EXTRACT

Proposal summary page

Proposal full title **S**mart **E**quipment for **P**roduction of **BIOGAS**

Proposal acronym **SEPBIOGAS**

Strategic objectives addressed
The main objective of SEPBIOGAS is development of a smart biogas production line adjusted to a novel holistic system for more sustainable society. "Smart" means that the production line is highly flexible, robotised, computerised, offers clean working environment, can use as raw material biomass from a variety of sources and is economically feasible. Increased production of biogas will accelerate growth in the production of renewable electricity in already developed cogeneration systems.

Additional objectives are improvement of

- equipment for bioconversion accustomed to needs of microorganims, based on a process of high solids anaerobic digestion in batch bioreactors;
- solutions and technologies for pre-processing of biomass from a variety of sources;
- methods/recipes for high solids digestion using several mixtures of biomass from a variety of sources;
- methods for upgrading of biogas;
- quality of the second product – biofertiliser.

Proposal abstract
Objectives of SEPBIOGAS are: a) to enhance the yield of biogas plants; b) to improve upgrading of biogas; c) to improve quality of the second product – biofertiliser and d) to minimise emissions and vulnerability.

By re-engineering of technologies in pre-processing, processing and post-processing of various types of biomass, by modern logistics and by enhanced precision in all steps will be created new knowledge that is necessary for more sustainable bioconversion where the emphasis is placed on achieving high conversion efficiencies and high reliability of the technology.
For successful establishment of sustainable energy systems with appropriate equipment and methods that optimise bioconversion i.e. for obtaining right hardware and software for achieving high yield of biogas as well as better upgrading and use of biogas SEPBIOGAS will use innovative holistic approach.

Project SEPBIOGAS has focus on optimisation of the fuel supply chain taking into consideration all aspects of biogas production from various types of renewable biomass and also preparation of the biogas to high standards and specifications, such as co-generation to electricity and heat or production of heat or use of biogas as fuel for vehicles. In addition second product of improved high solids digestion will be achieved as biofertiliser of good quality. Simultaneously with efficiency improvements fewer emissions will appear and thus environment will be protected.

The White Paper on renewable energy indicates a target for biomass and waste in 2010 of 135 Mt, of which 45 Mt would be provided by energy crops. It also indicates that the production of liquid biofuels (biodiesel and ethanol) in 2010 would make use of 18 Mt of biomass from

energy crops but with smart improvements in microbial conversion to methane in biogas the economic evaluation can show the multifunctional impact when a part of bioenergy returns to cultivated soils as biofertilisers.

B.1 Scientific and technological objectives of the project

The main objectives of **SEPBIOGAS** are:

- To create new knowledge resulting in demonstration of **smart biogas production line** adjusted to a novel holistic approach for more sustainable society. "Smart" means that the production line is highly flexible, robotised, computerised, offers clean working environment, can use as raw material biomass from a variety of sources and is economically feasible. **By increased production of biogas accelerate growth in the production of renewable electricity** in already developed cogeneration systems.
- To higher efficiency of biogas utilisation by improving and testing more efficient technologies for biogas upgrading and utilisation.
- To bring together European groups in order to combine their particular knowledge, experience and skills in an effective way towards the design, synthesis and testing of these new materials in adapted reactors is a venture that can bring holistic results.

Additional objectives are:

- Re-engineering and improvement of bioreactors accustomed to needs of microorganims that carry out formation of methane, by modern measurement, process monitoring and control techniques;
- Improvement of solutions and technologies for pre-processing;
- Improvement of methods/recipes for high solids digestion by advanced process design for achievement of higher yield of biogas;
- Improvement of methods for pre-treatment and conditioning of biogas;
- Production of valuable biofertilisers;
- Improve hygienisation of outputs – inactivation of pathogens and weeds;
- Put value on bioenergy in biofertilisers;
- Innovative upscaling of bioreactors;
- Minimising of emissions by improved environmental performance.

Hypothesis
The flexible equipment accustomed to needs of microorganims and based on a process of high solids anaerobic digestion in batch bioreactors will be cheaper in the long run than present rotting systems where biomass is often diluted in water. Instead of high expenses in several parts of the rotting system such as size of bioreactor, heating of the in water diluted substrate during processing, dewatering of the effluent, handling of the water and sludge as well as formation of unpleasant smelling gases a novel system that uses bioreactors for high solid digestion will allow more sustainable use of the biomass.

Using high solids digestion of biomass from a variety of sources will increase the yield of biogas 4 to 6 times per volume of bioreactor (results presented from research on high solid digestion). Some batch systems with high solid digestion are already built in full scale but in suggested concept better pre-processing of raw materials and advanced process monitoring and control techniques will result in shorter retention time and thus will be more economically feasible.

Additionally the second valuable product will be achieved – biofertilisers of better quality than sludge or composts. These biofertilisers contain most of the plan nutrients and also part of the bioenergy from raw material. Both the nutrients and the bioenergy in biofertilisers are very important for microorganisms in cultivated soils and for soil fertility/productivity. Biofertilisers can minimise soil degradation by increased amount of humus and also increase carbon sequestration, improve damaged soils and prevent some soils from wind erosion. Step vice upscaling of bioreactor from prototypes where suitable method will be developed have to be finished in view of local needs.

The concept of high-solids digestion presented in this proposal is suitable to small, medium and large-scale users both in urban and rural areas, for the production of energy rich methane in biogas and energy rich biofertilisers. The use of this system will avoid the use of correspondent quantities of fossil energy sources. By developing and using a mobile biogas plant, the system can be tested, then full scale plant will be adjusted to local needs and following commercialisation will then become marketable.

Enhanced energy efficiency is a key strategy for decreasing the cost of and environmental damage caused by energy conversion. In this project we suggest a design in which energy efficiency improvements are aligned with the whole technical energy system and several other systems such as infrastructure (modern logistics), transport, waste and wastewater management, planning, building, policy making in EU, etc.

In addition to an increase of 4 to 6 times the yield of biogas per volume of bioreactor following measurable result will be achieved within the project:

- shorter retention time;
- savings in total energy costs;
- production of biofertilisers adjusted to needs in cultivation systems – decreasing use of agrochemicals, increasing carbon sequestration;
- inactivation of pathogens;
- inactivation of weeds;
- decomposition of several man made chemicals;
- reduction of GHG (Greenhouse Gas) and CAC (Critical Air Contaminant) emissions; improvement of working and global environment;
- increased employment – “Green Jobs” and “Green Purchasing”

In the first studies on anaerobic process modelling special attention was paid to the description of the final stage of the anaerobic digestion, methanogenesis which was considered also as the most important step of overall process. These models were very simple and consisted of a limited number of equations. More complicated models describing two or even more bacterial groups and also including inhibition kinetics, pH calculations and gas-phase dynamics came later. [Gavala H.N., Angelidaki I., Ahring B.K., Kinetics and Modeling of Anaerobic Digestion Process, Advances in Biochemical Engineering/Biotechnology, vol. 81,57-93, 2003]. Nowadays a large number of models can be found in the literature describing anaerobic and aerobic digestion, each of them having its own potential and worth. However, no unified modelling framework for digestion process exists so far. In this project the bioconversion of biomass to methane during three step (aerobic-anaerobic-aerobic) digestion process will be modelled.

State of the art

Last year[1] was estimated that there are nearly 3 000 methanisation plants in Europe to which the 450 waste storage centres which valorise biogas must be added. Annual production of these installations is estimated at 2 304 ktoe. The sector represents approximately 5% of all the energy resulting from biomass in Europe. Nevertheless, an important point must be emphasised: all the biogas production units do not necessarily valorise this renewable energy source in the form of final energy (electricity or heat). Part of this production (approximately one half) does not find any market outlet and ends up being burnt off in flare stacks.

The European Commission is targeting 1 000 megawatts of installations at the conclusion of the Campaign for Take-Off (at the end of 2003) and 15 million toe of biogas production in 2010. The 2010 objective is going to be much more difficult to attain. Only an annual growth rate of 30% will make it possible to reach the threshold as desired by the European Commission. Therefore 30% growth is necessary.

B.2 Relevance to the objectives of the Priority

SEPBIOGAS is well relevant to Priority 6.1.ii - Sustainable Energy Systems: *Research activities having an impact in the medium and longer term and* Area: Section 6.1.3.1.1.1 “Cost effective supply of renewable energies” as well as Topic: Innovative approaches to improving the yield of medium to large scale biogas plants. Results can be used also in small scale biogas plants.

There is a great need of environmental technology innovations, for example on more sustainable manufacturing biomass and biological processes that are crucial for better use of renewable energy. Also improvement of practices and logistics for collection, transport and treatment of all kinds of renewable biomass including organic waste and residues from plants and animals, human and animal excreta as well as fuel crops will enhance cost efficiency.

This project covers creation and also the improvements in the whole supply chain: a) use of biomass from a variety of sources; b) pre-processing; c) processing; d) post-processing; e) use of both valuable and energy-rich products – biogas and biofertilisers.

Form scientific point of view the SEPBIOGAS wants to increase the knowledge important for achieving the strategic goal of more efficient use of bioenergy from biomass. There is an urgent requirement for creating new knowledge for building cost-effective equipment and for generating better methods that lead to improved production and utilisation of biogas at lower costs.

In addition all these improvements will have a great impact on development and manufacturing novel technical goods for tomorrow’s infrastructure in urban and rural areas and also in both developed and developing countries.

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[1] EurObserv ’ER 2001, last update: 31-07-2003 http://europa.eu.int/comm/energy/res/sectors/bioenergy_en.htm

As the technical and methodological enhancement leads to better care of the environment, human health and to decrease vulnerability in energy supply, the whole society will profit from this holistic and more sustainable approach.

The needs of an expanding population demand dramatically transformed man's manufacturing activities. Innovative eco-sustainable production processes must be devised along with stabilization of population growth and the adoption of a sustainable consumption agenda. Processes should avoid or drastically reduce the use of non-renewable raw matter sources and seek cost-effective sustainable alternatives, whilst also reducing the production of waste and emissions.

The optimization of the bioconversion processes towards a higher biogas production and high quality biofertiliser should be a benefit by lowering the current cost of disposal.
Biogas will be used for cogeneration systems that can fulfil, even exceeding the energy needs of the setting up plant and preventing a higher consumption of fossil fuel, thus contributing to reduce the carbon dioxide impact on global heating of the planet.

B.3 Potential impact

Research and technological development will result in demonstration of equipment for bioconversion of biomass using batch bioreactors for high solids digestion to prove the viability of new technologies that will offer a potential economic advantage, but which cannot be commercialised directly.

Expected impacts of this STREP on the society:

- Increased utilization of bioenergy bound in various types of biomass;
- Increased recycling of plant nutrients, energy rich compounds and beneficial microorganisms to soils;
- Realization, demonstration and verification of the new bioconversion system using innovative logistics and batch bioreactors BTF for high-solid digestion of biomass that could be used in countries inside and outside EU;
- Increased job opportunities – "Green Jobs" and "Green Purchasing";
- Improvement of working and global environment;
- Decreased pollution, vulnerability and losses of energy and nutrients;
- Strengthening local economics;
- Increased interest in and general public awareness of biomass use;
- Enforcement of legislation improvement in the field of renewable energy.

The project innovates the state of the art in several ways, substantially improving currently employed techniques in terms of cost, efficiency and eco-sustainability.

Elaboration of new methodologies and techniques for efficient co-processing
In the natural world, there is no such thing as waste. Nature efficiently recycles materials within a very complex ecological process. Our industrial processes have not yet been developed to this level of efficiency or complexity. However, there are many new and exciting developments which reduce the environmental, social and financial costs of waste treatment and disposal.

This technology offers an eco-sustainable, cost-efficient alternative. The autothermal digestion of biomass where an air injection starts an aerobic digestion that generates enough heat to bring thermophilic conditions without need of external energy input is an interesting and challenging option. Thermophilic process covers in excess the heat requirements in form of biogas production, which can be used for co-generation systems or converting the methane gas to carbon dioxide (with a lower global warming potential than carbon dioxide from fossil energy sources).

Demonstration

There have been a number of studies reporting different approaches to the dry solids digestion of renewable biomass. However, there is not an available, full comprehensive characterization study, as proposed in this project. In addition, as a result of the investigation a portable pilot-plant will be available. The demonstration plant will be available for experiments, improvements and for demonstration of the digestion processes either in-situ or being carried to new facilities.
Starting from the laboratory data, an optimization of the operating conditions will be easily obtained, which means remarkable savings in time and costs.

Project SEPBIOGAS has focus on optimisation of the fuel supply chain taking into consideration all aspects of biogas production from various types of renewable biomass and also preparation of the biogas to high standards and specifications, such as co-generation to electricity and heat or production of heat or use of biogas as fuel for vehicles. In addition second product of improved high solids digestion will be achieved as biofertiliser of good quality. Simultaneously with efficiency improvements fewer emissions will appear and thus environment will be protected.

Biomass in municipal and industrial waste, residues from agriculture, horticulture, forestry, green areas, from human and animal excreta and from fuel crops contains a great amount of renewable energy – bioenergy a should be used as a raw material.

The only problem is the luck of modern equipment and efficient methods. Like in cooking we need both facilities and recipes. Therefore in this STREP we want to use expertise, skilfulness and competence of all partners to build up new knowledge necessary for sustainable solutions. In Fig. B.3-1 shows possibilities to produce biogas from many types of renewable biomass.

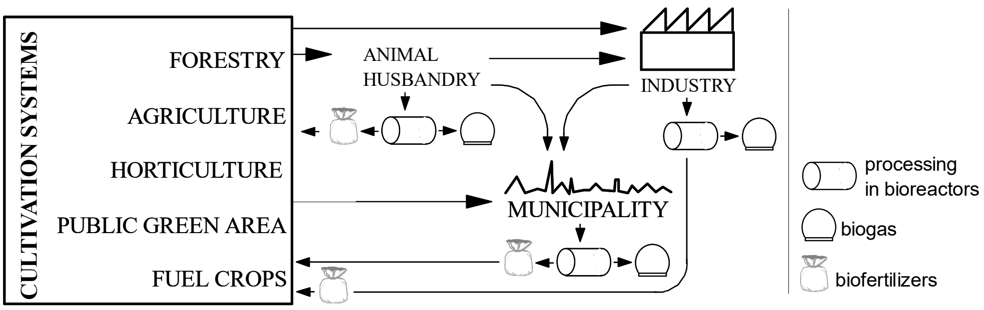

Fig. B.3-1 A flow diagram for use of biomass for bioconversion to biogas and biofertilisers.

EXTRACT

The EUs commitment to a significant reduction in greenhouse gas levels combined with legislation arising from a number of European Directives has emphasised *the need for alternatives to combustion of biomass.* Unfortunately, present systems for biological transformation (composting and rotting) use old-fashioned methods that are neither efficient nor environmentally sustainable. Therefore we want to **radically improve both technology and methods**.

Most of the energy from renewable biomass today comes from wood products, dried vegetation, crop residues, and aquatic plants. Biomass has become one of the most commonly used renewable sources of energy in the last two decades, second only to hydropower in the generation of electricity. Due to its low cost and renewable nature, biomass now accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries, where it is mostly used for cooking and heating…

Biomass will succeed at some level as an alternative source of renewable energy because it is capable of being implemented at all levels of society.
(Information from http://www.altenergy.org/Renewable/Biomass/biomass.html

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Example: Residues from slaughterhouses, carcass, and human and animal excreta are not often used as raw material for production of biogas in a sustainable way. For example in 1998 the European rendering industry transformed (using a lot of energy) a total of 16.1 million tons of animal material into 3 million tonnes of meat-and-bone meal and 1.5 million tonnes of fat suitable for use in animal feed. While most of these 16.1 million tonnes came from healthy animals inspected in slaughterhouses, 1.8 million tonnes came from animals that died outside slaughterhouses or other condemned materials. As the excluding of above-mentioned materials from the food chain is necessary, the alternative option is to use their RB and produce biogas and biofertilisers in modern facilities. These 16.1 million tons of animal contain approximately 80 TWh bioenergy. Using the concept of bioconversion presented in this proposal will result in biogas with energetic value of 26 TWh and about 40 TWh of energy will remain in biofertilisers.
