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Sustainable Development as Global Strategy for the Future and Challanges of Educating Engineers

Abstract

Sustainable development on global scale is the concept of development of the post-modern society in the interdependent world with limited resources, increasing population and strongly affected environment. This development strategy is without reasonable alternative.. Entering the Third Millenium, engineers and scientists are given crucial role in its implementation which should be reflected in their education mitigating thus still prevailing technocratic approach especially at technical universities. Mean features of such education are discussed. Model of educating engineers for sustainable development, as well as achieved results and experience with education in chemistry and chemical technology are presented.

Introduction

At the end of the 20th century, the world having passed through industrial, scientific technological and information revolutions with the population having reached 6 billion recently is more and more interdependent. Means of transport and communication have shortened the distances, the gap between rich and poor has widened, polluted environment and lack of enough food and clean water endangers ever growing part of population, the carrying capacity of nature has been nearly exhausted, natural resources are more close to their end.

The worldwide interdependence which is the constituent element of that what is called globalisation is felt as a threat which should be avoided or fought against. This fatal misunderstanding, making globalisation guilty for the problems of contemporary world leads crowds of young people in many capitals to streets and squares to protest happenings ending usually with violations. This way, based on exaggerated feelings leads to nowhere.

The way out, respecting globalisation as objective reality is sustainable development, which is a strategical concept and thus the task for active handling. As such, it should be explained, accepted and respected.

Sustainable development as a strategical concept for the future of mankind entering the Third Millenium

It is in the long run impossible to live byeond one´s resources. The same is true for national and global population. The available resources are in the long term sufficient for a limited population and a certain life-style. Since the classical 1972 report of the Club of Rome *Limits to Growth* an increasing awareness on the system principles defining conditions for the long-term productivity of the biosphere has been initiated. These principles in themselves embody the aspects of resource availability, environmental impact and those of material flows. An already starting point of defining the system approach and its requirements is the quote from the report by the Brundtland´s UN Commission for Environment and Development of 1987:*Sustainable development is development that meets the needs of present without compromising the ability of future generations to meet their own needs.* Sustainable development, obviously not only as environmental phenomenon, but as a strategy of the development of post-modern society has been reflected in the documents of the UN Conference on Environment and Development (UNCED), Rio de Janeiro, 1992, mainly in Agenda 21 and in a couple of international agreements adopted till now.

Sustainable development is often considered as environmental or even only ecological phenomenon. Impetus for its definition stems certainly from environmentalists who were the first being aware of threatening pollution of air, water and soil and endangered biota with proceeding losses of biodiversity and eventually chemical, physical and microbial factors afflicting human health directly and indirectly through nutritional chain and lack of enough clean water and food.

Sustainable development cannot be reduced in this way. It is actually a complex and multifacet phenomenon and a true development strategy of the post-modern society, encompassing environmental, economic, scintific, scientific-technological, technological, socio-economic, political, socio-political military-political, military-technological, legal, cultural, ethical, moral and pure human dimensions. Any anthropogenic and technological activities entering the 21st century should be carried out within the framework of this strategy (which has no reasonable alternative), respecting the limited carrying capacity of the Earth, meaning not only turn of fossil to the renewable resources but also all kinds of environmental impact.

Sustainable development as a basic requirement for educating engineers

Till now, the technocratic approach in the education of engineers still exists, aimed mainly to the highest productivity of all engineer´s activities from ideas, over fundamental and applied research, advanced research and development, design and control of production process and its cost-effectiveness. This has been in agreement with the leading idea of economic growth and high productivity in the modern capitalist society measuring the living standard only according to the material consumption and posing thus pressure on

ever increasing productivity and volume of material production, consuming more and more non-renewable raw materials and energy and taking not into account limited resources and carrying capacity of the Earth.

Graduates of technical universities posses a specific position in the society´s elite due to their role in material sphere and any technogenic activities connected with material production, flows of materials and energy, mobility, housing etc. and even to their role in non-material sphere, such as state and public administration, education, health care, media, inner and outer security, services etc. All these activities have environmental impact, both positive and negative, intentional and non-intentional, direct and indirect. The activities of engineers should be intentionally oriented towards forming and protection of environment and to considerable decrease of harmful consequences of their activities. It is to be stressed that the role of engineers in any society is inherrently active and therefore their education must take this crucial element of engineer´s characteristic into consideration.

The above mentioned technocratic approach of engineers is based on overestimation of general propedeutic and special disciplines and mostly fully neglecting formation of biological feeling, respect to nature and environment, social and environmental ethics, as well as a system of moral commitments and professional responsibility.

Some effort to inform undergraduates on the environmental impact of the industrialised society already exists. At all faculties, there is at least one discipline dealing with this problem but in general, with the exception of specialists educated for environmental protection and for technologies of environmental protection as well as sanitation and remediation of already damaged or at least injured environment, engineers are not systematically prepared for the tasks awaiting the whole population of engineers (independent of their branch) in the 21st century, which are already envisaged in the legislation of EU and required by the legislation of some EU countries (The Netherlands, Germany, France, Sweden, Finland etc.) which have formulated their national environmental policy based on the principles of sustainable development (while the government headed by Václav Klaus considered sustainable development as ideology).

It is obvious that the best elaborated system of environmental education exists at faculties of chemical technology due to the character of chemistry, chemical technology, penetration and proliferation of their products into all human activities and due to triad of hazards posed to humans and biota, where:

- The first hazard lies in the technological process, yielding emissions to air, waste waters and wastes with actual and/or potential environmental indoor (workplace) and outdoor usually long-term pollution which environmental impact depends on parameters of toxicity and especially on ecotoxicity, including bioaccumulation and entering the food chains
- The second hazard is given by the products of chemical technologies, i.e. chemicals, their use as raw materials in other technological branches or/and their end use and their physical, chemical and toxicological (and ecotoxicological) properties determining their environmental impact, entrance into food chains and endangering human health.
- The third hazard is given by the character of technology and technological equipment and possibility of occurence of incidents, accidents and disasters due to explosions, implosions, burning etc. with direct effects of blast wave, inflammability and secondary effects due to toxic plume, ignition, injuries and material damages.

The development in minimizing environmental impact of chemical technologies has already proceeded through main steps, starting with dilution of emission to contemporary end-of-pipe solution, i.e. capture of emission to air, waste water cleanup and handling with waste.

Current and future requirement to chemical technologies, consistent with the strategy of sustainable development encompass a fully new approach, including the crucial shift from the end-of-pipe solution to the solution at source, i.e. introducing the concept of *cleaner technologies.* This means pollution prevention and waste minimization, wasteless technologies or at least with minimum wastes, indoor recycling or outdoor recycling assurance. Such new approach needs thorough analysis of material and energy flows, material and energy balance, avoiding of emissions to air, water and soil and thinking on the fate of product in its whole life cycle (i.e. from mining raw materials over all production and transportation steps till the moment of loss of useful properties and change to waste and reuse). This means that the solution lies in the first line in the pre-production steps, from ideas, over oriented fundamental and applied research, advanced research and development to projects and design of production. The only way in many cases is considerable change in the technological process or change of the product or of its precursors.

At present, there is already the first experience in the introduction of the concept of cleaner production within the framework of a system having environmental, economic and management facets. This can be witnessed by the approach of the pollution prevention, applied in the US or in the approach of the EU standards in the series of ISO 14000, including the EMS (environmental management system), EMAS (environmental managing and auditing scheme), EL (environmental labelling), LCA (life cycle analysis) and all other instruments of cleaner production, as reflected in the ISO series 14 000, consistent and cross-linked with the respective ISO series 7000 and 9000. This clearly shows the existing and build-up intercorrelation and interdependence of production and trade corresponding to the fundamentals of macro- and microeconomics not neglecting ecological and social aspects.

Reflection of sustainable development in present education of chemical engineers

Faculty of Chemistry, Brno University of Technology was re-established in 1992 and therefore the two-stage environmental education, reflecting main principles of sustainable development has been implanted into its curricula from the beginning and without any friction typical for "stone" faculties and universities respectively.

The first stage, common for all undrgraduates (irespective of their study branch) contains fundamentals of Ecology, General Biology, General Toxicology and Biochemistry (I,II) beside relevant parts of general disciplines with some environmental information, like General Chemistry, Inorganic Chmistry, Organic Chemistry (I,II), Physical Chemistry (I,II,III), Analytical Chemistry (I,II), Instrumental Analytical Chemistry, Chemical Engineering (I,II), Chemical Technology, Chemical Informatics etc.

The second stage is represented mainly by the study branch *Environmental Chemistry and Technology* (starting from the 6^{th} term) and horizontal penetration among the study branches mainly in the problems of wastes, waste water cleanup, sanitation and

remediation, recycling technologies, legal and economic instruments of environmental protection etc.
This study branch encompass in the first line scientific disciplines, necessary for understanding the technological disciplines (and at the same time giving graduates better possibilities at the job market, comparable to those at the graduates of classical universities), such as Environmental Chemistry (I,II), Hydrochemistry, Hydrobiology, Special Toxicology, Ecotoxicology, Quantitative Structure-Activity Relationships, Nuclear Chemistry, Dosimetry of Ionizing Radiation, Microbiology.
Main stress has been laid on the technological disciplines, such as Technology of Purification of Drinking Water, Technology of Waste Water Cleanup, Water Management of Landscape, Communes and Industry (I,II), Technologies of Handling with Wastes, Technologies of Air Protection, Technologies of Soil Sanitation and Remediation, Risk Analysis and Chemical Safety, Environmental Analysis and Monitoring, Legal and Economic Tools of Environmental Protection.
Study Programme is terminated by Diploma Thesis, orinted mainly to practice of environmental technologies and environmental analysis and monitoring.

Faculty of Chemistry has accredited also the doctoral study programme Envoronmental Chemistry in 1997.
Leading scholars of the Institute of Environmental Chemistry and Technology take part in various courses, organised by Ministry of Health in Toxicology and by Ministry of Defence within the framework of NATO – Partnership for Peace Programme for leading authorities of Chemical Corps, Civil Protection, Environmental Protection and Emergency Planning. The above mentioned institute organises also qualification courses in the Environmental Problems for personnel of schools, state and public administration, industry, services etc.
All these activities contain multifunctional structured information consistent with the strategy of sustainable development. This approach has been deepened recently joining the Baltic University Programme, mainly its two disciplines "The Baltic Sea Environment" and "Sustainable Baltic Region" introduced experimentally into the doctoral study programme. It continues this year in a modified manner under the depiction "The Central European Environment" and "Suistanable Central European Region", amended by more relevant information on the Czech and Slovak Republics and neighbour countries, utilizing mainly data of our own studies and data by Czech Ministry of Environment. These disciplines will be more attractive and can be used as a base for educating non-chemists in the problems of sustainable development in future.

Sustainable development in future education of engineers

Experince of educating chemical engineers, both undrgraduates and doctoral students can be successfully utilised in the education of engineers of all branches, because especially the environmental impact of *any* production possesses similar features.
At present, also in the education of chemical engineers, the problems of sustainable development are scattered, even if very systematically among a great number of disciplines.
Because the most important imperativ of sustainable development is the complex of engineering tasks emanating from the idea of cleaner production as reflected in European Standards mainly in the series ISO 14 000, we are preparing for a new discipline named "Sustainable development and cleaner production" with accumulated information till

now contained in other disciplines . Planned introduction of this discipline reflects also requirements for engineer´s knowledge and skill given by the membership of the Czech Republic in OECD, as well as by its association and future full membership in the EU.

Contents of planned discipline Sustainable Development and Cleaner Production:

- Global problems of mankind entering the Third Millenium
- Sustainable development – scientific, technological, legal, economic and sociopolitical aspects. Indicators of sustainability. Reflection of sustainable development in the state policy of developed countries (D, F, NL, A, S, FIN)
- International obligations of the Czech Republic in environmental protection (UNCED, Agenda 21, Montreal Protocol, Basel Agreement, Kyoto Agreement etc.)
- Changes of the environment in Central European Region and their trends
- Status of environment in the Czech Republic – atmosphere, waters, soil, nutritional chain, mineral resources, biodiversity, human health. Impact of anthropogenic and technogenic activities, mobility, housing etc.
- State environmental policy of the Czech Republic
- Czech environmental legislation – environment generally, water management, waste handling, air protection, agricultural soil, forest management, geological research, territorial planning
- Environmental policy of OECD and EU – Fundamentals of West European integration (Mining Union, Euratom, Brussels Treaty, Maastricht Treaty, Amsterdam Treaty). Environmental protection in EU – individual compartments, nuclear and chemical safety
- Association Agreement of the Czech Republic with EU and harmonising legal norms in environmental protection
- Realisation of the environmental policy on the regional and communal level – structure of state and public administrative organs and their role
- Principles and strategy of cleaner production
- Pollution prevention and waste minimization – Flows of materials and energy
- Transition from the end-of-pipe solution (liquidation of consequences) to the solution at source
- Realisation of cleaner production. Transformation of managing system
- Life Cycle Analysis in all phases from mining raw materials to the deposition of non recyclable residue
- Indoor and outdoor recycling
- Change of product, change of materials, change of technological procedure
- Interaction and feedback of scientific technological, technological, economic, environmental, administrative and managing aspects of technological and auxiliary processes. The role of engineers in all phases of the life cycle, mainly in the pre-production phases
- Examples of introducing cleaner production in chemical, pharmaceutical, food, material and consumer technologies +)
- Environmental management of enterprise and its tools (ISO 14 000) Environmental Managing System (EMS), Environmental Management and Auditing Scheme (EMAS), Environmental Audit (EA), Environmental Impact Assessment (EIA), Life Cycle Analysis (LCA), Enviromental Labelling (EL) etc. Terminological problems in the main world languages. Relations to ISO 7 000 and 9 000.
- Economic and legal aspects of cleaner production

- Cleaner production and market

Note: +) Possibility of seminar work to this topic according to the study branch.

It is obvious that this scheme can be adapted for any engineering study branch and can thus serve as a good model

Conclusions

By no doubt, sustainable development and its reflection in the duties, commitments and professional ethics of engineer of any study branch is the practical reason why it should be a matter of education in order to prepare contemporary population of undergraduates of technical universities for their role in the postmodern society. Need of incorporation of such education goal is stressed due to the membership of the Czech Republic in the OECD and its future membership in the EU that have already adopted sustainable development as their development strategy.

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