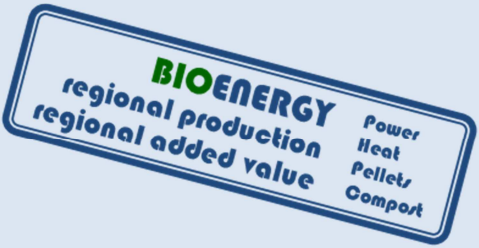
ENERCOM

ENERCOM Project

Polygeneration of Energy, Fuels and Fertilisers from Biomass Residues and Sewage Sludge

Information and Results



ENERCOM Project was supported by the European Commission under the Seventh Framework Programme (FP7/2007-2013) under grant agreement nr. TREN/FP7/EN/218916 "ENERCOM"

The ENERCOM project aims at the construction and test running of a pilot composting plant, using sewage sludge from the surrounding municipalities as well as green waste and bark, which the municipalities intend to discard. While the conventional way of treating sewage sludge and greenery waste is quite energy intensive, the project aims at demonstrating a new, high efficient material Flow Management concept. Energy consumption for treatment shall be replaced by energy production through polygeneration of electricity, heat, solid fuels and high value compost, thereby offering a new environmentally friendly and cost-effective path for recovery instead of disposal.

Background

For the year 2010, it was estimated that about 11.8 million tons of dry solid of sewage sludge were produced in the 27 European member states. As a result of a growing number of newly built defecators the amount of sewage sludge will increase to 12.8 million tons until 2020. Sewage sludge is the final product of waste water treatment processes from domestic, trade and industrial sources. Waste water passes three stages of processing - the primary physical and/ or chemical, the secondary biological and the tertiary nutrient removal treatment. The sludge consists of water and solid materials originating from the human metabolism or other substances from household or industrial activities.

Until the end of last century, sewage sludge was mainly used as fertilizer in farmlands and within the composting industries. As the effects of the substances contained in sludge such as Polychlorinated biphenyl (PCB), Absorbable Organic Halogenated (AOX) compound, heavy metals or hormones are not yet completely identified, this type of utilization is increasingly rejected by consumers and national legislations. Switzerland

completely phased out from agricultural disposal of sewage sludge in 2006. Other countries are following that trend. A big potential for thermal treatment remains in the Eastern European countries. The European integration process fosters environmental technologies and standards also in these countries.

Thermal Treatment

The thermal treatment of sludge thus is becoming a dominating method for the disposal of sewage sludge. For example, in 1995 only twelve percent of Germany's sewage sludge was disposed via thermal treatment, in 2011 already 55 percent were disposed in this manner. A high ratio of thermal treatment is conducted in large scale plants; about 48 percent of sewage sludge is used for co-incineration of coal fired power plants.
Today different thermal treatment methods exist, such as mono- and co-incineration, pyrolysis and gasification. Stationary fluidized bed firing systems combined with disc drying systems are beyond the state of the art in large scale power plants. For large scale incineration a huge amount of sewage sludge is needed which requires longer transport routes. In contrast small or medium sized plants have the advantage of more regional added value by using regional sources with lower transportation costs.

The technology proposed to be demonstrated within the polygeneration power plant of the ENERCOM project can be applied to any sludge and organic matter treatment plant on an EU wide level. About 3.000 existing plants contain a potential of renewable energy equivalent to about 70 TWh.

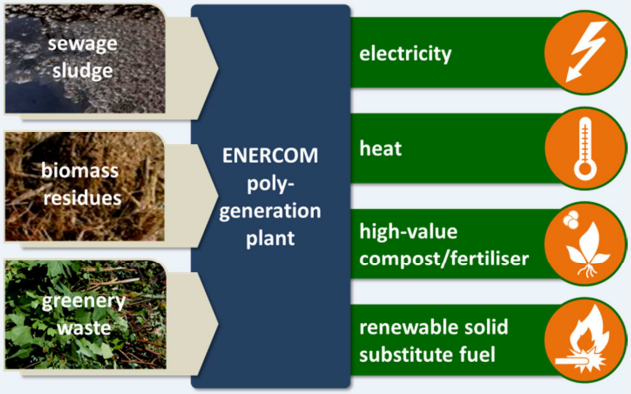
Resource-efficient

The proposed activity of the ENERCOM demonstration plant contributes to the implementation of the EU policies on sewage sludge, water and soil (i.e. 2000/60/EC, 86/278/EEC). By re-using residues as fuels, the pilot plant will save natural resources. Compared to agricultural disposal of sewage sludge, the thermal treatment significant-

ly reduces soil and groundwater pollution by heavy metals, PCB, AOX and other substances contained in and emitted by sludge.

Phosphate Recovery

Resulting from decrease of sewage sludge applied to farmlands and the limited resources of natural phosphate deposits, the need for phosphate recovery from sludge is currently being discussed in the R&D sector. In case of Germany about half of the phosphate consumption in the agricultural sector could be substituted by phosphate from sludge. Ashes remaining from the thermal treatment of sewage sludge as proposed within ENERCOM thus have to be seen not as a waste product but as a source of recovered phosphate.



Simplified scheme for input and output

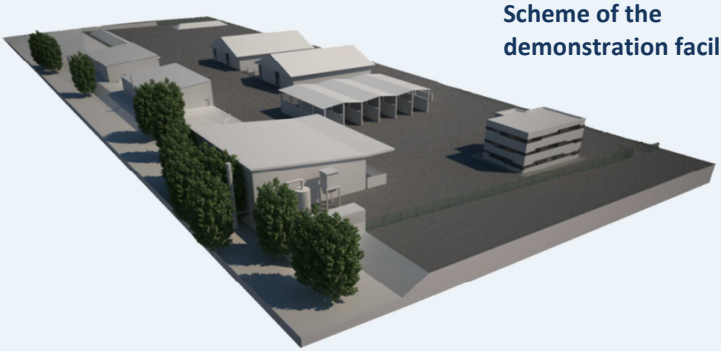
ENERCOM Objectives

The ENERCOM demonstration plant is set up on an existing compost production facility in Fridhaff, Luxembourg which is owned and operated by Soil-Concept.

The aim was to build up a new polygeneration plant which is able to process larger amounts of sewage sludge, to produce less but higher quality compost as well as pellets as storable substitute fuel and to deliver electricity and heat to the grid. The plant provides an environmentally friendly and profitable way for the disposal of sewage sludge. Thereby it maximises energy output, and reduces greenhouse gas emissions. High overall energy efficiency is achieved by

- demonstrating the flexibility of the proposed polygeneration with regard to energy and material flows, responding in a flexible manner to varying market conditions and changing legal frameworks,
- providing a more efficient way to remove heavy metals and other harmful substances from sewage sludge by concentrating them in the ash of a gasification process and removing them through an innovative separation process,
- providing a path for recovering minerals and nutrients not only from sewage sludge, but also from biomass used for energy generation, by combining energy generation with compost production, allowing for efficient recycling of minerals and nutrients from ashes.

The demonstration plant provides an example for adaptation of the technology to other plants.

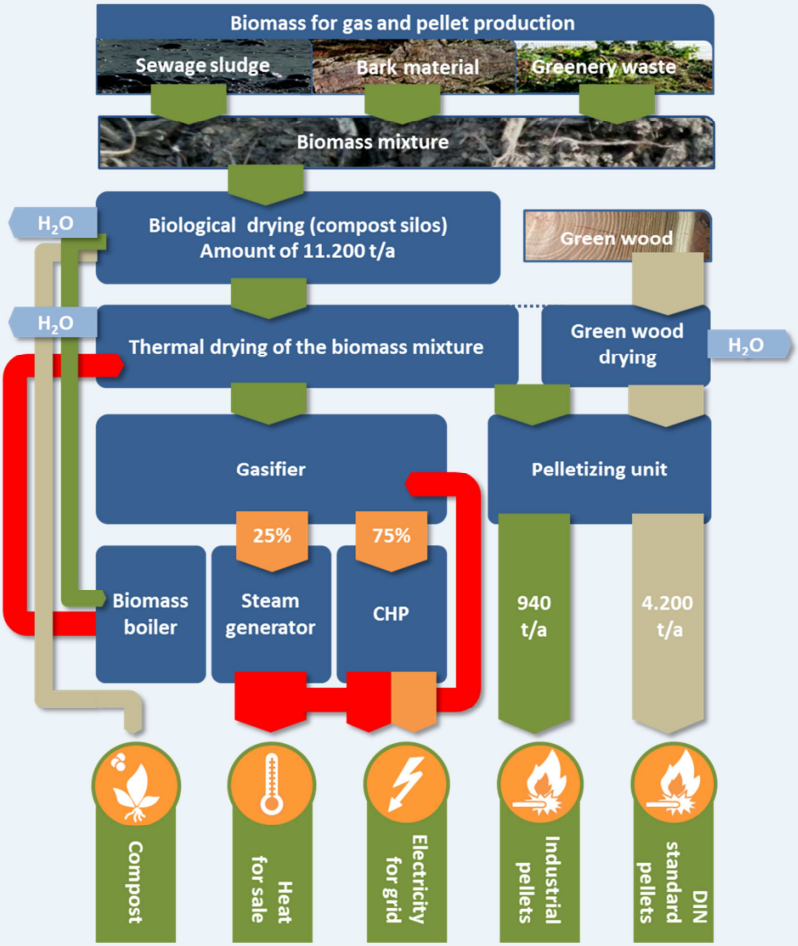


Scheme of the demonstration facility

How does the plant operate? Concept and technical information

Estimated input and output of material and energy

The input material for the polygeneration power plant requires a mixture of pre-treated sewage sludge, greenery waste and bark material. The further treatment processes such as thermal drying, ventilation, gasification and pelletizing need additional input of power and heat. Beside its own consumption the plant is able to produce energy, heat, substitute fuel and compost. The following flow chart shows the processes, technical components and material flow within the demonstration plant.



Flow chart for the demonstration plant

The Institute for Applied Material Flow Management (IfaS) situated in Trier, Rhineland-Palatinate, calculated proposed amounts of input and output material flow shown in the following figure.

Mass and Energy Balance (01.01. - 31.12.)			
Inputs	**Amount**	**Ouputs**	**Amount**
1 Raw materials		1 positive	
Sewage Sludge	12.000 t	Electric energy	1.536 MWh
Greenery waste	10.549 t	Heat	2.502 MWh
Bark material	1.759 t	Pellets	1.683 t
2 Operating and auxiliary materials		Compost	7.545 t
Absorption oil	42,2 t	2 neutral	
Rape oil	16,8 t	Evaporated material	11.021 t
Limestone	77,4 t	Gasified material	3.384 t
LPG	21,1 t	Rejected heat	940 MWh
3 Energy		Rejected fuel energy	1.956 MWh
Electricity	546 MWh	3 negative	
Heat	2.502 MWh	Ash	833 t
4 Energy Removals			
Electricity*1	990 MWh		
Heat*2	940 MWh		
Fuel*3	1.956 MWh		
Total			
Materials	24.466,0 t		24.466,0 t
Electricity	1.536 MWh		1.536 MWh
Heat	3.442 MWh		3.442 MWh
Fuel	1.956 MWh		1.956 MWh
*1 Energy Removal from raw materials which can be sold			
*2 Energy Removal from raw materials which is rejected			
*3 Energy Removal from fuel which is rejected			
Assumption for Screening oversize: Greenery waste/bark material = 50/50 in relation to Input-mass			

Mass and Energy Balance of ENERCOM (source: 4th annual report 2012)

Efficient drying process

Drying sewage sludge usually requires high energy input. The ENERCOM project consortium considered following requirements for more efficient drying:

- How to minimize moisture content for energy efficient gasification (High DS for higher net calorific value,
- how to minimize energy consumption during the drying process,

- how to minimize emissions and odour of volatile substances,
- how to prevent contamination of the soil.

Efforts of ENERCOM

The owner and operator of the pilot plant modified its formerly used compost silos and installed new technical components at the facility. The demonstration plant exploits following benefits:

- Compost produces low heat which reinforces the natural drying process.
- A ventilation system additionally dries the mixture up to 65 % dried substance.
- A newly installed basin collects waste water to prevent contamination of the soil.
- An acid scrubber reduces emissions from volatile elements.

A thermal drying unit dries the material up to 85-90% dried substance. A complex heat recovery system installed in the demonstration plant redirects heat from the gasification process to the thermal drying unit and thus significantly lowers energy consumption.

Acid scrubber at the demonstration facility in Fridhaff, Luxembourg.

Pellets used as solid recovered substitute fuel

Pellets produced from biomass residues will substitute fossil fuels. For the optimal exploitation of energy the ENERCOM project consortium considered following requirements:

- How to minimize moisture content for pelletization,
- how to achieve optimal toughness of pellets,
- how to maximize net calorific value,
- how to minimize energy consumption along the production line,
- how to minimize emissions from fuel combustion (according to limit values at the Directive 2000/76/EC),
- how to minimize ash content.

Efforts of ENERCOM

The ENERCOM consortium carried out a feasibility study for production of solid recovered substitute fuel made from dried sewage sludge, greenery waste and bark material. Within the study the consortium partners tested different compost compositions added with sawdust and

peat and recommended following modifications for the pelletization of solid recovered substitute fuel:

- Pellets produced not only from sewage sludge but from a compost mixture have better characteristics regarding high net calorific value and low moisture content. Low content of compost and high content of saw dust increases the net calorific value.
- Pelletization is more energy intensive than briquettization but energy consumption depends also on the equipment and optimization of processes.
- Large scale fuel combustion plants have a lower impact on the environment due to higher combustion temperatures as well as better automation and controlling of the combustion process.

Pellets produced from sewage sludge, greenery waste and bark material within ENERCOM project

Gasification including removal of heavy metals

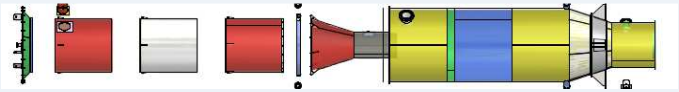
The advantage of gasifying sewage sludge is that it destroys all organic compounds including harmful substances like PCB and AOX thus lowering the impact on soil contamination. The removal of heavy metals remains one of the main tasks within the gasification process to avoid environmental pollution. The ENERCOM project consortium considered following aspects for an optimal gasification process:

- How to minimize energy consumption
- How to achieve the highest removal rate of heavy metals
- How to optimize the heating system of the gasifier

Efforts of ENERCOM

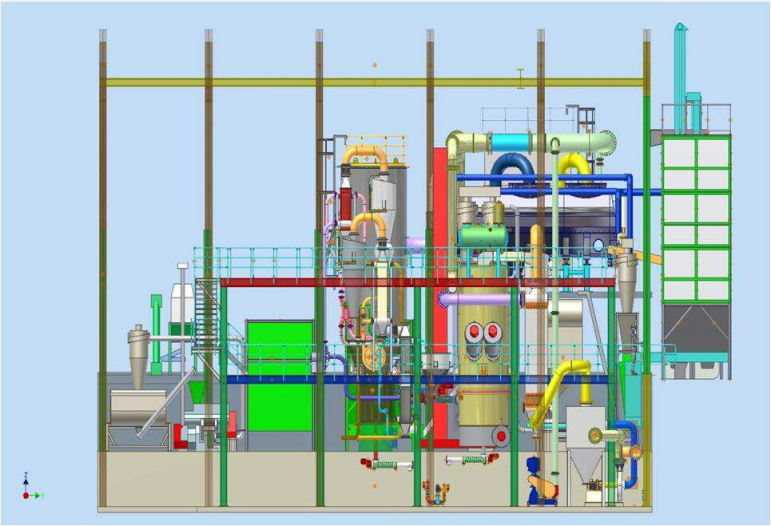
The consortium investigated the behaviour of heavy metals within the gasification stage and recommended best practice conditions for thermal treatment of sewage sludge and biomass within an appropriate reactor:

- Cl-containing additives from volatile chlorides with the heavy metals and are partly evaporated.
- 20g Cl/kg dry ash, a temperature of 1,000°C and residence time in the gasifier of 30 min enable the highest heavy metal removal rate.
- An indirectly heated reactor shows better results on heavy metal removal but has higher corrosion risks than a directly heated reactor.



Scheme of gasifier components

Gasifier inside view during construction



Scheme of technical components within the gasifier hall

Efficiency via an intelligent material flow management

What about high efficient technology if there is a lack of raw material components like bark, if transportation distances are very long or if higher market prices lead to unprofitable purchase of raw material? Saving resources and additional expenses depends on well-conceived material flows. Aspects like input, output, logistics, mass and energy balance, and regional added value have to be analyzed in order to affect a high overall efficiency of the demonstration plant and to respond in a flexible manner to varying market conditions and changing legal frameworks.

Efforts of ENERCOM

ENERCOM has developed several tools to optimize the material flow management of the demonstration plant:

- A calculator tool computes how much of one material could substitute another if the material inputs are shifting.
- A UMBERTO model calculates energy and material flows within the demonstration plant.
- The analysis of material input (raw materials) and output (pellets), logistics, mass and energy balance visualizes outcomes of the demonstration plant
- A calculation method promotes stakeholders to create more benefits by optimising monetary flows of regional added value.

Product or Waste? Legal Implications

Sewage sludge is an end product with a critical impact on the environment and is thus classified as waste. If assumed harmful and worthless waste turns into valuable fuel what is the impact on the legislation?

The ENERCOM consortium conducted legal aspects of ENERCOM pellet production and cross-border trading.

The plant produces two products for two different purposes, i.e. compost to use as soil improver and fertilizer (1) as well as pellets which will be used to be burnt (2). The evaluation focusses therefore separately on the part of compost material as outcome from the above process as well as on the produced pellets for heating and the legal conditions for their respective marketing/shipment within the EU.

Since this compost is a mixture of sewage sludge from municipal waste water treatment, of greenery waste from municipal green areas such as parks and streets, and from bark collected from the public areas of the municipalities, a set of major legal texts are applicable. The sludge and the two

other bio waste components will be mixed in the proportion of 60 % sewage sludge and 40 % greenery waste plus bark. If this mixture would constitute a new product does not have to be decided here, as according to § 4 para 13 of the German Ordinance on Sewage sludge, the compost produced from a mixture of sewage sludge with different other materials, these different biomass materials to be mixed into the sewage sludge have to correspond each separately to the limits of hazardous substances.

Waste Framework Directive (WFD) defines waste

According to the WFD waste is "a substance or object which the holder discards or intends or is required to discard" (Art. 3 Nr.1). It only applies to movable objects or substances, as land and buildings are excluded from the scope of the directive. It further requires the intention of the holder of the object or substance that he is willing to discard these. The waste qualification will only cease if and when the waste has undergone a recovery operation and complies with certain criteria, which are transposed by Member States into national law.

The Urban Waste Water Directive

The urban waste water directive (Directive 91/271/EEC) regulates the collection, treatment and discharge of urban waste water and of waste water from certain industrial sectors for environmental purposes. This Directive concerns sewage sludge insofar as it sets the parameters for its environmentally and technically sound re-use and disposal with a mandate for MS to adapt their regulatory measures.

The Landfill Directive sets out the conditions for waste to be disposed of

The landfill Directive 1993/31/EC aims at preventing and reducing the negative effects of waste disposed in landfills on the environment Since the ENERCOM plant is designed to reuse and re4. The Shipment of waste rules indicate the conditions for the

shipment of waste within the EU or from and to third countries. Since ENERCOM will recycle the treated material to 100 %, the Landfill Directive will only marginally play a role.

Regulation (EC) N° 1013/2006 on shipments of waste

The Regulation (EC) N° 1013/2006 on shipments of waste regulates supervision and control of shipments of waste within the EU or with transit through third countries, transit through the EU from or to third countries. Different procedures apply for hazardous or semi hazardous waste as compared to nonhazardous waste, all intended for recovery. Should the end products of the plant be considered waste, when it comes to their marketing, this regulation would need to be respected.

ENERCOM perspectives

The proposed demonstration plant shows new business opportunities for stakeholders who are planning solutions for thermal treatment of sewage sludge combined with biomass. Economical and ecological advantages are:

- Energy self-sufficient, decentralized treatment of biomass residues.
- Intelligent material flow management which balances out changing market conditions and offers multiple valorised products like high value compost, pellets as storable substitute fuel, power distribution to the grid, surplus heat for drying processes and local heat distribution to a nearby industrial park
- Regional added value by recovering biomass residues in the region
- Protection of natural resources by substituting fossil fuels

Contact Information

ENERCOM Project was supported by the European Commission under the Seventh Framework Programme (FP7/2007-2013) under grant agreement nr. TREN/FP7/EN/218916 "ENERCOM"

Project Coordinator

The project was coordinated by the Institute for Applied Material Flow Management. For further information on the ENERCOM project please contact:

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Investor, owner and enduser

The pilot plant situated in Fridhaff, Luxembourg is owned and operated by the company Soil-Concept. It is open for visitors from municipalities, compost industries and experts. For further information please contact:

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Spin off

SYNERCO S.A.R.L. as an independent Spin-off company from the ENERCOM project was founded in Luxembourg in 2008 with the objective to bring investigated innovative know-how from the ENERCOM project to the market. For further information please contact:

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Project Website

www.enercom-project.info

Project Consortium

A consortium of eight partners has worked on the implementation of ENERCOM

- Institut für angewandtes Stoffstrommangement (IfaS)
- Soil-Concept S.A.
- L.E.E. Landwirtschaft *Energie* Emwelt s.à.r.l.
- BISANZ Anlagenbau GmbH
- BIOS BIOENERGIESYSTEME GmbH
- Kaunas Technological University, Institute of Environmental Engineering Vilnius department (KTU APINI)
- Kuhbier Law Firm
- B.A.U.M. Consult GmbH

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All information about ENERCOM derives from annual reports and deliverables of the ENERCOM project as well as personal contact to project partners.

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Statistics online portal EUROSTAT of European Comission: http://epp.eurostat.ec.europa.eu

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Illustrations
ENERCOM consortium

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