BIOENERGY AND ITS VISION

Víglaský J.
Faculty of Environmental and Manufacturing Technology, Technical University in Zvolen,
T.G. Masaryka 2117/24, 960 53 Zvolen, Slovak Republic
viglasky@vsld.tuzvo.sk

Abstract
The present state of fuel and energy basis in the world as well as in Slovakia urges on the need for radical intervention to the energy sector. This will initiate a change of fuel basis – transition to renewable sources of energy as an alternative to fossil fuels and it will also initiate the need for change of present technological basis in energy sector. The main problem with energy is that we are running short of traditional resources of supply. This sentence is the proof that the world energy situation is very complicated. In fact, it is never too early for a sustainable solution. One of the solutions is to replace traditional energy carriers such as raw oil, natural gas and coal with renewable energy resources and carriers. World-wide, there is an increasing demand for biomass, for production of renewable CO_2-neutral fuel and as an inexpensive environmentally friendly raw material source for pulp and industry production. Short-Rotation-Plantations (SRPs) hold much promise in fulfilling these demands. SRPs combined with the safe application of waste water and sewage sludge for irrigation and fertilization purposes are a very promising alternative source of income due to the high economic biomass potential, the fast growing wood biomass demand for raw material (pulp) or wood chips, the low cost water treatment and the enormous potential to be used for irrigation and fertilization purposes. Thanks to this procedure, SRPs are high efficient biomass production systems with additional contribution as biological filters to a low-cost and environmentally safe biological wastewater and sludge treatment.

Keywords
biomass, energy crops, energy plantation, bioenergy

1 INTRODUCTION

The economic situation for European as well as Slovakian farmers deteriorated constantly during the last decade because of increasing cost pressures on agricultural products. Priorities in EU's Common Agricultural Policy change and foresee to strengthen farmers' role in rural development and fulfilment of quality standards for environment, animal protection and food security. To be competitive, farmers are obliged to adapt their business activities in terms of alternative products and quality requirements. SRPs combined with the safe application of wastewater and sewage sludge for irrigation and fertilization purposes are a very promising alternative source of income due to the high economic biomass potential, the fast growing wood biomass demand for wood chips and wood pellets, the low cost water treatment and the enormous potential to be used for irrigation and fertilization purposes.
Thanks to this procedure, SRPs are high efficient biomass production systems with additional contributions as biological filters to a low-cost and environmentally safe biological wastewater and sludge treatment. Thus SRPs perfectly meet general requirements not only for farmers in the former EU15 but also in the new Member States and Candidate Countries.

2 SRC-WILLOW *(Salix spp.)*

Following the structure of a Collective Research Project, RTD performers like research centres and universities carried out research activities on behalf of Industrial Associations or Groupings (IAGs) in order to expand their knowledge base and improve the overall competitiveness of large communities of their members which are almost Small and Medium Enterprises (SMEs).
In the project: BIOPROS "Solutions for the safe application of wastewater and sludge for high efficient biomass production in Short-Rotation-Plantations", the participating IAGs gained knowledge about the economic, environmental and technical feasibility of SRPs for different local conditions and market requirements, and have to transfer it to their SME members (farmers, biomass processors, engineers, decisions makers). This contribute to promote SRP biomass production between SMEs throughout Europe and abroad. The main focus lay on the safe and efficient application of wastewater and sludge to guarantee high yields and sufficient treatment performance without any negative environmental or hygienic impacts. Lack of knowledge about the high SRP potential and prejudices against the application of human residues was minimised during the project as well as barriers against the application of SRP-biomass. For this reason a wide range of aspects is still subject of research including SRPs' best practice and costs as well as related legislation and standards.

2.1 Idea of combining Short Rotation Plantations with wastewater/sludge safe application

The production of woody biomass from willow and poplars without application of wastewater or sewage sludge is very common in Europe and the reader should keep in mind that several guidelines for such plantations have been published elsewhere. As the focus in BIOPROS project was specifically on the safe reuse of human organic residues within SRPs, this innovative idea and collected knowledge brought a lot of specialized additional information about such practices.
It is anticipated that this information package will serve as a training tool for different end-users such as trainers, farmers, researchers and other stakeholders who are interested in combining Short-Rotation-Plantations with wastewater/sludge safe application.
Short-Rotation-Plantations involve numerous scientific and technological aspects due to their multipurpose approach of combined biomass production and wastewater/sludge treatment, bringing together biological and microbiological science, soil science, plant science, pathology, environmental sciences and engineering.
These aspects incorporate the following range of topics which have been developed within the BIOPROS project:

- SRP-crop related aspects (selection and specific breeding)
- Crops' nutrient and heavy metal reduction performance
- Cultivation efficiency (optimal irrigation and fertilisation, harvesting, weed and pest control, etc.)
- Most suitable soil conditions (soil conditioning)
- Microbial nutrient degradation
- Technological aspects of safe and efficient wastewater/sludge irrigation/fertilisation (dosage, distribution, pre-treatment, quality controls)
- Environmental and sanitary impacts

Under different local climatic conditions, diverse qualities and quantities of wastewater and sludge, in combination with different crops, can lead to varying biomass yields and treatment performances.
Therefore adaptation of gained results within BIOPROS project is expected at national conditions.

2.2 Main objectives

Scientific and technological objectives:

- To enable a three-fold efficiency increase in Short-Rotation-Plantation (SRP) biomass production at national conditions, by reusing wastewater and sewage sludge for irrigation and fertilisation.
- To enable the safe and efficient application of wastewater and sewage sludge in SRPs.
- To promote SRP biomass production at national conditions by transferring the generated know-how to potential SRP end-users and market actors.

Environmental objectives:

- To increase the production of CO2-neutral wooden biomass in SRPs as a renewable raw material for different technical purposes, by up to 3 times.
- To reduce the application of natural water resources for SRP irrigation by 30%.
- To substitute chemical fertiliser use by 100%.
- To completely prevent the pollution of aquifers and surface waters potentially arising from uncontrolled wastewater and sludge reuse by developing standards for safe and efficient SRP operation.
- To contribute to soil improvement on agricultural land by humus and nutrient enrichment.

Social long-term objectives:

- To increase farmers' income by 10% thus strengthening their independency from regressing subsidies (e.g. from EU's Common Agricultural Policy - CAP).
- To create employment in rural areas in particular and throughout the whole biomass sector.
- To strengthen sustainable development initiatives more generally in rural areas.

2. WILLOW *(Salix spp.)* IN SLOVAKIA

Willow (Salix spp.) includes several tree and shrub species, some of which grow fast and have been cultivated for energy generation in "energy forests" in Sweden since the first oil crisis in the 1970s. Clones of Salix viminalis are mainly used in the energy forests. Other species such as Salix dasyclados have also been cultivated, but to a much more limited extent.

Willow is a short rotation coppice crop, what makes it profitable crop for agricultural sector. It has been tested and studied for more than twenty years in some European countries. Willow cultivation is not a new activity in our country either. Plantations had been established in some parts of Slovakia aiming to gain biomass for industry. Willow plantations are being established in wide range in the countries like Sweden, Great Britain and

Denmark and they are also getting to East European countries. Willow can be also used for waste water treatment, soils contaminated by heavy metals, revitalisation of landfills and landscapes endangered by erosion. Willow has almost the same net heating value as the wood fuels, approximately 18.6 MJ/kg.DM.

Willow (Salix spp.) includes several tree and shrub species, some of which grow fast and have been cultivated for energy generation in "energy forests" in Sweden since the first oil crisis in the 1970s. Clones of Salix viminalis are mainly used in the energy forests. Other species such as Salix dasyclados have also been cultivated, but to a much more limited extent. Willow is a short rotation coppice crop, what makes it profitable crop for agricultural sector. It has been tested and studied for more than twenty years in some European countries. Willow cultivation is not a new activity in our country either. Plantations had been established in some parts of Slovakia aiming to gain biomass for industry. Willow plantations are being established in wide range in the countries like Sweden, Great Britain and Denmark and they are also getting to East European countries. Willow can be also used for waste water treatment, soils contaminated by heavy metals, revitalisation of landfills and landscapes endangered by erosion. Willow has almost the same net heating value as the wood fuels, approximately 18.6 MJ/kg.DM. Willow is mostly cultivated in the field trials of south-west Slovakia, where several farmers work with commercial plantations currently totalling about 600 hectares.

3 BIOENERGY SECTOR

Since heating causes most of the energy consumption in buildings in most of Eastern Europe countries, the introduction of a low carbon fuel for heating can significantly affect their region's emissions. District heating has been proved to be much more energy efficient that traditional individual heating systems, as well as a major contributor to greenhouse gases emissions reduction in many countries. It is an extremely flexible technology which can make use of any fuel including the utilisation of waste energy, renewables and, most significantly, the application of combined heat and power (CHP). Replacement of fossil fuel with wood fuel would typically reduce net CO_2 emissions in the process by over 90% (assuming that the wood supply is managed in a sustainable way). Energy crops can be grown to meet the needs of the market and provide a secure long-term resource.

ZVOLENSKA TEPLARENSKA Inc. / Zvolen CHP Inc. - the main heat supplier for inhabitants and industry Zvolen CHP plant was originally commissioned in 1954. Overall installed output is 311 MW in heat production and 44, 3 MW in power production. There were two pulverised firing boilers, each of them with the output 108 MW, combusting low quality brown coal (lignite), two 38 MW gas and oil burning boilers and one mobile 19 MW gas boiler. For electricity production there were three back-pressure turbines (25, 5,8 and 4,4 MW) and one 9,1 MW condensing turbine. As fuel coal, natural gas and oil were used in 2005.
Annual supply to the consumers was 788 910 GJ of heat and 102 459 GJ of electricity in 2004. Some 60 % of the heat production was used for heat and hot water supply to more than 9.000 houses and apartments. Supply to industrial consumers represents 40 % of produced heat, of which 9 % to public buildings (schools, administrative and social buildings) and 31 % to industrial enterprises. Heat is also used in industry mainly for buildings heating. Only a very small portion of heat is used for technological purposes. That causes operational problems because of two very different peaks in heat production in winter and in summer and, thus also influence the efficiency of the plant.
The plant used pulverised lignite with up to 1 % of sulphur content as fuel. Annual consumption is 180 thousand tons of lignite with the energy content 11,09 GJ.t-1. The content of sulphur in emitted flue gas is as high as 3.500 – 4.000 mg SO_2/m^3. It causes serious environmental problems in the region.
New national limits for greenhouse gases emissions are 1.700 mg SO_2/m^3 and 600 mg NOx/m3 with the effect from 1 January 2007. It was clear, that old boilers were not able to achieve those limits without substantial technical improvement and large investments. Therefore the power plant ordered a study analysing different technical solutions from the point of view of their impact on environmental acceptability and economical feasibility of the operation in the future.

Recent situation at the Zvolen CHP plant

The Zvolen CHP plant is recently 100 % state owned joint-stock company. The government has decided on privatization of four recent CHP plants which are recently state joint-stock companies, including the Zvolen power plant. The process of its privatization has not been yet concluded. This does not have any impact on the decision to implement the project of boilers conversion regarding their impact on environmental acceptability and economical feasibility of the operation in the near future.

Co-firing of low-sulphur brown coal and wood chips as the most efficient solution

The main problem with energy is that we are running short of traditional resources of supply. This sentence is the proof that the world energy situation is very complicated. In fact, it is never too early for a sustainable

solution. One of the solutions is to replace traditional energy carriers such as raw oil, natural gas and coal with renewable energy resources and carriers.
There were several technical alternatives analysed in a feasibility study. Finally the alternative of conversion of two boilers for co-firing of low-sulphur brown coal and wood chips was recognized economically the most efficient and environmentally positive solution. It was calculated that the proportion of brown coal and wood chips will be 70 : 30 %.
Zvolenska teplarenska Inc. / Zvolen CHP Inc. is the largest producer and supplier of energy in the area of the town Zvolen as well as surrounding region. The mentioned plant originally used Slovak brown coal as fuel, which had installed heat output of 216 MW in two boilers, K-01 and K-02 each having an output of 108 MW. Power output of the plant is realized in a 25 MW counter pressure turbo generator (TG-01) and a 9 MW condensation turbo generator (TG-5).
Slovak brown coal did not allow the plant to conform to standards regarding pollutants. The major problems exceeded concentrations of sulphuric oxides in flue gases (1700 mg $SO_2.m^{-3}$). The Zvolen CHP Inc. decided to solve this environmental problem by implementation of the Project „Ecologisation of heat source by using co-firing of wood chips (30%) in the Zvolen CHP Inc.“ and applied for a non-recourse financial grant (NFG) needed for its financing. The Project was accepted in 2005 and the provider of the financial help *the Ministry of Environment of the Slovak Republic* approved 470 million SKK from the sources of the EU and the state budget as NFG, which originally represented 95% of capital costs of the Project. On 24th April 2006 the company made a contract for work with selected contractor Slovenske energeticke strojarne Inc. Tlmace (further on just SES). The building process started immediately after the contract was signed in 2005, by realization of the first phase of the project, in which the following facilities were reconstructed: the K-01 boiler, the facility for receiving, storage and internal transport of wood chips to the combustion chamber of boilers, control system and automatic monitoring of flue gases (AMFG).
The first phase was finished by complex examinations in March 2007. After this date the implementation of a second phase of the Project started by reconstruction of K-02 boiler. The second phase was finished with complex examinations of K-02 boiler that took place in May 2008.
Annual wood chips consumption is up to 70,000 tonnes. Chips will be stored in 9.000 m^3 open depot and in 3.000 m^3 silo. Chips will be fed into boilers from 720 m^3 silo.
The exchange of the fuel base (100% lignite) for low-sulphur brown coal with a CV of 13.5 $MJ.Kg^{-1}$ demanded a change of the combustion chambers, main and stabilizing burners and pressure parts of the boiler. The combustion chambers of K-01 and K-02 were supplemented with a band grate enabling effective burning of wood chips. All peripherals of the boiler were reconstructed and it was provided with a modern control system Siemens-Semantic. The emissions are continuously monitored by AMFG connected to the control system of the boiler and with remote data transfer to the internet website. The K-02 boiler was reconstructed for the required lower output of 65 MW. This boiler will be mainly put to use during winter consumption peaks and in periods out of the main heating season.
The primary objective of this project was to ensure fulfilment of stricter emission standards valid in the EU and the SR after 1st January 2008, which was demonstrated by examinations – a complete operational test of AMFG and by single-shot measurements of emitting pollutants in sense of valid legislation, Fig. 1.

An equally important goal of the reconstruction was to ensure long-term sustainable competitiveness in the open market with heat in the area of Zvolen. The achieved results confirm that this goal has been fulfilled, too.
Zvolen belongs to one of those towns in which there is long-term development of a district heating (DH). The heat supply from DH brings reliability, safety, certainty of deliveries, comfort, service and renewal of facilities in the price of heat and also lower loading of environment (1200 mg $SO_2.m^{-3}$). In the last couple of years the often repeated question was whether this way of central heating and preparation of hot service water is favourable for households, as well as deliveries of technological heat to industrial consumers. These questions were answered in the communal energy concept of town Zvolen.

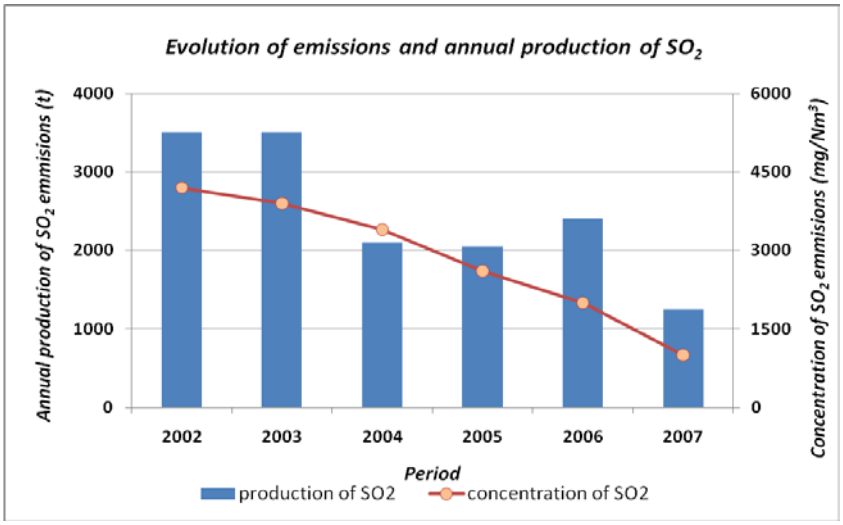
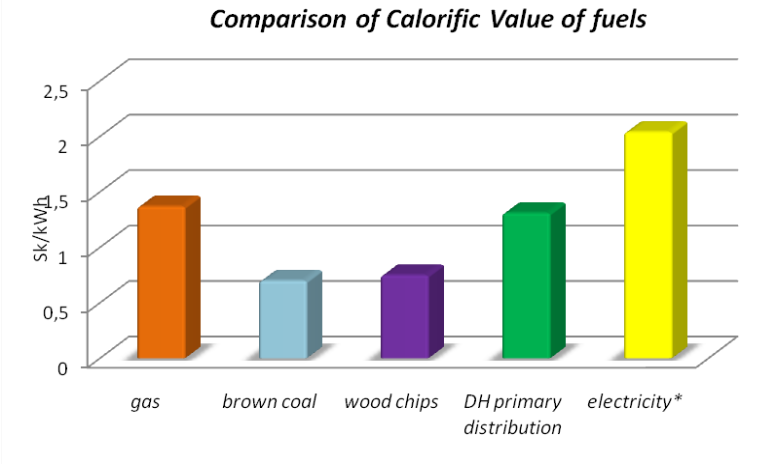


Fig. 1. Evolution of emissions and annual production of SO_2

The new Regional energy concept evaluated heat from DH as the most effective as well as the most favourable for the final consumer. The experience from recent years has proven these claims to be right. Zvolen belongs among one of the towns with the lowest price of heat and the lowest heat consumption per equivalent housing unit, which means, that the citizens of Zvolen belong to those with the lowest payments for heat. The cost of heat is mainly influenced by prices of applied fuels or actually energy carriers (65%). The competitive comparison is also complicated by the usage of different units, in which the contained heat energy is measured. By the new standards, the price of gas is set for delivered kilowatt-hours (kWh) of energy, the distribution companies set consumption of electricity directly in kWh, the heat supply is measured in GJ and solid fuels are bought in tons. For better orientation and comparison the prices of individual energy carriers are recalculated into the same unit (kWh) and same delivery standard in the next graph, i.e. on the primary distribution outlets, Fig. 2.



* tariff rate of electricity for heating

Fig. 2. Comparison the prices of individual energy carriers

From the graph it is obvious that the price of the heat from SCSH of Zvolenska teplarenska Inc. is competitive, the main reason of the favourable price is the fact, that ZT uses fuels with lower cost (coal, wood chips) and it is able to transform them into final products (heat and electricity) effectively in its facilities.

DISCUSSION

By the implementation of the project the main problem, which is the reduction of greenhouse gas emissions, will be solved. Greenhouse gases emissions after the conversion will be lower than allowed limits which will be force after1 January 2008, i.e. 1.637 mg SO_2/m^3, 600 mg NOx/m^3, 250 mg CO/m^3 and 50 mg fly ash/m^3.

Main environmental effects will be as follows:

- reduction of SO_2 emissions by 1.000 tons, e.g. 47 % comparing to 2004
- achievement of SO_2 emissions limits after 2008 and thus possibility to continue in operation

• reduction of CO_2 emissions by 37.000, e.g. 17 % in comparison to 2004
• automatic continual control of emissions level and production process control
• reduction of ash production by one third – from 25.000 tons to 16.700 tons annually
• by improvement of the automatic control of the combustion process production of all pollutants will be significantly reduced.

There will be also significant positive economic effects after the project implementation.
The main items are as follows:
• reduction of fuel procurement costs up to10 %
• lower energy prices for consumer
• creation of new job opportunities in the region for biomass harvesting and transport
• increase of electricity production – it is expected that up to 80 % of local electricity consumption will be produced by the Zvolen CHP plant
• increase of the income for the plant due to the higher price of electricity supplied to the grid produced from renewable energy sources
• reduction of the load of pollutants in the region and the improvement of the environment will bring significant indirect economic profit due to improvement of living conditions of citizens and their health state.
The costs of the project implementation was approx. 14 million €. The costs was partly covered by the European Regional Development Fund, partly by the state budget and partly by the power plant.
It is envisaged that this innovative project in Zvolen will initiate similar projects in Slovakia as a whole, but special attention has been given to meet criteria of environmental regulations.

4 CONCLUSION

The Slovak Republic is a country highly dependent on the import of all kinds of fuels. Mainly fossil fuels are used for production of heat and electricity. Because of large use of brown coal also production of pollutants, including greenhouse gases, is very high. That causes serious environmental problems. On the other hand there is a large potential of domestic renewable energy resources – significance of biomass is growing rapidly in energy sector, which is attractive and inspiration future for forest and land owners.

Biomass production vision and bio-energy sector
The biomass resources should be considered as the efficient and promising RECs for and from rural sectors. The bio-energy sources are decentralized, cheap renewable energies suitable for continuous energy supply and for conversion of them into various more valuable secondary energy carriers. The transportation and storing of biofuels are much easier compared to energy carriers originating from solar, wind or geothermal energy. The caloric value of absolutely dry biomass 17-24 $MJ.kg^{-1}$ equal to that of the medium quality brown coal and even the air dry biomass sources, having 14-16 $MJ.kg^{-1}$ caloric value at 15-20% of moisture content, are suitable for feeding of small, medium and concentrated heat supplying units in the range of 10 kW up to 10 MW thermal capacity, at a reasonable cost of biomass handling.
In the near future, an increased demand is expected for biomass-phytomass as an inexpensive environmentally friendly raw material source for production of renewable CO_2-neutral fuel. The search for new energy crops, which have potential yields of more than 50 tonnes of DM per hectare annually, as a raw material base for industrial production of different biofuels, is becoming a task of strategic importance.
Crop production strategies need to be developed that are as efficient as possible in capturing sunlight (solar energy) and storing it in plants (the solar battery).

5 ACKNOWLEDGEMENTS

The paper was prepared with a financial supports provided by the EU Commission within IEE Program. *The Project BIO-HEAT "Promotion of Short Rotation Coppice for District Heating Systems in Eastern Europe",* Contract N°: IEE/09/890/S12.558326; co-financed by European Union in years 2010 – 2012. The authors are indebted to the mentioned institutions for helping to sponsor this research work.

References

[1] VIGLASKY, J. (2001): Demonstration Project of Wood Fired Heating Plant in Zvolen. In: Proceedings of Inter. Conference „Renewable Energy Sources on the Verge of the XXIst Century". PL - Warsaw, 10_11th December 2001, pp. 281-285.
[2] VIGLASKY, J., LANGOVA, N. and SUCHOMEL, J. (2005): Development of bio-energy in Slovakia. In: Proceedings of Central European Biomass Conference 2005, January 26-29, 2005, Graz, Austria, 8 p.

[3] Viglasky, J. and Langova, N. (2005): Industrial wood waste or strategy energy raw material. In: Bioenergy 2005. Inter. Bioenergy in Wood Industry Conference and Exhibition, Jyväskylä, pp. 285-287
[4] VIGLASKY, J., LANGOVA, N. and SUCHOMEL, J. (2008): Successful biogas case studies in Slovakia. In: Proceedings of Central European Biomass Conference 2008, January 16-19, 2008, Graz, Austria, 10 p.
[5] VIGLASKY, J. LANGOVA, N., SUCHOMEL, J., SKVARENINA, J. and GEFFERT, P. (2007): Potential of Biomass production in Short-Rotation-Plantations by using wastewater and sludge for irrigation and fertilisation. In: Proceedings of Success and Visions for Bioenergy – A European workshop on thermal processing of biomass for bioenergy, biofuels and bioproducts. 22-23 March 2007, Salzburg, Austria, 6 p.
[6]VIGLASKY, J. (2007): The opportunities and visions for energy crops and bioenergy in Slovakia. In: Proceedings of Conference "The Role of renewable energy in central and eastern Europe" 2008, April 22nd – 24th, 2007, Gallbrunn, Austria, 11 p.
[7] ILAVSKY, J. and JANKOVSKY, J. (2006): Environmental and economic gains of the conversion of the Zvolen district CHP plant from low quality brown coal combustion to co-firing of biomass and low sulphur brown coal. In: World Bioenergy 2006, 30 May – 1 June 2006, Jönköping, Sweden. pp. 19-23.

Author addresse:
Prof. Dr. Jozef Viglasky,
Technical University in Zvolen,
T. G. Masaryka 2117/24,
960 53 Zvolen, Slovakia

Phone/fax: +421 45 5206 875; E-mail: viglasky@vsld.tuzvo.sk, www.tuzvo.sk