Akademie věd České republiky
Strategie AV21
Špičkový výzkum ve veřejném zájmu

MODELLING SMART GRIDS 2018

Modelling, Optimization and Detection

Akademie věd České republiky

MOD workshop

September 20, 2018

CIIRC, Jugoslávských partyzánů 3, Praha 6

metro A Dejvická

Energy Day 2018

September 21, 2018

Czech Statistical Office, Na padesátém 81, Praha 10

metro A Skalka

System Modelling

September 22, 2018

Czech Technical University, Karlovo nám. 13, Praha 2

metro B Karlovo náměstí

CAAT

General programme

Thursday, September 20, 2018

8:30 – 17:00	Registration
8:55 – 9:00	Opening
9:00 – 12:30	Modelling, Optimization and Detection I
12:30 – 14:00	lunch
14:00 – 17:30	Modelling, Optimization and Detection II

Czech Technical University, Czech Institute of Informatics, Robotics and Cybernetics, Jugoslávských partyzánů 1580/3, 166 36 Praha 6, Dejvice; GPS N 50°6.23817', E 14°23.67588', metro A Dejvická

Friday, September 21, 2018

8:30 – 9:00	Registration
8:25 – 8:30	Opening
8:30 – 13:30	Energy day 2018: Keynote lectures
13:30 – 14:00	lunch
14:00 – 16:00	Energy day 2018: Round table discussion
16:00 – 17:00	Conclusions of the Round table discussions of Energy days 2015 - 2018

Czech Statistical Office, Na padesátém 3268/81, 100 82 Praha 10, N50°4.20417', E14°30.47880', metro A Skalka

18:30 **Informal discussion meeting *Future of energetics*, Violino klub, Krakovská 5, Praha 1**

Saturday, September 22, 2018

8:30	Registration
8:55 – 9:00	Opening
9:00 – 12:10	Energy system modeling

Czech Technical University, Faculty of Mechanical Engineering, Karlovo náměstí 13, Praha 2, building A, room 312
GPS N 50°4.57418', E 14°25.14200', metro line B station Karlovo náměstí

Keynote Lectures

Hynek Beran
Czech energetics after 2022

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Energy system story

The energy system of the Czech Republic, similarly as the energy system of the majority of European countries, has been developed in the period between 50´s and 80´s of the last century, i.e. between the end of WW II and the political changes in 1989. Energy production on both sides of "iron curtain" was a strategic industry providing energy to produce steel, weapons etc. After the political changes the heavy industry has been significantly reduced, however, the surplus in installed capacity of power plans remained. This surplus has been the "physical" origin of market design. Cheap energy enabled rapid development of alternative consumption, e.g. hypermarkets, air conditioning etc. No special measurements for system control in the infrastructure have been taken, the prevailing system up to now is only surplus – market. On the other hand huge market deformation suppressed all natural investment activities. Subsidized renewable and debited fossil resources together on the market compete for variable costs.

Risks and Challenges of the 20´s

After 2022 significant changes and risk factors are expected:

a) About 40% of fossil power plants will not meet the new European emission limits and will be closed
b) In neighboring Germany all the nuclear power plants will be closed. The power lines from the North from offshore and deep offshore wind power plant will not be ready
c) CZ has two nuclear power plants. The elderly one, Dukovany, needs prolongation of safety certificates after 2025. Both the technological and political situation is not 100% clear.
d) Main renewable energy in CZ is solar. The installed capacity grows up. This energy I unstable and dependent on weather – i.e. requires additional system regulation or storage.

The expected results from the above mentioned situation are:

- ✓ After 2022 or 2025, Czech Republic can have problems with balancing the system on the hourly base. Surplus at noon caused by photovoltaic + nuclear, deficit at morning and afternoon peak.
- ✓ When closing lignite power plants, CZ stops to be and energy exporting country and remains a country with a neutral power export / import balance. The surplus of regulatory capacity / ancillary services on exporting lignite power plants will be significantly reduced.
- ✓ When closing also nuclear power plant, the balance is about minus 20%. No export from neighboring countries can be expected, however, gas turbines can be used.

Need of new system design

This situation is a great challenge to develop new strategy of energy system control based on Energy 3.0 (i.e. automatization in the infrastructure) and Energy 4.0 principles. The main features are:

a) Significant part of the system control must be in the embedded structure cooperating with the central system.
b) In the time of deficit, the system must not provide "rolling blackout". It should be designed to distribute the energy to intelligent infrastructures, which can regulate themselves, and it has to communicate with their requests, not only to switch them off.
c) The origin of the above mentioned tasks is primarily technological. They are sophisticated control tasks. New methods are to be used for such system (predictive control, multi agent, etc.).
d) On the other hand, both the legislative rules (unbundling) and the possibility of both market and distribution tariff motivation must be taken into account.

Hynek Beran is specialist in power system control and energy policy. Secretary of the Energy Commission of the Czech Academy of Sciences, head of Workgroup "Knowledge power systems" at Czech Institute of Informatics, Robotics and Cybernetics of the Czech Technical University, founder of the Czech Energy Society. Former secretary of the Independent Energy Commission of the Czech Government. Professional experience in power system control, normative of power system reliability and market design- Participant of the grant „Implementation of the Renewable Energy – security of supply". Business experience in development of EMS, international consulting in Slovakia, Russian central dispatch company and other countries. Today oriented to system stability and transformation using decentral and renewable energy. Professionally interested also in social impact of energy transformation, tariffs, impact on environment and social adequacy.

Jakub Kúdela et al.
Applications of advanced cloud technologies in energy sector

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According to McKinsey analysis new technologies may have demonstrable impact on utility earnings at the level of 23% EBIT improvement all along the value chain from generation, distribution to retail. At Microsoft CZ we built digitized energy value chain model to demonstrate how modern technologies like AI and IoT can have a real impact on the industry. The goal is to showcase several business scenarios that are relevant to utility stakeholders combining physical and digital world.

Purpose Technology can not only help accomplish specific goals, but it can also help connect people, processes, things and data to enhance the fundamental agility and insight of organizations, empowering people to recognize and act as quickly as today's fast-changing world requires.

Contribution We have built functional business scenarios like connected drone, workplace safety or remote monitoring on top of open-source technologies like CNTK framework. We believe the value is not only in real time data processing, but these solutions can eventually be used by businesses to optimize their operations.

Keywords Cloud, data, AI, IoT, digital utility

Jakub Kúdela is currently Account technology strategist at Microsoft CZ performing in-depth analysis and data-driven support of decision making for management and other business users.

T. Piasecki et al.
Advanced metering infrastructure solutions for smart grids

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The presentation describes the Huawei perspective of modern telecommunication technologies adaptation in SmartGrids environment bringing new opportunities that become available. Special attention is pun on AMI systems when the new generation of PLC communication comes into the market. Broadband Power Line communications play similar role as 4G technologies in GSM world – brings totally new quality of services available for harsh industrial environment. Huawei as the leading ICT solutions company has developed a PLC-IoT specification which offers raw bitrates up to 25 Mbps in PHY layer and operates in frequency range 2-12 MHz. The specification is able to fully comply the European standards and also exist as international standard IEEE 1901.1.

T. Piasecki is Solution director for Energy sector, CEE&Nordic Regional Region, Huawei. He has more than twelve years' experience in Smart Grids systems and Smart Metering projects operating in Europe:

- Almost two years in Huawei – the world leading ICT company, as the energy sector expert for Smart Grids technologies.
- Six years of cooperation with ENERGA-Operator – the most innovative DSO in Poland, supporting the AMI project implementation and the development of the operator's IT architecture. Also the Board of Directors member representing this utility company in the PRIME Alliance Association for more than two years.
- Five years of experience as the member of high executives of APATOR SA, a leading Polish manufacturer of smart meters - taking positions of R&D Department Director, a proxy of the company, as well as Secretary of the Supervisory Board of the subsidiary company APATOR Rector. Active promoter of PLC technologies in Poland and the region. More than twenty-five years' experience as a developer, designer, analyst and IT architect.

Jean-Michel Poggi
Disaggregated electricity forecasting using wavelet-based clustering of individual consumers

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Recently, the increasing deployment of smart grids infrastructure requires the development of more flexible data driven forecasting methods adapting quite automatically to new data sets. The idea is to disaggregate the global signal in such a way that the sum of disaggregated forecasts significantly improves the prediction of the whole global signal. The strategy is in three steps: first we cluster curves defining super-consumers, then we build a hierarchy of partitions within which the best one is finally selected with respect to a disaggregated forecast criterion. The proposed strategy is applied to a dataset of individual consumers

from the French electricity provider EDF. A substantial gain of 16 % in forecast accuracy comparing to the 1 cluster approach is provided by disaggregation while preserving meaningful classes of consumers. From a statistical viewpoint, the proposed approach combines several tools: wavelets to represent curves, wavelet-based hierarchical clustering to aggregate customers and non-parametric forecasting using the kernel method to forecast electricity consumptions. This talk is related to a sequence of joint papers, from 2012 to 2017, authored by J. Cugliari, A. Antoniadis, X. Brossat, Y. Goude, J-M. Poggi.

Jean-Michel Poggi is professor of Statistics at Paris-Descartes University and Lab. Maths Orsay University. His research interests are in time series, wavelets, tree-based and resampling methods, applied statistics. Research activities combine theoretical and practical contributions together with industrial applications (mainly environment and energy) and software development. He is Associate Editor of three journals: Journal of Statistical Software, CSBIGS (Case Studies in Business, Industry and Government Statistics) and Journal de la SFdS. He is Elected Member of the ISI. He is Vice-President of ECAS, member of the Board of Directors of the ERS of IASC, Council Member of the ISI.

Jaroslav Sixta
Energy statistics in national accounts

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Energy sector plays a very important role in the operation of any economy and its specificity shall be adequately reflected in macroeconomic statistics. This concerns price statistics, foreign trade statistics and not least national accounts and GDP. We will thus present and discuss the treatment of energy sector in the above-mentioned statistical areas as well as the treatment of emission trading permits.

Jaroslav Sixta, vice-president of the Czech Statistical office from April 2018, has been professionally engaged in the field of macroeconomic statistics and national accounts. He contributed to implementation of European national accounts standards (ESA 1995 and ESA 2010) at first in the area of non-financial assets and useful life models, then in input-output tables. Concurrently, he cooperated also in capitalization of intangible assets in accordance with the ESA 2010 standard. Besides his work for the Czech Statistical Office he devotes his time also to scientific and pedagogic activities in the domain of economic statistics and national accounts at the University of Economics, Prague, Czech Republic. He cooperated there in estimates of the gross domestic product of the CR for the years 1970 to 1989. He is also an author or a co-author of two teaching texts and over a hundred of scientific and professional papers, conference papers, and research studies.

Invited and contributed presentations

Jaromír Antoch
Prediction in extremely short time series

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Prediction of the next value, respectively estimation of the probability of exceedance over a given threshold in very short (7-10) or extremely short (4-6) observations is a complicated problem. In this lecture we will present one possible approximate approach based on the growth curves. Our ideas and experience will be illustrated on real data set.

J. Antoch is professor of statistics at the Charles University of Prague. He is author of many papers and books published by prominent publishing houses. He is specialized especially in simulations, robust statistics, change point detection and applied statistics. He served, among others, as President of the International Association for Statistical Computing, member of the Council of the International Statistical Institute, President of the Czech Statistical Society, etc.

Marek Brabec
Statistical surveillance in gas distribution networks

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In this work, we will consider a problem of surveillance for a natural gas distribution network and how it can be tackled with formalized statistical modeling approaches. The monitoring is based on measurements of daily throughputs in regulation stations. Regulation station is a hub that serves a local (closed) network of hundreds to thousands of end-customers. Due to technical problems, different throughput irregularities happen during routine gas distribution network operation. The simplest is the case of zero flow due to an accident or maintenance, but many other, more complicated irregularities occur (e.g. proportional reduction due to the pressure decrease, or increase due to the pipeline leakage, illegal consumption, etc.). On the other hand, the normal trajectory of the daily flows is quite complicated, being strongly dependent on weather (primarily on temperature). We need to account for these influences properly in a statistical model to be able to distinguish between normal and unusual values

or trajectory segments with good operational characteristics. To this end, we model the dependency of the flows on ambient temperature and its lags either in a Generalized Additive Model or in a state-space model for the time series of flows. Here, several complications arise, because the relationship to temperature:

i) is nonlinear,
ii) comes as a distributed lag submodel,
iii) is time-varying (with much more flat structure during warmer parts of the year than during the Winter).

We account for these features by details of the temperature sub-model inspired by the structure of the temperature dependence in the official Czech Republic Standardized Load Profiles for natural gas that our team developed previously. Once the state-space model for the set of monitored stations is estimated/filtered/predicted, we use it for various checks both in online and offline regimes. These include not only innovation residuals but also much more focused characteristics like the discrepancy between temperature response on a given station and on the majority of others. We illustrate both the models and monitoring statistics performance on real data from the Czech Republic.

Marek Brabec is leading scientific worker at the Institute of Computer Science of the Czech Republic. He is author of many papers published by prominent publishing houses. He is specialized in statistical modelling.

Ivo Bukovský et al.
Multi-scale uncertainty analysis for oxyfuel combustion

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The oxyfuel combustion in a bubbling fluidized bed combustor is relatively new technology, and the combustion process represents a complex nonlinear nonstationary process, where it is also impossible to observe all necessary process variables to reliably determine system behavior, i.e. to properly design state vectors for reliable predictive models. In our work, we study the original method of Multi-Scale False Neighborhood Analysis (MFNA), this time, with focus on oxyfuel combustion process data and we compare the method with potentials of other relevant methods, such as the linear cross-correlations and nonlinear mutual information. The outcomes of the method is the evaluation of uncertainty in input-output data, i.e. the evaluation of uncertainty between measured system states and process output variables that can serve for better design of predictive models such as polynomial regressors or neural networks.

Ivo Bukovský is associate professor at the Czech Technical University in Prague. Currently he serves as the head of Department of Instrumentation and Control Engineering. Artificial intelligence, higher order neural networks, time series analysis and prediction, and nonlinear adaptive control multi-scale analysis belong to his main areas of interest.

Eliška Cézová
Statistical process control in energetics

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Important part of the Czech electricity is produced since almost 70 years in coal power plants, most of them located in NW of the Czech Republic typically very close to the open-cut coal mines. In this lecture we will concentrate on selected problems of the statistical process control that can be used for their incident-free functioning.

Eliška Cézová is assistant professor at the Czech Technical University in Prague. She is specialized in statistical process control.

Michal Černý
Selected problems in optimization

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Mical Černý is professor at the University of Economics Prague. He is author of many papers and books published by prominent publishing houses, specialized in the theory of complexity of algorithms, econometrics and optimization, among other topics.

Gejza Dohnal et al.
Multi-scale uncertainty analysis for oxyfuel combustion

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This lecture introduces a bridge between Learning Entropy (LE), which was introduced a few years ago as a novel concept of "non-probabilistic information measure" of learning process of incrementally learning systems, and a classical multivariate statistical process control (SPC) approach to sequential on-line change point detection. Using SPC methods we are able to quantify and detect "unusual learning effort" and hence the change of underlying process behavior during a process monitoring without any consideration about the underlying process.

Gejza Dohnal is professor at the Czech Technical University in Prague. He is specialized in statistical process control, reliability, quality control, and statistical applications. He successfully lead many large projects, let us mention REQUEST among others.

Zdeněk Fabián
Uncertainty and information

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What amount of information carries one item taken from a continuous distribution (relative to other possible values)? What is the mean information of a continuous distribution? The statistical notion, Fisher information, carries information about a parameter involved only. As mean uncertainty is usually considered the continuous equivalent of Shannon's entropy, the differential entropy. However, its value can be negative! Does it have any sense? Is it eligible to extrapolate theory developed for discrete models to continuous models with infinite support? In our contribution we provide unexpected solution: Mean information of continuous models is extended Fisher information, mean uncertainty is its reciprocal value.

Zdeněk Fabián is scientific worker at the Institute of Computer Science of the Czech Republic. He is specialized in information theory, modelling uncertainty and the use of artificial intelligence in data analysis and modelling.

Francisco Urbano Garcia
Sensors Selection via Autoencoders : Showcase for the aerospace industry

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When selecting the sensor measurements that will eventually make it into a commercial product from a set of sensors installed in a development product, a variety of reasons may be considered ranging from cost to weight and, of course, the utility of such information for a specific business purpose —usually maintenance and health monitoring. We explore in this paper the use of auto encoders for such task for one main reason; auto encoders' uncanny ability to detect potentially complex non-linear relationships in data where more traditional and linear methodologies would readily miss them. This approach will allow to select a smaller set of sensors without loss of information when non-linear relationships are present or, alternatively, increase the amount of useful information for a given number of sensors. As a showcase for this approach we will be using data coming from sensors installed in a GE Catalyst (c) turbo-propeller engine testbed.

Francisco Urbano Garcia is a scientific worker General Electric Aviation CZ, a world-leading provider of commercial, military and business and general aviation jet and turboprop engines and components as well as avionics, electrical power and mechanical systems for aircraft. He is specialized in proposing complex measurement and monitoring, maintenance policies, and subsequent data analysis and modelling.

V. Holý et al.
Time dependence of arrivals in queuing models

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A common assumption in the queueing theory is that times between arrivals follow the exponential distribution with a constant rate. We relax this assumption by considering a much broader class of the generalized gamma distribution. More importantly, we allow the mean duration (inverse of the rate) to be time-varying in two following ways. First, seasonal and diurnal patterns in arrivals are captured by the cubic spline. Second, clustering of arrivals is captured by the generalized autoregressive score model. This leads to a more faithful representation and more accurate predictions of the mean and extreme values of the arrival process. As an application, we optimize the number of servers with regard to extreme values of arrivals. We demonstrate the added value of our approach in an empirical and simulation study.

Vladimir Holy is postdoc at the University of Economy, Prague, specialized in econometry.

Miluše Kavěnová
Recent developments and challenges in energy statistics

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Abstract
Energy statistics in the Czech Republic are responding especially to national and EU policy-makers' growing needs and requests for more detailed and more recent data, going beyond energy balances, as a way to support decision-making processes. Energy balances remain the most important and most used tool, but an increasing focus is also being placed on energy efficiency indicators, physical energy flows and the development of new common IT tools. This trend is then implemented with the existing European, international and national organizational set-up of institutions involved in energy statistics, in which various stakeholders at various levels have interconnected roles. This includes several institutions at the national level, and this, in turn, has necessitated increased communication and coordination between stakeholders.

Miluše Kavěnová is the head of the Energy Statistics Unit in the Czech Statistical Office (CZSO). She has been with the CZSO since 2007, heading the Energy Statistics Unit from 2016, after having led the Statistical Survey Coordination Unit in the General Methodology Department.

Lubomír Lízal
Economical aspects of the development of decentralized energetics: Grid tariffs and economical motivation

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Both current grid tariffs or newly considered "Smart" tariffs determine behavior of consumers. Each tariff scheme motivates to a different behavior and has, among others, impact on the stability of the network and investment activities. In this lecture we will concentrate especially on the economic aspects of these problems.

Lubomír Lízal, Anglo American University President from August 2018, is a Czech economist who served most recently as a member of the Bank Board of the Czech National Bank. He has worked as a senior researcher in the Economics Institute of the Academy of Sciences of the Czech Republic and as an associate professor at CERGE UK. He also served as a joint director of these institutes. He is a member of many renowned scientific boards including the Scientific Council of the Faculty of Electrical Engineering at the Czech Technical University and the Czech Statistical Council of the Czech Statistical Office. He was a member of the National Economic Council of the Government and is a member of the supervisory board of energy company ČEZ.

J. Picek
Construction of (not only) power plants and analysis of climatological data

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Lecture will be devoted to the problem of estimation and prediction of "high" quantiles of temperature and precipitation series. Seemingly simple statistical task becomes very complicated if the data, on which the decision is based, are short, being unfortunately standard situation in the case of most of environmental data. There will be discussed different approaches suggested both for the estimation and construction of prediction limits. This seemingly academic problem becomes one of the crucial questions when power plant of any type is projected and the impact of the weather has to be taken into account.

J. Picek is professor of applied mathematics with expertise in statistics. He is author of many papers and books published by prominent publishing houses. He serves since 2016 as dean of the Faculty of natural sciences of the Technical university of Liberec. He is specialized especially in robust statistics, statistical climatology, climate variability and detection of climate changes.

Jiří Plešek, Miroslav Chomát
Strategy AV21

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Top research in the public interest" is the motto of the new strategy of the Czech Academy of Sciences, which presents itself more strongly as an institution whose primary mission is high quality research focused on the problems and challenges faced by contemporary society. Topics such as the **future of energy in the Czech Republic**, public health or the quality of public policies involve complex sets of problems, the solution of which requires broad-based interdisciplinary research. The Czech Academy of Sciences has therefore adopted Strategy AV21 based on a set of coordinated Research Programmes utilizing interdisciplinary and inter-institutional synergies in order to identify the problems and challenges of our time and to harmonize the efforts of research institutes of the Czech Academy of Sciences towards their solutions. Concise information concerning the topics concerning energy will be presented.

Jiří Plešek and Miroslav Chomát are representatives of the Institute of Thermomechanics highly involved in the project *Strategy 21* of the Czech Academy of Sciences.

Václav Pokorný
Energetic system management in practice

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Energetic system management system offer complex solutions for the energy administration on one hand and securing energetics needs in a long-term horizon. Emphasis is usually on the long term ahead prediction of the energy consumption and prediction of the development of the market. In the lecture we will concentrate on selected economical and technical aspects neede d for its successful running and administration.

Václav Pokorný is PhD student at the Czech Technical University in Prague.

L. Volf, J. Svoboda
Tools and approaches for real-time monitoring and control of local energy networks

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"You can't control what you can't measure." This rule is valid more than where else in energy distribution networks field. An operator of a local distribution network, i.e. an energy distributor, has to combine its interests and priorities (consumption curve as flat as possible) with an energy trader contradictory interests (energy well to buy and better to sell, regardless of how it is distributed). We have developed hardware and software tools and approaches to measure and control appliances, based on a superefficient communication-database platform. It allows collecting information from a structured data network (electrometers, thermometers, pressure gauges and other sensors), these data in real-time processing and then control the network (e.g. to balance on the basis of the current state of the electricity market). We are open to offering the real data in real-time (including all the historical data) and the real energy infrastructure for verification of optimization models and hypotheses.

Keywords Energy, distribution, network, control, measure, trader, market, data, electrometer, optimization

AlbisTech is a private company which is on the energetics market since more than ten years. AlbisTech provides a unique systems for real-time management of its business emphasis on a combination of different cost sources, that save routine operations in depatments of energy distribution, health care, etc. Their system NEST OF ENERGETICS (NEO) is an autonomous system providing functions replacing human work, from monitoring measured values of energy consumption and supply, through monitoring of the state and quality of the network, automated evaluation, reporting, and billing to customers. It belongs among the total life cycle systems. Thanks to the high-performance technology, it is able to handle any number of consumption points, in a 15-minutes multichannel profile, with full data history and real-time.

Tupý, Teringl, R. Lamich
Asset renewal in ČEZ Distribution using technical condition evaluation tools

ČEZ Distribution, Prague
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The aim of the presentation is to introduce mid and long-term asset renewal cost simulations of distribution network for high voltage (hv), middle voltage (mv) and low voltage (lv) with use of predictive and simulation tools based on technical condition evaluation. The presentation is focused on multi criterial technical evaluation of asset condition and use of CAPEX and OPEX simulations for strategic management and investment plan preparation including visualization of technical conditions of assets in GIS.
R. Lamich, Tupý and Teringl are managers in the division Strategies of distributor's activities of ČEZ.

Vladimír Wágner

Possible scenarios and risks of Czech power industry development

Czech Academy of Sciences, Nuclear Physics Institute, Prague
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Possible scenarios of the Czech power industry future will be discussed. The two critical points are expected during next thirty years. Many coal power stations will be closed during start of twenties not only in the Czech Republic. All Germany´s nuclear reactors will be shut down in stages by the end of 2022. Annual Czech electricity production will tightly cover consumption in this time but coverage of daily and seasonal demand diagrams by the existed capacity will be difficult without significant grid and accumulation improvements. Not only nuclear power station Dukovany will be shut down during thirties. New power capacity should be ready in this time.

Vladimír Wágner joint Nuclear Physics Institute of ASCR just after ending of his university studies of nuclear physics on Faculty of Mathematics and Physics of Charles University. He was member of group which studied nuclear structure using nuclear spectroscopy methods up to 1990 and now he is member of Relativistic Heavy Ion Group. He made his diploma and Ph.D. thesis dealing with a structure of deformed nuclei at this institute. Presently he is studying mainly hot and dense nuclear matter. Such matter is for example inside neutron stars or is produced during supernovae explosion. Small volume of such matter is possible produce by collision of heavy nuclei accelerated to the very high energy (nucleus velocity near to the velocity of light). He is involved also to the studies of possible application of relativistic proton reaction with thick target for neutron production and using of obtained neutron field for transmutation of radioactive waste.

Local Organizing Committee

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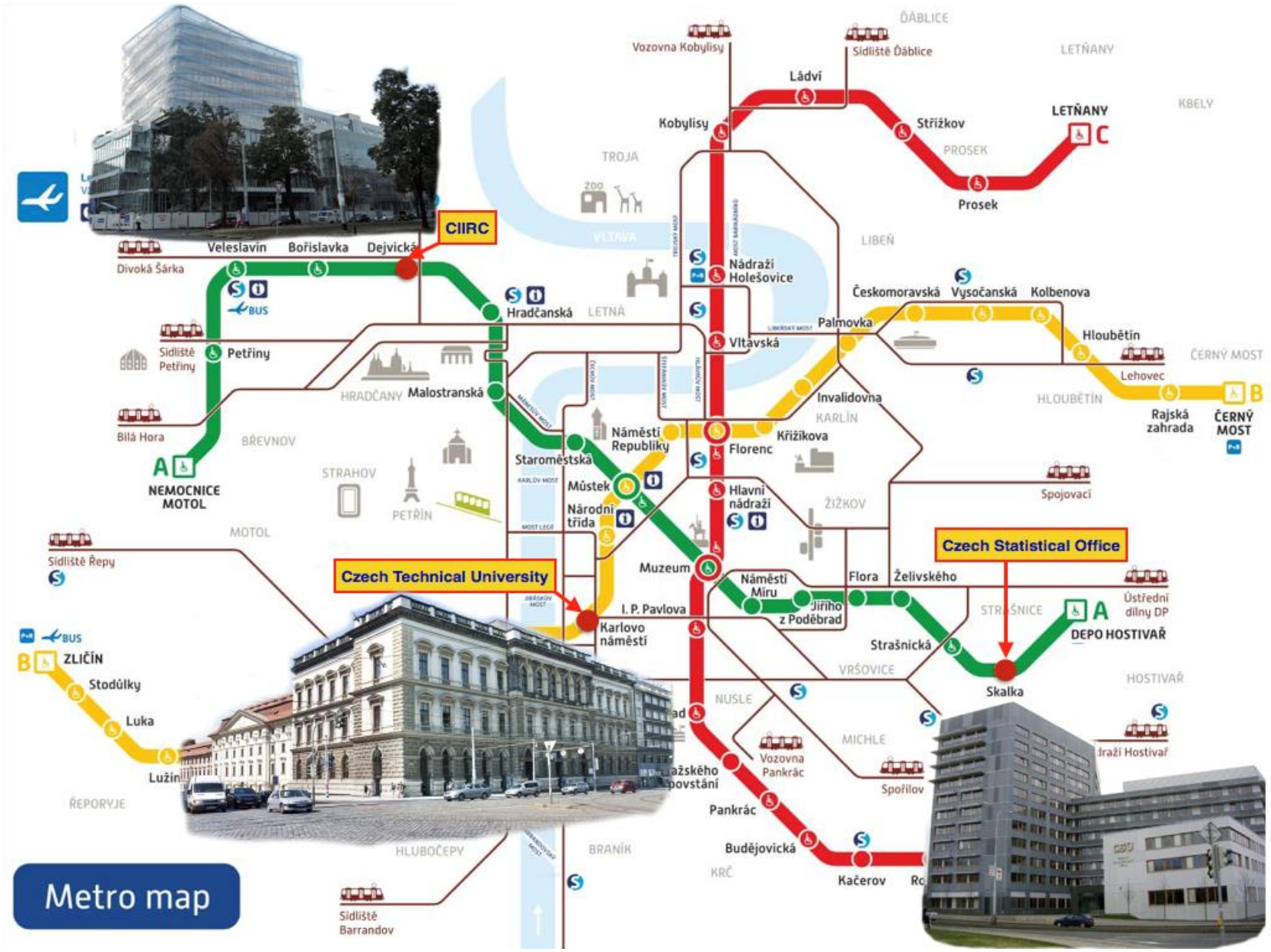
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BŘEVNOV
A
NEMOCNICE MOTOL
STRAHOV
PETŘÍN
Staroměstská
Můstek
Národní třída
Hlavní nádraží
ŽIŽKOV
Spojovací
MOTOL
Sídliště Řepy
Muzeum
Náměstí Míru
Flora
Želivského
Jiřího z Poděbrad
I. P. Pavlova
Karlovo náměstí
STRAŠNICE
Ústřední dílny DP
A
DEPO HOSTIVAŘ
Strašnická
VRŠOVICE
Skalka
HOSTIVAŘ
BUS
B
ZLIČÍN
Stodůlky
Luka
Lužiny
NUSLE
MICHLE
Vozovna Pankrác
Spořilov
Pankrác
Budějovická
Kačerov
ŘEPORYJE
HLUBOČEPY
BRANÍK
KRČ
Sídliště Barrandov