ENERGY EFFICIENCY AND AGRICULTURAL ENGINEERING

CONCEPT OF UNIVERSITY COURSE ON ENERGY IN AGRICULTURE

M. Martinov, P. Schulze Lammers, M. Bux

Abstract: *In the region of South-East Europe, there is a pronounced need for improvement in higher education in agricultural engineering as well as for the creation of new teaching material. The creation of a course on energy in agriculture has been identified as one important and future-oriented project that can contribute to the progress towards sustainable agriculture. This text points out the educational needs in that field and outlines a possible structure and content consisting of chapters designed to meet these needs.*
Keywords: *education, energy, agriculture.*

INTRODUCTION

In developed European countries the interest in agricultural studies is evidently decreasing (Gierath, J. 2001). Bringing negligible profit or even losses, agricultural production is not very attractive. As the centre of agricultural production may be expected to move East and South-East in an integrated European market of the future, the controlled development of agriculture in South-East Europe is a task of high importance today. It should provide enough food both for domestic consumption and for exports, especially of local specific products. In consonance with the policies of the European Community, agricultural production in South-East Europe should also follow the principle of sustainability, for example through the production of renewable raw materials and energy. University education and life-long learning are of paramount importance in this context because the realisation of these national and international aims depends on the work of qualified personnel.

At present, the most significant process in the field of higher education is the introduction of a two-stage study system, which has been defined by the Bologna Declaration and subsequently adopted by many universities in Europe. By ensuring comparable levels of education in different fields of knowledge, both in agriculture and forestry, this system is intended to facilitate the mobility of individuals throughout Europe (Tesic, M. and M. Martinov. 2001).

The restructuring of studies through the development of appropriate curricula, syllabi, and a credit point system is under way. Although this process is neither easy nor rapid, it has already shown results. A group of universities of Northern Europe (two from Finland, two from Norway, one form Denmark, Sweden and Iceland each) have set up a network called NOVA University (the Nordic Forestry, Veterinary and Agricultural University). Another group of universities from six Western European countries has established a network called Euro League (Gierath, J. 2001).

The Eastern European Centre at the University of Stuttgart-Hohenheim has initiated the creation of a network of universities for South-East Europe, which is intended to be realised through a number of different projects such as TEMPUS. It is hoped to improve the education in agriculture and agricultural engineering and to raise its quality to levels attained elsewhere in Europe. Furthermore, it should meet the need for experts able to improve the region's agricultural production and to bring it level with that of developed European countries while respecting the region's social, economic and environmental conditions.

Problem identification

While the introduction of two-stage studies is a political issue which should be backed by appropriate legislation, the development of curricula, syllabi, and an appropriate credit system is mainly a task of universities, in which legislation should be restricted to a harmonising role. Apart from that, the realisation of the complete reform depends on the availability of advanced teaching material. This material should be harmonised for the universities included in the network compatible with that used in developed countries. Only with adequate and up-to-date teaching material will an improvement of the study system be possible.

After identification of this problem, the Network for Advanced Education in Agricultural Engineering in South-East Europe dedicated itself to the task of creating new teaching material. Acting within the framework of the Stability Pact and sponsored by DAAD (German Service for Academic Exchange), it initially included three South-East European universities (from Hungary, Romania, and Yugoslavia) and the University of Bonn as coordinator. Subsequent to the project presentation in October 2001, the network has been extended to include universities from Bulgaria, FYR Macedonia, and Turkey. It is still open to all interested universities.

FORM AND CONCEPT OF TEACHING MATERIAL

The development of teching material is a demanding task in itself, but in itself it does not have much influence on the free and independent selection of complete syllabi in different countries and universities It is intended to improve and harmonise education, especially in the developing European countries. The material will eventually take the form of complete courses, but at the same time it will allow the use of individual parts in university courses or modules. The following considerations are intended as a guide towards this aim:

1. As the material cannot possibly cover all aspects of agricultural engineering, it must focus on central subjects. Although in developing countries there is a lack of knowledge and teaching material on many subjects, the material should focus on future-oriented subjects which are most attractive in terms of further development and sustainability in agriculture. It should be as useful for life-long learning as for the advanced education of students who will enter their profession only after a number of years.

2. The material should contribute to the qualification of experts for international activities. They should be able to comprehend international scientific and professional literature. For this reason, teaching material reaching up to the requirements of MSc studies should be made available in English.

3. Teaching material should be easily accessible for students and other interested people. The material is expected to be used in different ways, i.e. either as a whole course or in one or more parts. Universities and lecturers will probably modify courses by integrating issues of local interest, or they might add to or cut certain parts. As a whole as well as in part, the course could be used for short courses in contexts of life-long learning. To facilitate improvements and updates to the latest scientific achievements, the material should be easy to change. These demands can only be met by material in an electronic form. In that form, it can also be made available on the internet and in local computer networks, and it facilitates teleteaching and different forms of virtual classroom teaching.

4. Initially, material should be designed for university teachers already familiar with a number of the topics dealt with. Teaching sheets, containing tables, schematic illustrations, equations, photos, and a minimum of textual explanations, seem to be the most adequate form. Apart from that, substantial bibliographies of teaching material should be included. This material can be progressively completed by text explanations provided by teachers or scholars.

5. The material should reach high quality standards, contain the latest research in the field, and, last but not least, deal with economic, social and environmental impacts of agriculture. This can only be realised through the cooperation of experts from developed countries and from South-East Europe. The task groups should on the one hand be coordinated by experts and professors from reputable universities in the European Community, but they should on the other hand include professors from South-East Europe.

In accordance with the above, the following fields of activities have been chosen for inclusion in the project:

- Information Systems in Agricultural Engineering
- **Energy Conservation and Renewable Energy in Agriculture**
- Environmental Protection and Systems Engineering including Precision Farming
- Interactions Between Agricultural Engineering and Economics and Social Needs.

In agricultural production in almost every country, energy inputs, in different forms, are on high levels. The reduction of these inputs, by using agricultural products and residues as renewable energy sources, is and will remain an important issue in future. It is closely related to the environmental problems arising from agricultural production on large surfaces. Energy consumption also has economical impacts, in the developing countries of South-East Europe even more so than in the rest of Europe.

As a model for its didactic approach, this text draws on teaching material from the University of Stuttgart-Hohenheim, Germany (Mühlbauer, W., Bux, M. and S. Ritterbusch. 2001).

CHAPTER OUTLINE

The chapters and their content should on the one hand include basic principles of teaching on energy in agriculture. On the other hand, they should take into consideration specific social and economic conditions in South-East Europe. They should also respect the profile of the target group – graduate students, future MSc's in agricultural engineering.

After their studies, course participants are expected to work as employees in engineering and consulting companies, farm machinery producing companies, governmental administration, extension services, advisory organisations, etc. They should be qualified to understand global problems and strategies, but also to act according to local needs and to solve practical problems of their immediate environment.

The course should contain up-to-date information on energy inputs in agricultural production and on the ecological and economical consequences of their use. Practical problems of energy conservation and alternative energy use should provide a picture of the complex background for professional activities and, at the same time, stimulate the students' individual creativity and work ethic.

The below chapter outline tries to take into consideration the above-mentioned requirements and statements.

Chapter *INTRODUCTION*

An introductory chapter should provide an overview of the world energy problem with regard to its present state and to its long-term tendencies. A typical example of such information is an analysis of current energy consumption by sources, Fig. 1. The introductory chapter should also deal with global and regional energy policies, generally as well as specifically for agriculture and rural areas. The basic relations between energy consumption and their economic, environmental, and social impacts need to be outlined.

Chapter *ENERGY CONSUMPTION FOR AGRICULTURAL PRODUCTION*

The elaboration on energy consumption for agricultural production should consider all inputs, i.e. fuel, mechanisation, fertilisers, pesticides, propagation material, irrigation, transport etc. It should also include data on energy inputs in different agricultural products, for example Fig. 2, as well as data on the „agricultural energy gain", i.e. the relation between energy input and output in agricultural production. These data should provide an impression of the energy flow in agriculture and identify possible energy-saving activities.

One important problem of the countries of South-East Europe which the material should also deal with is the amount of energy lost through commodity losses.

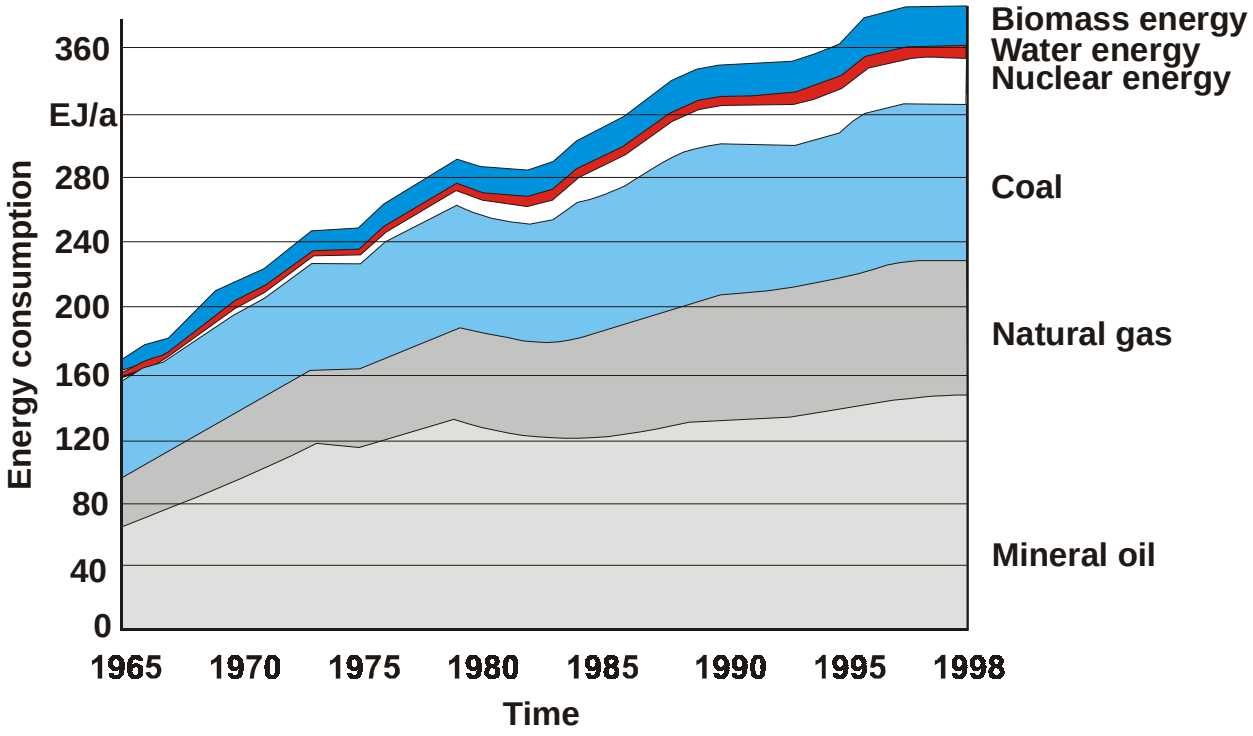

Fig. 1 Trend of energy consumption by source (Kaltschmitt, M., Hartmann, H., 2001)

Tab. 1 Gross energy value for feeds, dry basis (Jurgens; 1978)

Feed	Gross energy, MJ/kg
Wheat grain	18,8-20,1
Barley grain	19,2-22,3
Corn grain	18,4-23,2
Corn cobs	18,5
Soybean meal	19,8-20,2
Soybean hay	18,3
Alfalfa hay	18,8
Skim milk	15,4

Chapter *GUIDELINES FOR ENERGY SAVING*

Energy saving has to be portrayed as one of the most important contributions to energy conservation. More important than the actual saving of fuel, this includes the reduction of energy-intensive inputs generally. A typical example from the field of agricultural engineering is the appropriate distribution of nitrogen fertilisers, based on N-min method. This issue is closely connected with agricultural machinery and the accuracy of

distribution. As an example of the standardised evaluation of machines, Fig. 2 shows how this question also touches on environmental aspects.

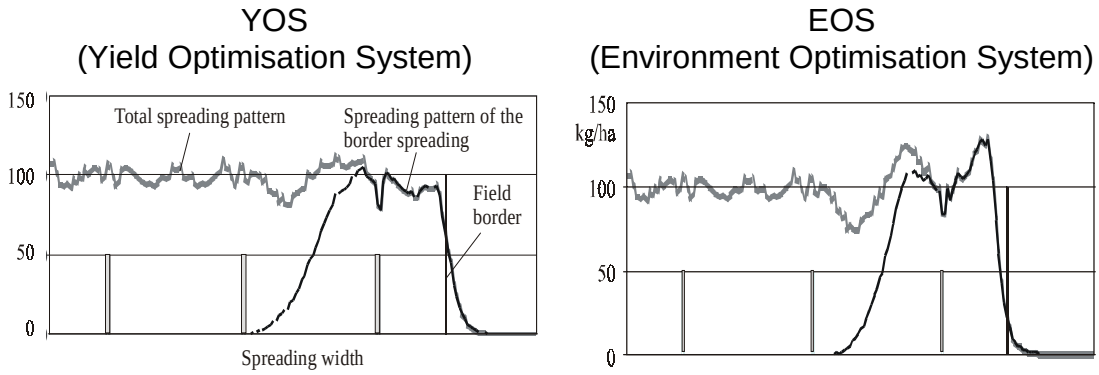

Fig. 2 Example of border spreading – YOS and EOS, primarily at 24 (28) m working widths, Ammonium sulphide 24 % N (Persson, K. 2001)

Special attention has to be paid to the possibilities of selecting energy-saving technologies for crop production, e.g. for soil tillage and conservation.

Chapter *ALTERNATIVE ENERGY IN AGRICULTURE*

This is to be the most substantial chapter of the course. It will contain the following sub-chapters:

Solar energy
Crop residues, biomass as a fuel
Vegetable oils as a fuel
Biogas
Other alternative sources

The focus will be on solar energy because of its status as the most important alternative energy source. At present, its use in agriculture is negligible, but it may be expected to become significant in future. Fig. 3 may serve as an example of the presentation of equations in the teaching material.

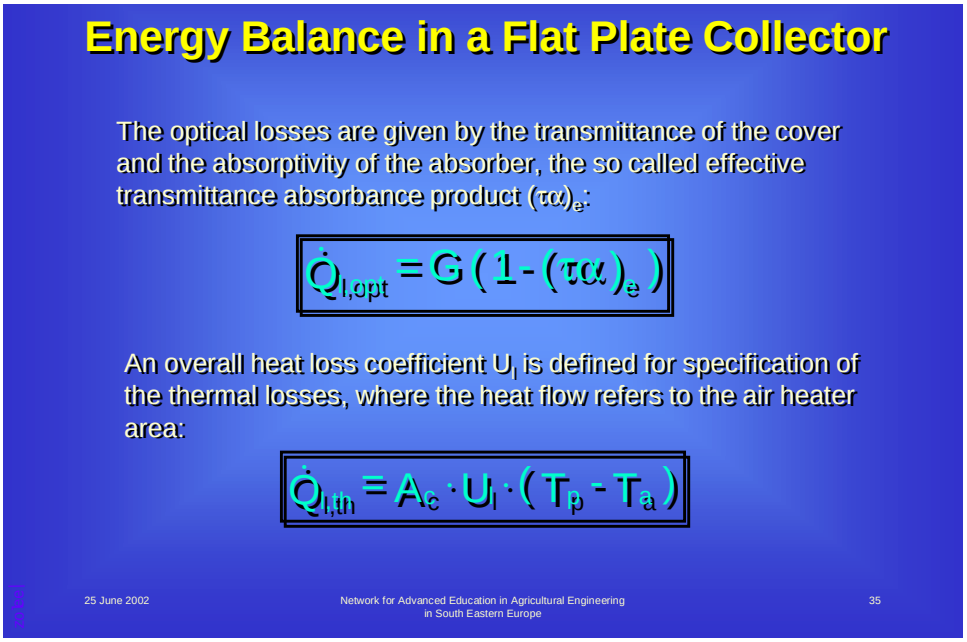

Fig. 3 Energy balance in flat plate collector (Mühlbauer, W., Bux, M. and S. Ritterbusch. 2001)

The use of biomass as an alternative energy source in agriculture and rural areas has increased. The relevant subchapter will include all important aspects of biomass production, harvesting, transport, storage, processing, and conversion to energy. In South-East Europe, the use of crop residues is of special importance and will accordingly be focused on.

Vegetable oils and biogas will be included in subchapters as renewable energy sources already used in agriculture and rural areas.

A subchapter on "other alternative sources" should review other, if somewhat less alternative, energy sources currently drawn on in the region of South-East Europe, such as wind energy, geothermal energy, methanol, etc.

Chapter *ENERGY AND INFORMATION TECHNOLOGIES*

This chapter should include all aspects of the use of IT in the field of energy in agriculture. This chapter will explain the basic principles of energy plant regulation and automation. It will also name addresses of institutions that provide information on renewable energy and other relevant data, for example www.fnr.de .

Chapter *ENVIRONMENTAL ASPECTS*

This chapter will deal with general and regional policies of environmental protection and their impact on energy in agriculture. In particular, it will illustrate how energy saving, the use of solar energy, and the use of biomass as a closed CO_2 circle contribute to the reduction of CO_2 emissions. It will also contain legislation and guidelines concerning environmental requirements on energy plants. An example is information on regulations for exhaust gases and ash reuse, Tab. 2.

Tab. 2 Limit values for heavy metals, e.g. in ash for agricultural applications (Executive Order No. 823, DK), (CBT. 1998)

Heavy metals	Limit values in force 01.07.2000	
	mg per kg dry matter	mg per kg total phosphorus
Cadmium	0,4	100
Mercury	0,8	200
Lead	120	10.000
Nickel	30	2.500
Chromium	100	
Zinc	4.000	
Copper	1.000	

For all environmental demands, there will be short spefifications concerning conditions in South-East Europe. This subchapter should provide background information able to qualify graduate students to work towards sustainability in agriculture and energy use on the national, regional, and global levels. The teaching material could serve as the basis for a detailed insight into national regulations in developed countries.

Chapter *PLANNING OF ENERGY PLANTS AND MANAGEMENT*

The planning of energy plants is a subject of paramount importance, toward the realisation of which the information provided in the preceding chapters should contribute. In some developed countries, relevant instructions are already available (FNR. 2000, CBT. 1998, etc). For use in the teaching material, such instructions should be adapted to the needs and conditions in South-East Europe. For example, it could include instructions for improving and putting into operation again of traditional rural stoves, which were used in the past for crop residue combustion in the region's rural areas.

This chapter should also contain information on basic procedures and data for economic calculations and for the management of energy inputs both in agricultural production and in energy plants. It should also contain information on the principles of national policies relating to energy in agricultural production and their support of alternative energy.

CONCLUSIONS AND FUTURE WORK

The development of a university course on energy in agriculture for South-East Europe may be expected to have a number of benefits:

- Improvement of high education in the field of agricultural engineering
- Harmonisation of knowledge in South-East Europe with that in the European Community
- Contribution to students' and teachers' mobility
- Facilitation of university and economic cooperation within South-East Europe and with the European Community
- Contribution to energy policy and improvement of energy situation in regional agriculture
- Improvement of the economic and environmental condition in South-East Europe and the European Community.

A task group for the creation of the course has already been established, but it is still open for other interested contributors. The course is intended to be finished by the end of the year 2002. It will be available free of charge for institutions as well as individuals.

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ABOUT THE AUTHORS

Prof. Dr. Milan Martinov, Faculty of Engineering, University of Novi Sad, Novi Sad, Yugoslavia, E-mail mmartog@uns.ns.ac.yu

Prof. Dr. Peter Schulze Lammers, Institute for Agricultural Engineering, University of Bonn, Bonn, Germany, E-mail lammers@uni-bonn.de

Dr. Markus Bux, Institute for Agricultural Engineering in the Tropics and Subtropics, University Stuttgart-Hohenheim, Stuttgart, Germany