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Scientific paper

MATERIAL AND ENERGY FLOW MANAGEMENT- LIFELONG LEARNING COURSES EXPERIENCES

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Abstract

Material and energy flow management is among the most important factors for the economic growth of a society in harmony with nature and it will play the main role only in the area of sustainable development. The three lifelong learning courses were developed in order to introduce this concept to the industry professionals and administration at the city and regional level. The main goal was to heighten awareness of participants to this topic, as in Serbia it is relatively new approach in corporate and administrative management. The results of the courses confirmed the interest in this kind of lifelong learning courses with suggestion to join it in a single course with emphasise on the specific participant's problems.

Key words: *lifelong learning, material and energy flow management*

1. INTRODUCTION

People are changing the environment, which fact is today undeniable and based on a number of evidences. The rapidity of influences on the ecosystems is increasing and the pressure on the Earth's ecosystems is reaching its limits, i.e. the point of no return. Ecosystems are characterised by constant flows and transformations of matter through a biogeochemical cycles (substance turnover or cycling of substances) such as carbon cycle, nitrogen cycle, water cycle, phosphorus cycle, etc. There is no waste in natural systems. Ecosystems are in process of a constant change, in the past driven by natural forces, but nowadays under increasing humans' influences. The unmatched usage of resources from the environment and in the same time excessive pollutants discharge to the environment is the basic type of connection between the environment and society. Resources and energy sources are becoming scarcer and in the same time more valuable. The highly efficient use of raw materials and energy, tied with the prevention of waste creation and loss, are becoming an imperative in future society development.

Material flow analysis (MFA) is one of the different methodologies that deal with material and energy flow management in industrial and natural systems [1]. It is a depiction of physical flows (material and energy) that are related to the economy. It was adopted as a policy tool after the UN conference in Rio de Janeiro, 1992.. Material and energy flow analysis improves effectiveness of material and energy use. Integrated Pollu

Prevention and Control Directive (IPPC Directive) requires comprehensive analyses of all energy and material flows as part of the approval of new industrial installation, and the modernisation of existing ones [2].

The Western Balkans countries, Serbia amongst them, can aspect the number of challenges on their way to the EU. One of the most pronounced is the transition of its industrial and energy systems into a renewable and sustainable sector. Difficulties are met with equivalent opportunities to phase out energy intensive structure of the society and reduce greenhouse gas emissions, save energy, reduce waste creation as well as to protect nature. By choosing for a material and energy flow analysis potential savings can be identified in industrial, regional and country level in order to establish resource and energy efficiency.

The conditions in surrounding area of the Republic of Serbia, especially in the European Union, clearly show that the country needs a very deliberate and organized system of the education in the area of energy efficiency and sustainable development as one of the key conditions for the development of the Republic of Serbia towards a society based on knowledge capable to provide good employment of the population [3].

The goal of this article is to present results of the Tempus project concerning the lifelong learning (LLL) courses programme on material and energy flow management conducted at the Faculty of Technology, in Novi Sad, Serbia.

2. LLL ON MATERIAL FLOW ANALYSIS

Material flow analysis is a systematic assessment of the flows and stocks of materials within a system defined in space and time [4]. MFA connects the sources and and final sinks of a material. The results of an MFA can be obtained by a simple material balance comparing all inputs, stocks, and outputs of a process. This characteristic of MFA makes it the method attractive as a decision-support tool in resource management, waste management, as well as environmental management [4]. Material flow analyses are conducted on a national, regional or city scale, but it can also be conducted along an industrial supply chain involving a number of companies. Although this is not new concept in sustainable development, its application in Serbia is sporadic and it needs to be promoted. It can be achieved through lifelong learning courses aimed to introduce this concept to industry sector as well as to public services personal and stakeholders.

In the frame of higher education lifelong learning has special place. As a special form of activities within educational areas, higher education institutions will organize and implement the lifelong education following a general technological progress, the development of the area and the needs of the labour market, and lifelong learning to adapt ECTS system and it will include elements relating to non-formal education [5].

The cooperation of companies, the state and the academic sector in the areas of energy and material usage efficiency is crucial in order to develop new technologies and for effective technology transfer and their incorporation in the production systems of the Republic of Serbia. With this goal in mind at Faculty of Technology Novi Sad three lifelong learning courses are developed:

- Industrial Material Flow Management,
- Course 2: Ecosystem Management, Industrial Ecology and Zero Emission,
- Course 3: Ecosystem Management Engineering Principles of Sustainable Water and Energy Management

Developed lifelong learning courses have similar concept. The first part of the courses consists of short introduction to ecosystem management as a

- Course 1: Ecosystem Management,

holistic approach to an environmental protection and sustainable development. Its main goal was to present a nature's way to deal with material and energy flows in ecosystems. In the same time relations between society and environment were examined and possible solutions to achieve sustainable development with economic progress.

The second part was different for each of courses, related to the topics of material flow analysis. The topics are: industrial ecology and zero

emission; and engineering principles of sustainable water and energy management and industrial material flow management. At this section of the course participants are introduced to defining and understanding the flows of energy and materials through setting up material and energy balances. During the course analytical techniques and concepts for goal setting with respect to energy and material sustainability will be defined. These concepts include ecological footprint, the Natural Step, Factor 4 / Factor 10 and other assessment tools [3].

In order to obtain the objective information about the level attendee's knowledge related to the main topic of courses and to evaluate course quality questionnaires were done prior and after the each course. The scope of this questionnaire is about exiting of knowledge on material flow analyses as well as on ecosystem management i.e. sustainable development. The participants were employees in public services, industry professionals, and stakeholders from the city and provincial level.

3. DATA EVALUATION

This questionnaire consists of ten questions, which are related to the specific course content. Correct answers gained maximum points per question, while incomplete gained certain point's fraction while false answers gained null points. Every question carries the same number of points (10), and results of the tests were expressed as percentage of whole test points. The comparative analysis of the results achieved at the introductory test and exam results of tests for each course are shown in tables 1, 2 and 3.

4. RESULTS AND DISCUSSION

The results of introductory tests show a wide variety of knowledge, from very high (80.83%) to very low level (12.33%) depending on specific course topic. The highest scores of introductory test were accomplished during course 3. In the case of exam after the course better results were achieved in second group i.e. course 2. As for overall results it can be seen that best scores are achieved at introductory test for course 3, whilst best results for exam are obtained in course 2.

The results for the first part of courses related to ecosystem management showed that best results for introductory test were achieved in the third group of participants i.e. at the course 3. The results can be expected as the third group of participants was mainly made up of stakeholders at city level that are familiar with environmental problems of the region. On the other side, high scores obtained in introductory test were followed with slightly higher performance at the exam, (Table 3.).

Table 1. Results at the test and exam - course 1

Topic	Test %	Exam %
Ecosystem management	36.67	95.15
Energy efficiency and Eco-efficiency in industry	33.33	93.33
Industrial Material Flow Management	32.00	99.09
Fundamentals of material and energy balances	12.33	81.52
Overall achievement	**38.11**	**92.27**

It could be concluded that higher knowledge at beginning of the course prevented participants to adopt more specific information in regard to the ecosystem management. On the other hand, the biggest acquiring of new knowledge in for this topic was observed in the group that took the first course.

In the case of fundamentals of material and energy balances that were covered in the all three courses results are somewhat unanticipated. In the first group mainly made up from industrial professionals lowest score was achieved only 12.33%. After the course results of the exam were significantly improved, 81.52, but still lower compared for the groups 2 and 3. Other topics related to the material flow analysis had relatively high results obtained at introductory test. The topic of industrial material flow management was reasonably well known by the industrial professionals, although in that group lowest results were achieved for fundamentals of material and energy balances. On the other hand participants of

the third course showed highest knowledge at the introductory test.

Table 2. Results at the test and exam - course 2

Topic	Test %	Exam %
Ecosystem management	28.67	75.00
Zero Emission Concept	46.67	100.00
Industrial Ecology	33.33	100.00
Fundamentals of material and energy balances	20.00	100.00
Overall achievement	**32.17**	**93.75**

The third course participants were mainly from the city administration and public services. They had gain experience through other lifelong learning courses that they took part in.

Table 3. Results at the test and exam - course 3

Topic	Test %	Exam %
Ecosystem management	80.83	85.00
Sustainable Energy Management	62.50	91.67
Sustainable Water Management	45.00	88.89
Fundamentals of mass and energy balances	63.33	87.30
Overall achievement	**60.33**	**88.21**

At the end of each course evaluation was done. Results of the courses evaluation indicated that concluded that it would be more effective to make a general course covering the main features necessary for the adoption of the basic principles
attendees were satisfied with the course content but suggestion was that these three courses should be rearranged into one with emphasize on the case studies and existing problems.

The future single course would include basic theoretical features of the three previous courses with underlining real problems facing participants. In that manner more examples would be made of specific problems those more related to attendees. The focus would be on the creation of material and energy flows in selected industry processes as well as regional balances.

5. CONCLUSION

In this paper, the courses of lifelong learning from the material and energy management flows are presented. Courses were developed and held in three topics arrangement (1) The management of material flows in industry, (2) Industrial Ecology and the concept of zero emissions, and (3) engineering principles of sustainable management of water and energy. At the beginning of each course anonymous test was carried out about knowledge of course topic. At the end of the course participants are divided written materials and presentations. The first course was held for the NIS, the oil refinery in Novi Sad, the second for regional administration, Autonomous Province of Vojvodina, APV, and the third course for the administration of the City of Novi Sad.

After the the course participants took the exam to evaluate their progress at selected topics. Results achieved on the exam clearly show significant improvement in knowledge compared to the beginning of the course (course 1: 38.11% test and 88.92% exam; course 2: 32.17% test and 93.75% exam; course 3: 60.33% test and 88.21% exam). As can be seen, the maximum knowledge of the introductory test is shown on the course 3 and minimum on the course 2. On examination the most knowledge has been shown on the course 2 (93.75%). Achieved knowledge of the other two courses were about the same (88.92% course 1 and course 3 88.21%).

At the end evaluations courses was done. The evaluations were positive, whilst the number of proposals, and comments was minimal. It was concluded that it would be more effective to make a general course covering the main features necessary for the adoption of the basic principles of management of material and energy flows and that the next step in cooperation with the participants can result in more specific courses, tailored to their interests.

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