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A CONCEPTION OF THE IMPLEMENTATION OF LIQUID BIO-FUEL PRODUCTION IN THE PODLASIE PROVINCE

1. Introduction

The concept of the development of liquid bio-fuel production in the Podlasie province is an element of the integrated waste management strategy for the region of Podlasie (North-Eastern part of Poland). The present situation in the field of waste management is quite similar to the problems existing in other regions and cities of Poland.

The increasing amount of generated waste is stimulating efforts towards alternative types of treatment, which would be environmental friendly, that is, would radically reduce the amount of waste accumulated and by means of recycling reduce use of natural resources. In particular the rapid increase in the amount of municipal waste is a problem is the Podlasie province. During the next few years existing disposal sites will have be up. Establishing new disposal sites will probably be impossible, due to local communities defending themselves against this. Therefore it is necessary to look for new ways of solving this problem.

Concepts of disposal need to meet a range of requirements, such as:

- marked reduction of environmental pollution,
- *effective recovery of energy and raw materials,*
- *comparatively low investment costs.*

At the same time steps aimed at the implementation of the production of fuels from renewable and non-conventional resources have been taken. They mostly concern production of bio-diesel, use of biogas and biomass for energy purposes. This is also happening in the Podlasie province. Actions taken by one of the local firms, with the help of

a group of scientists, are aimed at meeting two goals: sustainable waste management, as well as bio-fuel production. The general assumptions of the of creating a new bio-fuel plant are:

– processing the waste that is currently generated and also the waste, that has accumulated,

– utilising regional waste sources, for example the timber industry and food manufacturing,

– using biomass of agricultural origin and thus stimulating development of agricultural production in the region,

– supplying materials for re-use and bio-fuel components which do not cause an increase in the emission of greenhouse gases,

– minimal environmental and other effects connected with its operation.

2. General conditions of liquid bio-fuels production

The area of the province amounts to 20,180 square kilometres, with 36 towns and 3950 villages and is inhabited by 350,000 people. Podlasie, situated in the North-Eastern part of Poland, contains perhaps the most valuable areas of natural beauty in Poland. Protected areas occupy almost 32% of the province and this feature defines to a great extent how various problems are managed.

As shown in Figure 1, in the year 2000 the waste generated increased to 1.2 million tons, 40% of which was municipal waste. Moreover, the amount of municipal waste is increasing relatively quickly – in 1999 the rate of increase was 4,6% and 7,1% in 2000. About 1,500 tons was hazardous waste, the most important of which were waste oils.

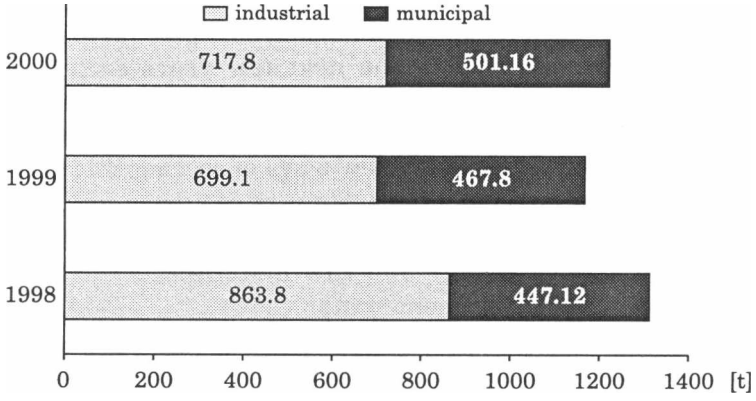

Fig. 1. Waste produced in the Podlasie province 1998–2000

Source: *Rocznik Statystyczny Województwa Podlaskiego 2001*, 2002.

The dominant means of municipal waste disposal is storage in public municipal landfills and since 1999 28 modern sites have been established in the province. Local authorities decided to establish a waste separation plant, which is being put into operation at the moment. However, due to a lack of receivers of sorted materials for re-use, its success is questionable. Therefore, one of local firms operating in the field of waste management decided to establish and finance a new waste treatment plant, using technologies combining waste recycling and bio-fuels production.

This concept of solving waste management problems is linked to the fact, that high quality of environment is considered a substantial factor in the economic and social development of the region. Moreover, the province has favourable conditions for the production of agricultural feedstocks for industrial purposes. The indicator of agricultural land use per inhabitant for the province (0.98 ha) is twice as high as for Poland as a whole (0.48 ha). At the same time industrial crops have a minor share of the area sown, which shown by Figure 2.

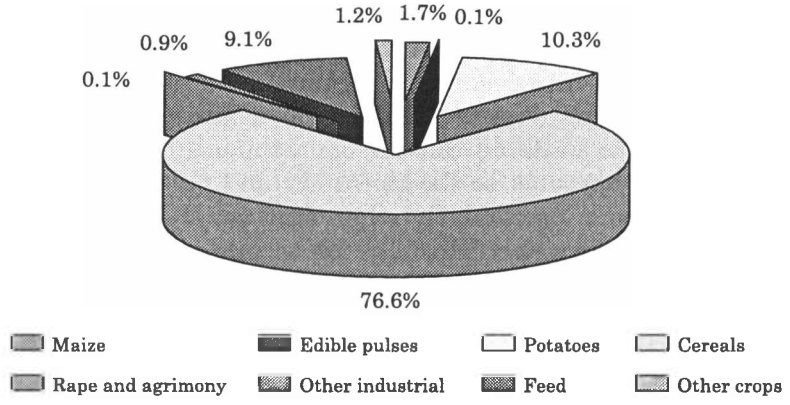

Fig. 2. Structure of the area sown in the Podlasie province in 2000
Source: *Rocznik Statystyczny Województwa Podlaskiego 2001*, 2002.

Therefore, production of bio-fuels from biomass of agricultural origin can be an opportunity not only for the local environment, but also for the economy.

Bio-fuels are liquid fuels produced from biomass feedstocks via a number of chemical processes. The two most advanced bio-fuels are bio-diesel (produced from vegetable oil) and bio-ethanol (produced from plant sugars). Other liquid bio-fuels such as bio-methanol and its derivatives have been researched and tested, but have not gained the commercial

potential and market share that bio-diesel and bio-ethanol have. These fuels can substitute fossil fuel (with or without engine modification) and have mainly have transport applications [Grzybek, 2001, 6–8].

Technologies for the production of these liquid bio-fuels are well understood chemical processes using proven techniques. Typical feedstock for these fuels are mainstream agricultural crops, such as oilseed for bio-diesel and wheat and sugar beet for bio-ethanol. Other feedstock being researched are various kinds of virgin or waste oils, or fats of plant or animal origin and lignocellulosic material such as wood. Since the main cost element in fuel production is expensive feedstock, these cheaper feedstock are predicted to help reduce overall fuel production costs.

The relatively simple chemical process of transesterification produces rape methyl ester (RME), which has properties almost identical to those of fossil based diesel. The main advantages of using bio-fuels include their direct substitution for fossil fuels, an existing pipe distribution network, and a commonly held acceptance that the levels of harmful emissions are lower than their fossil fuel equivalents. More recently, the environmental damage caused by burning fossil fuels, together with the resulting global warming, have had a positive impact on the consideration of liquid bio-fuels as a serious fuel option. Once these generic issues have been taken into account, the commercial availability of a fuel depends on another set of issues. These include the scale of industrialisation and access to suitable conversion technology, a suitable infrastructure to get the product to the consumer and public support for the use of liquid bio-fuels, particularly when food crops have been used in their production. The market status of the technologies is therefore not necessarily driven by their commercial viability and hence competition with fossil fuels, but by the push to secure transport fuel supplies, profitable use of land set aside, and to reduce environmental damage.

The use of pure bio-diesel is promoted for private vehicle use in Germany. It is very successful because of the large number of retail outlets with a comprehensive distribution network and the large number of privately owned diesel engine cars, the manufacturers of which (e.g. VW and OPEL), have approved the use of bio-diesel. For such technology to be successful, public support is very important. The success of bio-diesel use in Germany, France and Italy has occurred because of the willingness of the public to use the fuel in their cars.

The decentralised nature of liquid bio-fuel production requires a minimum amount of manpower per litre or tonne of fuel produced. These plants are likely to create opportunities for new and additional jobs, especially in marginal rural areas. NOVAMONT, the European leader in bio-diesel production in Italy and France, has concluded that 1 million

hectares of bio-diesel feedstock land would create 18,000 jobs, predominantly in the agricultural sector. Using the medium term econometric simulation model HERMES, Belgium concluded that for every 870 tonnes of bio-fuel produced, between 1,1 and 2,7 jobs were maintained or created within the country [*Pozyskiwanie paliw,* 2001].

The main risk barrier to the deployment of liquid bio-fuel technology across Europe, including Poland is the uncertainty that surrounds feedstock availability. The set-aside scheme, which is going to be introduced into Poland after joining EU, is a suitable mechanism to promote non-food crop production. If farmers were restricted from growing food crops, then the land could be suitably used for other applications.

One of the key reasons for the construction of liquid bio-fuel plants is tax exemption on the fuel produced from these plants. This fiscal incentive is a key incentive for investment in liquid bio-fuels plants, which otherwise would not be built. It helps to reduce the initial risks incurred in building the plant. However, other risks still remain, for example securing feedstock supplies. The reason for this uncertainty is the fact that oilseed rape which would be grown for industrial purposes on non-set-aside land might not be as profitable as food crops.

The construction of pilot or demonstration plants in Poland has been financially supported by capital grants, but the most important financial incentive, is the provision of tax exemption on bio-fuels produced from the plants. Without this (as happened in the UK) bio-fuel is between 2–3 times more expensive than its mineral fuel equivalent and thus cannot compete on the open market.

However, it is also often argued that if the negative environmental externalities of the oil industry in terms of air pollution, water pollution, global warming and human mortality were taken into account, then liquid bio-fuels would be very competitive indeed [Gogół 2001]. This argument would be strengthened further if the positive externalities and socio-economic benefits of rural development from liquid bio-fuel production and use were included in the equation. Without these factors, this price comparison between bio-fuels and mineral fuels is distorted.

Bio-fuels in their life-cycle (from the point of crop cultivation, to fuel produced and used) emit less harmful gases that their fossil fuel equivalents. The extent to which this is the case, is rather subjective. This is largely due to the differing methods for quantifying emissions when fuel is combusted – which is the part of the chain most focused upon. During the combustion cycle, it has been estimated that the emission of the most harmful greenhouse gases (apart from CO_2) N_2O and CH_4 from bio-diesel are four to six times lower than a light vehicle running on gas oil. The impact of a bus running on a 30% bio-diesel mix with gas oil

results in 25% less emissions than that of a bus running on pure gas oil. On balance, the use of bio-fuels could play a significant role in helping to reduce the overall level of greenhouse gas emissions, particularly of CO_2, in Europe. It has been estimated that this could be between 20 and 50% [*Pozyskiwanie paliw,* 2001].

The commercial use of liquid bio-fuels produced from renewable agricultural or forestry resources makes a positive contribution to the sustainable development of energy systems, as well as of the feedstock production sector (normally agriculture), which is under increasing pressure to diversify into alternative, more profitable non-food crop production.

3. Waste recycling and its meaning to the strategy

In the case of Bialystok and Podlasie province waste recycling technology is to serve as a basis for further processing of bio-fuels. The general assumption is that waste and sewage sludge are mixed together with biomass and then energy contained in the waste and biomass is transformed into fuels or feedstock for the synthesis of alcohol (which is then added to petrol).

When using oilseed rape as a feedstock, the production plant needs to be composed of such modules as:

– Thermoselect thermal treatment installation, processing waste and supplying synthesis gas for production of methanol,
– Methanol synthesis installation,
– Oil presser,
– Oil transestryfication installation.

This is illustrated by Figure 3, as the Ecomix Strategy. The strategy is copyrighted by Professor Lech Sitnik.

The set of installations described above enables the production of:

– methanol as a component of unleaded petrol or for fuel cells,
– rape methyl ester (RME), a fuel directly used in diesel engines, or as an addition to diesel oil (which makes so called bio-diesel).

Modular series fabrication of building and process components ensure efficient quality assurance, a short realisation time and relatively low investment costs. Particular elements can be changed depending on local needs and conditions, in particular regarding available feedstock.

In the region of Podlasie important feedstock for such processes is biomass of agricultural origin and in particular rape, at present used mostly in oil the industry. However, implementing the technology at full commercial scale will not be possible without a regular supply of readily available agricultural feedstock, which requires proper incentives from the public authorities.

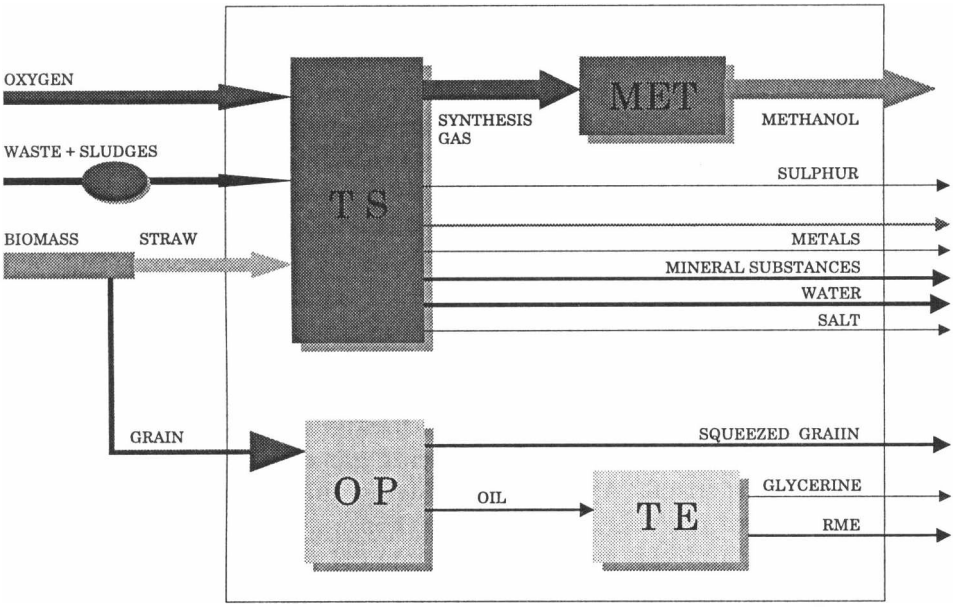

Fig. 3. EKOMIX Strategy

Source: Sitnik, 2000.

Thermoselect technology[1] meets present requirements with a process using pure oxygen to recover high-grade raw materials for re-use. It combines and optimises gasification, degasification and direct melting techniques in a continuous process for recovering materials, energy and chemicals from residual waste. Thermoselect is at present an important point of discussion in the waste management sector. In addition, renowned test institutes (for example TÜV, die Technischen Überwachungsvereine[2]) and experts confirm that the results of the process meet environmental standards.

The system can handle residue from automobile shredders, medical waste material, sewage sludge, and other industrial waste, as well as ordinary municipal waste. Untreated residual waste of all kinds (household, industrial, hospital waste and sludge) is compressed to a fraction of its original volume and then rammed into the degasification tunnel. In the degasification tunnel, the organic constituents of the residual waste

[1] Information regarding Thermoselect technology can be found at: www.thermoselect.com, as well as from.Sitnik [2000].

[2] TÜV Rheinland/Berlin-Brandenburg is a German service group operating in 40 countries, documenting the safety and quality of products, systems and services.

are degasified in an air-free environment and converted into a coal-like carbon product (charcoal). Controlled injections of oxygen are used to gasify all carbonaceous components at temperatures above 2,000°C. Dioxins, furans and other organic compounds are split into the smallest possible inorganic molecules (H_2, CO_2, CO, HCI, H_2O) at temperatures of 1,200°C to 2,000°C and are thus reliably destroyed. Shock-cooling separates metals and mineral substances, extracting raw materials, which are granulated and separated ready for use by the metalworking and construction industries.

The synthesised gas produced in the high-temperature reactor flows automatically through the gas cleaning plant. Shock-cooling the gas freezes the stable states attained at high temperature, which eliminates the risk of de novo synthesis of dioxins, furans and other organic compounds in the Thermoselect process. During gas cleaning, pollutants are absorbed or condensed. After de-sulphuring and removal of the last traces of pollutant material, the pure synthesised gas can be used for energy production and the synthesis of chemical products.

– Products of the thermal selection process are:
– Pure synthesised gas for energy production, or as a feedstock for the synthesis of chemical products such as hydrogen, hydrocarbons, ammonia and alcohols.
– Pure water to meet internal plant requirements.
– Mineral substances for the construction industry, as a substitute for natural stones.
– Metals for the metalworking industry.
– Mixed salt for the production of caustic soda.
– Zinc concentrate for the recovery of zinc and lead.
– Sulphur for the production of sulphuric acid.

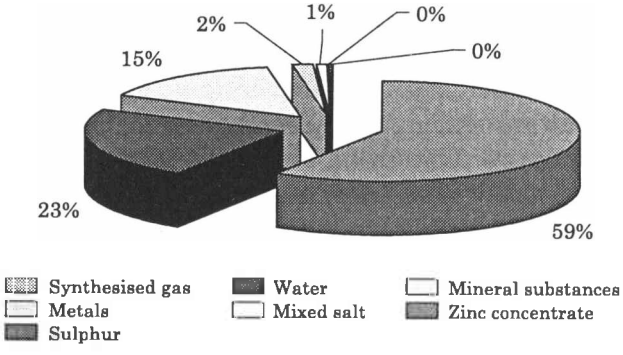

Fig. 4. Thermoselect process products

Source: www.thermoselect.com

Conventional waste incineration yields only energy and generates highly toxic filter dusts, ashes, slag and unusable waste gases. As owners and users of the technology claim, in the Thermoselect process there is no possibility of harnessing waste incineration to synthesise chemical products. Any emissions that occur are well below standard threshold limits, as shown in Figure 5. The synthesis of chemical products does not cause any direct emissions. Synthesised gas and water are to be utilised for the internal needs of the plant, other products can be sold as pure materials for re-use.

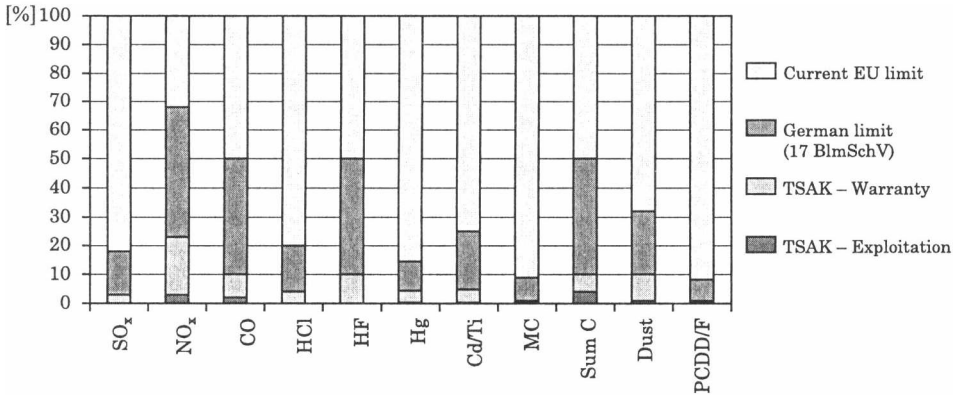

Fig. 5. Comparison of Thermoselect plant emissions to the threshold limits
Source: Sitnik, 2000.

Comparative life cycle analysis of different thermal waste treatment processes conducted in Switzerland indicates that the environmental burden caused by the Termoselect technology (providing electricity is produced) is lower than that caused by traditional incineration technologies [Hellweg et al., 1998]. The results of evaluation by means of the Swiss Ecopoints Method are shown by Figure 6.

4. Organisational aspects of implementation

It is important to stress, that the fierce discussion about Thermoselect technology itself should not be considered an important argument against introducing it in Poland, unless a plant does not meet legal environmental standards. The proposed strategy uses only one element of technology introduced by Thermoselect and puts together a range of other well known technologies that are in operation separately.

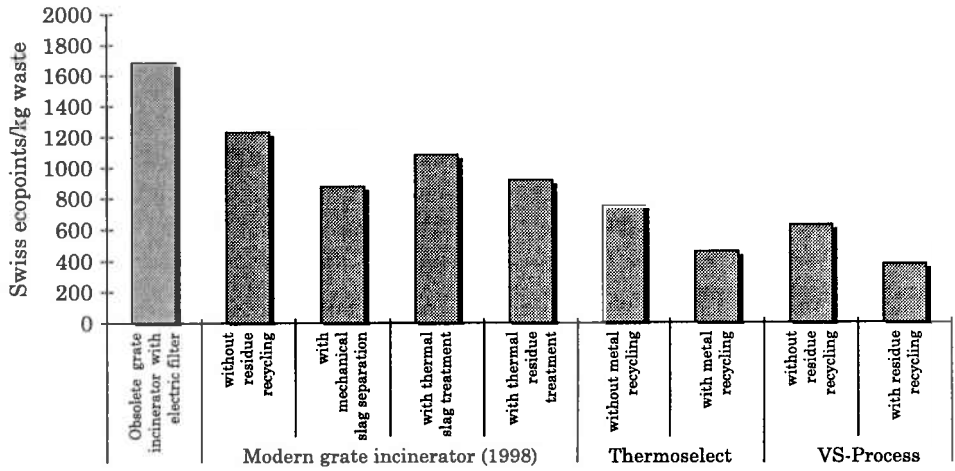

Fig. 6. Life cycle assessment of different thermal waste treatment processes
Source: Hellweg et. al, 1998.

No matter, what the individual characteristics of a technology are, the design phase has to answer such questions, as:

– Is the amount and energetic value of waste sufficient according to the capacity of the installation?

– What are the possibilities of collecting, selecting and using waste and raw materials processed in the plant?

– What are the conditions of the optimisation of supply and distribution of products?

– Is future activity going to be environmentally effective?

– What steps are to be taken in order to find public acceptance for the plant?

Such research is being conducted at the moment. Experience with utilisation of waste for energy purposes indicates, that it is efficient when located in areas, where a sufficient amount of waste has been generated. Generation of waste is concentrated in the city of Bialystok, with over 100,000 tons of waste per year. The first suggestion regarding location of the plant was therefore the city of Bialystok, as it would require the minimum transportation of waste. This, however, also requires changes in acts of local law, that is to say the local spatial plan, as it forbids the building of such a plant in the area which has been suggested.

It is estimated that the plant will process about 200,000 tons of waste, produced in Bialystok, as well as in neighbouring communities and about 100,000 tonnes of rape. As only straw is processed in the thermoselection process, seeds are to be used for production of bio-fuels.

In the year 2000 rape was grown in an area of only 1000 ha in the province, whilst in order to produce such an amount of rape an area of 40,000 to 50,000 ha is required, depending on how great the yields are. This shows the potential for agriculture. Providing the price of one tone of rape is 900 PLN (about 225 euro) and one tone of straw – 100 PLN, the revenues of local farmers are about 100 million PLN per year.

The estimated investment costs are about 80-120 million euros, depending on the particular technical option, which has not been decided yet. The project will be probably financed purely by private investors, including banks with no support from local authorities. In such a case the economic results of the enterprise are more likely to be positive.

An important question in such kind of activity is legal regulation. Waste recycling using this particular set of technologies is legally restricted. Therefore, it will be necessary to sign a license agreement. From a legal point of view the activity can be classified either as an incineration or a recycling plant, which however does not change the legal conditions. In both cases, according to the law, the plant might cause significant environmental damage and consequently an Environmental Impact Assessment is required. Such an assessment has been prepared and the conclusions are that the plant will not cause any negative impact on the quality of the environment. An additional problem is the public relations of the Thermoselect technology, which have caused public discussion on the whole project.

5. Conclusions

The main idea of the project is to combine, which are already known and proved, and use them in a new way. The effect will be a number of goals realized at the same time: a solution to waste disposal problems, environmentally sound fuels and encouragement of economic development in the region. Utilising waste for energy purposes makes it possible to produce comparatively inexpensive energy. Simultaneous production of liquid bio-fuels in such an agricultural region as the Podlasie province, apart from solving waste disposal problems, provides an environmentally sound fuel and creates a basis for the economic development of the region.

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