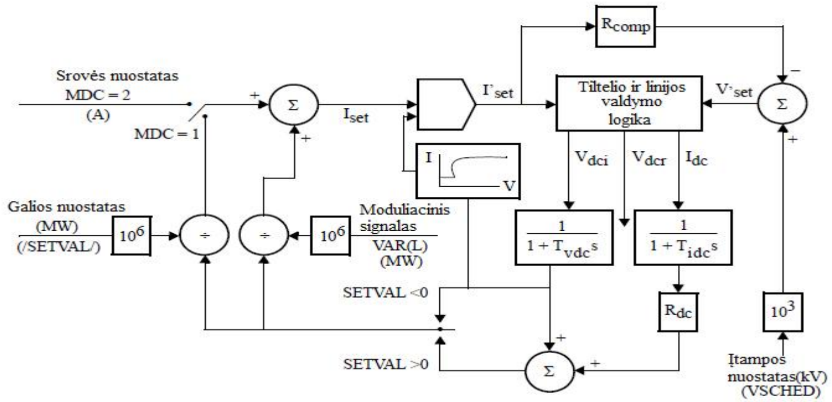
Load – frequency control systems



Load-frequency control system for pumped hydro (MATLAB/Simulink)

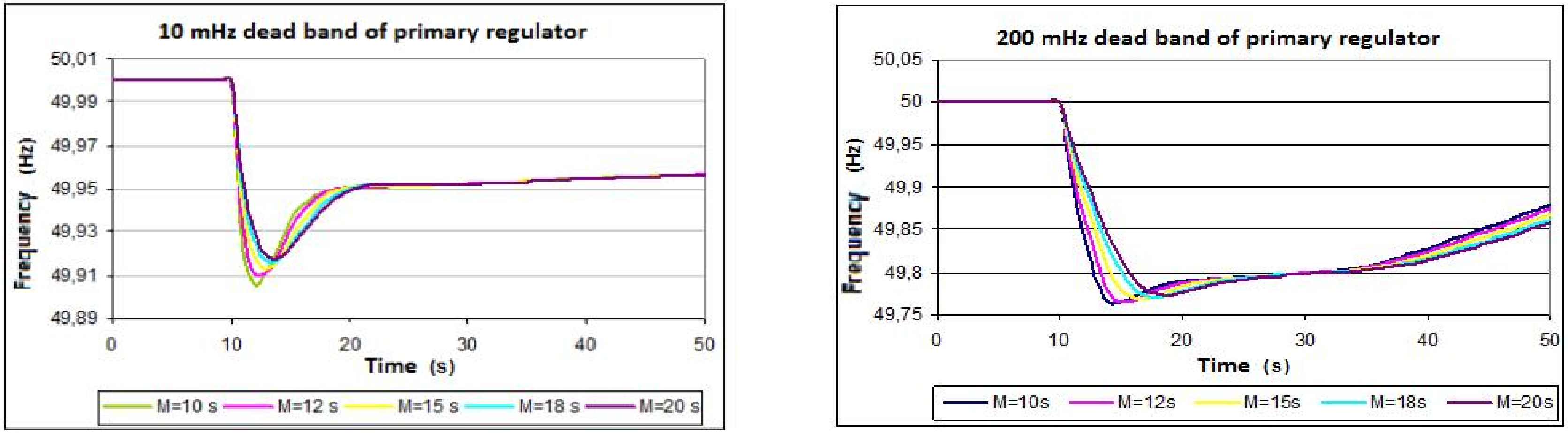


Load-frequency secondary control model (MATLAB/Simulink)

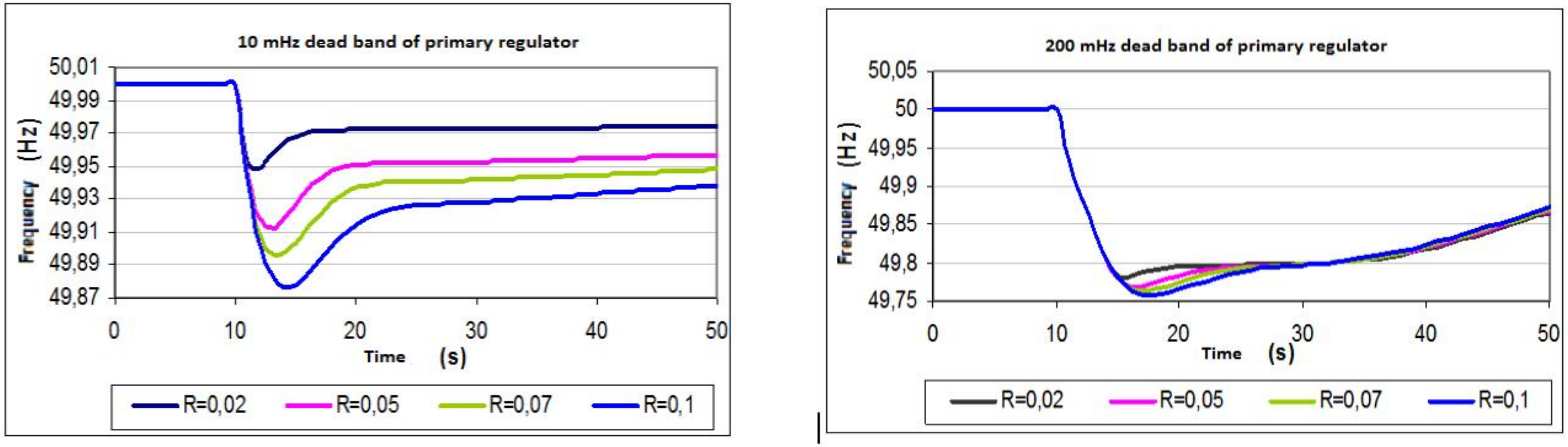


Model of HVDC /B2B station (PSS/E)

Power system frequency deviation



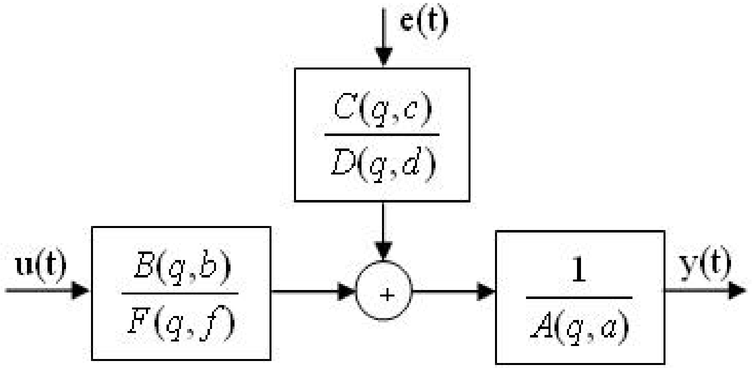
The influence of mechanical inertia's time constant (M=2H) in EPS for frequency deviation processes, when dead band of the primary turbine regulators is a) 10 mHz, b) 200 mHz



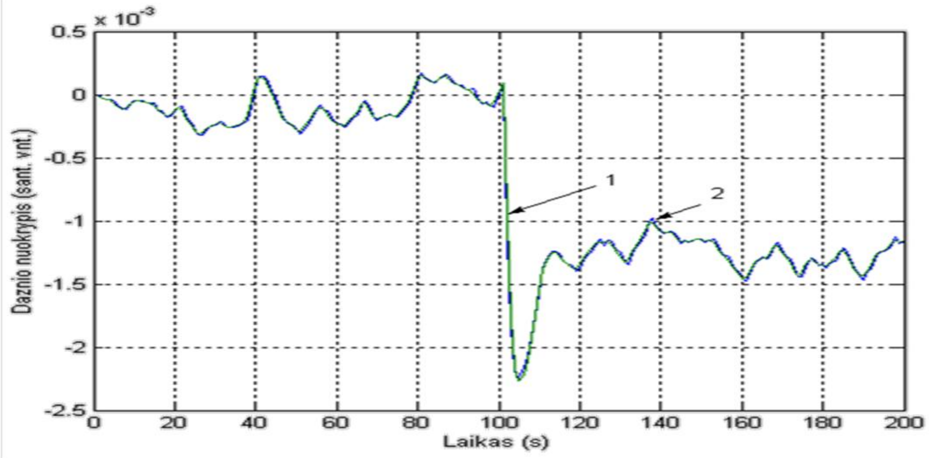
The influence of EPS droop for frequency deviation processes, when dead band of the primary turbine regulators are a) 10 mHz, b) 200 mHz (MATLAB/Simulink)

PARAMETER IDENTIFICATION

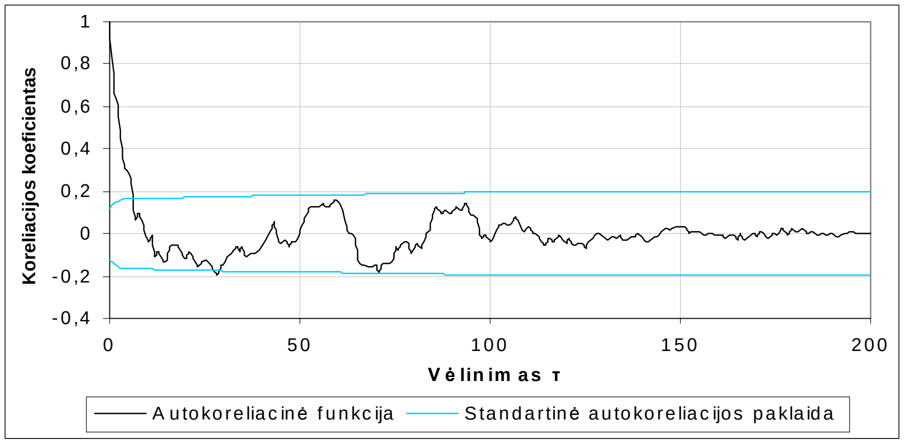
Parameter identification:
Parametric identification



$$A(q,a)y(t) = \frac{B(q,b)}{F(q,f)}u(t) + \frac{C(q,c)}{D(q,d)}e(t);$$



Frequency variation characteristics: 1 – derived from factual values, 2 – derived from identified parameter values



Autocorrelation function of random component of frequency measurements obtained from passive experiment

Parameter identification: Spectral analysis

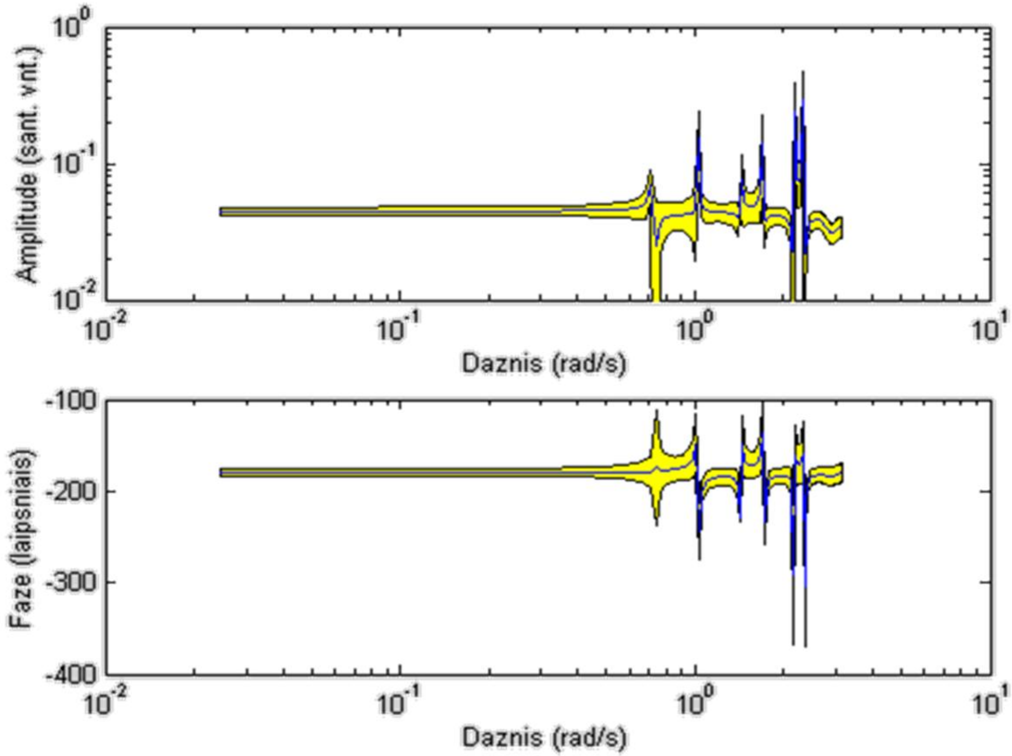
$$\hat{S}_{yy}(\omega) = \sum_{\tau=-M}^{M} \hat{R}_{yy}(\tau) W_M(\tau) e^{-i\omega\tau};$$

$$\hat{S}_{yu}(i\omega) = \sum_{\tau=-M}^{M} \hat{R}_{yu}(\tau) W_M(\tau) e^{-i\omega\tau};$$

$$\hat{S}_{uu}(\omega) = \sum_{\tau=-M}^{M} \hat{R}_{uu}(\tau) W_M(\tau) e^{-i\omega\tau};$$

$$\hat{G}_N(i\omega) = \frac{\hat{S}_{yu}(i\omega)}{\hat{S}_{uu}(\omega)};$$

$$\hat{S}_{vv}(\omega) = \hat{S}_{yy}(\omega) - \frac{\left|\hat{S}_{yu}(i\omega)\right|^2}{\hat{S}_{uu}(\omega)}.$$

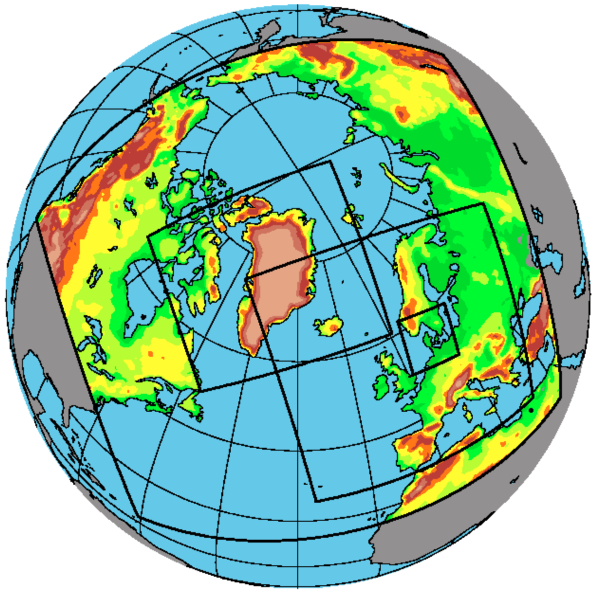


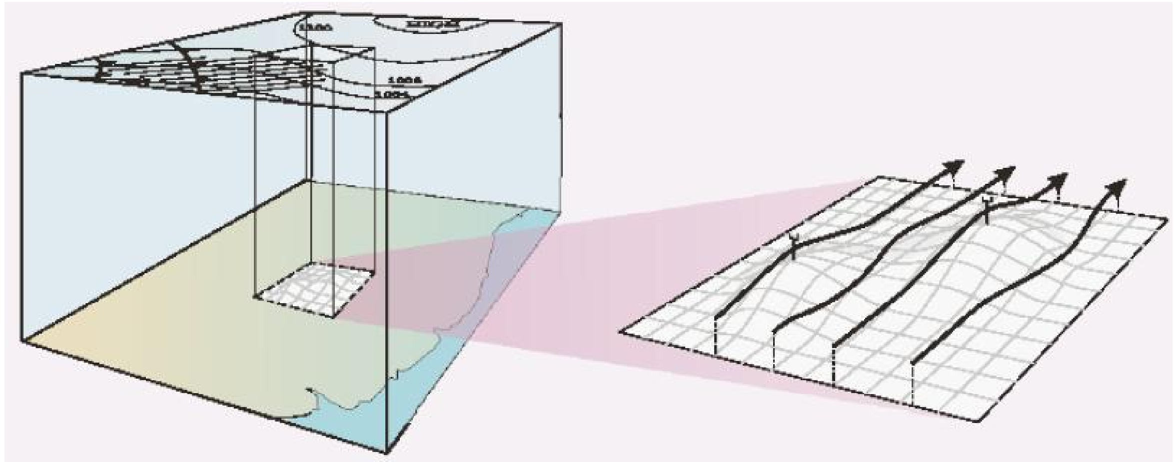
Amplitude/phase response characteristics of power systems derived from the model with imbalance power P_{nb} in model's input and frequency f in model's output

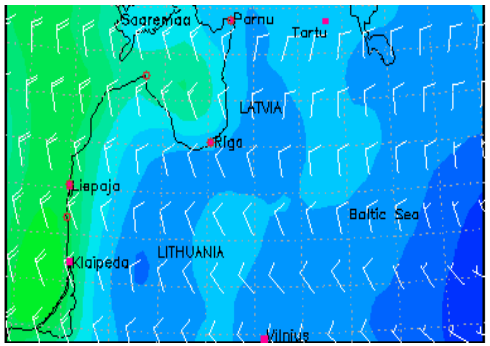
RENEWABLE GENERATION FORECASTING

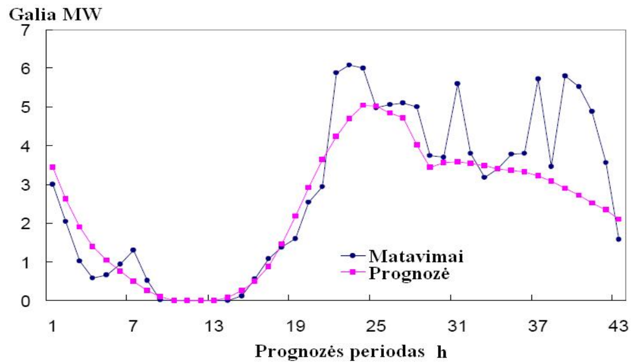
Partner: Laboratory for renewable energy and energy efficiency

Physical forecasting models



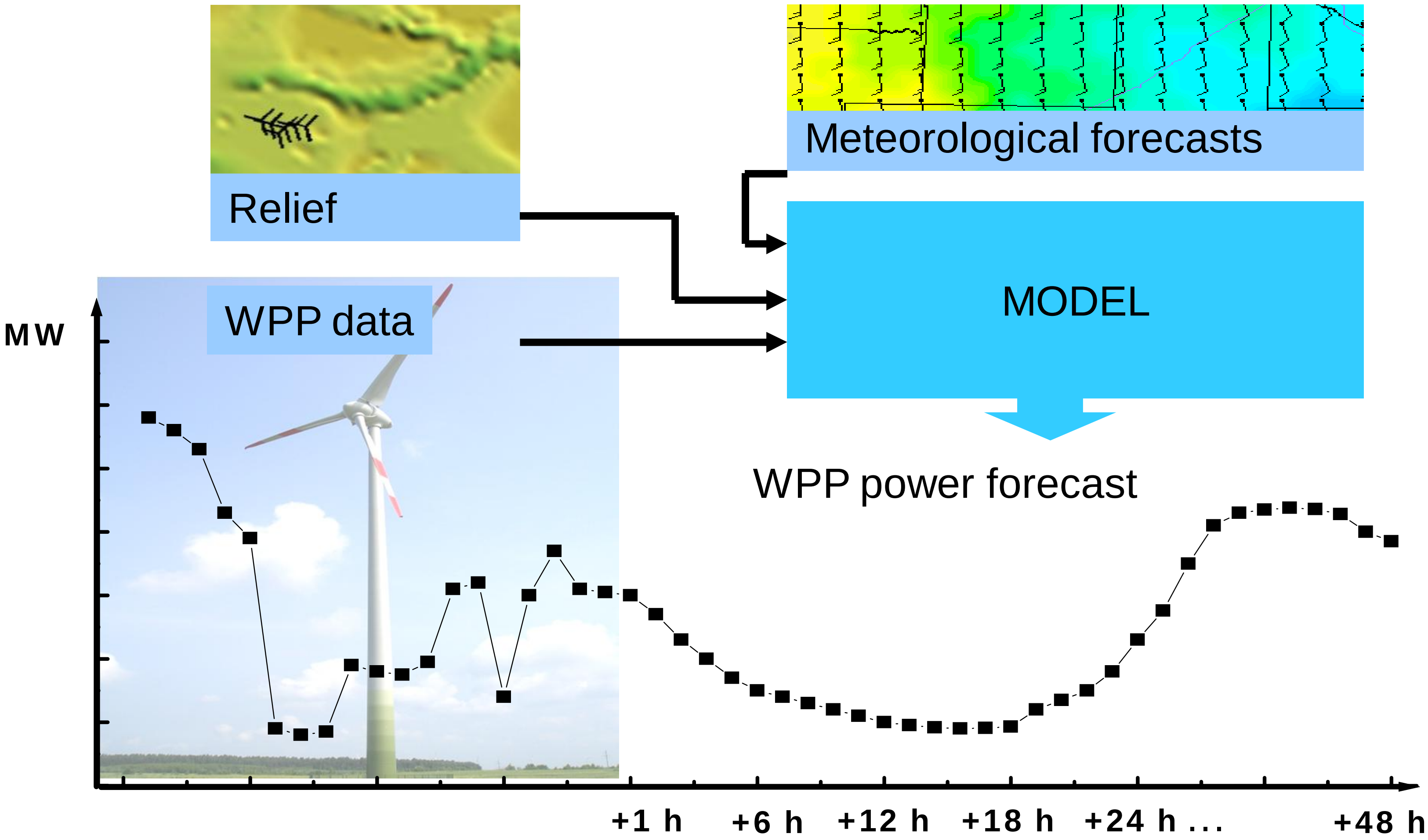






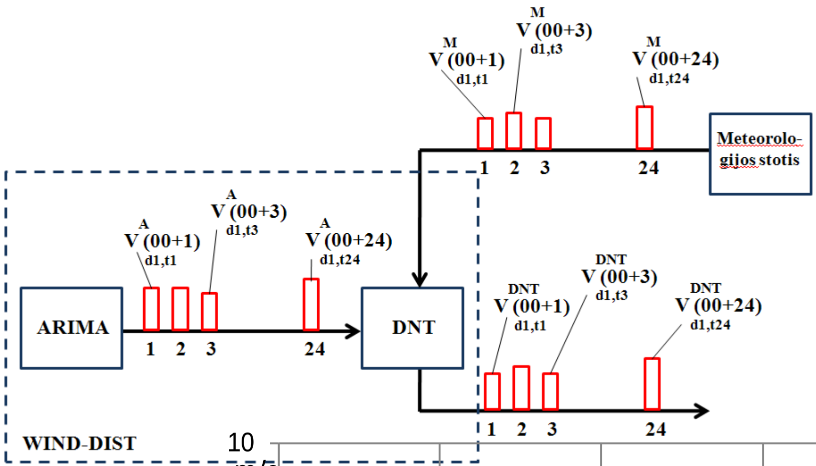
- ✓ Research and modelling of wind flow variation in different regions of Lithuania
- ✓ Development of short term wind power plant prediction system

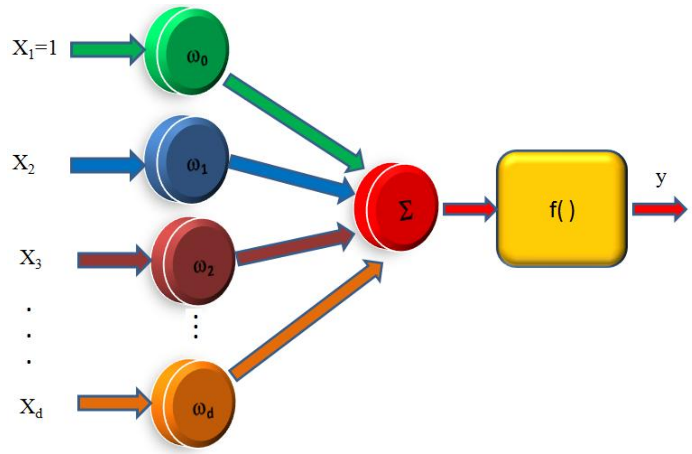
Physical forecasting models

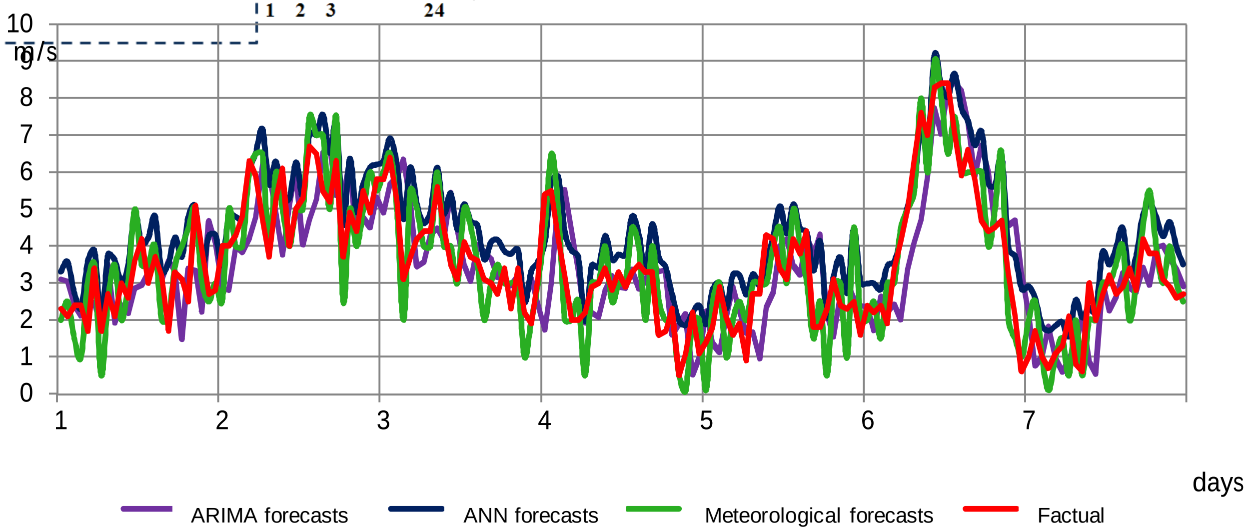


✓ Focus on short term forecasting period

Statistical / time series forecasting models







LABORATORY’S MAJOR RESULTS

International projects

7FP. *Planning for Energy Efficient Cities* **(PLEEC).** Coordinator: Eskilstuna Energi & Miljö AB, SWEDEN. 2013-2016.

7FP. *Product and Process Design for Ambient Intelligence Supported Energy Efficient Manufacturing Installations* **(DEMI)**. Coordinator: TECNALIA, SPAIN. 2010-2013.

H2020-LCE-2016-2017. *Keep the Energy at the right place!* (**EnergyKeeper**). Coordinator: Lithuanian Energy Institute, LITHUANIA. 2016-2019.

Projects

- National state-funded project *Operational planning of smart distribution grid.* Lithuanian Energy Institute, 2015-2017.
- National state-funded project *Research of application of small power wind power plants and solar energy systems and their extension possibilities in Lithuania.* Lithuanian Energy Institute, 2013-2014.
- *Analysis of Asynchronous Operation (Swings) in Cross-border Sections.* Report of Lithuanian Energy Institute under the contract with TSO Litgrid, 2013-2014.
- National state-funded project *Possibilities of Lithuanian power system synchronous operation with ENTSO-E taking into account perspective development of generation sources*. Lithuanian Energy Institute, 2012-2016.
- *Overview and Comparative Analysis of Lithuanian Power Reserve Market*. Report of Lithuanian Energy Institute under the contract with SC LIETUVOS ENERGIJOS GAMYBA, 2012-2013.
- *Analysis of Transmission Network Stability and Voltage Levels after Connection of Large Wind Power Park.* Report of Lithuanian Energy Institute under the contract with JSC VEVP. 2010-2011.

Publications included in THOMSON REUTERS WoS

- Augutis J., Žutautaitė I., Radziukynas V., Krikštolaitis R., Kadiša S. *Application of Bayesian method for electrical power system transient stability assessment* // International journal of electrical power and energy systems. 2012. Vol. 42, p. 465-472.
- Klementavičius A., Radziukynas V., Radziukynienė N., Pukys G. *Homogeneous generation period method for the analysis of wind generation variation* // Energy conversion and management. 2014. Vol. 86, p. 165-174.
- Radziukynas V., Klementavičius A., Radziukynienė N., Kadiša S. *Challenges for the Baltic Power System Connecting Synchronously to Continental European Network* // Electric Power Systems Research. Vol. 140, November 2016, p. 54-64.

Chapters in books published by renowned international publishing companies

Klementavičius A., Radziukynas V. *Differentiated reliability pricing model for customers of distribution grids* // Handbook of networks in power systems I. Energy systems / Ed. A. Sorokin et al. Part 1. Berlin Heidelberg: Springer-Verlag, 2012, p. 213-239.

Radziukynas V., Radziukynienė N., Klementavičius A., Naujokaitis D. *Operator's interruption cost-based sectionalization method for 3-feeder radial distribution architecture* // Optimization and security challenges in smart power grids / Ed. Pappu Vijay, Carvalho Marco, Pardalos Panos. Ser. Energy systems. Springer, 2013, p. 1-30.

Radziukynas V., Radziukynienė I. *Optimization methods application to optimal power flow in electric power systems* // Optimization in the energy industry / Ed.J. Kallrath, P.M. Pardalos, S. Rebennack, M. Scheidt. Springer, 2009, p. 409-436.

“REAL ACTIVITIES” PROPOSALS

EERA
ESI SP2

EERA *SP2 Forecasting, aggregation and control, WP2*

Proposed "real activity":

Coupling the wind and solar electricity generation forecasts in the EU with the exchanges of power generation reserves across the EU transmission networks

(Tasks 2.1, 2.2, 2.3)

Rationale:

It is necessary to evaluate the demand of cross-border balancing power in EU regions caused by large-scale wind&solar electricity integration

EERA *SP2 Forecasting, aggregation and control, WP3*

Proposed "real activity":
Development of integrated smart metering infrastructure (meters, communication, data concentrators) for electricity, heat, gas and water supply systems
(Tasks 3.1, 3.2, 3.3)

Rationale:
Multi-energy meters may be more cost-effective than single-energy meters

Technology:
Two-way data communication (network operator to/from meter)

Major output:
Infrastructure architecture, synergy evaluation

EERA *SP2 Forecasting, aggregation and control, WP3, WP4*

Proposed "real activity":
Development of innovative demand-side management methods targeted for integrated DA/real time control of loads in electricity, heat and gas distribution systems

(Tasks 3.1-3.4, 4.1-4.5)

Rationale:
The demand-side response could be introduced to heat and gas systems to support the demand response in electricity systems, virtual power plants and microgrids

Major output:
Demand-side response aggregation models, activation mechanisms, performance measurement indicators, synergy evaluation

EERA *SP2 Forecasting, aggregation and control, WP4*

Proposed "real activity":

Feasibility of integrated outage management system in urban area for electricity, heat, gas and water supply networks enabling remote monitoring of networks, identification of equipment failure site, the joint repair crews, and outage data management system

(Tasks 4.1-4.5)

Rationale:
Integrated approach couples different networks thus needing less resources for monitoring, identifying, site-visiting, repair and analysis activities than in case of individual networks

Major output:
Procedures, methodologies, synergy evaluation

EERA *SP2 Forecasting, aggregation and control, WP4*

Proposed "real activity":
Smart buildings and electricity & heat self-generating buildings interacting with electricity, gas, and districting heat and cooling networks

(Tasks 3.3, 4.1-4.5)

Rationale:
Building energy management systems have a huge energy efficiency potential

Scope:
Public and office buildings

Major output:
Infrastructure architecture, synergy evaluation

EERA *SP2 Forecasting, aggregation and control, WP4*

Proposed "real activity":
Feasibility of integrated network wear monitoring system in urban area for electricity, heat, gas and water supply networks enabling remote monitoring of equipment wear level, calculation of work life resources and predictive scheduling of repairs and replacements of worn-out equipment

(Task 4.1)

Rationale:
Ageing of networks could be monitored and unexpected outages could be prevented.

Integrated approach suggests less resources than individual network resources

References:
European Technology Platform for Smart Grids (2013): strategic research agenda for 2035

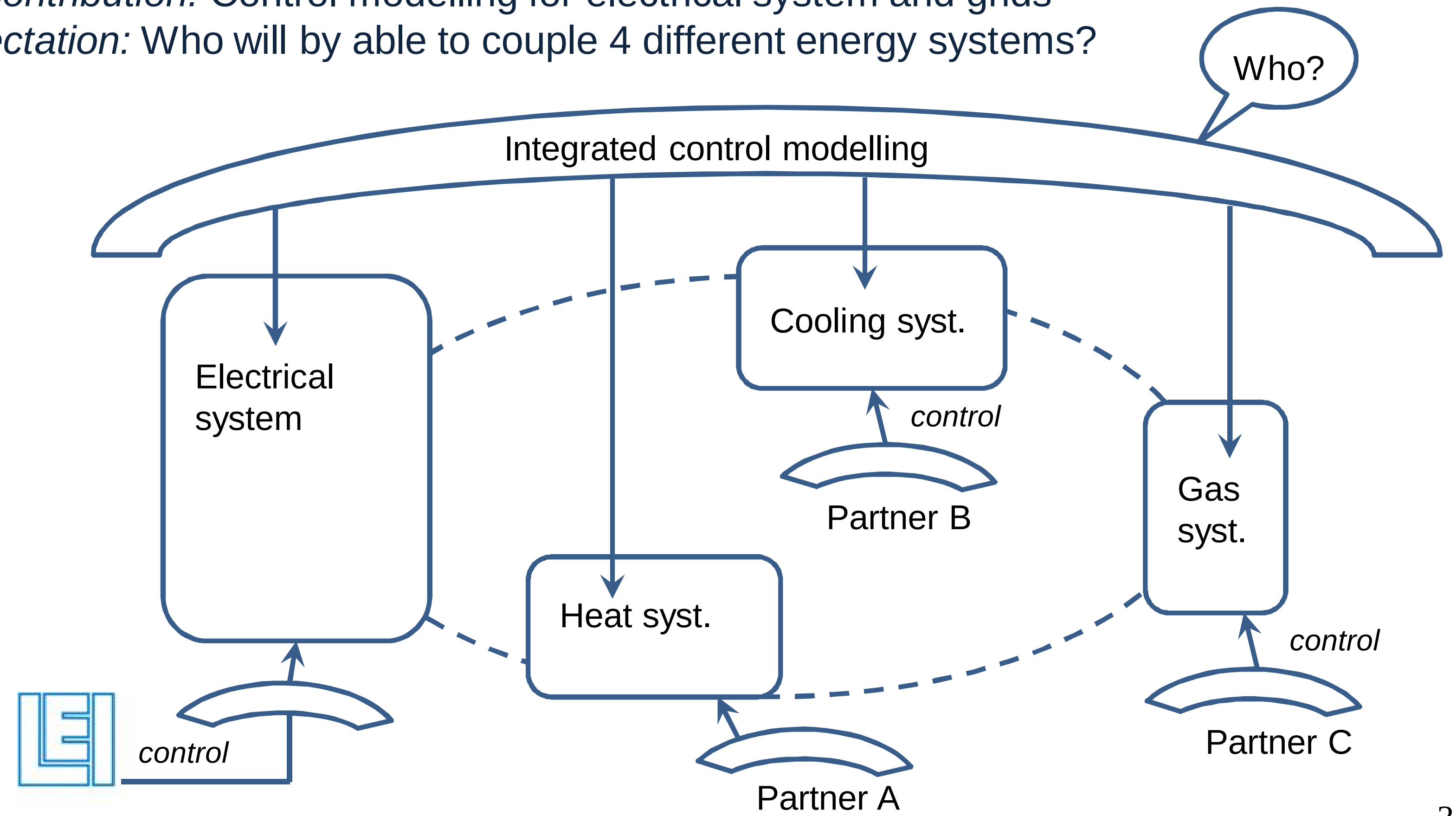
Major output:
Procedures, monitoring system architecture, synergy evaluation

DRAFT IDEA FOR INTEGRATED CONTROL

EERA
ESI SP2

EERA *SP2 Forecasting, aggregation and control*

Proposed idea: Control for integrated/multi-energy system
Problem: May the integrated control in short term and real time bring benefits and synergy?
Major output: 1) Outline of integrated control framework; 2) Control modelling results
LEI contribution: Control modelling for electrical system and grids
Expectation: Who will by able to couple 4 different energy systems?



Laboratory of Systems Control and Automation

Questions?

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