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European Research Area and Energy Engineering Education

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ABSTRACT*: The role of education is most important in the field of energy efficiency and rational use of energy. Energy in the Czech Republic is a strategic commodity toward sustainable development. Energy policy needs analysis in global, regional and world level. Mechanisms for improving energy efficiency are not limited to technologies but, on legal conditions (energy conservation law), consumer behaviour and education in the field of energy efficiency and sustainable development. This must be achieved using innovative technologies which, in addition have to be combined with urban energy planning, management techniques, improved standards, which also address economic and social aspects within framework of a cost-effective integrated approach for all energy requirements. It is necessary to introduce advanced information's into educational programs and immediately secure dissemination to the industry. Energy engineering education in the field of sustainable development is organised in the faculties (Mechanical engineering, Metallurgical, Mining and Geology and Economy). Department of energy engineering-TU Ostrava has own Engineering program in power machines and equipment's in specialisation: thermally powered equipment, industrial power generation, environmental techniques, and renewable sources of energy.*

1 INTRODUCTION

The European citizens are increasingly concerned by how to properly respond to global climate change. In addition, the recent crisis, following oil price instabilities, has demonstrated once more the vulnerability of the European energy supply. The European Commission have recently adopted a **Green Paper** entitled" **Towards a European strategy for the security of energy supply**" discussing what should be done to prepare EU the demand for energy and, in particular, for electricity will continue to increase in the next 20-30 years and meeting the challenge of security of energy supply will be key for the development of dynamic and sustainable economy in Europe.

Global and EU energy supply is currently dominated by combustion of fossil fuels, which results in the emission of the main green house gas CO_2 which is considered to be linked to global warning. A shift towards sustainability based on new(e.g. hydrogen and fuel cells) and renewable energy sources (wind, biomass, solar, PV, etc.) is necessary, but needs substantial and continued RTD effort which has to be supported jointly by industry and public sources in the EU. The recent liberalisation of the energy and electricity market is generating important changes, such as the development of distributed or " embedded " generation, which represent not only challenges, but also opportunities that to be exploited.

The take-off foreseen by the **White Paper** on Renewable energy sources and the development of distributed generation necessitates the immediate provision of condition for access and effective integration into the existing and evolving energy networks, as well as the preparation of the next generation of energy production and distribution infrastructure. Such an infrastructure will need to manage flexibly and effectively the supply of many thousands of small generators and a few hundred big ones to a huge and highly variable demand.

The single EU energy and electricity markets needs to respond rapidly to these challenges in order to gain full potential of the opportunities offered by new technologies. The obstacles are however not only require multidisciplinary action involving social and economic, as well as scientific research, to address policy, legal and administrative barriers.

The establishment of a European Research Area for the integration of renewable and other sources of energy generated in a decentralised manner will help to accelerate the change paradigm and achieve the objectives of sustainability and security of the energy supply for the EU. Joint European efforts stimulating the symbiotic interactions of new and renewable energy technologies, advanced storage and

conversion systems, systems engineering, information and communication technologies and advanced electronics are currently under way and will hopefully result in new approaches to manage and operate the energy networks of the future, able to ensure a stable and reliable supply responding to the quality requirements of demanding customers operating in the knowledge economy.
The **White Paper " Energy for the future"**: Renewable sources of energy- for a community strategy and action plan" has set the target to achieve a minimum objective of 12 % penetration of renewable energy sources (RES) in the EU by 2010. Each member country is encouraged to produce a higher share of its energy supply from renewable sources. Yet the existing energy supply system in the European Union has to now substantially been based on large central stations, mostly fossil fuelled.

Integration of RES and distributed generation (DG) refer to the integrated or stand-alone use of small. Modular energy conversion units close to the point of consumption. Integration of RES and DG differs fundamentally from the traditional model of central generation and delivery in that it can be located near end-users. Locating RES and DG downstream in the energy distribution network can provide benefits for customers and the energy distribution system itself.

2 PRIORITIES IN THE SIXTH FRAMEWORK PROGRAMME. EUROPEAN RESEARCH AREA

Large scale generation of electricity and/or heat with reduced CO_2 emissions from biomass, including combined heat and power. The objective is to decrease the global and local environmental impact, while reducing the costs, of the generation of electricity and/or heat on a large scale, for new and retrofitted plant, based on biomass or waste and mixtures thereof.

Priorities ERA: combustion and other thermo chemical conversion processes (e.g. gasification, pyrolysis); generation of electricity and/or heat with reduced CO_2 emissions from coal, biomass, waste or other fuels; improving the efficiency of gas turbines; combined heat and power.

Development and demonstration, including for decentralised generation, of the main new and renewable energy sources, in particular, biomass, wind and solar technologies, and of fuel cells. For renewable energy sources and for fuel cell systems the aim is to realise their promise for grid connected and 'stand alone' (stationary and mobile) applications producing electricity, with or without usable heat, with significantly lower pollutant emissions compared to established technologies.

Priorities ERA: fuel cells, for both stationary and transport applications; clean conversion and cost-effective use of biomass in the context of energy generation systems for heat and power; wind energy, in both on-shore and off-shore applications; solar technologies, photovoltaic and solar thermal technologies; other renewable energy options that can contribute significantly to overall programme objectives.

Integration of new and renewable energy sources into energy systems. The objective is to overcome problems, including public acceptability, associated with integrating new energy sources into the energy system with attention to improved environmental compatibility and safety, focusing on solutions with a high potential for success.

RTD ERA priorities: overcoming the technical problems associated with the integration of renewable energy sources into energy grids and processes; hybrid systems, combining different renewable or renewable with conventional systems; improving acceptability of renewable e.g. reducing visual intrusion and noise; identifying, and seeking ways to remove, non-technical barriers to integration of renewable

Distributed generation.

Can be defined as the integrated or stand-alone use of small, modular electricity generation resources by utilities, utility customers and private individuals or other third parties in application that benefit the electric system, specific end-use customers or both. Looking across the borders, the USA show that especially reciprocating engines and gas turbines have been rapidly building a presence in the electric utility industry. These decentralised applications continue to taw steadily: Back power at 7 % p.a., base load covering systems at 11 % p.a., peaking covering covering application at 17 % p.a.

The European development of distributed power generation has so far mainly driven by the necessities to increase the use of RES. Apart from hydroelectric power and biomass, wind power has up to accounted for the major part of this development with mean annual growth rates of 38 % between 1993 and 1999. Currently, utility-wide wind power monitoring systems are being developed.

Technologies bundled into the distributed generation system will increasingly include interfaces for connection to local supervisory control and data acquisition (SCADA), distributed control systems (DCS) and/or Internet/Intranet systems. Other technologies that are necessary for a complete system include developments in:

- Metering
- Protection and control
- Remote monitoring and fault diagnosis
- Automated(decentralised) dispatch and control
- Site optimisation of electrical/thermal outputs

The following section offer a short description the generally applied technologies for distributed power generation.

Small hydroelectric power.

Rated at an installed capacity of 10 MWe or less currently contribute with more than 37 TWH/a to about 2,5 % of the EU electricity market. Based on a fairly stable growth rate of 3 % p.a. over the last decades by means of modernisation, reconditioning and exploitation of new sites, about 50 % of the remaining small hydro power resources in Europe is expected to be developed by 2015. Improved turbines designs, cost effective plant construction in combination with new technologies and improved control and operating strategies have the potential to reduce the initial cost as one main barrier for the future exploitation.

Wind power.

Modern wind turbines convert wind power to electrical power, with a rated generator power of marketable models currently rating up to 2,5 MWe. Hub-heights reach more than 100 m, rotor diameters are typically 65 m for 1,5 MWe machines. Rotor construction is either variable blade angle (pitch regulation) or non-variable, conversion from mechanical to electrical energy is via either synchronous or induction generators. Synchronous generators are usually equipped with pulse width modulated converters, control of these converters is essential for regulating the behaviour of the windmill on the electric grid, e.g. reactive power adjustment. The technical availability of marketable systems has reached 98 to 99 %, typical turnkey costs of wind power projects are around 900 to 1100 EUR/kWe

Photovoltaic power.

Conversion of solar energy to electrical energy has been technically possible since the late 1930´s. A main objective is to bring down the high cost of photovoltaic systems, 6000 EUR/kWe still being common. Typical applications of photovoltaic cells include small installations of < 10 kW on building rooftops or remote systems that can not be connected to the electricity grid. There are, however, EU projects and national programmes to promote (large) grid connected systems. Grid connection is usually made through an inventor and grid accepts all power from the photovoltaic system.

Combined heat and power (CHP) plants.

CHP use the fuels for the production of both electric power and heat, thus working with a high efficiency. Compared to traditional boiler plants and conventional electricity production, those plants are able to save appr. 30 % of the primary consumption. Furthermore, this leads to a reduction of carbon dioxide (CO_2) emissions by roughly 0,5 kg per kWh electricity production.. This type of energy supply is especially useful for consumers with a continuous and steady-going heat demand.

Micro-turbines.

Operate on the same principles as traditional gas turbines. Typical is a very high number of RPM of the turbine and generator, such as 70 000 - 120 000 RPM. The generator produces high frequency AC power that is converted to 50 Hz by power electronics. Typical power ratings could range from 25-500 kW although multiple units may be directly interconnected to provide up to several MW. Capital costs are expected in the 500 – 1000 EUR/kW range and electrical efficiencies should range from 27-32 %. Utilising the exhaust heat can improve the overall efficiency up to 80 %.

Fuel cells.

Fuel cells are characterised by the type of electrolyte used, examples include alkaline, proton exchange membrane, phosphoric acid, molten carbonate and solid oxide. Depending on the electrolyte the fuel cells operates between 80 and 1000 ^{o}C, ignoring this produced heat cells efficiency can range between 35-65 %. Utilising the produced heat can raise the efficiency to over 80 %. Target capital costs (assuming large volume manufacturing) range 800-1300 EUR/kW. New small fuel cell developers who were previously aiming at the transportation markets see residential generation at about 1 – 10 kW power rating as lucrative market.

Hybrid power for community energy services.

Hybrid power systems usually consist of a convential generator powered by diesel or gas engine/turbine and a renewable energy source such as solar, wind, or hydroelectric. Batteries are often included in hybrid systems for a continuous power availability and/or more steady-going diesel operation.

Mini-grid

Mini-grids are typically characterised by multipurpose electrical power service to communities with populations ranging up to 500 households with overall energy demand ranging up to several thousand kWh per day, as it can be found e.g. on Greek islands of Kythnos – project MORE and PV-MODE.

3 BARRIERS TO THE INTEGRATION.

Policy and legal barriers for distributed generation:

- Unconformity between technical interfaces and legal frameworks as the distribution system operator (DSO) is not the owner of the RES.
- Lack of regulatory framework for the interaction between a variety of decentralised generation operators and DSO regarding indemnification and insurance.
- Not clarified responsibility for quality and reliability of energy supply and legal framework for grid access and power wheeling.

Administrative barriers

- Lack of standardised contracts for interconnection of decentralised generation units.
- Variety of contracts with different decentralised generation operators
- Limited experience with monetary assessment of additional values (e.g. peak shaving, load management).
- Lack of tariffs for demand shapes, backing services, distribution wheeling, etc.
- Lack of acceptance of emerging regulatory necessities.

Technical barriers

- Lack of standardised power interfaces between decentralised generation units and distribution network.
- Lack of standardised communication interfaces for control and supervision
- Lack of suitable control strategies and procedures for electrical apply systems with high decentralised generation penetration.
- Lack of strategies and procedures for decentralised ancillary services (frequency and voltage control) on different voltage levels.
- Lack of experience with the operation of electrical supply systems with high penetration of RES as an intermittent energy source

Indicative RTD subjects:

- Develop new technology and concept for the operation and exploitation of the electricity networks and mini-grids. They include systems for frequency and voltage regulation, development of intelligent protection systems, two-way real-time communications integrated into power system (supply and consumption).
- Socio-economic and pre-normative research to liberalisation of energy market and RES integration.
- Address technical and non-technical issues related to large shares of RES and decentralised energy in overall energy supply which are expected in the long term. This includes measurements of RES and other decentralised energy production systems, as well as prediction and planning techniques for integration and acceptability, and quantification of externalities and benefits.

- Integration of RES and non-RES energy sources and storage systems, in particular hybrid systems (including co-generation) and stand alone systems, to ensure a cost-effective and reliable supply able to cope with any demand fluctuation.
- Critical technologies offering high potential for distributed and decentralised generation, such as micro gas turbine (below the MW range) and small to medium gas turbine (up to 40 MW).

4 THE ROLE OF ENERGY ENGINEERING EDUCATION

Energy engineering education in the field of sustainable **development** is organised in the faculties (Mechanical engineering, Metallurgical, Mining and Geology and Economy). Department of energy engineering-TU Ostrava has own **Engineering** program in power machines and equipment's in specialisation: thermally powered equipment, industrial power generation, environmental techniques, and renewable sources of energy. **BC program:** economy and management in power generation industry, environmental engineering. **PhD program:** advanced combustion systems, power machines and equipment, environmental protection in industry. **Industry program:** environmental protection / energy efficiency in industry, clean energy technologies, power machines and equipment's, energy efficiency consulting, energy conservation law, legislation, renewable sources of energy.

Program in centre for energy performance contracting and energy audits. The energy audits is one of the first tasks to be performed in the accomplishment of an effective energy cost control program in the Czech Republic.

National university research centres will support sustainable energy development and will ensure dissemination of results into educational programme. It will be part of European centres of excellence. One of the criteria generally used to define the centres of excellence is their capacity to produce knowledge that can be used for industrial purposes. The main objective is: networking of existing centre of excellence in Europe and the creation of virtual centres through the use of new interactive communication tools, a common approach to the needs and means of financing large research facilities, more coherent implementation of national and European research activities, improving the attraction of Europe for researcher from the rest of the world and promotion of common social and ethical values.

The role of education is most important in the field of energy efficiency and rational use of energy. Energy in the Czech Republic is a strategic commodity toward sustainable development. Energy policy needs analysis in global, regional and world level. Mechanisms for improving energy efficiency are not limited to technologies but, on legal conditions (energy conservation law), consumer behaviour and education in the field of energy efficiency and sustainable development.

This must be achieved using innovative technologies which, in addition have to be combined with urban energy planning, management techniques, improved standards, which also address economic and social aspects within framework of a cost-effective integrated approach for all energy requirements. It is necessary to introduce advanced information into educational programs and immediately secure dissemination to the industry.

5 CONCLUSIONS

Energy in the Czech Republic is a strategic commodity toward „**Sustainable development**“. Energy policy needs analysis in global, regional and world level. Mechanisms for improving **energy efficiency** are not limited to technologies but, on **legal conditions** (energy conservation law), consumer behaviour and education in the field of energy efficiency.

The main task is: how to integrate all energy sources and how to reach higher level of energy efficiency?

It is necessary to develop energy strategy and secure deployment and dissemination into the market new available technologies. Rational use of energy is task for Czech energy policy. The ways are:

- to reduce energy consumption (energy audits) and stimulate market penetration of clean energy technologies (simultaneous production of heat and electricity),
- to improve the impact of the use of energy on the environment,
- new operating strategy (fuel switching, emission reduction strategy, demand side approach, energy management, least cost analysis),
- integrated load management for heating, cooling and electricity consumption as well as technologies for the storage and distribution of energy, including innovate cogeneration systems,

- dissemination of energy efficiency consulting and energy performance contracting projects.

This must be achieved using innovative technologies which, in addition have to be combined with urban energy planning, management techniques, improved standards, which also address economic and social aspects within framework of a cost-effective integrated approach for all energy requirements. It is necessary to introduce advanced information's into **educational programs and immediately secure dissemination to the industry.**

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