Teaching of clean energy production at the Silesian University of Technology in Gliwice, Poland

Ryszard K. Wilk
Silesian University of Technology
44-100 Gliwice, Poland, Akademicka 2
Email: rwilk@polsl.pl

***"Abstract"*-Poland holds great amounts of high quality bituminous coal, about 60% of European resources are located just in Poland. On the other hand, Poland has got small amounts of crude oil, natural gas and other renewable sources of energy. Only biomass can play a real important role in the supplying of primary energy. Taking into account the production of electricity, solid fuels cover about 95% of Polish needs of energy. On the other hand, it is generally known that combustion of fuels is the most important source of the emission of SO_2, NOx, dust, CO and CO_2 in the anthropogenic emission. That is why knowledge on clean energy technologies is very important in the teaching of Polish engineers. The academic staff of the Faculty of Energy and Environmental Engineering of Silesian University of Technology invented and put into execution a new specialization of engineering education: "Clean Energy Technologies". The process of teaching of clean energy technologies has a logical composition: from the easiest technologies to the most difficult technologies. The sequence of teaching is as follows: technologies connected with the saving of energy, cleaning of fuels, primary methods of decreasing of pollutants (clean combustion), secondary methods of decreasing of pollutants (desulphurization, denitrogeneration, removal of dust), new high efficient energetic cycles, gasification of solid fuels, fuel cells and hydrogen technologies as a high efficient technology of energy production. The lectures, laboratory trainings, designing and 2 months industry practice are assumed as the best way of teaching of future engineers. The graduates from this specialization plays an important role in Polish energetic and heating companies. A lot of Polish leading positions in energetic companies are occupied by them.**

Index terms: Camera ready
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INTRODUCTION

Poland hasn't got abundant resources of crude oil and natural gas, neither considerable areas with adequate wind and swift flowing water-courses nor fissile materials. Thus, the production of electric energy and heat is based mainly on the combustion of coal (95%) and biomass as a renew able source of energy. On the other hand, Polish power engineering is already to a considerable extent exhausted. About 80% of the Polish power stations require retrofitting or ought to be constructed anew. It is general known that the combustion of fuels, particularly hard coal and lignite is the main source of pollution in the environment, providing about 90% NO_x, SO_2 and CO emissions, about 60% dust and nearly 100% CO_2, both in power engineering, heat engineering and transport. On the one hand, fossil fuels constitute the national wealth, being the fundamental source of primary energy, but on the other hand also a clean natural environment is a national wealth. Nowadays the criterion of the quality of energy installations runs as follows: an energy installation must be perfect with regard to its high energy efficiency and at the same time ecologically beneficial for the environment, i.e. it must be characterized by a very low or even zero emission of contaminations.

Can both these requirements , a high energy efficiency and a low emission of noxious substances, be reconciled ? The answer is "yes". This is accomplished within the framework of the so- called clean energy technologies (CET). At the Faculty of Energy and Environmental Engineering of the Silesian University of Technology engineers specializing in the domain of clean energy technologies have been instructed for already eight years. Those are indispensable, because Polish power engineering is presently undergoing a process of modernization and reproduction of energy resources. They may also prove to be useful in other countries of the European Union, as their professional knowledge is on a high level, and their language abilities should not be a problem.

PRINCIPLES CONCERNING THE TRAINING OF ENGINEERS IN THE DOMAIN OF CET

Instruction concerning clean energy technologies is run as a specialization for students in the range of studies "Environmental Engineering" beginning with the sixth term,

- Marks are adjudged according to ECTS,
- The terms up to three comprise mainly fundamental knowledge as well as information in mathematics, physics, chemistry and so on.

- In the course of the next three terms students specializing in "Environmental Engineering" acquire knowledge concerning the fundamentals about the natural environment and ecology. This knowledge constitutes a good preparation for a further extension of information concerning energy processes, gas purification technologies, the management of wastes, the contamination of the environment due to motorization, purification processes of wastes caused by motorization, unit processes, mass and heat transfer, catalysis, the rate of chemical reactions and combustion etc. We are of the opinion that mutual permeation of information concerning environment protection on the one hand and power engineering and the design, construction and operation of energy installations will permit to train perfect specialists in the field of clean technologies both in power engineering and motorization.
- In Poland engineers are still trained within single-stage MSc studies. Two-stage studies will be started in the academic year 2008/09, in compliance with the order of the Minister of Science and Higher Education. Attempts have already been made earlier aiming to introduce a two-stage system, as far as technical studies were concerned, but encountered considerable opposition. Our enterprises only reluctantly employ engineers who have graduated after merely seven terms. Also the students definitely prefer single-stage MSc studies.
- Teaching of clean energy technologies, both in power engineering and motorization is successively, starting with the simplest and cheapest to the most complex and expensive ones. e.g.
    1) purification of fuels (clean fuels),
    2) energy saving as the best way of environment protection,
    3) primary methods of reducing the emission of noxious substances, e.g. low-emission combustion,
    4) secondary methods of restricting the emissions, e.g. wet desulphurization,
    5) new highly efficient energy cycling,
    6) gasification of solid fuels,
    7) fuel cells and hydrogen technologies.
- As has already been mentioned, two-stage studies will be introduced in Poland in the first term for students enrolled in the academic year 2008/09. For five years (2008-2013) the training will be realized in two ways, viz. single-stage MSc studies and double-stage studies. In the course of these five years the process of teaching will be subjected to observations and investigations.

TEACHING STANDARDS FOR THE SPECIALIZATION "ENVIRONMENTAL ENGINEERING"

Table 1 and Table 2 present the specification of the subjects of study realized as fundamental subjects.

TABLE 1.
SPECIFICATION OF FUNDAMENTAL OBJECT OF STUDIES; MINIMUM NUMBER OF HOURS AND MINIMUM NUMBER OF ECTS POINTS

	Fundamental subjects of studies	Number of hours	ECTS
1	Mathematics	120	
2	Physics	60	
3	Chemistry	60	
4	Biology and ecology	60	
5	Environment protection	30	
6	Technical drawing and descriptive geometry	30	
7	Informative fundamentals of designing	60	
8	Technical thermodynamics	45	
9	Fluid mechanics	45	
10	Materials science	30	
11	Mechanics and strength of materials	30	
12	Civil engineering	30	
13	Hydrology and science of the earth	30	
14	Statistics	30	
15	Environmental chemistry	30	
16	Town and country planning	15	
17	Reliability and safety of engineering systems	15	
18	Management of the environment	30	
	Σ	750	77

TABLE 2.
SPECIFICATION OF SPECIALIZATION SUBJECTS CONNECTED WITH THE ENVIRONMENTAL ENGINEERING, MINIMUM NUMBER OF HOURS AND MINIMUM NUMBER OF ECTS POINTS

	Subject of specialization studies	hours	ECTS
1	Air protection		
2	Water economics		
3	Water and sewage engineering		
4	Sanitary installations and networks		
5	Management of wastes		
6	Heating engineering, ventilation and air conditioning		
7	Soil science and recultivation		
8	Soil mechanics and geotechnology		
9	Melioration		
10	Protection against noise and vibrations		
11	System of spatial information		
12	Monitoring of the environment		
13	Pro-ecological technologies		
14	Alternative sources of energy		
15	Automatic control engineering, operation of devices		
16	Technology and organization of plumbing		
	Σ	360	36

As can be gathered from Table 2, there is some freedom in fixing the number of hours assigned for the respective subjects of specialization, but the total number of hours must amount to at least 360 (36 points ECTS). The rate of the division depends on the decision of the given Faculty Council, taking into consideration the existing tradition and also the level and number of specialists in the given discipline.

The training of an MSc engineer requires 3500 hours of lectures and classes (300 ECTS). The fundamental and specializing subjects amount to at least 1110 hours (Table 1

and Table 2 – together 113 ECTS). This means that for strictly specific subjects there remain at the most only 2090 hours, assuming that 300 hours must be set apart for the preparation of the master thesis. In other words, the training of a specialized MSc engineer requires about 187 point ECTS, including the time devoted to completing the master thesis.

THE TRAINING OF A SPECIALIST IN THE DOMAIN OF CLEAN ENERGY TECHNOLOGIES

The graduate ought to possess the following qualifications:

- To have a comprehensive knowledge within the range of natural science and technical sciences,
- To command a specified knowledge concerning energy processes, fuels and their combustion, energy devices and combustion engines, thermal engineering and professional power engineering and motorization,
- Be able to solve problems in the range of environmental engineering,
- To know how to coordinate and to realize researches,
- To be well acquainted with the ways of purifying gases and fuels, catalytic after-burning and dust extraction,
- Be able to manage legal and administrative problems,
- Be ready to work in a design office, research centers,
- Know English and speak it fluently,
- Feel the necessity of developing constantly his knowledge and professional ability and also comply with ethical and legal standards.

At the Faculty of Energy and Environmental Engineering of the Silesian University of Technology the specializing subjects have been chosen keeping in mind the traditions of the Faculty, the scientific output of its professors and their achievements. The compulsory subjects of studies and the maximum number of hours devoted to each of them have been specified in Table 3. The eligibility in the choice of the subjects to be studies is restricted; from among seventeen, six subjects should be compulsory (cf. Table 4). The students are also entitled to choose an individual course of studying, 30% of didactic training (duties) being chosen by the student himself. Moreover, the students are obliged to pass an eight weeks professional apprenticeship during the vacations.

The staff running this kind of studies comprises 2 full time professors, 2 associate professors, 4 assistant professors and 8 PhD students. The total number of students specializing in CTE amounts to 26 persons.

The fundamental part of this kind of studies comprises 50 ÷ 60 % of lectures. The remaining part includes classes, designing, laboratory classes and seminars. As far as the topic of the master theses is concerned, the students may suggest their preference. Preference is practical topic imposed by the requirements of the national economy, particularly the needs of power plants, heat- and- power stations, the producers of boilers, furnaces and burners, devices applied for the protection of the environment, as well as automobile car factories and administration.

TABLE 3.
SPECIALIZATION SUBJECTS CONNECTED WITH CLEAN ENERGY TECHNOLOGIES

	Subject of studies	hours	ECTS
1	Electrical engineering		
2	Internal environmental engineering		
3	Management of wastes II		
4	Technologies of air protection II		
5	Transfer of heat and heat exchangers		
6	Gas dynamics		
7	Fuels, their treatment and combustion		
8	Mechanics of multi-phase media		
9	Conversion of energy		
10	Process engineering		
11	Fundamentals of thermal metrology		
12	Dust extraction of combustion gases		
13	Water and steam boilers		
14	Energy machines and installations		
15	Combustion engines		
16	Desulphurization of combustion gases		
17	Pro-ecological exploitation of engines and motor cars		
18	Measurements in environment protection		
19	Low-emission combustion		
20	Propagation of contaminations and monitoring		
21	Thermodynamics II		
22	Degasification and gasification		
23	Biomass as a fuel		
24	Water and sewage management in industrial plants		
25	Fluid technology		
26	Pre-diploma design		
27	Diploma seminar		
28	Computer modeling of thermal-flow processes		
29	Fundamentals of thermal power engineering		
30	Thermal and catalytic after-burning		
31	Safety and fire protection		
32	Fuel cells		
33	Hydrogen technologies		
34	Master thesis	300	15
	Σ	1705	169

TABLE 4.
SPECIFICATION OF FACULTATIVE SUBJECT OF STUDIES

	Subject of studies	hours	ECTS
1	District heating and heating		
2	Ventilation and air conditioning		
3	Noise control		
4	Municipal power engineering		
5	Test investigations of motor cars		
6	Modern fuel technologies		
7	Utilization and storage of energy wastes		
8	Membrane technologies in environmental engineering		
9	Utility biotechnology		
10	Utilization of waste energy		
11	Computer-aided modeling II		
12	Oil and gas technology		
13	Power engineering and the environment		
14	Electric machines		
15	Geodesy and photogrammetry		
16	Management studies		
17	Foreign language		
	Σ	285	18

CONCLUSION

Clean energy technologies as a specialization was started in 1995, and the first graduates finished their studies in the academic year 1997/98. Altogether in the course of ten years 190 MSc engineers and engineer graduates were trained, and all of them have found work. Seven of these graduates have obtained doctor degrees and five functions in leading positions in research centers. Eight others have taken over leading economical positions and 15 are employed in local administration. The future of the energetic industry in Poland forecasts is optimistic. In the nearest 20 years, about 30000 MW of power stations have to be modernized and built in new clean technologies. Similar needs refer to the motorization development and communal heating sets.

The specialty of clean energy technologies has proved to be indispensable in the Polish economy .

ACKNOWLEDGMENTS

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REFERENCES

[1] Act of the Ministry of High-School Education of September, 5th, 09, 2005

[2] Decree of the Council of the Faculty of Energy and Environmental Engineering, concerning the creation of the specialty CTE, May 1995.