SEBE – Sustainable and Innovative European Biogas Environment

Work package 4: Technology framework and research

Country: Slovenia

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LIST OF ABBREVIATIONS

AD – anaerobic digestion

CHP – combined heat and power

CNG – compressed natural gas

GP – guaranteed purchase

OS – operating support

RES – renewable energy system

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EXECUTIVE SUMMARY

Biogas plants (machinery which extract biogas from organic residues and waste materials), are an excellent investment for the future as energy solutions, and this is clearly a growing awareness also in Slovenia where there is a lot of potential for their construction in the countryside.

Biogas is a renewable energy source and one of the most promising, most efficient and environmentally-friendly energies in the future. The production of green, environmentally friendly energy from biogas is an important contribution to reducing greenhouse gas emissions and reducing energy dependence on fossil fuels and imported energy sources. Energy obtained from biogas on the other hand offers several advantages in the field of obtaining electricity and thermal energy, fertilizers and waste management. For this reason, the biogas and biogas plant experts forecast an even more promising outlook.

The basic purpose of biogas plants is the processing and energy-efficient use of organic wastes generated in agriculture and animal husbandry (manure, slurry, silage, etc). The most important function of biogas plants is ecological, because in obtaining biogas mostly organic residues and wastes are used. Another of its features is the obtaining of green energy, which is subsidised to the manufacturer and represents the main source of income.

Increasing the use of renewable energy and reducing greenhouse gases in the atmosphere are the basic guidelines of the European Union, and our country is no exception to this fact. Slovenia has pledged that by the year 2020 it will reduce greenhouse gas emission by 6 percent and increase end-user renewable electrical energy forms from the present 16 percent to 25 percent.

All the developed countries of the European Union have been promoting the construction of biogas plants for many years. These are important factors for the provision of renewable sources, since they allow the production of green energy (with no greenhouse gas emission), whilst having a number of positive effects. In this manner, not only are electricity and heat as well as some excellent organic fertilizers obtained, but new jobs can be also created as the basic for the higher standard of life. The biogas plants can, among other things, also resolve the question of uncontrolled accumulation of organic waste (kitchen or slaughterhouse waste, waste material from the production of juices, wine and beer, dairy wastes, manure and slurry), which can all be fully recovered and thus help to maintain a clean environment. Their operation (without odour and noise emission) in contrast to some public opinion, is not only a promising and less damaging way of obtaining energy, but also a step towards a cleaner and healthier environment and independence from energy.

In Slovenia there are currently 12 biogas plants (of which 5 are the result of Keter Organica development and knowledge) with a total power of 14.7 megawatts serving more than 40,000 households. According to analysis made by Agricultural Forestry Chamber, Slovenia has enough potential to make (in the most conservative scenario) 86 megawatts from biogas plants, and with the best scenario as much as 147 megawatts, without substantially interfering with primary agricultural production. This would enable enough electricity to be supplied to more than 319,000 households. The largest agricultural potential for biogas production in Slovenia is the Pomurska and Podravska regions, followed by Central, Savinjska and Gorenjska regions. The lowest agricultural potential for biogas production is currently in Zasavje, Charintia and the Inner-Krast regions.

Biogas plants are an excellent solution for providing electrical and thermal energy in our rural areas, while at the same time producing great organic fertiliser without any unpleasant odour. At the same time the plants can also provide local energy independence and so many more opportunities for economic prosperity. The potential for the construction of biogas plants in the

Slovenian countryside is more than enough, merely lacking awareness that it is possible to preserve the environment, reduce energy consumption, create jobs and thus create a basis for rural development.

By the year 2020, in accordance with EU directives, Slovenia must show that at least 25 percent of its gross energy usage is accounted for by renewable energy sources. In terms of electrical energy, the goal is that renewable energy sources will represent 39.35 percent of the total energy usage. This is an extremely ambitious number. /22/

In Slovenia have been executed projects on the biogas topic and this project are Biogas Region, Big>East, 4biomass, Madegascac, and AGRIFORENERGY 2. Within the projects many seminars and conferences have been organized on the topics of biogas and biogas plants. The main focus is on agricultural biogas plants, because a lot of promotion has been done for farmers as potential owners of biogas plants. At each opening of a new biogas plant, the event is published in local newspapers. The topics in the newspapers are a positive presentation of biogas plants, where the emphasis is on the positive impact on the environment. There are especially introduced that even in the next to facility is no detection of unpleasant odours and also digestate, which is carted on the field after finishing the anaerobic digestion process, does not have an unpleasant odours.

1. GENERAL BACKGROUND AS INTRODUCTION

Slovenia has within planning and construction of biogas plants her showpiece company Keter Organica, that already quickened penetrates on foreign markets. Keter Organica is subsidiary of group Keter Group. For period 2010-2011 are already subscribed 23 contracts for construction of new large biogas plants – mainly abroad (Croatia, Serbia, Macedonia, Romania, Hungary). /16/

Biogas market is one of the most interesting renewable energy sectors for the farmers in Slovenia. Although there was some interest among farmers for building biogas plants also in the past decades – Austrian example was near enough - there was however a major barrier to it, namely financing. The investment risk was simply too high. After feed-in tariff system was introduced in 2002 things started to evolve. But it was mainly after 2006 when the feed-in tariffs become interesting enough and later on when subsidies for investment into RES installations for farmers were prepared by Ministry of Agriculture that biogas begun its real take-off. However, due to the price categories within the feed-in support system which were in favour of bigger plants (around 1MW). These were also the results.

HSE, Holding of Slovenian Power Plants commissioned a study on biogas potential in Slovenia in 2008. One of the parts is also the potential within Agriculture. In the least aggressive scenario some 45 MW electric power installed would be possible, in the business as usual scenario – compromising food production - around 78 MW. Then there is also almost unexploited sector of food processing industry.

Exploiting biogas from agriculture and also from landfill gas and wastewater treatment plants is relatively new approach in Slovenia. First installations were on two bigger farms and the interest has increased after the feed-in law was introduced in 2002. Since then the biogas use is promoted by higher price of the produced electricity. Mainly the bigger farms and their investors saw an opportunity for building a biogas plants and the result is that they are planning larger plants, 1 MW and above. Also almost all potential biogas plants that are currently in preparation or in construction phase are larger than 1 MW. In year 2010 Keter Organica developed biogas plant called Mini Organica, which is suitable for smaller farmers ant it has power to 50 kW.

2. STATE-OF-THE-ART OF TECHNOLOGY AND APPLICATIONS

2.1. Biogas Production for Energy Generation

A few biogas plants are from Slovenian producer Keter Organica, which is in total Slovenian property. They have their own researching group so they can do R&D part for their own. They offer biogas plant on key. They provide all documentation, construct the biogas plant and they also have the service team qualified for MWM gas engine service. Most other biogas plants are imported foreign technologies.

Within the substrates for biogas plants, the basis is still slurry/manure from farms. For higher yield of biogas are mainly used energy crops (corn silage, grain silage, grass silage).
As substrates in biogas plants are also used separately collected organic waste, organic domestic waste, foods with expired shelf life, sludge from waste water treatment plant, oils and fats from grease traps, blood and other wastes from slaughterhouse industry, floats, and waste from dairies.

All biogas plants in Slovenia are private. Currently operate 12 biogas plants in Slovenia and 3 of them are conditionally agricultural and others are agricultural. Most of biogas plants in Slovenia are 1 MW power and investment cost for this type of biogas plant is from 5 to 6.5 millions euro.

Keter Organica ia a trademark by Keter Group. Keter Organica, one of the most successful Slovenian companies in the energy sector, offers a futures energy solution – biogas and biogas plant. Investing in clean, renewable energy sources is one of the best investments for the future, and at the same time can also be an excellent business opportunity. This is demonstrated by the success story of the Maribor company Keter Organica, the sole biogas plant manufacturer in Slovenia.

Thanks to premeditated development and numerous innovations that have effectively improved and financially reduced the process of obtaining green power from biogas, the company has managed, only a few years, to achieve remarkable breakthroughs in domestic and foreign markets. The high standard of Organica biogas plants, which as a result of Slovenian knowledge and innovation combine the latest technological solutions such as the upgrading of regular Organica biogas plants to obtain bio ethanol from surplus heat, have today set a new standard in Europe for the energy production from biodegradable waste, which according to experts exceed even the highest world standards.

Organica biogas plants differ from others at first sight. In contrast to other providers, Organica uses only premium materials and technology from the world's best known manufacturers. As one of the most successful Slovenian firms in the energy sector, who, despite the economic crisis, reached 250 percent growth increase in 2010 in the design and construction of Organica biogas plants in domestic markets and in South East Europe and Russia, there is no coincidence that the company is looking to the future with great optimism.

At Keter Organica, a Keter Group subsidiary, which, together with its related companies is technologically equipped and specialised towards implementation of the most complex products in the field of renewable energy resources and strategic investments, they are trying to increase awareness in their business – the design and construction of top Organica biogas plants.

As a socially responsible company and also an important holder of development in the field of renewable energy sources in Slovenia, they are convinced that their investment in biogas power plants is the correct investment for the future. /22/

Until now all built biogas plants have been operating. Some are in trial operation, some are under construction, and few are planned.

2.2. Biogas as Vehicle Fuel

Technological development for production of biomethane from biogas is carried out in company ENOS LNG d.o.o. Jesenice. At the moment the main focus of their interest is in biogas from landfills of municipal wastes and from waste water treatment plants. They have a device for natural gas liquefying, and this is the only device of this type in Central Europe.

At the moment in Slovenia we do not have special legislation for the field of upgrading biogas for vehicle fuel. The developers are using foreign technical standards for biogas upgrading.
In company ENOS LNG d.o.o. they cooperate with car sellers, who distribute cars on methane as vehicle fuel. They also actively cooperate with two local car remodelers that modify cars from benzene drive to methane drive.

The use of biogas as vehicle fuel needs strong promotion from the gas companies (e.g. build new filling stations) and the state support (e.g. taxes, reduced taxes to car owners, etc.). Additional, municipalities or major enterprises can play an important role promoting biogas to their buss fleets (e.g., using local regulations, public awareness, corporate social responsibility).
In Slovenia have been already installed the first filling devices for CNG of small capacity, which stand in Ljubljana, Maribor, Kranj and Jesenice. The filling devices are the result of a join project of Slovene energy companies Enos Jesenice, Energetika Ljubljana, Energetika Maribor, Energap Maribor and Domplan Kranj. In Slovenia are in use first cars on CNG, but until now there is no usage of biogas as vehicle fuel. /14/

In Slovenia, the use of biogas as vehicle fuel is not established and because of the small quantities of produced biogas in country is not expected to be in the near future the use of biogas as vehicle fuel increased. /23/

2.3. Biogas to Biomethane

Until now Slovenia doesn't have facility for upgrading biogas to biomethane. Keter Group is developing technology for cleaning and storage of biomethane, isolated from biogas and also company ENOS LNG d.o.o. Jesenice working on biogas upgrading.

Supplier of natural gas in Slovenia is company Geoplin d.o.o. Gas is bought in Russia and Algeria. Geoplin is also in charge of international gas transport to Slovenia and operates national gas pipeline. Company supplies almost all gas distribution companies.

For local distribution of gas various public companies in bigger cities (such as Ljubljana, Maribor, Celje and others) and private companies based on issued concession are in charge.

Figure 1: Slovenian gas network. /12/

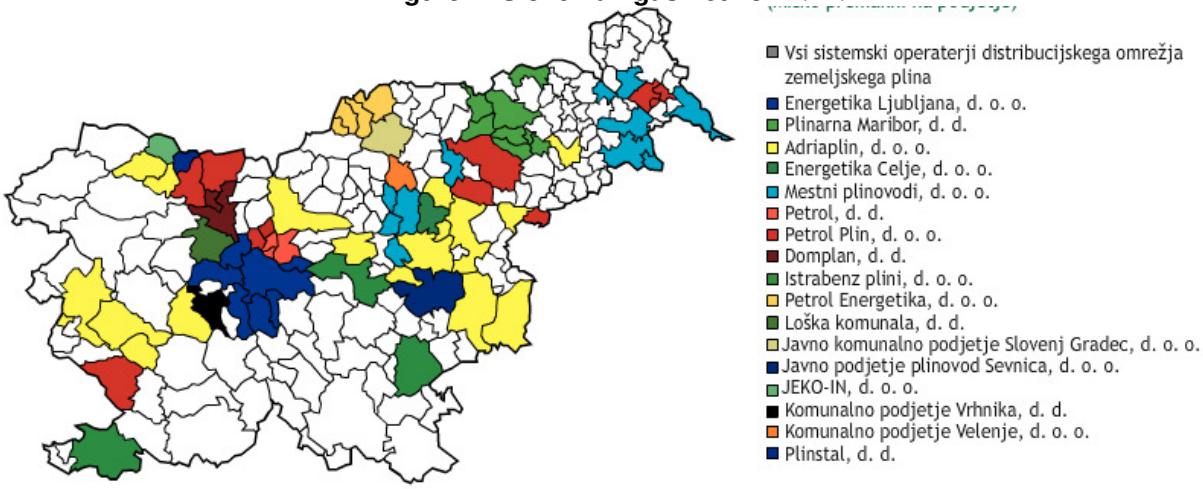

Figure 2: Slovenian local distribution. /13/

Company Geoplin plinovodi operates the Slovenian gas pipeline transmission system as natural gas system operator. Pressure of the gas in transmission pipeline is 3 bar. When biogas plant decides to connect to the pipeline than this plant is treated as natural gas supplier. Plant operator should contact company Geoplin plinovodi if the injection point is in the transmission pipeline. Otherwise it should contact local distribution company, listed above.

Supply of purified biogas is in the location where special station is build for measuring and controlling gas quality and characteristics. If the requirements are not satisfied than the supply is stopped. Since there are no project is Slovenia, we have no experiences yet and also the allocation of the costs should be negotiated and what will be the costs for gas transport.

Biogas could be feed into the natural gas grid satisfying grid requirements where there are two possibilities: a) connection to the national grid operated by company Geoplin or b) to the distribution grids operated by several distribution companies. These grids have different characteristics. In both cases it is necessary to get the approval from the company for connection and become gas supplier. Then the station is set and gas controlled. /8/

3. RESEARCH IN THE AREA OF BIOGAS PRODUCTION

1. KETER INVEST researching group (Keter Organica)

In Keter Organica they developed, with the knowledge of their researchers, the technology, engineering, computer control system, correct biological process and composition of biogas plants. They have designed and construct biogas plant on key, taking into account the needs of investors. Up to now they have built mostly 1 MW power biogas plants. In year 2010 they developed biogas plant called Mini Organica, which is suitable for smaller farmers ant it has power to 50 kW. It cost approximately 420 thousand euro and it is suitable for farmers with ten hectares of cultivable land and 30 head of cattle. In Keter Organica they also provide the necessary documentation, including studies and approvals and building permission before starting the investments. /19/

Together with the former adviser to United Nations for fermentation Alexander Nizamov they are developing technologically advanced device for simultaneous production of biogas and bioethanol, where they will be use all redundant heat from combustion of biogas.

With disclosure of latest plans, the company Keter Organica managed to classify Slovenia in the world's top innovations for obtaining alternative energy. Biogas plant Keter Organica in village Ginjevec in the northeast of Slovenia will be the first in the world, where it will be possible with biogas plant upgrading to use excess heat for bioethanol production.

At the moment they have the biggest investment in Vučja vas, it is worth 11 millions euro. There they are building the second largest institute in Europe for the development in field of biogas, which will include renewable energy research centre and the most powerful, 3.6 MW biogas plant Organica, which will be upgraded for bioethanol production. At the institute they will be introduce a new plants, which could be with rapid growth replaced the current plants, such as corn. /24/

Design and construction of the biogas plant Organica have been successfully offered in Croatia, Serbia and Macedonia, where they have set up their subsidiaries. In short they plan to open new subsidiaries in Romania, Bulgaria, Hungary and other promising markets.

In June 2010 Keter Invest joined to the network his first roof solar power plant of 1 MW power and at the moment it is the largest roof solar power plant in Slovenia. The location of the solar power plant is on the roof of industrial facility, and floor area of plant is 25,000 m^2. Investment value of solar power plant was around 3 million euro. Construction of the on key project was trusted to Slovenia's only manufacturer of photovoltaic modules, the company BISOL, company Keter Invest acted in the project as an investor. Company BISOL can be classify as the highest quality manufacturer of photovoltaic modules in the world.

That in Keter Invest beside investments in biogas and biogas plants have decided to invest in other environmentally-friendly renewable energy sources is the result of a clear awareness that energy in Europe and in our country is becoming an increasingly important part of the economy and it is one of the main axes of development.

In this project of roof solar power plant collaborated two successful Slovenian companies known for business excellence, each in its field. They are both indicating the value of local knowledge, top technology and innovation. /18/

Keter Invest is the first partner of MWM GmbH company, which is one of the top global manufacturers of high-performance gas engine. They signed contract for servicing their engine in Slovenia, Croatia, BiH, Serbia, Macedonia and Kosovo. Keter Invest is also certificate owner of standard for system of quality management ISO9001:2008. /22/

2. Agricultural institute of Slovenia

Agricultural Institute of Slovenia is a public research institution founded in 1898. The number of persons employed at the Institute is 156, of whom 84 are researchers.

The work of Agricultural Engineering Department takes place in offices and in laboratory for physical measurements located in Ljubljana and in the Laboratory of Agricultural Engineering and Process Engineering located in Jable near Mengeš. The field research work takes place on various locations in Slovenia. The Laboratory of Agricultural Engineering and Process Engineering is equipped with modern measurement instruments used for the most demanding measurements carried out on agricultural machines and in process engineering to meet the demands of research work and industrial development. In the workshop of the Department, machines are adapted for the needs of experimental work required for research projects, industry, educational purposes, other departments of Agricultural Institute of Slovenia, etc.

The research work involves research and development research projects. The investigations are conducted in co-operation with the Faculty of Mechanical Engineering Ljubljana, Biotechnical Faculty Ljubljana, Faculty of Agriculture Maribor, Forestry Institute of the R. of Slovenia, Slovenian industry of agricultural machines and devices, etc. Active cooperation is maintained with the following foreign Institutions: Faculty of Agriculture Zagreb – Institute of Agricultural Mechanisation, Universität Hohenheim - Institut für Agrartechnik, BBA, etc.
One field of work at the Department is alternative energy sources. They participate in project Intelligent energy Europe – Biogas Regions 2007 -2010. /1/

3. Natonal Institute of Chemistry Slovenia – Laboratory for Environmental Science and Engineering

In the Laboratory for Environmental Science and Engineering they conduct basic and applied research on national and international level in the following areas: wastewater treatment, sludge treatment, anaerobic slurry treatment, renewable resources (biogas production), ecotoxicology, water quality assessment and process engineering. They conduct interlaboratory comparison for Slovenian and foreign laboratories that monitor wastewater. They also advise industry partners and end users how to resolve wastewater or slurry treatment. /20/

4. Institut "Jožef Stefan" Centre for Energy Efficiency

Centre for Energy Efficiency of Institute Jožef Stefan in its work covers the areas of efficient energy use, long-term planning in the energy and activities to reduce greenhouse gases and air pollutants. Today Centre represented the location of collection and transfer of knowledge about efficient energy use on juncture of energy consumers, countries, energy suppliers, equipment and services and other interested public, at the same time it covers the environmental impacts of energy use and energy conversion. The most important part of Centre for Energy Efficiency work is also cooperation with state institutions in the field of efficient energy use, planning in the field of energy, environmental benefits (CO_2 tax), emissions trading, for the advisory role in the energy sector remains strong associated with industrial companies and institutions.

On the field of promoting efficient energy use and energy consulting in industry and at institutions Centre for Energy Efficiency carried out energy reviews, energy concepts, feasibility studies or pre-investment studies with the emphasis on CHP systems and form, monitor and evaluate programs for efficient energy use, the introduction of energy efficient technologies and energy management, informing and awareness of energy consumers and other target groups, and promotes energy efficient technologies and processes.

On the field of international cooperation Centre is involved in many European projects, financed within the research program (6^{th} Framework Programme), or programs of General

doctorate for energy and transport, European Commission. Projects cover mainly field of promotion use and renewable energy sources. /15/

5. Energy Restructuring Agency - ApE

Energy Restructuring Agency (ApE) is one of the leading Slovenian independent consulting companies in the field of energy efficiency and renewable energy sources. Our range of services include energy demand analyses, execution of energy concepts, feasibility studies, master plans, concept engineering, project management, financing and supervision and promotional activities and research work on the field of energy etc.

The mission of our activities is strongly connected to sustainable development and decrease of impact of energy use to the environment. The development of Renewable Energy Sources and Energy Efficiency plays an important role for sustainable development of our country.
Since the foundation of the company in 1991 we co-operates with all the Ministries and Agencies, which regulates this field (Office for Energy and Agency for Rational Use of Energy at the Ministry for Spatial Planning, Ministry for Agriculture, Forestry and Food), and local authorities (communities etc). In the international field we performed some projects in the framework of PHARE, THERMIE, SAVE, ALTENER and INCO-COPERNICUS programs.

In this regard we performed for our clients a broad series of promotional campaigns in the media, international workshops and publications, analyzed few approaches for financial support of activities, managed the call for tenders for projects financed by former Ministry for Energy and later by also former Ministry for Economic Affairs. ApE also executed some financing schemes for governmental support to households for rational use of energy and renewable energy sources. /6/

We do not have special national rules for technology testing in experimental sites or technology pilots, but we have legislative framework for biogas plant construction, which contain building, environmental and energy legislation.

4. PUBLIC ATTITUDE TOWARD RENEWABLE ENERGY

Building and operation biogas plant requires a set of official document and confirmation for building and operation of biogas plants. Permits and license are described chronologically. It has to be emphasized that not all permit are required for specific biogas plant since it depends on several factors. When you are building a plant that will be for your needs only than you need only building and operating permit. In case that you sell produced energy that you have to acquire also energy license for plant above 1 MW and energy permit. When using organic wastes for biogas production than plant operator has to acquire a permit for waste processing/ recovery. /10/
Chronological review of permit acquirement for biogas plants:

- Plan for land use – Permit to build

Building any kind of object is allowed only on building land set in Municipal spatial plan. If the potential location of the biogas plant is not addressed as building land than the category of that area should be changed. In many cases municipality asks also for town planning scheme. Both plans can be obtain by the municipality. The whole procedure is normally long lasting and complicated. It usually takes around 6 months.

- Energy license

The energy license is required for power plants above 1 MW. Agency for Energy approves the license based on the application for period 5 years. It is relatively easy to obtain the license and it takes around one month and costs around 20 €.

- Energy permit

The investor must obtain energy permit for power plants above 1 MW before applying for the building permit. With this permit it is set: location and area of the plant, type of the plant, conditions for performing energy activities on the plant, conditions related to the plant commissioning.

- Permit for waste processing/recovery

In case of using organic wastes for biogas production the plant operator must obtain permit for waste recovery. Ministry for spatial planning sets with the permission:

- source and quantity of the wastes that can be treated on the plant,
- procedure of processing,
- objects and devices for waste recovery.

Nevertheless, it is possible to process the wastes without the permission in case of:

- non hazardous wastes,
- the processing is on the location of source of the wastes,
- processing only own wastes and
- meeting all requirement for waste recovery.

- Building permit

For biogas plants it is necessary to obtain building permit.

- Operating permit

Operating permit represent permit for using the plant and it should be obtained before the first start of the operation of the plant. /7/

One bad experience is in one smaller town or better village where potential investor is still planning to build bigger 1.5 MW biogas plants in the centre of this village. Although, the new location is on old farm it is located in the city centre and people are strongly against building huge digesters and having lots of trucks driving the input into the plants. This is an example where biogas plant should be located in the margin of the village. It is also a problem in the size of the biogas plant. Smaller, located in farms bled in with the existing infrastructure and in this cases local people is satisfied with the solution for bad small. /9/

Construction of the biogas plants is encouraged by the subsidized price for the sold produced electricity. Country in many ways promotes energy efficiency. The majority of investors and owners of biogas plants run that plants with purpose of electricity production and selling it at subsidized price. The excess heat production, in many cases, is not fully exploited.

Greatest emphasis should be on biological wastes and other wastes from food-processing industry as substrates for anaerobic digestion process. Less acceptable are cultivation of different energy crops for usage in biogas plants. A lot of energy and money are necessary for energy crops cultivation and for harvest. On the other hand in Slovenia is still insufficient system of biological waste collection and a great amount of this type of wastes end at the landfills and caused greenhouse gases. More should be done for better exploitation of biological wastes and this should have priority over the exploitation of energy crops.

Communities often are not supportive of the use of innovative technologies because they are unwilling to assume risks associated with testing and use of these schemes in their neighbourhood. Strengthening of social acceptance (sensitisation, information, participation, etc.) is needed.

Public acceptance and of such schemes are relatively poor. Environmental awareness taking into account the global change and the reduction of land and water pollution is still weak.

5. PROJECT EXAMPLES

5.1. Biogas plant Gjerkeš in Dobrovnik (Keter Organica technology)

Dobrovnik is situated namely in the Pomurje region which is one of the least developed in Slovenia and which was hardly hit by the crisis and globalisation effects in general. Biogas production is also seen as a mean of preserving soil und underground water from over contamination with pesticides, which is also one of the problems of the region resulting from over cultivation in the past. Important fact is also that the plant was built and developed by a local company Keter Organica, which is becoming the biggest developer on biogas in Slovenia and also an important player in renewable energy production in Slovenia.

Biogas power plant Keter Organica Gjerkeš 1 of 1 MW power is located in agricultural business zone on 14,000 m^2 and it has beside producing facilities built all the ancillary facilities such as a temporary depot for separated manure, two terminal storage tank for fermented substrate of volume 7,600 m^3 and trough silo of 20,000 m^3 for input substrate storage (silage from crop production, organic waste and chicken manure from neighbouring farm) as well as storage for separated manure. Whit all this facilities are attained all the criteria for safe storage of input and output materials. Farmer Branko Gjerkeš grows plants on 250 hectares of land for green energy production. The investment in biogas plant is worth 6.5 millions euro and it should be repaid in eight years. It started operating in July 2009.

Figure 3: Biogas plant Organica Gjerkeš 1 in Dobrovnik. /4/

Figure 4: Biogas plant Keter Organica Gjerkeš 1. /4/

The process for gas production is carried out in two fermenters and two by fermenters. Addition of substrates takes place in mixing pit, from where it is pumped into fermenters in several day intervals, which are controlled by a computer program. In the fermenters or digesters are carried out decomposition process and substrate is stirred and co substrates (maize and grass silage, and manure) are added. After the filling both of fermenters, the digested substrate is daily recirculated into by fermenters and after that it is stored in the lagoons. Digestate is quality and not aggressively fertilizer, which is carried away on fields or it is separated and stored in a silo.

For untroubled functioning of the biogas plant cares computer system, which monitors and analyses all the parameters in biogas production. In fermenters it takes care of working temperature, pH value, and simultaneously gas analysis, stirring, and output of slurry and biomass. Loading and unloading of fermenters are also managed by computer. Biogas, which is produced in fermenters is cleaned in cleaning system and than stored in the gas storage tank. Biogas from gas storage tank is fuel for gas engine, which is also controlled by computer.

Figure 5: Computer system of biogas plant. /4/

Electric generator is driven by gas engine and produced energy is sent through the transformer into the national electric grid. Biogas plant itself spends about 6 % of generated energy.

Meanwhile the gas engine is cooling; it produces a lot of heat, of which approximately 30 % is spent for fermentrers heating. The rest heat is sold to the nearest company Ocean Orchids, over district heating system.

Figure 6: Greenhouse of company Ocean Orchids, which is supplied by heat from nearly biogas plant. /4/

Figure 7: District heating system building near biogas plant Gjerkeš. /4/

The total volume of fermenters is 10,000 m^3, in which controlled anaerobic digestion process of manure and co substrates take place. The residence time of co substrates in fermenters is 60 days. The heating technique takes care for constant temperature in the fermenters (http://www.bioplinarna-gjerkes.si)

Keter Organica introduces some improvements and innovations related to the optimization of biological process. Among the major improvements is with plastic coated interior of concrete fermentors, which provides total air-tight of the process. They design a larger storage tanks, which allowing longer retention time for organic matter fermentation and consecutively better efficiency of the process. An important part of the development was also their implemented software for biogas plant operating and control.

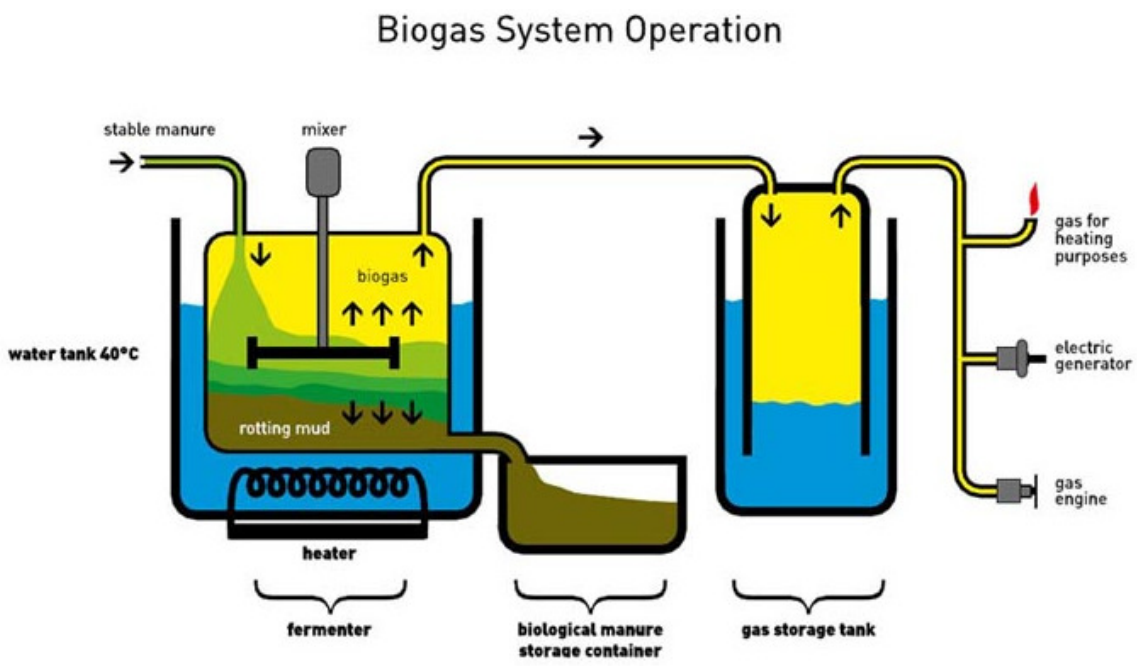

Figure 8: Keter Organica system operation. /22/

Since heat is needed and feedstock is enough from own production they are already expanding the plant with another 1 MW unit. They are also planning the production of bioethanol and pelletizing of digestate. Furthermore together with the company Ocean Orchids they intend to make also some kind of demo-educational centre for biogas and renewable energy in general, which was mainly foreseen for children but also for all others to raise awareness. /4/, /11/, /22/

5.2. Biogas plant KOTO d.o.o., Ljubljana

KOTO d.o.o is located in capital city of Slovenia and it is manufacturing and trading company with 170 employees. Company main activity is collection, transportation and treatment of animal by products category 1, 2 and 3. Production takes place in two factories CAT 1/2 and CAT 3. Other activities are: collection and treatment of raw hides, biogas production with cogeneration of electricity and heat, collection and treatment of waste for alternative fuels and other trading activities. In year 2007 they have started with biogas production. Biological process of biogas production takes place in heated gas-tight reactors. Produced biogas, which contain up to 73 % of methane, is used on CHP unit for electricity and heat generation.

The location for the erection of thermophilic biogas plant in Ljubljana, precisely in Zalog, was chosen because of disposable 1000 m^2 building plot close to the KOTO factory, because of the possibility for optimal use of the existing pre-treatment equipment as well as stuff's experiences and expertise with waste handling. One of the facts is the presence of available biological waste on the market and need for new treatment plant for electric energy which could not be supplied from electricity net in short period.

The capacity of the Ljubljana biogas plant is 8000 tons per year. The biogas plant was started up in September 2007. Cogeneration unit was purchased in 2006. Biological waste such as, separately collected organic waste, organic domestic waste, foods with expired shelf life, sludge from waste water treatment plant, flotation sludge and fat from fat traps, blood, and slurry are treated.

The produced biogas is burned on the generator set with power 526 ekW, which is adjusted for natural gas and biogas, from which green electricity and heat are produced. The heat is

used for heating of reactors, for steam production needed in other processes and for heating of the offices in cold periods. Electric bio energy is used for own needs of processes in factory and the rest is distributed to the net. The plant is in full operation with two 500m^3 digestors since June 2008. Digestor rest (liquid fertiliser) is cleaned as waste water.

Figure 9: Biogas plant with reactors (from left to the right): front hydrolysis tank, back digester 1, digester 2, digester 3, and front anaerobic filter. /3/

Figure 10: Side view on the biogas plant. /17/

Figure 11: Anaerobic filter. /17/

Technology for pretreatment of feedstock with sterilisation developed investor with use of existing equipment for heat treatment. The Technology for biogas production is Swedish, with separated hydrolysis and fixed roof digestors. Biogas is cooled and continuously used on the CHP without intermediate storage. Cooling tank was remodelled to digestor in year 2010. Three digesters are of 500 m^3 are heated through a heat exchanger. Continuous process in digesters is thermophilic and takes place at the temperature 55 °C. The substrate is kept in the digesters 15 to 20 days. The substrate is continuously stirred to avoid setting. Biogas is stored at the top of the digesters and continuously discharged to the gas engine.

The investment in biogas plant is worth 2,760,000 euro. As feedstock they used 1000 tons per year liquid cattle manure, 1000 tons per year source sorted biological waste, 5000 tons per year, organic kitchen waste, 500 tons per year wastes from slaughterhouse (blood) and other industry wastes. In one year they produce up to 4,000 MWh of electric energy and use 3,000 MWh of coproduced heat from 1.8 million m^3 produced biogas. With produced electricity they cover 50% of their own needs on the location. /3/, /17/, /21/

Figure 12: Biogas plant in year 2010. /17/

5.3. Biogas plant "Bioterm d.o.o." Letuš Slovenia

The family farm owned by Anton Flere comprises 36 ha of own and hired land and 90 head of cattle. In 2003 a biogas plant which is still in the phase of expansion started to work on the farm. Biogas is produced from cattle manure, organic wastes from kitchen and leftovers from the processing of milk in dairy plants. At the beginning phase there were two smaller engines for the production of electricity and recently they have built a third one.

Cattle manure from the stable comes into reinforced concrete sump (mixing tank) of 25 m^3 volume, together with organic wastes from kitchen which had been previously thermically treated and ground.

Substrates are mixed by a mixer and conducted into digester of 300 m^3 volume and second digester of 300 m^3 volume at 36 °C temperature. The process goes on from 60 to 80 days.
In 2007 the biogas plant was enlarged. A new reinforced concrete digester of 290 m^3 volume and second digester of 400 m^3 volume were built. In the first one the substrate remains 40 days, biogas is produced at 36ºC, in the second one the substrate remains 20 days at 55º C

temperatures. All the substrate from the older digester and older second digester and from the new digester goes in the new second digester at 55 ºC.

The final tank for the processed manure is made of reinforced concrete and has a 1500 m^3 volume. The processed manure as a more environmental friendly manure is applied on their own and hired fields, and on the fields of other farmers who do not have organic fertilisers.

Figure 13: Biogas plant owned by farmer Anton Flere. /2/

Biogas is kept in gas storage tank (air bag gas storage) of 90 m^3 volume. At the beginning of operation of biogas plant two engines of 60 and 62 kW were installed. In 2008 a new and more powerful engine of 150 kW was installed. The farm has also a system used for thermic treatment organic wastes from kitchen.

They decided to build a biogas plant because of bad smell caused by liquid manure which disturbed the neighbours when applied. The price of the construction up to now is essentially higher than the initial investment plan. The investment in biogas plant is worth 6.5 millions euro until now. The biogas plant will be expanded in future.

Figure 14: One of the digesters on biogas plant. /2/

As feedstock they used 2200 m^3 per year liquid cattle manure, 2000 m^3 per year house organic waste and 180 m^3 per year dairy rest. Biogas plant produced 1500 m^3 biogas per day, from which they produce 754 000 kWh electric energy per year. /2/

6. SPECIFIC ASPECTS

6.1. Country characteristics

Slovenia is a country in Central Europe and it has been a member of the European Union since 2004. From a geographical point of view it has 20.273 km^2 of land; of witch about 60 % is covered with forests. As of 2009 Slovenia has a population of 2,032,362 and a population density of 100 inhabitants per km^2.

Slovenia is one of the most diverse European countries. It lies on the junction of Alpine, Mediterranean and Pannonian landscapes. The natural conditions result in a high share of rural areas with large number of small settlements and specific land use. Forests cover about 60% of the entire Slovenian territory. The agricultural land is relatively scarce, especially arable land. More than 70% of agricultural land is located in regions with unfavourable conditions for agricultural production and is used mainly as permanent grasslands.

Prekmuje (the most east area of the country) has the greatest potential for agricultural biogas plant, because of flat country and a lot of cultivated farmland.

Figure 15: Relief map of Slovenia. /25/

The Slovenian government adopted a Decree (on 14 March 2002) on the price and premium for the purchased electricity from qualified producers or electricity from RES (feed -in tariff) - Uredba o pravilih za določitev cen in za odkup električne energije od kvalificiranih proizvajalcev električne energije , Ur.l. RS, št. 25/2002 (Decree on the Rules for Setting prices and for

purchasing electricity from qualified electricity producers, Official Journal of the Republic of Slovenia No 25/2002). The new decree defines a fixed price and premium (feed - in tariff) for the purchased electricity from qualified producers (QP) of electricity from renewable energy resources (small hydro, biomass, wind, geothermal, solar, waste and all other RES for power plants – biogas plant).

The fixed price and premium for the purchased electricity from bio-energy sources in Slovenia is defined in the Decision on prices and premiums for the purchase of electricity from qualified electricity (Sklep o cenah in premijah za odkup električne energije od kvalificiranih proizvajalcev električne energije, Ur.l. RS, št. 65 in 98/2008 (Decision on prices and premiums for the purchase of electricity from qualified electricity producers, Official Journal of the Republic of Slovenia No 65/2008 and amendment 98/2008).

The last change in fixed prices and premiums for the purchased electricity from RES was in May 2009 with Ordinance on subsidies for electricity produced from renewable energy sources (Official Journal RS, no. 37/09) The Ordinance defines the types of support regarding to biogas plant sizes. Slovenian biogas plant market is divided into four system-size categories: micro (specified power of less than 50 kW), small (specified power of less than 1 MW), medium (specified power from 1 to 10 MW), large (specified power from 10 to 125 MW), and renewable energy source production facilities (specified power of 125 MW and above). The owners of biogas plant have to make a decision what type of support they would like to receive from the Centre for RES/CHP support. The following types are possible:

- OS - Operating support
- GP - Guaranteed purchase

If the beneficiary decides for operating support, this means that they have concluded an open contract on the market ("the market agreement for the sale of electricity"). The beneficiary issues separate invoices: for electricity to their supplier / trader and for support to Borzen (The Centre for RES/CHP support).

Guaranteed purchase means that a power plant enters the Centre for RES/CHP support's balance group that operates within Borzen In such a case the beneficiary sells electricity to the Centre for RES/CHP support and issues a uniform invoice at the price for guaranteed purchase. In this case the producer does not and is not permitted to conclude a separate market agreement for the sale of electricity.

The producer can receive one or the other type of support, but they cannot receive both simultaneously. The right to choose the type of support (GP / OS) is given to RES units up to 5 MW and CHP units below 1 MW. Larger units can receive support only as OS.

Methodological determination of the level of support: the level of operating support or guaranteed purchase is determined on the basis of reference costs published in the Methodologies for Determining Reference Costs. They are composed of fixed and variable reference costs:
Reference costs = Fixed reference costs + Variable reference costs

The fixed part of reference costs is methodologically determined every five years or earlier if there are significant changes to capital costs and other investment parameters. They are determined on the basis of investment costs and operating costs. Once the producer enters the system, their fixed reference costs remain the same for the entire duration of receiving support.

Variable reference costs are determined only for those RES generating plants where the input fuel represents a financial cost. The variable part of the reference costs shall be determined annually on the basis of changes to the reference market price of electricity and input fuels - determined by the Energy Agency of the Republic of Slovenia.

For biogas obtained from biomass (one or more substrates) and biodegradable waste, Ordinance defines some supportive aspects. Where the annual useful heat deployment exceeds 15% of the input biogas energy, the RES generating plant shall be eligible to a supplement of 10% of the operating support for this RES generating plant. Heat from biogas plants used for obtaining biogas shall not be deemed to be useful heat.

Where manure and slurry represent annually more than 30% of the volume of substrate for obtaining biogas, the RES generating plant shall be eligible to a supplement of 10% of the operating support for this RES generating plant. Where manure and slurry represent annually more than 70% of the volume of substrate for obtaining biogas, the RES generating plant with a nominal electrical capacity of up to 200 kW shall be eligible to a supplement of 20% of the operating support for this RES generating plant.

26. 11. 2010 completion to Ordinance on subsidies for electricity produced from renewable energy sources was issued (Official Journal RS, no. 94/10). A new provision is: Generating plants for biogas production, which using for biogas production substrates that contains more than 40 volume percent of grain or corn silage and others grains, are not justified for support from this Ordinance. /5/

6.2. Summary of Positive and Negative Aspects

There are many possibilities for investment in biogas plant. Two of these possibilities are Third Party Financing (TPF) and Public-Private Partnership (PPP).

Barrier to use TPF or PPP lies in people themselves. In practice it is in many cases impossible to reach an agreement between two (or more) farmers to build a common biogas plant. Reaching an agreement with public entity (for example municipality) is even harder.

However, there are several farmers that are interested in the TPF and are searching for investors since they are not able to invest on their own. /9/. There is somehow lack of knowledge and information not only to the farmers but also to the industries (owners) and the general public about the possible energy exploitation of wastes and their final uses (e.g. electricity, heat, injection to the grid, transport fuel).

Potential investors that are already thinking about biogas plant have made contact with domestic companies offering services (consultant or even building a whole plant) and also with foreign (especially from Austria, e.g. Agrinz GmbH). In general knowledge on biogas technology is relatively good concerning bigger investors and quite poor on the individual – farmer level.

Communities often are not supportive of the use of innovative technologies because they are unwilling to assume risks associated with testing and use of these schemes in their neighbourhoods. Strengthening of social acceptance (sensitisation, information, participation, etc.) is needed.

Public acceptance and of such schemes are relatively poor. Environmental awareness taking into account the global change and the reduction of land and water pollution is still weak.

In spite of raising interest for biogas plant building in Slovenia there is still a considerable lack (or it is not widespread enough) of knowledge about factors that influence the process of biogas production. The same is true also for the economical part of biogas plants and with environmental-veterinary-sanitary regulation on treating of input and output substances of the bio-

gas process. One needs to understand that it is extremely difficult to provide the kind of the general cost estimates for the investment or for the operating cost.

Therefore, the detail planning of the process, the costs and revenues estimation with all due respect to the local circumstances is a must before the final decision about the project realization is made.

6.3. Further topics

7. REFERENCES

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/4/ Bioplin Gjerkeš, proizvodnja in distribucija energije, Opis bioplinske naprave. http://www.bioplinarna-gjerkes.si/, January 2011.

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/25/ The World Atlas, Relief map of Slovenia, http://europe.theworldatlas.net/slovenia/map.html, January 2011.

ANNEX

Annex 1: Supplementary Figures and Tables

You can put in here large tables or figures, which you feel are not well suited in the main text body

Annex 2: List of Biogas Equipment Suppliers

1. Keter Organica d.o.o., Organica biogast plant, representation and service for MWM gas engine, http://www.keterorganica.com/.
2. Ecos, storitve pri varovanju okolja,d.o.o, biogast plant type ECOS BP 500T, biogas plant type ECOS BP 1000M, http://www.ecos.si/bio/.
3. IMP d.d. Jurca Borut, representation for Jenbacher, http://www.imp.si/.
4. Avtek Marko Berčič, representation for Caterpillar, http://www.teknoxgroup.com/si/.
5. ELECTRAS NOVA d.o.o., representation for EISENMANN, http://www.electras-nova.eu/eng/index.htm.
6. B.R.C. d.o.o. Franc Antlej, representation for TEDOM cogeneration units, http://www.brcdoo.si/index.php/kogeneracija.

Annex 3: List of Biogas Plants

Figure 16: Biogas plants in Slovenia on December 2010. /1/

Biogas plants:

1. Biogas plant in Dobrovnik (Gjerkeš, s.p.) – power: 1 MW.
2. Biogas plant Lendava – ECOS, d.o.o. (Pavlinjek) – power: 4.2 MW.

3. Biogas plant Kolar 1 – Logarovci (Kolar, s.p.) – power: 1 MW.
4. Biogas plant Kolar 2 – Ginjevec (Kolar, s.p.) – power: 1 MW.
5. Biogas plant Bioterm, d.o.o. (Anton Flere) – power: 0.272 MW.
6. Biogas plant Nemščak – Panvita Ekotech, d.o.o. –power: 1.46 MW.
7. Biogas plant Motvarjevci – Panvita Ekotech, d.o.o. – power: 0.839 MW.
8. Biogas plant farm Ihan (FI-EKO, d.o.o.) – power: 0.526 MW.
9. Biogas plant in Zgornje Pirniče (Petač, s.p.) – power: 1 MW
10. Biogas plant Črnomelj – BIOENERG, d.o.o. – power: 1.36 MW.
11. Biogas plant in Sobetinci – Vargazon, s.p. – power: 1 MW.
12. Biogas plant Ilirska Bistrica – BIO FUTURA, d.o.o. – power: 1.1 MW

There are some biogas plants in planning or under construction:

1. Biogas plant in Sobetinci – Vargazon, s.p. – power: 3.6 MW.
2. Biogas plant in Dobrovnik – Gjerkeš, s.p. – power: 2.4 MW.
3. Biogas plant in Ormož – Šijanec, s.p. – power: 1.2 MW.
4. Biogas plant in Dolič pri Destrniku – Arnuš – power: 1.2 MW.
5. Biogas plant in Središče ob Dravi – Jurša, s.p. – power: 1.2 MW.
6. Biogas plant in Markovci – Tadič – power: 1.2 MW.
7. Biogas plant in Noršinci – Cigut – power: 1.2 MW.
8. Biogas plant in Vučja vas – Keter Organica – power: 3.6 MW.
9. Biogas plant in Lešje pri Majšpergu – Tacinger – power: 2.4 MW.
10. Biogas plant in Nova vas pri Ptuju – Lacko – power: 1.2 MW.
11. Biogas plant Rückert NatUrgas® Perutnina Ptuj – power: 1MW.

Annex 4: List of Research Centres

1. Slovenian Energy Restructuring Agency, http://www.ape.si/.
2. Agricultural institute of Slovenia, http://www.kis.si/pls/kis/!kis.web?m=0&j=EN.
3. Institut “Jožef Stefan” Centre for Energy Efficiency, http://www.rcp.ijs.si/ceu/sl/o-nas.
4. ireet, Energy, Ecology ant Technology Research Institute, http://www.ireet.com/eng/.
5. Keter Invest, Keter Organica, http://www.keterorganica.com/.
6. Faculty of Ariculture and Life Sciences Maribor – Department of Biosystems Engineering, http://www.fk.uni-mb.si/index.php?id=86.
7. Natonal Institute of Chemistry Slovenia – Laboratory for Environmental Science and Engineering, http://www.ki.si/en/research-departments/l05-laboratory-for-environmental-sciences-and-engineering/
8. Biotehnical Faculty Ljubljana, http://www.bf.uni-lj.si/en/.
9. Faculty of Chemistry and Chemical Technology Ljubljana, http://www.fkkt.uni-lj.si/si/?220.

Annex 5: Others