DERri
Distributed Energy Resources
Research Infrastructures

TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

User-Project Acronym	ITEH
User-Project Title	IT solutions for optimal strategy of energy technology choices
Main-scientific field	Modeling of DER and Smart grid element impact to the grid
Specific-Discipline	Smart house element modeling for algorithm and methodology creation

Lead User of the Proposing Team:

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Activity type and legal status* of Organization	State Research Institute
Position in Organization	Leading Researcher

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

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Position in Organization	Research Assistant

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Activity type and legal status* of Organization	State Research Institute
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Activity type and legal status* of Organization	State Research Institute
Position in Organization	Research Assistant

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

Date of submission	30. 7. 2012
Re-submission	YES_____ NO_____
Proposed Host TA Facility	DSM-EH (Research facility in portfolio of RSE)
Starting date (proposed)	1st October 2012

Summary of proposed research

The primary motivation of the work is required revision of operational and long-term management of distribution networks due to the substantial changes compare to the conventional pattern.

Increase of variable generation, introduction of DSM programs through controllable loads and market sensitive customer participation requires the setting up advanced strategies for network operation and energy management, prospectively with consequences to the network planning and dimensioning.

In frame work of project ***IT solutions for optimal strategy of energy technology choices*** will be elaborated by the Institute of Physical Energetics (IPE) methodology and network management algorithms applicable for the optimal sustainable development of the MV and LV networks with final implementation into new designed software instrument.

Current research related to the modeling of DER and Smart grid elements impact to the grid is based on Lab experience (FP6 project EU-DEEP) and focuses on DER decision making approach and implementation such as the DER design process, technology integration (ERA NET project SMARTGEN) and interconnection issues.

The focus on the energy management in distribution network via DER and load control in an energy and market perspectives, taking advantage of DERri ***(Demand side Management Experimental House (DSM-EH) in RSE)*** research facility with practical measurements and technology testing will considerably contribute to the quality and veracity of Lab research results in ongoing and forthcoming tasks. The results and new knowledge from the modeling and simulation will then be applied for development and evaluation of design methods including phase of decision making and investments planning for grids with active DER.

State-of-the-Art

Institute of Physical Energetics (IPE) is the leading institute in Latvia in the field of energy research. Its main activities cover a wide scope of energy research issues, such as the modeling and analysis of the energy - environment interactions, the energy - environmental policy studies, the pricing and tariff policy in the energy sector, the energy efficiency improvement and energy conservation programmes. Integration of the technologies directed towards the rational use of energy to ensure sustainable development of the Latvian energy sector and optimization of the heat energy production and consumption systems in Latvia are given special attention in the research work of the Institute.

IPE participated in various national projects such as National Research Programme "Technologies for Innovative Production and Use of Energy Resources and Provision of Low Carbon Emissions by means of Renewable Energy Resources, Support Measures for the Mitigation of Environmental and Climate Degradation".

Lab of PSMM at the IPE has experience with Elaboration of Criterion for Blackout Prevention; The Approach for Electrical Network Optimization under Liberalized Electricity market; The Approach for Energy Supply and DG System Development Strategies Research; The Network Reliability Optimization under Liberalized Electricity Market; Load Studies of Latvian Electricity Supply System; elaboration of the Development Dynamic Model for System „Distribution and Distribution Generation"; Information Technologies for Providing Sustainability of Transmission Electrical Networks and Generation,

Researchers of Lab of PSMM at the IPE have experience in EU FP6/FP7 projects. In FP6 project EU-DEEP (The Birth of a European Distributed Energy Partnership that will help the Large-scale Implementation of Distributed Energy Resources in Europe), and currently are involved in research of FP7 project ICOEUR (Intelligent Coordination of Operation and Emergency Control of EU and Russian Power Grids) and 1st SmartGrids ERA-Net Joint Call SMARTGEN (Efficient Identification of Opportunities for Distributed Generation based on Smart Grid Technology).

A key effort for research in the field of energy is the sustainable development of simulation and analysis framework that will contribute to reach the objectives of Joint Programme on Smart Grids Sub-programme 2: Energy Management. The framework of simulation and analysis will consider different types of distributed energy resources, energy controls, networks, and market characteristics.

IPE have contributed for the Sub-programme 2 of the EERA JP on Smart Grids. The contribution of IPE for Sub-programme 2 will focus on 3 tasks:

Task 2.1: Simulation and Analysis model.

- Review and analysis of existing models
- Identification of required extensions based on sustainable development methods
- Plan for development of future improvements
- Implementation of extensions in Baltic region
- Model validation with practical example

Task 2.3: Market Design with DER

- Improvement and Definition of bidding algorithms
- Definition of markets (with implementation to model)
- Analysis of DER impact (based on Simulation model)

Task 2.4: System Design with DER

- Review of current distribution network design procedures in Baltic Region

The Laboratory of Power Systems Mathematical Modeling at the IPE is long-experienced in a field of software development primary for the sustainable development management of power systems briefly overviewed below:

The software LDM is suitable for reinforcement planning of HV, MV and LV distribution network under information uncertainty. There are four main LDM functions: technical and economic estimation of the network, definition of economically appropriate actions from the given set of alternative actions (constructions, reconstruction or elimination of network elements) and terms of their realization, estimation of power supply quality and definition of the most effective actions to improve it, risk analysis as a decision-making tool under information uncertainty.

The software family consists of five software solutions:

- The software LDM-TG is suitable for sustainable development management of transmission network and generation. Including economic analysis and optimization of the development plans a method is proposed that takes into account the outlooks for upcoming 20-50 years and the initial information uncertainty. The developed methods make possible estimation of the technically-economic state, including market conditions and power system development.
- The software LDM-AVE performs investment efficiency analysis of reconstructing and new constructing 330-110-20-10-6kV network objects including local power stations, using technical economical calculation methods and dynamic optimization of network.
- The software LDM-VZ performs investment efficiency analysis of reconstructing and new constructing low voltage network objects and also of transformer substations (20/0.4 or 10/0.4 kV) under uncertainty, using a criterion of net present value (NPV) and dynamic optimization of network. LDM-VZ is suitable for using at the level of distribution network enterprises.
- The software LDM-SG is suitable for dynamic planning of medium voltage distribution network in urban and rural areas including DER analysis. Software allows making comparison in multi-step development up to 10 variants applying periodic regular year criteria with possibility calculating reliability and other criteria in each variant in each step.
- The software LOSSES – that is designed for the calculation of technical losses in low voltage including network designing. By special option this software provides commercial losses estimation.

The selected relevant Articles published by Applicant/s:

1. Z.Krishans, A.Mutule, Y.Merkuryev, I.Oleinikova. Dynamic Management of Sustainable Development. Methods for Large Technical Systems // Springer, London, 2011, P. 190. ISBN 978-0-85729-055-7
2. M. Turcik, I. Oleinikova, Z. Krishans Method of Power System Sustainable Development Optimization in Liberalized Market Conditions // Latvian Journal of Physics and Technical Sciences 2011, N3; (Vol. 48) June 2011, Riga, Latvia; DOI: 10.2478/v10047-011-0017-6;
3. M.Turcik, A.Obushev, I.Oleinikova. Interstate DC Line Performance Assessment Methods // The 3rd International Youth Conference on Energetics 2011 // Leiria, Portugal, July 7-9, 2011. - Conference Proceedings (on CD 7 pp.). ISBN 978-989-95055-6-8 (USB)
4. M.Turcik, I.Oleinikova, M.Kolcun. Inter-regional Transmission Capacity Development // International Scientific Symposium-Elektroenergetika 2011 // High Tatras, Slovakia, September 21-23, 2011
5. A.Obusev, A.Lvov, A.Mutule. Estimation of Small Scale HPP Affect on Distribution Network Reliability under Market Conditions // 8th International Conference 2012 Electric Power Quality and Supply Reliability (PQ2012). Tartu, Estonia, June 11 – 13, 2012. - Conference Proceedings ISBN: 978-1-4673-1978-2
6. A.Purvins, I. T. Papaioannou, I.Oleinikova, E. Tzimas. Effects of variable renewable power on a country-scale electricity system: high penetration of hydro power plants and wind farms in electricity generation// Energy, 2012, Vol. 43 ISSUE 1, 225.- 236. lpp. ISSN 0360-5442

7. M.Turcik, I.Oleinikova. Analysis of Electricity Market Price Formation Factors // The 9th Annual Conference of Young Scientists on Energy Issues "CYSENI 2012", Kaunas, Lithuania, May 24-25, 2012 - Conference Proceedings (on CD). ISSN 1822-7554
8. A.Mutule, A.Obusev, A.Lvov. The Approach for Hydro Power Plant Generation Optimization under Uncertainty // 13th International Scientific Conference Electric Power Engineering 2012 (EPE'2012). Brno, Czech Republic, May 23-25, 2012. - Proceedings of the 13th International Scientific Conference, Brno University of Technology, Brno, Czech Republic, 2012, P. 253-256. ISBN 978 - 80 - 214 - 4514 – 7
9. M.Turcik, I.Oleinikova, A. Obushev, M.Kolcun. Probabilistic Method for Wind Production Forecasting and Energy Markets Trades Optimization in Power System with Large Wind Specific Gravity // 12th International Conference on Probabilistic Methods Applied to Power Systems, Istanbul, Turkey, June 10-14, 2012, Proceedings of PMAPS 2012 (on CD pp.155)

Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental scientific and Technical value and interest

Required revision of operational and medium term and long term management of distribution networks due to the substantial changes also calls for new instruments in modeling which will help to handle this new tasks especially related to DER and other Smart grid elements with impact to the grid. The actually proposed research activity in field related to the energy management in distribution network is focused on Smart house element modeling for algorithm and methodology creation. Due to that reasons as most suitable DERri research facility has been selected RSE - Demand side Management Experimental House (DSM-EH).

As it's declared, facility makes possible to carry out several tests on different energy management strategies as well as simulation of the user presence via sub-system which operates domestic appliances. According to available description, research facility comprises central system for managing of loads and thermal system, automation system with possibility for setting various profiles and except usual home electrical devices and equipment also storage unit, a photovoltaic conversion generator as well as micro cogeneration unit.

All those DSM-EH functionalities will be used in order to test:

- energy management possibilities and evaluated based on monitoring of real-time consumption,
- demand control programs and demand-side management possibilities,
- DSM possibility for demand reduction,
- price formation monitoring depending on consumer behavior,
- voltage and connection monitoring,
- energy storage system possibilities,
- Smart house element modeling principals etc.

The tests performed in a DSM-EH shall contribute in following research targets:

- Estimation of coincidence in load diagrams and values of coincidence factors in a case of aggregated modeling of DSM-EHs.
- Difference in market prices according to involvement of responsive demand, possibly estimation of impacts by SGT equipped Smart-Houses to the final end-user prices.
- Specification of role and capacity requirements of energy storage (operational principles, behavior modeling).
- Specification of DSM-EH suitability according to evaluated reaction time and duration time i.e.

suited for: Day-ahead commitments (day-ahead market); Longer duration (operational reserve); Real-time response (regulation); Short duration (frequency regulation).

- Domestic appliance load characteristic modeling - Advanced load profile model development (e.g. Software libraries of load profiles)
- Comparison of functionalities implemented in RSE DSM-EH with those used currently by TSOs/DSOs on a basis of bulk remote control (e.g. HDO system in Czech republic, Slovakia)

Data and observations obtained in a particular DERri research facility might serve as input to the technical/economic feasibility studies which might be performed for different counties/areas, different market structures and operation, legislative environment, social conditions etc. In addition data acquired during simulations in DSM-EH research facility could be very useful for forthcoming researches related to the involvement of electrical vehicles into grid, combine possible charging profiles with uncertainty factor with different strategies (energy management strategies, inhabitants behavior, etc.) applied in DSM-EH. All those findings and data shall be transformed as improvements and extensions of conventional (traditional) planning and applied in design of new Information Technology for Optimal Energy technology choice and management principally shown on figure below.

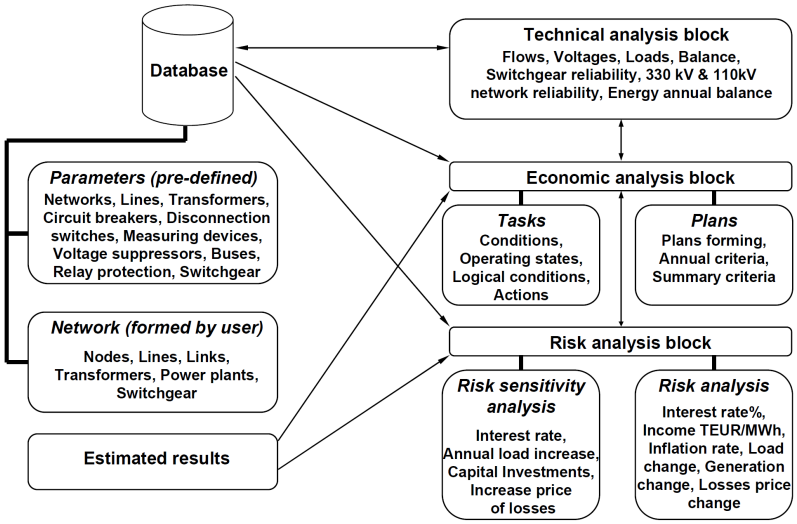

Fig. 1 Principal structure of IT technology

Besides using technical facility itself, one of the additional great benefits expected from the visitation and use of the DERri research facility is also in a form of possibility personally discuss those issues with local experts.

Originality and Innovation of proposed research – Broader Impact

The task within framework of this project is an implementation of Methods appropriate for the Power System Sustainable Development in liberalized market conditions for Smart Distribution Grid operation and control. Those Methods are uniquely elaborated by the IPE PSMM based on long-term experience with solving of real engineering tasks as well during designing of various software as presented in Ch. State-of-the-Art of this Proposal, those are also already published in Literature 1 (see Ch. State-of-the-Art/References).

The expected outcomes of work will contribute to the definitions of the guidelines for the decision making and planning phase of investments that concern MV substations, distribution network structure and equipment, in order to comply with requirements of smart energy delivery system in long-term. The presently proposed research activity in DERri research facility represents one of

the elements in overall Work Plan which covers, inter alia, a systematic overview on existing technologies and network design/operation practice, multi-criteria analysis of in-house and international experiences, best practice formulation. Preparation analysis and guideline for system approach in terms of network design and operation.

The aim of the final step is to devise the next generation of the software instrument appropriate for sustainable development and planning which will contribute to the successful, technically and economically optimal deployment of the smart grids.

Moreover, there is an considerable involvement of young researches to this particular research related to SGT and its applications by IPE which may bring an positive outcomes and inspiration to their research education.

Proposed Host TA Infrastructure/Installation – Justification

As the most suitable TA infrastructure for solving of complex issues related to the demand side management, automation and behavioral functionalities including DER and renewable generation has been identified Demand side Management Experimental House (DSM-EH) which is in research facility portfolio of the Ricerca Sistema Energetico (RSE). According to the available information about installed technology and testing possibilities DSM-EH, TA User/s do not intends to deliver any additional parts or components to be tested in proposed TA Infrastructure, the planning activities considering with use exclusively existing infrastructure and functionalities of TA Infrastructure.

Results from practical studies in Demand side Management Experimental House (DSM-EH) will contribute to the formation of the methodologies and algorithms for energy management strategies. It will facilitate the Analysis of DER impact to PS based on simulation results as well as contribute to the system modeling with DER including market behavioral characteristics of end-users, the gained outcomes will be applied in distribution network design procedures.

Synergy with ongoing research

Along with the proposed research, the relevant ongoing research most related to the Smart grid development and deployment is identified for *EERA JP on Smart Grid SP2 Energy management* and *SMARTGEN: Efficient identification of opportunities for Distributed Generation based on Smart Grid Technology*. Objectives of *SMARTGEN* are focused on increase penetration of SGT in European countries by introducing an efficient tool for identification of distributed generation (DG) and load management (LM) opportunities based on appropriate and socioeconomic use of SGT. The IPE in this task already developed:

- Developed detailed SGT-models with as accurate as possible load and production schedules for the 24 hours
- Developed the “SMARTGEN Models” which illustrates both energy resources and grid information visually by combining SGT scenarios with input from Geographical Information Systems (GIS) and Network Information Systems (NIS)
- Facilitate information sharing between system operators and project developers by introducing a planning tool which can be used by all parties in the development process

Both mentioned ongoing research projects are strands of IPE research activities, hence outcomes may be easy disseminated and applied among them.

Dissemination – Exploitation of results

- *Lectures, Bachelor, Master and PhD Theses:* Acquired results and knowledge will be implemented at the Riga Technical University lectures as well as Theses elaboration where IPE Researchers closely cooperates in students' education processes.
- *International/local conferences and seminars & publishing activities:* Research staff actively participates on various events on local and international level which giving opportunities to disseminate and discuss results of research activities. Those are published in numbers of reports and scientific journals including conference proceedings.
- *Regional and European-scale projects and activities:* The ongoing related projects and activities of IPE e.g. EERA JP on Smart grid, SP2 Energy management, SP 5 Transmission Planning ERA-NET: SMARTGEN, etc. In addition, Laboratory of Power System Mathematical Modeling at Institute of Physical Energetics is involved in project: European Social Fund Project „Scientific Group Supporting Latvian Activities of the European Strategic Energy Technology Plan", as task leader of activity "IT solutions for optimal strategy of energy technology choices" in the context of European Strategic Energy Technology Plan.
- *International working team of IPE PSMM:* International young team is an eligible and perspective scientific group with great potential of future use and dissemination of acquired knowledge.
- *Software:* Intended newly developed software instrument is an efficacious way to bring obtained results and knowledge from DERri research facility towards its users.

Time schedule

Optimal target starting date in research facility (DSM-EH) has been identified by Applicants on October 2012 with proposed duration 2 weeks (10 working days).

The rough estimation of working schedule:

- Deeper understanding and familiarize with available technology including preparations: 3 days
- Measurement and testing: 5 days
- Summarization and evaluation: 2 days

Indeed, those might be precisely specified after consultation.

Description of the proposing team

Irina Oleinikova

Doctor of Engineering (Dr.sc.ing.), was born in Riga, Latvia, on September 16, 1974. Received the BSc, E.E., MSc and Dr.sc.ing. degrees from the Riga Technical University, in 1994, 1995, 1997 and 2000 respectively. Author more than 120 papers, including 4 books.

Present position:

- Leading Researcher of the Institute of Physical Energetics, Laboratory of Power System Mathematical Modeling
- Associate professor at Riga Technical University
- Task leader 'IT solutions for optimal strategy of energy technology choices' of Project: European Social Fund Project „Scientific Group Supporting Latvian Activities of the European

Strategic Energy Technology Plan"
- Member of the Baltic Association of Electric Power System Researchers
- Expert of the Latvian Council of Science
- IPE representative in Board of Latvian Electrical power engineers and Electrical builders Association (LEEA)
- Sub-task leader (Transmission model development) in EERA JP on SmartGrid SP5 Transmission Planning. EERA JP on SmartGrid SP2 Energy management, participants.

Previous relevant experience:

Participation in EU Project of the FP6: "EUropean Distributed Energy Partnership (EU-DEEP), 2004-2008. FP7: ICOEUR, ERA-NET: SmartGen. (for more see Ch. State-of-the-Art/PSMM Activities in this document above)

Mario Turcik

Born in July 1985 in Humenne, Slovakia. Bachelor and Master degrees of the Electrical Power Engineering from the Technical University of Kosice, in 2008, 2010 respectively.

Actual status: Research Assistant in Laboratory of Electric Power System Modeling at the Institute of Physical Energetics in Riga (Latvia). PhD student at the Technical University of Kosice (Slovakia). Involved in EERA JP on SmartGrid SP2 Energy management and SP5 Transmission Planning. Field of professional and research interests: Power System Development and Planning, Design and Operation of Market with Electricity, Smart Grids.

Anna Mutule

Doctor of Engineering (Dr.sc.ing.), was born in St.Petersburg, Russia, on December 16, 1975. She received the BSc and MSc and Dr.sc.ing. degrees from Riga Technical University, in 1999, 2002 and 2005 respectively. Author of 80 papers, including 1 book.

Present position:
- Leading Researcher of the Institute of Physical Energetics, Laboratory of Power System Mathematical Modeling
- Assistant professor at Riga Technical University
- Task leader 'Research of European Smart Grids' of Project: European Social Fund Project „Scientific Group Supporting Latvian Activities of the European Strategic Energy Technology Plan"
- Member of the Baltic Association of Electric Power System Researchers
- Expert of the Latvian Council of Science
- Member of the Board of Latvian Electrical power engineers and Electrical builders Association (LEEA)

Previous relevant experience:

Participation in EU Project of the FP6: "EUropean Distributed Energy Partnership (EU-DEEP), 2004-2008. FP7: ICOEUR, ERA-NET: SmartGen;´

Programme Chair of the Latvian State Research Programme Project: Elaboration of the Development Dynamic Model for System „Distribution Networks and Distribution Generation", 2006-2008.

Artjom Obushev

Born in Riga, Latvia on November 7, 1986. Received his BSc, MSc degree from the Riga

Technical University, in 2008 and 2010 respectively. Currently he is PhD student in Riga Technical University.

Actual status: Research Assistant in the Laboratory of Power System Mathematical Modeling at the Institute of Physical Energetics.

Field of professional and research interests: Methods of Mathematical Modeling of Electrical Networks and Systems.

Additional, non-direct users and specifications related to participation of the proposing team:

All members of the proposed team are members of the research staff of PSMM at the IPE. Irina Oleinikova and Anna Mutule working as Leading Researchers, Mario Turcik and Artjom Obushev as Research Assistants and at the same time PHD students. Moreover, on annual basis our Lab hosts several bachelor and master students which may be assumed as non-direct users of outcomes from DERri.

From the proposing team for the personal participation in DSM-EH during the full scheduled time period 2 weeks (10 working days) is nominated Mario Turcik.

Irina Oleinikova is intended as second user who may join the DSM-EH during proposed, scheduled time period, however, only for shorter time e.g. 3 days, in order to be able familiarize with technology and use acquired knowledge in further research and educational tasks.