The Sustainable Development 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.

Key words: environment, energy, education, engineering, dissemination

1. Introduction

The promotion of sustainable development enabling competitiveness and employment necessitate decouling economic growth from environmental degradation. Minimising the environmental impact of the cost-effective production and use of energy in Europe will help preserve the ecosystem by reducing emission at local and global levels and by increasing the share of new and renewable energy sources in the energy system. It will also have socio-economic impacts by enhancing the capability of European industry to compete in the world markets, helping to secure employment and promoting social cohesion with less favoured regions.

The Kyoto objectives which imply for European Union a reduction of 8 % of the greenhouse gas emissions (corresponding to 600 million ton per year CO_2 equivalent) between 2008 and 2010 (compared to 1990 level) are the driving force for the development of new technologies, innovation and associated measures. Another driver is the Council Resolution on renewable energies of may 1998 which considered the target of doubling the share of renewables in the EU energy balance from 6% today to 12 % in 2010 provides useful guidance for increased efforts at Community level as well as in Member States. **Energy research and development and innovation in engineering education is therefore concentrated to following areas:**

I. Cleaner Energy Systems, including renewable energies

II. Economic and efficient energy for a competitive Europe

CO_2 is produced for 33 % in large scale electricity plants and for 67 % in dispersed and small scale systems in buildings, industry, and transportation. Major options to reduce CO_2 emissions are given below:

- Rational use of energy-RUE in buildings, industry and transport which in the short and medium term can be expected to make an important contribution to CO2 reduction;. in particular by means of non-technical measures to stimulate RUE. In the medium and long term research and technological development - RTD should be focused on cross-cutting technologies which can be expected to have a major impact (eg. development of cost-effective fuel cells for all end use sectors);
- Replacement of coal and oil by natural gas and methanol this in view of the fact that CO_2 emission per unit of energy produced for natural gas is much lower than for oil or coal.

(Coal 90, Oil 73 , Natural gas 47 gram CO_2 per M Joule). In 1997 the primary energy consumption in Europe consisted of 205 M toe coal and 707 M toe oil. There is therefore much scope for short and medium term CO_2 reduction; a CO_2 tax could be a suitable measure to stimulate such a replacement. RTD should be focused on technologies related to natural gas.

- Replacement of petrol engines by Diesel engines preferably using fuels derived from natural gas with very low particulate emission;
- Energy supply based on renewable energy sources-RES and related technologies such as fuel cells, electrolysers, hydrogen storage, etc. Here a major contribution to CO_2 reduction can only be expected in the long term due to a too high cost, slow introduction and non-technical barriers; cost reduction is here the major issue;
- Capture and underground storage of CO_2 in particular for large scale electricity production. This technology however is expensive and may lead to a 60% increase in electricity cost, partly because of a strong reduction of the efficiency of electricity production by 20% to 30%. Fuel cell power plants are here at an advantage due to the fact that they can extract CO2 without any extra energy cost; in addition they have a higher efficiency;
- Increased production of electricity with nuclear energy.

Long term approach to CO_2 reduction

In a strategy which aims at a sustainable and energy efficient energy production, conversion and storage, RTD is to play a major role in bringing about a breakthrough for renewable technologies in such a way that they can cover the overall energy demand. It is however not likely that this will be achieved very soon; the Council resolution on renewable energies of May 1998 (White Paper) aims for a doubling of the part of renewable energies in the EU energy balance from 6% today to 12 % in 2010. Only after around 2030 it may be expected that renewable and related technologies (eg. hydrogen as energy vector) will start to play a major role.
Key to reducing CO2 emissions is a balanced mix of research, demonstration, Kyoto mechanisms, subventions, creation of new high tech. companies (venture capital), tax reductions and addressing non-technical barriers tailored to the need of different technologies.Fig.1.

2. The main topics in sustainable energy development and new education model.

I. Cleaner Energy Systems, including renewable energies

I.1. Large scale generation of electricity and/or heat with reduced CO_2 emissions from coal, biomass and other fuels, 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 solid, gaseous or liquid fuels - fossil, biomass or waste and mixtures thereof.
Priorities: *combustion and other thermochemical 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.*

I.2. 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: *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, photovoltaics and solar thermal technologies*; *other renewable energy options that can contribute significantly to overall programme objectives*.

I.3. 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 priorities: *overcoming the technical problems associated with the integration of renewable energy sources into energy grids and processes*; *hybrid systems, combining different renewables or renewables with conventional systems*; *improving acceptability of renewables e.g. reducing visual intrusion and noise*; *identifying, and seeking ways to remove, non-technical barriers to integration of renewables*

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I.4. Cost effective environmental abatement technologies for power production. In the short term, the objective is more efficient combustion. In the longer term, capture and sequestration of CO_2 are options to be further explored including its use to enhance recovery of hydrocarbon reservoirs and coal bed methane so providing a net reduction in greenhouse gas potential. Polluting emissions, particularly NO_x, SO_x and dust, should be reduced by treatment of the flue gas after the combustion process.
Priorities: *emission abatement technologies for power stations (e.g. for reducing emissions of CO_2, SO_x, NO_x and other pollutants)*; *hot gas cleaning*; *including understanding of basic scientific phenomena.*

II. Economic and Efficient Energy for a Competitive Europe

A reliable, clean, efficient, safe and cost-effective energy supply and services for the benefit of its citizens is essential for the good functioning of society, the competitiveness of industry in European and world markets, and the quality of the global and local environment. Efficient end-use technologies will be a key option for the achievement of the Kyoto target in terms of greenhouse gas emissions reduction. They are expected to account for at least 60% of the overall emissions reduction from current levels in the short term and 30% in the long term. A more efficient use of energy is required with technologies capable of achieving substantial overall cost and energy intensity reductions. The focus of the EU strategy for energy efficiency over the next ten years has to be the full realisation of the significant economic potential for energy efficiency which exists in the EU, estimated to be as much as 18% of 1995 energy consumption by the year 2010. RTD and innovation have a role to play within this strategy. Accordingly the following objectives address all stages of the energy cycle - production, distribution and final use - to improve efficiency and reduce costs.

II.1 Technologies for the rational and efficient end use of energy.

The objective is to make a major step towards a sustainable energy system by substantially reducing the energy intensity of demand and making much more effective use of energy. The focus is on areas offering the greatest contribution to sustainable use of energy. For the built environment the aim is 30 % energy saving by 2010 and 50% in the longer term. The aim is to double the share of renewable energy in the residential and commercial sector to some 12 % of the total energy use in this sector. For transport the aim is energy savings of 5-10% in the medium term and, in the longer term (2020 horizon), to achieve aggregate reductions in CO_2 of 25%. For the industrial processes the aim is to provide the basis for reducing energy intensity (>20% in the short term and >30% in the longer term).
Priorities: *particular emphasis will be given to cross sectoral technologies, such as process control, and an integrated approach to improving energy efficiency in the built environment, transport and industry, including agriculture*; *lighting, space heating and cooling and the integration of renewables into buildings*; *improved energy and environmental performance of vehicles and the corresponding infrastructure, including fuels, energy storage, conversion, combustion and transmission*; *reduction of energy intensity of industrial processes where emphasis will be given to process integration, separation and drying*.

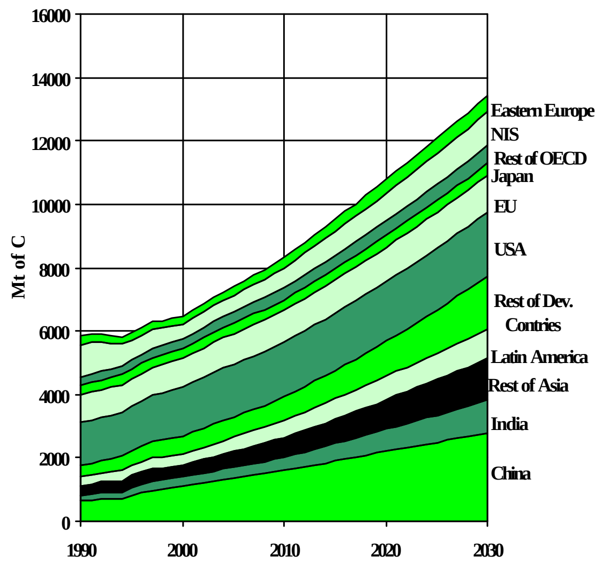

Fig. 1 Reference Case - CO_2 Emissions

II.2. Technologies for the transmission and distribution of energy. For electricity the objective is to improve and assure the quality, reliability and cost-effectiveness of electrical power supply necessary to meet user's needs. This should be set in the context of a liberalised market where additionally RTD investment is under intense pressure. Greenhouse gas avoidance and reduced environmental impact are the principal objectives in addition to making gas and liquid fuel transport and supply systems more cost-effective and safer.
Priorities: *intelligent energy transmission and distribution systems*; *long distance transmission of gas and electricity*; *optimised network management and control systems*; *optimal system efficiency for electricity, gas, and district heating and cooling systems*; *superconductivity*.

II.3. Technologies for the storage of energy on both macro and micro scale. The objective is to assure power quality and optimise local load factors for both grid connected and stand-alone locations. At the medium/micro-level with the trend towards clean vehicle propulsion, self-contained equipment and mass-produced portable devices have the potential for spin off to applications having a major effect on the energy system. For gas storage more cost and operational effectiveness, and assurance of safety is needed.
Priorities: reliable and cost efficient energy storage technologies, including liquefied natural gas and liquefied petroleum gas, H_2, advanced batteries, both macro and micro, for stationary and mobile applications.

II.4. More efficient exploration, extraction and production technologies for hydrocarbons. The objective is to allow more efficient identification of hydrocarbon resources available world-wide and particularly within the EU and to optimise their exploitation, reducing the costs and environmental impact of their production with the development of technologies which will be more competitive in global markets, while enhancing health and safety.
Priorities: *improved tools for characterisation and management of hydrocarbon reservoirs*; *exploration and production technologies for hydrocarbons, especially for hostile sub-sea locations*; *reduced environmental impact and improved recovery techniques for hydrocarbons, including those of wider application e.g. for geothermal energy*; *recovery of hydrocarbons from coal beds.*

II.5. Improving the efficiency of new and renewable energy sources. The objective is to further improve the design and performance of the individual components in renewable energy systems which contribute to overall system efficiency and cost effectiveness as applied to the costs of manufacturability, installation, operation, maintenance and end of life.

Priorities: *biomass exploitation and management of waste as a fuel resource*; *improving efficiencies of photovoltaic cells and wind turbines*; *reducing costs of production of renewables technologies (e.g. turbine blades, PV modules).*

II.6. The elaboration of scenarios on supply and demand technologies in economy/environment/energy (E3) systems and their interactions, and the analysis of the cost effectiveness (based on whole life costs) and efficiency of all energy sources. The objective is to develop strategies for the production and use of energy, for the introduction of new energy technologies and for policy development. They must reflect the needs and behaviour of consumers and take into account human, natural, economic and geographical resources which have an impact on energy. The economic instruments which could make these strategies feasible and cost effective should be specified.
Priorities: *long- and short-term scenario analysis at the global, Community, and regional level of supply and demand in the context of economic developments, social and environmental needs*; *modelling and policy impact analysis*; *overall assessment of energy markets and technology impacts taking into account the operation of liberalised energy markets.*

3. The role of education in sustainable development-The University programs.

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.

4. 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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