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019809

Project acronym:
NextGenBioWaste

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Innovative demonstrations for the next generation of biomass and waste combustion plants for energy recovery and renewable electricity production

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Thematic priority : SUSTEV-1.1.1 - Cost effective supply of renewable energies

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Duration: 4 years

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SINTEF Energi AS

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential , only for members of the consortium (including the Commission Services)	

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Abstract
This report contains the publishable executive summary (Chapter 1) of the Final Activity Report for EC co-financed FP6 project NextGenBioWaste.

1 PUBLISHABLE EXECUTIVE SUMMARY

The project

The NextGenBioWaste project is a four year integrated project within the EU sixth framework programme that ended in February 2010. The total budget is 29 million Euro and the contribution from the European Commission amounts to 11,5 million Euro.

17 legal entities did agree to establish NextGenBioWaste. The consortium encompasses 8 European utility companies, 2 technology provider, 6 RTD providers, and 1 consultant/ engineering company, see Figure 1.1. The Co-ordinator is SINTEF Energi AS.

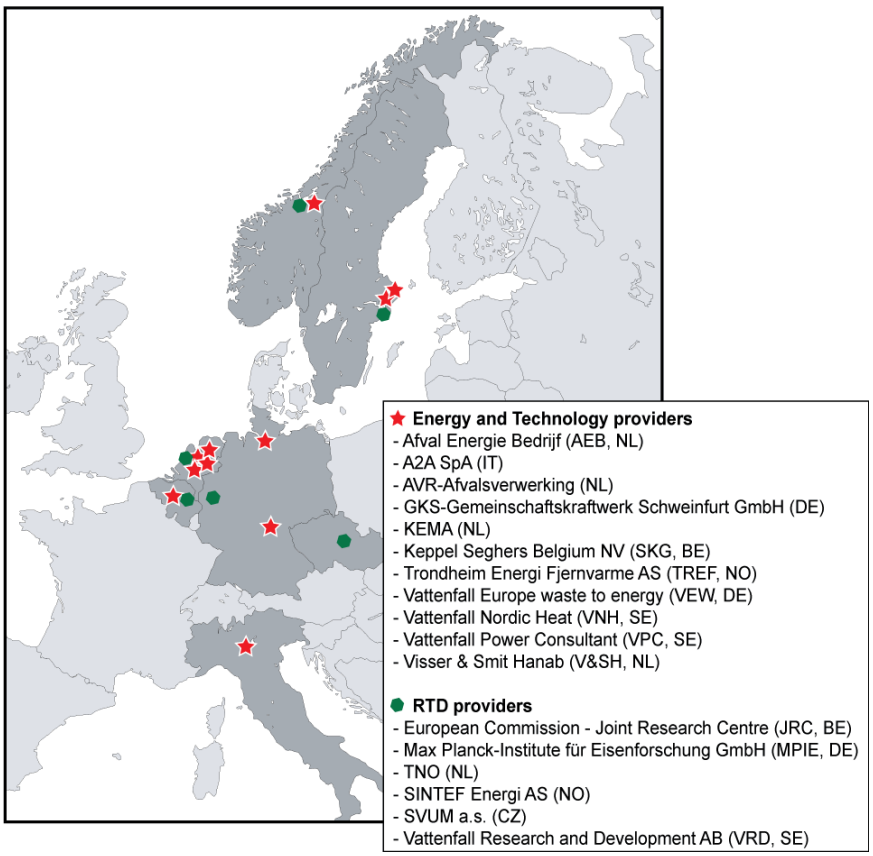
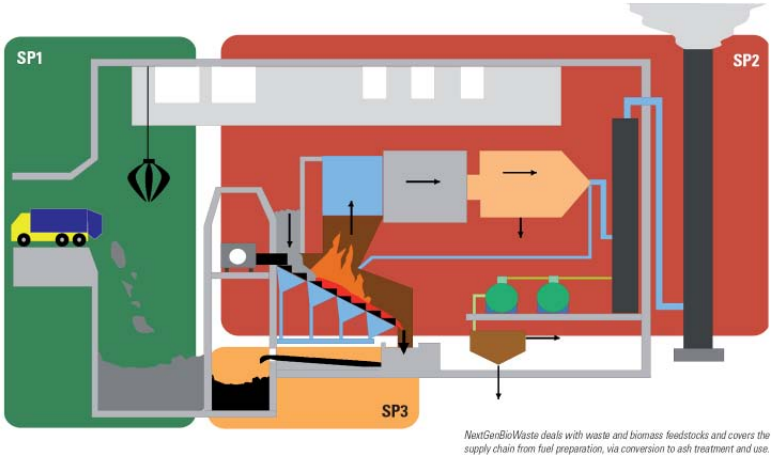


Figure 1.1 Partners in the NextGenBioWaste consortium

NextGenBioWaste responds to the need for new innovative technology for biomass and waste combustion plants and delivers results aimed at accelerating the market penetration of new technological solutions.

NextGenBioWaste has been targeting to perform innovative demonstrations of improvements to energy recovery and renewable electricity production from waste materials and other commonly used biomass feedstocks. This includes to demonstrate reduction in the costs associated with implementation of new technologies and to demonstrate how the technological solutions can be integrated under full-scale operating conditions. NextGenBioWaste has performed several large-scale demonstrations of different innovative concepts for the energy supply chain.

NextGenBioWaste deals with waste and biomass feedstocks and covers the supply chain from fuel preparation, via conversion and residue handling, up to wholesale of energy**.** NextGenBioWaste is organised as an integrated project (IP). The demonstration and RTD activities are structured in 4 sub-projects that respond to the objectives of the work programme:



- SP 1 Innovative fuel preparation and mixing
- SP 2 Conversion
- SP 3 Residue handling and use
- SP 4 Dissemination

Figure 1.2: The different NextGenBioWaste subprojects deals with fuel preparation and mixing, conversion (including emissions) as well as handling and treatment of residues.

Main achievements towards NextGenBioWaste targets

"The overall objective of NextGenBioWaste is to demonstrate innovative ways of improving the energy conversion and renewable electricity production using municipal solid waste materials and biomass for large-scale supply of renewable electricity and heating/cooling to end-users – at a more competitive cost and improved environmental parameters."

The practical implementation of this overall objective is articulated into four targets. Below are brief descriptions of a few selected activities and their outstanding achievements towards the project targets.

1. Increase the electrical efficiency for waste to energy plants [from 22% to 30% (gross generated)]

AEB is actively contributing to a paradigm shift in the perception of waste incinerators: from disposal units to an installation producing (renewable) energy and raw materials by increasing electrical efficiency and metals recycling. It is referred to as the Waste Fired Power Plant (WFPP) concept (see Figure 1.3). In order to increase the electrical efficiency of their plant by more than a third, **AEB** has taken a series of measures:

- Lining of critical heat surfaces in the boiler by Inconel 625
- Increase of the steam temperature (from 400 to 440°C) and pressure (from 40 to 125 bar) with an optimized boiler design to minimize corrosion and erosion
- Higher steam parameters could be achieved without a dramatic increase in corrosion by using a steam-steam heat exchanger for reheating. This heat exchanger is also fired by the waste incinerator. This is the first time this process is used in waste incineration. The reheater is patented and **AEB** is considering licensing this patent to builders and operators of WtE plants
- Minimization of the O_2 level in the flue gas from 8-11% down to 6% by implementing flue gas recirculation. The volume of flue gas is reduced by about 40%
- Maximum use of flue gas energy
- Minimization of the steam pressure after the turbine

These comprehensive steps have led to an increase of the gross electrical efficiency. In 2009, the average values varied from 26.3 to 33.3% against about 22% before NextGenBioWaste, largely meeting the aforementioned project target.

Improvements can also be attained by specific maneuvers. **SKG** designed an Eco-probe to determine the onset temperature of acid dewpoint corrosion to minimize excessive corrosion safety margins and maximize the exploitation of the low temperature end of the WtE process. **SKG** estimated that a 4% electrical efficiency increase is achievable when optimizing the temperature profile in the boiler. **GKS** carried out CFD simulations of the various components of their plant with the overall goal of identifying possibilities of reduced pressure drop. The resulting revamping of the **GKS** plant led to an energy saving corresponding to the electricity demand of more than 200 households.

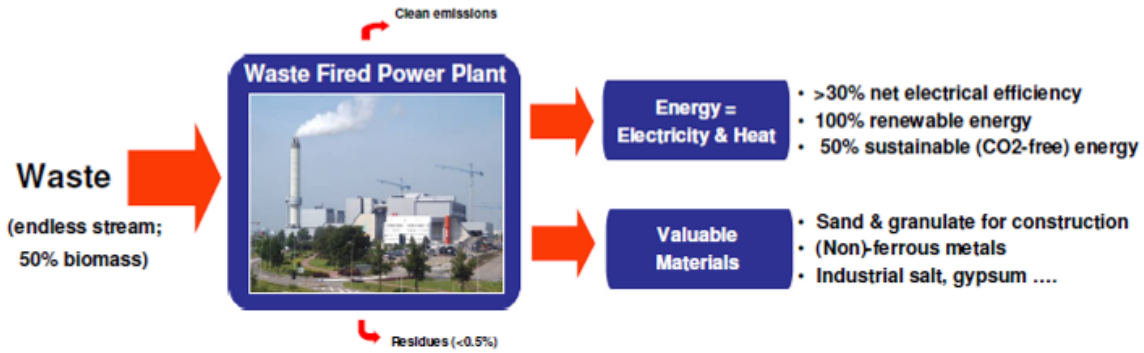


Figure 1.3. AEB Waste Fired Power Plant (WFPP) in a nutshell.

2. Double the lifetime of heat exchange components at existing steam parameters

Extending the lifetime of heat exchange components is strongly related to the mitigation of corrosion and/or its effects. NextGenBioWaste explored all the available classes of measures. Even though it was seldom possible to quantify the actual lifetime increase of given components, it can be said that the activities contributed significantly to the attainment of this ambitious target:

Corrosion-resistant materials. **MPIE** and **SVUM** have tested the corrosion behavior of a variety of alloys respectively in the laboratory and in the field in five different biomass combustion plants, four in the Czech Republic and one in Sweden and in different environments.
SVUM has shown that austenitic steels and Ni-base alloys have very good resistance with very thin corrosion layer.
MPIE, investigating the potential of newly developed laboratory materials, has reported good to excellent corrosion behaviour for the high alloyed Fe-Al intermetallics as well as the modified 9%Cr-steels. Their performances are comparable to the advanced steels and nickel based alloys, i.e. TP 347 H, Sanicro 28 and Inconel 625 as well as T 92 and may therefore be adapted to engineering applications.

On-line monitoring of corrosion. On-line monitoring of corrosion is a promising yet still little employed method because of the lack of proven techniques. Several novel techniques have been developed, tested, evaluated and sometimes validated by several NextGenBioWaste partners. **VPC** worked on corrosion probes containing both Linear Polarisation Resistance (LPR) and Electrochemical Noise (EN) sensors. The experiments were carried out in two full scale installations (GKS boiler in Schweinfurt, Germany and VNH Idbäcken BFB, Nyköping, Sweden). It was proven possible to measure relative corrosion rate with LPR while EN can be used to detect pitting corrosion.

KEMA developed three analytical techniques for corrosion monitoring in waste incinerators that were tested at AEB in Amsterdam. KEMCOM was able to measure on-line the corrosion rate and therewith could allow for the optimisation of process conditions to minimise the corrosion rate, however this requires experienced operators as well as a clear picture of the important parameters. KEMBUS/KEMWAT, an ultrasonic method, successfully measured wall thickness from the outside of the boiler (respectively offline and continuously). KEMCOP investigated on-line the degradation of different materials and showed that there is room for improvement when it comes to the corrosion resistance of coatings.

Corrosion-fighting additives. **Vattenfall**s ChlorOut comprises a sulfate additive and an analytical method (IACM) to assess its efficiency (see Figure 1.4). Ammonium sulfate has the ability to convert the highly corrosive alkali chloride into less corrosive alkali sulfate while IACM monitors the concentration of gaseous alkali chloride. Prior to this project, this patented concept had proven its efficiency in biomass-fired boilers (both fluidized beds and grates systems) but during NextGenBioWaste VPC was able to assess the efficiency of ChlorOut in waste incinerators whose corrosive environment is tougher. The KCl concentration in the flue gas was reduced by 50-60% (up to 90%) and almost no Cl was detected in deposits. A significant decrease in corrosion rate was observed. The overall results indicate that the lifetime of the superheaters will be twice as long as before.
SINTEFs thermodynamic calculations assessed further the efficiency of ChlorOut to reduce corrosion not only in biomass but also in waste boilers.

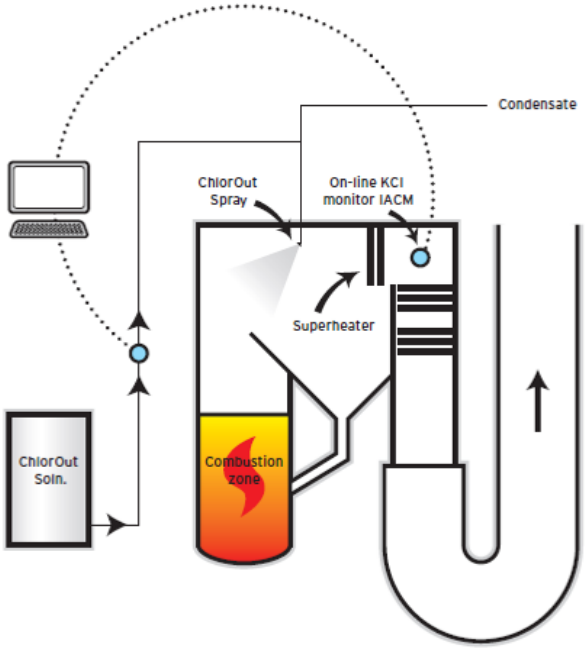


Figure 1.4. Schematic diagram of a Vattenfall ChlorOut installation

Novel design. **GKS** Chlorine Trap (CT) is a special bundle of special-designed tubes in front of the convection part. The “cold” tubes have to deliver a surface for condensation of alkali chlorides and the very narrow tubes are expected to catch the chlorine particles. To avoid blockage in the CT a special cleaning device had been installed: the so-called Horizontal Washing System. Full-scale tests at the GKS plant showed that the “Chlorine Trap” was able to reduce the corrosion by about 20-28 %.

3. Increase the electrical efficiency for biomass combustion plants [from 33% to 35%], while making the systems more cost-effective by the use of low-grade fuels

The VNH BFB plant in Nyköping was burning a 50/50 (energy basis) mixture of virgin biomass and demolition waste wood and was encountering serious operational problems, mainly defluidisation and plugging of the nozzles by metal parts (see Figure 1.5 left), which required monthly stops and manual clean-up (see Figure 1.5 right). In order to be able to burn 100% demolition waste wood in place of virgin wood chips, in other words to change to a more challenging fuel when it comes to plant availability, efficiency and emissions while reducing the operational issues, **VNH** had to design a new bed bottom, The design of the sand hoppers was a significant challenge as it had to allow for proper sand draining.
The retrofit was comprehensive but it was a threefold success as it allowed shifting to a low grade fuel while being able to improve availability (from 90 to 98%) and capacity (from 80 to 90

MWth), i.e. to significantly reduce the aforementioned operational challenges. The present market trends, legal conditions and customer demands make demolition waste wood profitable in this kind of boilers.

Figure 1.5. Fluidized bed plugged nozzles (left) and manual cleaning (right) before retrofitting.

4. Lower the fuel cost [by at least 1 mill.€/year for a 100 MWth biomass combustion plant while maintaining sub targets 2 and 3]

This NextGenBioWasteGBW target deals with the important subject of cost-efficiency and is mainly related to the retrofit activity at the **VNH** Nyköping BFB plant (see previous target). Shifting fuel from a 50/50 (energy basis) mixture of virgin biomass and biomass residues (mainly demolition waste wood) to 100% demolition waste wood had several economical implications: (1) Extra costs for the retrofitting; (2) Fuel savings as demolition waste wood is cheaper than virgin wood; (3) Supplementary income due to improved capacity and availability. Fuel shifting led to a saving of about 2.5 M€/y, as the plant has a total fuel consumption of 500 GWh/y and the price difference between demolition waste wood and virgin wood is 10 €/MWh. The total cost of the retrofit was about 2 M€, meaning that it is paid off in less than 10 months, not even including the income from the supplementary energy delivered, which is about 0.5 M€/y. The target is largely exceeded, showing that it is possible to burn a more problematic fuel than originally designed and still improve capacity, availability and cost-efficiency.

5. Ash upgrading and utilization

Sadly, this project target and most of the related activities (involving AVR, a Dutch partner) were canceled in 2007 due to regulatory changes in the Netherlands. The Dutch regulatory leaching limits for heavy metals were evaluated after 2005 and were adjusted in 2007, allowing higher leaching of both granular construction materials and shaped building products. For the utilization of MSWI bottom ashes the leachability of particularly copper and molybdenum were critical in the former regulations, because of which upgrading was necessary. In the new regulations leaching limits for copper and molybdenum are respectively a factor 3 and a factor 10 more lenient. The vast majority of Dutch MSWI bottom ashes (including all AVR ashes) now easily complies with leaching limits. No upgrading is necessary anymore.
However, several ash-related tasks did not stop and valuable results pertaining to ash treatment/stabilization methods and parameters controlling ash quality were obtained.

Use and dissemination of knowledge

The dissemination activities performed during the four years have been targeting at communicating project results as well as to enhance the publicity of the NextGenBioWaste project. The following dissemination actions have been carried out:

- The NextGenBioWaste website that was established in September 2006 is continuously updated with project news and publications (http://www.nextgenbiowaste.com).
- Dissemination material: A project brochure is produced, and a project presentation is made. Two NextGenBioWaste Newsletters are issued. These are available from the website. In co-operation with PSCA International LtD a 2-page article on NextGenBioWaste was produced and published in Public Service Review: European Union 18, in addition a 16-pages booklet with emphasis on the NextGenBioWaste project and the results was produced in co-operation with PSCA.
- Publications: During the four years project period 14 scientific publications, 6 popular science publications, 15 press clips, and more than 100 presentations are produced. Several scientific and also popular science publications are still in progress. Selected publications are available from the website.
- Two international conferences have been arranged to present NextGenBioWaste results. The presentations are available from the website.
    - First International conference on waste and biomass combustion", 8-10 October 2008, Milan, Italy
    - Second International conference on biomass and waste combustion", 16-17 February 2010, Oslo, Norway

Exploitation of results

The results achieved are of course exploited in the specific demonstration plants, and further optimising is also likely. Results and knowledge gained by the NextGenBioWaste project are internally distributed among engineers, managers and decision makers at the partners. The NextGenBioWaste partners will exploit their own but also project results in general in other plants. In addition to the general dissemination activities, some specific actions are also taken, to encourage further exploitation of the project results outside the NextGenBioWaste consortium. Important actions are:

- The results achieved by Keppel Seghers' Eco-probe demonstration on lowering of the boiler feedwater temperature without corrosion risk is utilized in a CHP-plant under construction in Manchester. Keppel Seghers as a supplier of WtE-plants will exploit this knowledge for the design of future plants.
- Corrosion resistant materials identified by SVUM are used in new boilers under design for straw combustion (by Biowatt) and in existing boilers for coal+wood chips and for fuel wheat straw (Operator: CEZ Hodonin, Czech Republic).
- The AEB reheater patent is licensed to builders and operators of WtE plants. This licensing is combined with consultancy activities, training and dissemination of best practices in waste management. Up to now, AEB is being part of two consortiums that are tendering for PFI contracts in the UK.
- The new bed bottom technology demonstrated in Nyköping and the knowledge gained will be used by Vattenfall in another plant under construction (CHP Jordbro).
- Implementation of some of the tools developed; online measurement of wall thickness (KEMBUS) and online caloric value sensor is seriously considered at AVR.
- A2A will propose that High-Dust SCR is included as a new BAT for emission control of WtE-plants.
- Visser & Smit Hanab is actively using the NextGenBioWaste results to design WtE-plants with less excess air and higher efficiency.

- TNO has the intention to further exploit the calorific value sensor together with industrial partners. As a first step TNO has made an offer to install the calorific value sensor to a major waste-to-energy company in France. This offer is still under negotiation. This first installation will be regarded as a pilot. The company has the intention to install the sensor in more waste-to-energy plants after successful demonstration.
- TNO has the intention to further develop and evaluate the MPC technology for waste incineration plants together with interested partners.
- The Combustion Layer Sensor developed by JRC is allowing on-line measurements of temperatures and gas concentrations on the grate. Patenting is under consideration. Agreement with a commercial company is signed in order to realize a technological transfer. This company may then commercially use the sensor to make measurements on request of MSWI operators.

Recommendations for further work

Overall, it can be said that NextGenBioWaste is a successful project which has reached its targets and made significant contributions to several key research areas in biomass and waste thermal conversion both through practical results and more fundamental knowledge. However, the project has also revealed that further improvements are possible, and obviously there are still significant challenges to solve in order to reach the ambitious European targets on renewable energy. One major topic is to raise the electrical efficiency even further, for biomass plants the ambition should be to exceed 40%, and for WtE plants to reach 36% which is a future goal for AEB in Amsterdam. Increased electrical efficiency could be reached through

- reduced corrosion and fouling at even higher steam parameters
- improved process control
- advanced combustion
- gasification systems

Another topic is to obtain more cost-effective fuels and fuel mixtures for biomass plants, to make the combustion systems more fuel flexible and still reach a high electrical efficiency. NextGenBioWaste has shown that it was possible, for a biomass plant burning waste wood, to reach an electrical efficiency at the same level as for virgin biomass.

The management of solid residues (fly ash and bottom ash) from combustion (and other thermal processes) for waste and biomass is also a very actual research theme, especially regarding long-term disposal or utilisation options, residue quality and removal of heavy metals. This task has not only scientific aspects but also economic implications and issues related to the public acceptance.

A fourth interesting topic is to reduce the CO_2 emissions through combined biopower/CHP and CCS, the only possibility for negative CO_2 emissions.

www.NextGenBioWaste.com

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