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ABSTRACT

This paper discusses the importance of energy and its association with the modern economy. Presently, 40% of Europe's electricity needs are based on coal. Preparing a clean energy technology requires improvements in conventional steam cycle technology. Education plays an important role in energy use, and universities need to organize education with regard to energy efficiency. Because of the importance of energy to society, it is necessary to introduce advanced information into energy education programs. (YDS)

University-industry Joint Program in Energy Management Education

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The use and supply of energy, its trade and associated technologies interact in a complex manner and are a factor determining economic growth, quality of life and respect for the environment in a modern economy. In this sense, energy should be regarded as a strategic commodity in the transition process towards sustainable development. The need for public intervention in the energy sector is well justified by the observation that market forces alone cannot lead to such desired changes. The energy policy needs global analysis in order to explore new challenges, options and choices. It will therefore address, from multidisciplinary perspective, the Energy - Environment - Economy - Technology issues at a world-wide, regional and local level, for medium and long-term time horizons. Mechanisms for improving the economic and social benefits of energy supply and energy efficiency and its use are not limited to technologies, but are also dependent on economic and legal conditions and on consumer behaviour. The market penetration of energy efficient technologies is hindered by a series of obstacles and market imperfections, e.g. lack of knowledge, different interests of actors and investment criteria, energy tariff distortions, traditions and behavioural differences.

Europe's and Czech energy supply will be dependent for the foreseeable future on fossil fuels, notable natural gas, oil and coal. Its economic well-being will depend on the while its environmental health will be governed largely by the extent to which they are used efficiently and polluting emissions minimized during the conversion of fuels to useful energy. Natural gas will continue its penetration into the European market even if its transport over long distances (Africa, Siberia, and North Sea). The petroleum share, will grow very slowly but constantly over the coming years. As for coal, for which the worldwide reserves are sufficient for 250 years.

Currently, about 40 % of the electricity in Europe and worldwide is based on coal. Coal will continue to be a vital factor in the world economy. Consumption of coal will increase rapidly in the developing countries and especially in China and India. Coal will also be continued to be used massively in Central and Eastern Europe and therefore it can be expected to expand greatly over the next decades.

The main objectives are to prepare the basis of and to support the demonstration of a new generation of Clean Energy Technology in order improve the ecological and economical acceptability of coal based power production. Therefore improvements for conventional steam cycle technology like pulverized coal fired boilers with innovative flue gas treatment or circulating fluidized bed combustion technology should be demonstrated. In the area of advanced (combined cycle) technologies integrated gasification combined cycle and pressurized fluidized bed combustion combined cycles with improved economics to promote their market penetration will be demonstrated.

In such a situation, a decisive action in the field of training and education concerning effective use of energy is needed. In this respect, the cooperation between the Power Engineering Department, Technical University Ostrava (VSB-TUO), and one of the biggest energy supply company in the region , Moravskoslezske Teplarny (MST), seems to be helpful and of consequence.

This informal but very wide reaching cooperation, including permanent feedback, consist in:

- possibility of operational tests on the MST equipment to verify technical parameters and develop modern testing techniques by Power Engineering Department, VSB-TUO,
- delivery of topics for diploma theses with a possibility of applying the results at MST,
- an opportunity for students to work on practical demands from industry in the framework of the prepared Students Energy Economy Center- a Project supported by the Ministry of Education,
- organizing tailor-made courses for MST employees, especially in the field of effective use of energy and lowering of its consumption,
- financial support for taking part at national and international conferences,
- assisting at an overall attempt to put down the consumption of energy at VSB-TUO, especially providing support in developing a cogeneration power unit at the University campus,
- cooperation with MST on building an Energy labolatory and demonstration of the Low Energy Family House (a joint project by VSB-TUO, Town Council of Ostrava, and supported by the Ministry of Education and Czech Energy Agency).

Thanks to the long-lasting cooperation, many University graduates find jobs as MST employees. The Power Engineering Department takes an active part in the process of finding solutions to partners practical problems and on the other hand MST employees participate in university committees and influence students decisions about their specialization and future career.

Educational and research project in the field of energy management- collaboration with the industry

The decades when the Czechoslovak economy was concentrated on the preferential development of mining, heavy industries, and chemical engineering have disrupted the natural balance of environment. Now that air, water, and soil pollution levels are regularly monitored, the results force us to reconsider our previous approaches to the problem, which often reflected the need for systematic reduction of pollutant emissions at their sources. Combustion processes generate mainly dust or fly ash and nitrogen oxides, NO_x , which in conjunction with SO_2 are particularly harmful to all forms of life. Industrial plants are often unaware that adjustment of the combustion process can reduce the NO_x, SO_2, and fly ash emissions.

This project is based on long-term Technical University of Ostrava investigations of operation of boilers and other combustion equipment and is focused on combustion process and its control in the furnace. The aim is to enhance energy efficiency while diminishing the amounts of pollutants generated, and dissemination of the results into engineering education and create opportunities for collaboration. Interest in this work has been intensified by newly adopted conservationist legislation.

Preliminary work was devoted to generalizing the findings of earlier research on the aerodynamics of furnaces in power generating blocks rated up to 500 MWe. This work covered the measurement methods employed in the furnaces, mathematical modeling and isothermal modeling of burners, carried out at the TU Ostrava over the period from 1960 to 1997. The research work (and dissemination to industrial courses) included the steps:

- conducting combustion trials on blocks selected to represent various combinations of fuel, furnace type, and combustion mode so as to ascertain the optimum operating conditions for each,
- designing and implementing simple modifications that can be introduced during shutdowns or minor repair work,
- ensuring optimum combustion conditions with higher energy efficiency secured by suitable process control systems,
- monitoring air pollution levels at significant localities and assessing how they are affected by the investigated pollution sources.

Every particular set of combustion equipment has some optimum operating state that combines maximum energy efficiency with minimum pollutant emission. The crux of our research and educational project is to ascertain and to help establish this state, disseminate new information into industrial courses and engineering programs.

Work in progress- collaboration with industry and topics for diploma theses.

In order to cover as many types of pollution-generating combustion equipment as possible and to define the fundamental measures needed to limit their contaminating effect to a bare minimum, the work was divided into : stoke-fired boilers, fluid bed boilers, pulverised coal boilers and flue gas cleaning.

Stoker-fired boilers.

Preliminary work performed in 1991-1997 consisted of combustion mode measurements on 45 stoker-fired boilers with unit rating ranging from 1 to 6 MW. Measures devised in this investigation were then applied to select boilers firing either partings or boiler-quality stone coal from the Ostrava -Karviná coalfield and located at mines in this basin. These were boilers at Fuèík mine, for 25 tons/hr, at the Paskov mine, for 12 tons/hr, at Heømanice , four units of 5.5 MW each, Staøíè I,II, III mine, where six boilers use supplementary output gas firing, power station Kolín, and in the industry: Slezan Frýdek Místek, Tesla Lanškroun, Litovel a Plzeòská teplárenská a.s. As part of this work, new control systems was evolved to
ensure their adherence to the optimum combustion parameters.

Fluid bed boilers.

Combustion trials accompanied by solid and gaseous emission measurements were carried out onignífluid-type installations at the following boiler houses: the František coal mine, with two units for 16 tons/hr each, the Líškovec MST plant with units of 20 and 30 MW, the Krnov MST plant of 70 MW, the Tatra truck factory at Kopøivnice, with units for 70 and 110 tons/hr and 84 MW, and Biocel cellulose factory at Paskov, with two units rated at 110 tons/hr each.

These plants all require high-grade fuels, with calorific values greater than 20 MJ/kg and with only minimum dust contents. As such fuels are no longer available, these units emitted huge quantities of fine solids and suffer rapid wear of their heat exchanger surfaces and flue gas ducts. Moreover, dust-trapping equipment cannot cope with high inlet concentrations and discharges more than the permitted amounts of fly ash into the atmosphere. The combustion air control systems cannot ensure optimum combustion at all

performance levels. In particular, the combustion trials in the Czech circulating fluidized bed boilers were carried out at Tøinec, Tisova and Porici Company in 1995- 1997. The combustion trials consisted from following experiments: guaranty steam output including measurement of guaranty quantities of temperatures and pressures, minimum steam output including measurement of guaranty quantities of temperatures and pressures, energy efficiency of the boiler CFB, efficiency of the desulphurisation process, solid and gaseous emission measurement.

Pulverized coal boilers.
Combustion trials at district heating plants in Karviná, Olomouc, Pøerov, Poøíèí, Chvaletice, Opatovice, Vítkovice, Ostrava SMT have shown that suitable interventions in the combustion process can influence not only the course of that process, but also its efficiency, the formation of SO_2 and NO_x at the point of combustion, and the physical properties of fly ash that govern the trapping efficiency of electrostatic precipitators. Another factor investigated was the way in which the course of combustion affects the toxic metals content of solid combustion products. Findings gained at power stations prove that modification of the combustion process can reduce NO_x emissions.

The continuing work was focused mainly on combustion trials and the definition of measures needed to reduce NO_x emissions at the following boiler installations:

- the Tøebovice power station of the SMT Concern, which has three forced circulation boilers, with Vítkovice-made combustion Chambers, rated for 220 tons/hr each, and two slug-type dry-bottom boilers of Vítkovice manufacture for 80 tons/hr each,
- the boiler house of Vítkovice Plant 8, which fires a combination of stone coal, coke oven gas and blast-furnace top gas, where we intend to study the reduction of NO_x by CO at appropriate temperatures.

Flue gas cleaning.
Research and development work on combustion fume cleaning equipment is being carried out in collaboration with W-eko ecological engineering company of Ostrov. The objective is to evolve cleaning facilities for both stone coal and brown coal firing boilers rated at 1 to 6 MW, which would dependably keep them within the legal emission limits. Apart from combustion trials, this work involves investigating the gas cleaning process in semi dry dust-trapping equipment and determining the optimum operating conditions for such equipment. Concurrently, we are performing market research studies and offering technical assistance in the introduction of this fume cleaning equipment to small industrial and district heating boilers.

The role of the Czech Energy Policy in engineering education

Czech Republic launched its program of economic reforms in 1991. The program comprised a major (85%) liberalization of domestic prices and external trade and privatization, firstly of small businesses through auction and then the partial privatization of state enterprises, through a nation-wide voucher scheme.

The Czech Republic was in very complex situation with regard to environmental protection. Tab. 1 Total emissions in Czech Republic (per year).

Emission	1985	1989	1990	1991	1993
SO_2	2598	2383	2260	2221	1918
NO_x	527	509	460	429	402
CO_2 (2)	185	172	162	156	139
solid (1)	1988	1263	1174	1171	955

(1) In thousands of tons (2) In millions of tons

This situation was a consequence of extensive development of industry and agriculture, inefficient use of natural resources and high emissions of air and water pollution. The root cause of the current problems is that for historical reasons. Our country has had an ineffective economy which did not take account of environmental factors. Our industries were structured in a way that encouraged high energy and raw materials consumption, and used technologies which have an unacceptable impact on the environment. The use of poor quality coal, combined with 15 years delay in construction of desulphurisation facilities has led to the present problems. Although energy production in general is the most significant pollutant, electricity production is not the dominant source of harmful emissions - heat generating facilities including household boilers account for the majority of emissions. The remainder is caused by a variety of other sources such as surface mines, chemical plants and transport.

The energy policy of the Czech Republic follows the Government Programme Guidelines of July 1992, and other related documents that the Government approved or dealt with. In particular the National Environment Policy of CR, European Agreement, European Power Generation Charter, the outcomes of Uruguay talks of GATT, Framework Agreement Concerning Climate changes, and further international documents that have been adopted by the Government or that are considered as being adopted in near future. In particular, it concerns an Agreement towards the Power Generation Charter, the Statement of the Power Generation Charter on Power Consumption Economy and Related Environmental Aspects, and the Statement towards the Agreement on Cross-Border, Long-Distance Air Pollution, and on reducing Sulphur Emissions or its Flow.

Strategic Aims of Power Generation Industry

- **Expectation** that market conditions put down the consumption of energy per GDP (Gross Domestic Product) unit in industry to the level on a par with EU developed countries by environmentally more suitable sources, and by restricting high-energy-consumption processes,
- **Safeguarding** domestic fuel and energy supplies with minimal cost and oriented towards environment-friendly technologies (fluidized bed combustion, coal gasification, combined steam-gas cycle, combined generation of electricity and heat, and after 2000, assuming its current problems are solved, also use of nuclear energy),
- **Diversification** of gas and oil supplies, particularly by joining the network of EU gas and oil pipelines, an increase of strategic reserves of fuel in CR to the level comparable with that of EU, inter-connection of Czech and West-European electricity networks,
- **Increasing** the effectiveness of geologically limited supplies of coal in CR in order to achieve their sustainability, also for future generations,
- **Providing** operational reliability for the whole energy system,
- **Defining** a market model of energy management accompanied by liberalization of prices and transfer of all future external costs on enterprises,
- **Giving up** direct intervention of State in the decision making of enterprises - the State will regulate natural monopolies in the legislative framework,
- **Minimizing** unfavorable environmental impact of the production, distribution and consumption of energy on a par with common levels in EU countries - Fig. 1, Tab.2.
- **Adjustment** of energy management for an entry in the European Union concerning legislative and technical aspects. A request for the full membership in OECD (Organization for Economic Co-operation and Development) and IEA (International Energy Agency) will accompany the integration in the European structures - Tab. 3.

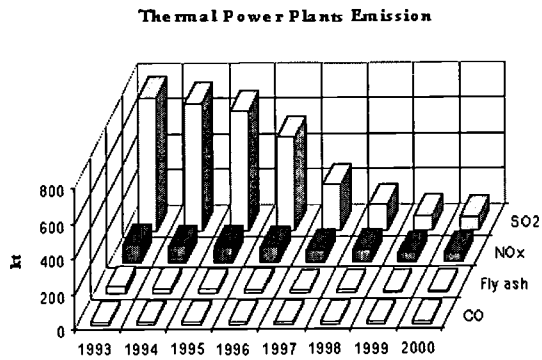

Figure 1.

Table 3. The obstacles and response of the integration energy industry in the Czech Republic.

OBSTACLES	RESPONSE	INDICATOR
1. Non-productive allocation of the investment resources	New energy policy	----------
2. Inadequate prices	Transparent pricing	price/costs
3. Inefficient energy utilisation	Strategy of energy effectiveness	consumption/GDP
4. Lack of environmental awareness and nuclear safety	Integrated approach to energy production and distribution	CO_2, SO_2, NO_x emission per kapita
5. Low productivity and quality of services	Market orientation	% of energy imported
6. Dependence on one supplier and one primary source	Security of energy supply	----------
7. Narrow profile in international grids	International transmission	capacity of transmission

New energy management strategy in the engineering education.

The energy market is being increasingly driven by competition and by market forces. The aggressive nature of the market is forcing power generators to choose generating strategies that will allow them to remain competitive.

In the EU, for example, privatisation of the utility industry has led to the spawning of combined cycle gas turbine power plants, to the virtual exclusion of other types

of power technology. Although a number of new strategies for power generation are being examined by generators one which has been identified as one of the most important for customers negotiating prices for purchased power is distributed generation. It involves sitting the generating capacity close to the source of consumption and involves using a larger number of smaller generating units instead ofrelying on a few central power generating facilities.

The strategy also offers limited opportunities to defer upgrading of transmission and distribution systems. A new type of generating plant operates in an intermediate duty cycle. This capability would allow the utility to consider different operating strategies such as fuel switching and emission reduction strategies that reduce hours of operation of older coal fired power plants and phased construction strategies that more closely match capacity expansion to demand- an important topic for our energy management courses.

The role of education -the University programs

Education in the field of energy efficiency is organized in the faculties (Mechanical engineering, Metallurgical, Mining and Geology and Economy). Department of power engineering-TU Ostrava has own energy efficient program (Ing.) in power machines and equipment's in specialization's:

- thermally powered equipment,
- industrial power generation,
- environmental techniques,
- renewable sources of energy.

BC. Energy efficient program:

- economy and management in power generation industry,
- environmental engineering

Ph.D. Energy efficient program:

- advanced combustion systems,
- power machines and equipment's,
- environmental protection in industry.

Industry energy efficient 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.

Center for energy performance contracting and energy audits in our department.

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

Summary

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.

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. Theways 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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