IEA Bioenergy

TASK 32
Biomass Combustion and Cofiring

END OF TASK REPORT

2001 - 2003

Prepared by:

Sjaak van Loo, Task Leader
TNO-MEP
PO Box 342
7300 AH Apeldoorn
The Netherlands

June, 2004

Operating Agent

Kees W. Kwant, SenterNovem, P.O.Box 8242, 3503 RE, Utrecht, Netherlands

Task Leader

Sjaak van Loo, TNO-MEP, PO Box 342, 7300 AH Apeldoorn, Netherlands

Participation

The below persons have represented the participating countries in the triennium 2001-2003. These persons have usually attended the Task Meetings and contributed to the subtask assignments and investigations. On some occasions, other experts

- Peter Coombes, Delta Electricity, Australia
- Ingwald Obernberger, Technical University of Graz, Austria
- Jerome Delcarte, Département de Génie Rural, CRA, Belgium
- Richard Logie, Department of Natural Resources, Canada
- Anders Evald, FORCE technology, Denmark
- Erich Nägele, European Commission, Belgium
- Jouni Hämäläinen, VTT Processes, Finland
- Sjaak van Loo, Netherlands (Task leader)
- John Gifford, Forest Research Institute, New Zealand
- Øyvind Skreiberg, NTNU, Norway
- Claes Tullin, SP Swedish National Testing and Research Institute, Sweden
- Thomas Nussbaumer, Verenum, Switzerland
- William Livingston, Mitsui Babcock Energy Limited, UK
- Larry Baxter, Brigham Young University, USA

Overview of the Task

Of all thermochemical conversion technologies available for biomass, combustion can be regarded as the most widely applied option, with a global market share exceeding 90%. If compared to gasification, pyrolysis, or liquefaction, it is observed that combustion technologies are in a further stage of development. Commercial availability is high and there is a multitude of options for integration with existing infrastructure on both large and small-scale levels.

Nevertheless, for further implementation of biomass combustion, combustion technology should be optimised to keep it competitive as gasification and pyrolysis develop. For obvious economic and environmental reasons, co-firing biomass with coal in traditional coal-fired boilers is an option that receives growing interests world-wide. Since this triennium, technical and non-technical barriers related to cofiring are therefore that have received increased attention from Task 32.

The continuing relevance of further development of biomass combustion technologies worldwide is reflected in the size of the Task. With 14 country members, Task 32 was the largest task within the triennium 2001-2003 of the Bioenergy Agreement. In addition to the European Commission, country participation included Australia, Austria, Belgium, Canada, Denmark, Finland, Netherlands, Norway, New Zealand, Sweden, Switzerland, United Kingdom and USA.

Task 32 aims to stimulate the expansion of the use of Biomass Combustion and Cofiring for the production of heat and power to a wider scale. This objective is to be reached by generating and disseminating information on technical and on non-technical barriers and solutions.

The emphasis of the activities in the Task is therefore on:

1. *Market introduction* for expanding the use of Biomass Combustion at a short term;
2. *Optimisation of biomass combustion technology* to remain competitive at a longer term.

In order to achieve its goals, Task 32 seeks industrial participation, interaction with other IEA Implementing Agreements and Bioenergy Tasks and the interaction with the European Union. Enhancement of industrial participation can be realised by formulating joint projects between participating members and industry.

Work Scope, Approach, and Industrial Involvement

Task 32 has contributed to further development and implementation of biomass combustion and cofiring systems in its member countries by exchange of information during semi-annually organised Task meetings, Task organized workshop on particular topics (with active industry involvement and eventually organized with other tasks), as well as Task initiated studies on certain specific combustion related topics such as aerosols emissions and cofiring.

Task Meetings and Workshops:

During the previous triennium, Task 32 has organized and conducted 4 Task meetings, each one in combination with a task organised workshop on a specific combustion related topic. The task meetings were used to effectively communicate progress and results of both national R&D programmes and task initiated projects. Three task meetings were combined with a field trip to advanced combustion plants or research facilities. Further, industrial experts frequently participated in task meetings as observer. The workshops were visited by around 50 to 100 delegates from many parts of the world. A meeting scheduled in September 2001 regretfully had to be cancelled as a result of the international situation with regard to travelling safety after Sept. 11, 2001. An overview of the meetings and workshops is given below.

Date	Location	Event
27-06-2001	Zürich, Switzerland	- International workshop on Aerosols from Biomass Combustion
28/29-06-2001	Zürich, Switzerland	- Task meeting and field trip to several new combustion plants
19/20-06-2002	Amsterdam, Netherlands	- Task meeting
20-06-2002	Amsterdam, Netherlands	- Seminar on recent progress in biomass cofiring worldwide (with Task 33 and EUBIONET)
18-02-2003	Salt Lake City, USA	- Task meeting and field trip to BYU research facilities
19-02-2003	Salt Lake City, USA	- Joint IEA/EPRI Biomass Interest Group meeting on advances in biomass combustion and cofiring - Meeting with ACERC
27-10-2003	Tokyo, Japan	- Task meeting and field trips to several commercial installations and research facilities
28/29-10-2003	Tokyo, Japan	- Joint meeting with Task 33 and 36 on Operating Experience and Techno-economic Benefits and Environmental Benefits of Energy Recovery from Renewable Waste Materials

Reports on all events can be downloaded from the Tasks website.

Subtask Studies:

The work programme of Task 32 has been based on a prioritisation of national activities, performed at the start of the triennium. Task members have then identified small and medium scale CHP systems as well as co-firing coal with biomass and related wastes as the most important topics. Stimulation of large-scale implementation of biomass combustion and co-firing can only be efficient if relevant knowledge is available. The focus of the activities has therefore been on gathering and dissemination of information on relevant expertise. In addition, some task budget has been made available for performing specific studies for which no national funding could be arranged, but which were conceived very relevant by the members of the task.

Most of the activities of task 32 with regard to biomass combustion based CHP are related to the collation and dissemination of information on economic performance, environmental acceptability, fuel flexibility and innovative combustion technologies. A major means of disseminating such information is the handbook on combustion and cofiring that has been published in 2001. An overview of specific activities that were initiated and partially funded by Task 32 is given below, followed by a more detailed description per activity.

1. a seminar on aerosol emissions from biomass combustion
2. an internet database on biomass fuel and ash composition from installations in practise
3. an international overview of CHP installations realised
4. Energetic Assessment of Energy Systems with Biomass Combustion
5. Determination of Efficiency for Automatic Biomass Combustion Plants and Comparison of Efficiency and Emissions for Different Operation Modes. (continued in next triennium)
6. Handbook on Biomass Combustion and Cofiring.

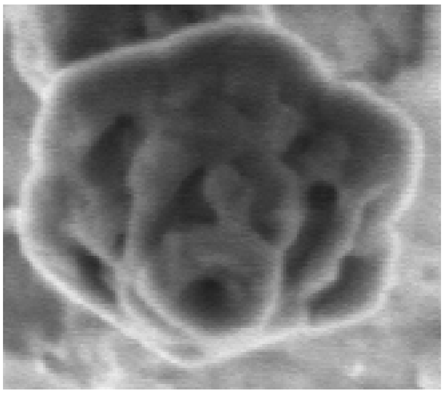
As for the smaller dedicated biomass combustion systems, members of Task 32 have initiated specific activities on cofiring issues, often with financial support from the task leader. Examples are

7. A global overview of cofiring initiatives (continued in next triennium)
8. A joint seminar with task 33 and EUBIONET on biomass cofiring
9. A seminar on ‘Operating Experience and Techno-economic Benefits and Environmental Benefits of Energy Recovery from Renewable Waste Materials
10. Formation of Striated Flows During Biomass-coal Cofiring (continued in next triennium)
11. Biomass Impacts on SCR Catalyst Performance (continued in next triennium)

A summary of all above mentioned task outputs is given below.

1. Seminar on aerosol emissions from biomass combustion

Together with the Swiss Federal Office of Energy, an international seminar has been organised June 2001 on aerosol emissions from combustion. This attracted about 50 participants from industry and research organisations. The seminar provided insight on the formation of aerosols and how a reduction in emission can be achieved using both primary and secondary measures. In some countries it has been shown that biomass combustion can be a significant source of aerosol emissions and of immission of fine particles in the ambient air (PM 10, PM 2.5, PM 1). For this reason, several countries consider reduction of aerosol emissions from biomass combustion as one of the priority research areas for bioenergy.



The report of this seminar was distributed widely. A number of papers and posters on aerosols from biomass combustion were presented at the 12th European Biomass Conference and Exhibition. In addition, the following statement was made and distributed by the members of Task 32 on the need for reduction of aerosol emissions from biomass combustion installations:

Need for reduction of aerosol emissions from biomass combustion installations

Several studies have indicated that the presence of aerosols in the ambient air may contribute to serious effects on human health (including increased mortality, hospitalization for respiratory and heart disease, asthma and lung function). For this reason, governments are tightening limits on aerosol concentrations and immissions.

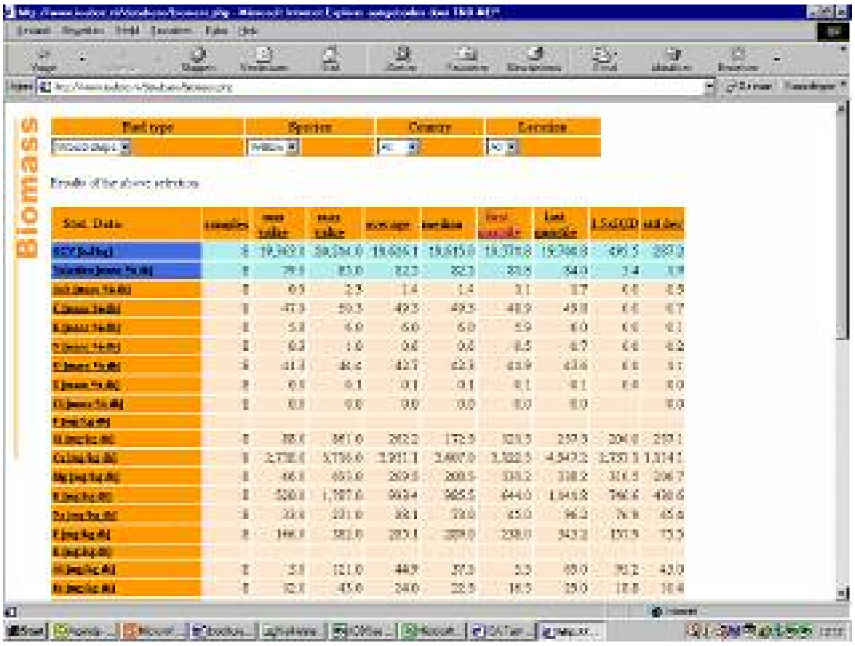
Solid ash and soot particles, emitted from biomass combustion installations, are important sources of aerosols. This is relevant for all biomass combustion systems (both small and large) that are not equipped with effective filtation devices, such as fabric filters. In many areas where biomass combustion systems without efficient particle separation devices are used, aerosol immission limits are strongly exceeded.

With existing technology, the policy aim to increase the contribution of energy from biomass as a renewable energy source may conflict with the aim to reduce aerosol emissions to acceptable levels. Therefore, mitigation of aerosols that result from biomass combustion deserves increased attention from research organizations, manufacturers of boilers and particle removal technologies as well as policy makers.

IEA Bioenergy Task 32 advises to support research and development on reduction of aerosols. Equipment manufacturers need to be encouraged to develop novel, low cost combustion installations and filtration techniques that result in low particulate emissions also in small-scale applications. Task 32 will be instrumental in market introduction of such systems by providing a platform for information exchange.

2. Internet database on biomass fuel and ash composition from installations in practise

The internet site of Task 32 contains a separate database section on the composition of ash, fuels and condensates originating only from actual installations. Specific reference is made to the exact location and type of combustion plant from which the sample was taken, and the origin of ash samples (bottom ash/fly ash) is indicated. In addition, the database contains details on composition of condensates originating from flue gas condensers as used in e.g. Denmark.



On the internet there are more databases available, however the distinct value of the Task 32 database is that it only contains data taken from actual installations, while in other databases the origin of the sample is often hard or impossible to trace. This makes it possible to evaluate regional variations in biomass composition, or variations in ash composition due to differences in plant design.

3. International overview of CHP installations

An international overview of biomass combustion based CHP installations was prepared in the period 2002-2003 with the aim to describe market conditions in the member countries of Task 32 for biomass combustion CHP on the one hand, and detailed techno-economical data of four selected reference systems on the other. This work has yielded two interesting reports that are both available at the Task 32 internet site:

- Basic information regarding decentralised CHP plants based on biomass combustion in selected IEA partner countries
- Techno-economic evaluation of selected decentralised CHP applications based on biomass combustion in IEA partner countries

The first report provides an overview regarding decentralised CHP plants (usually < 20 MW_e) based on biomass combustion in selected IEA partner countries, i.e. Austria, Belgium, Denmark, Finland, the Netherlands, Sweden and Switzerland. All participating countries have defined different targets concerning electricity production from renewable energy sources, three countries (Belgium, Denmark and Finland) have additionally defined targets concerning electricity production from solid biomass.

Investment subsidies for CHP plants based on biomass combustion are granted in Finland, Belgium and the Netherlands (in an amount between 5 and 40% of the total investment costs). Six countries indicated, that increased feed-in tariffs (or other support for electricity production from renewable energy sources) for electricity from biomass are available, i.e. Austria, Finland, Belgium, Denmark, the Netherlands and Sweden. Except Finland, in all countries the feed-in tariffs are secured for a specific period of time.
Emission limits for CHP plants based on biomass combustion are defined for the following parameters in the respective countries:

- Dust: all participating countries
- CO: Austria, Belgium, Denmark, Netherlands, Sweden
- NOx: all participating countries
- SOx: Belgium, Denmark, Finland, Netherlands, Sweden
- TOC: Austria
- PCDD/F: Belgium, Netherlands

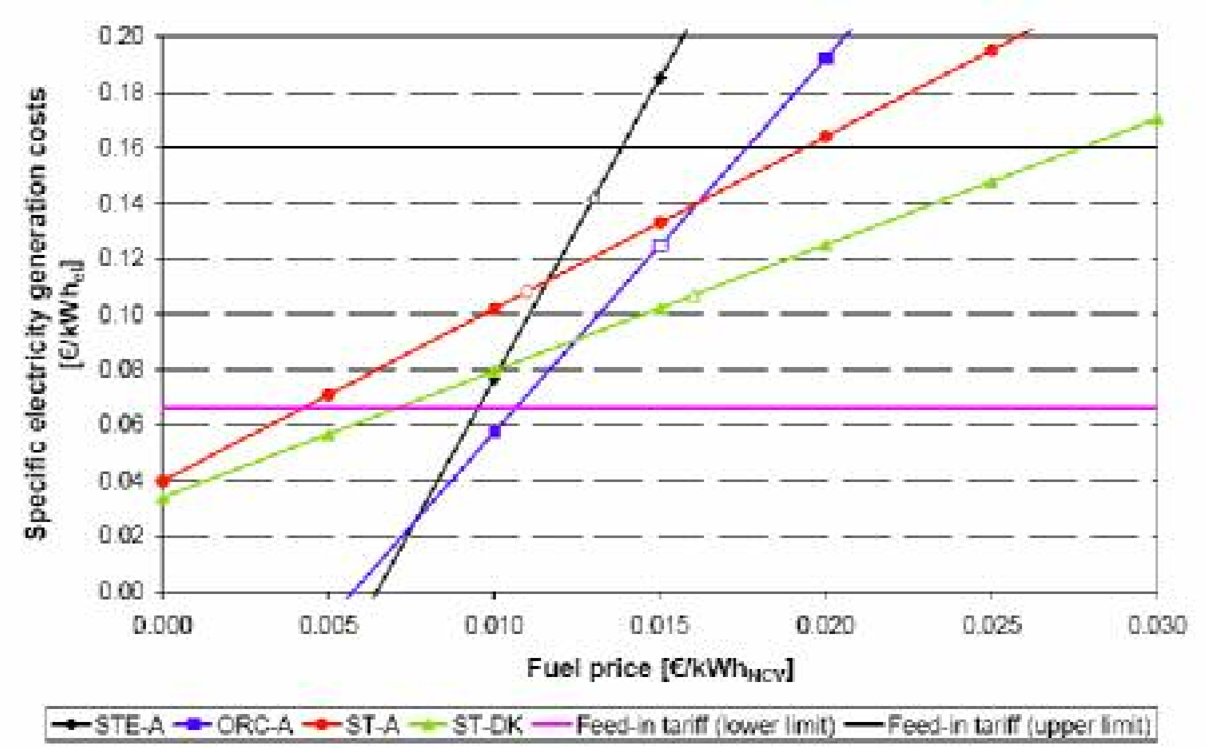
Several decentralised CHP plants based on biomass combustion are already in operation in the participating countries, most of them in Finland and Austria. The technology most commonly applied is steam turbines, with nominal electric capacities of up to 700 MW_e.

The steam turbine process is a well proven state-of-the-art technology in this field of application. ORC processes have successfully been demonstrated within two EU demonstration projects (Admont and Lienz in Austria) and have recently achieved market introduction in a capacity range between 400 and 1,500 kW_e. The worldwide first two demonstration projects for Stirling engines in biomass CHP plants are already ongoing in Austria with 4 and 8 cylinder Stirling engines (35 and 75 kW_e, respectively). A small series production of Stirling engines is planned to be launched in the years 2004/2005. Further CHP technologies based on biomass combustion are steam piston engines and steam screw-type engines. Due to several technical problems, the steam piston engine has been thrown back in his development. A biomass CHP plant based on a steam screw-type engine cycle with a nominal electric capacity of 800 kW_e has recently (November 2003) been put in operation in Hartberg in Austria in the framework of an EU demonstration project and show a promising performance.

The second report describes the techno-financial aspects of steam turbine processes (two plant configurations), ORC systems and Stirling engine based CHP systems. The following technical data is provided for all system types:

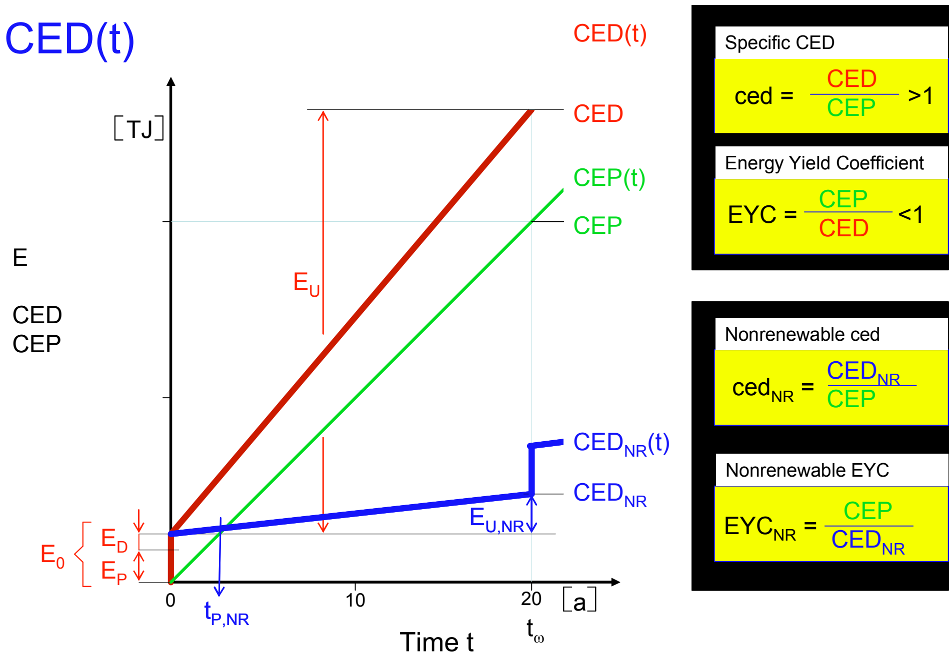
- Basic process description
- Interface between the CHP technology and the combustion plant
- Operating behaviour and efficiencies
- Control system and personnel demand
- Maintenance demand
- Special (technology related) operation costs
- Ecological aspects
- State of development
- Weak points
- Fuel characterisation and handling

Further, the second report provides detailed basic financial data (investment costs, O&M costs etc.) and evaluates financial performance of the different concepts under varying market conditions and frameworks. This may help potential investors to evaluate the financial performance of a certain CHP system under given market conditions or governments to design appropriate legislative and financial frameworks that stimulate market introduction of biomass combustion based CHP systems.



4. Energetic Assessment of Energy Systems with Biomass Combustion

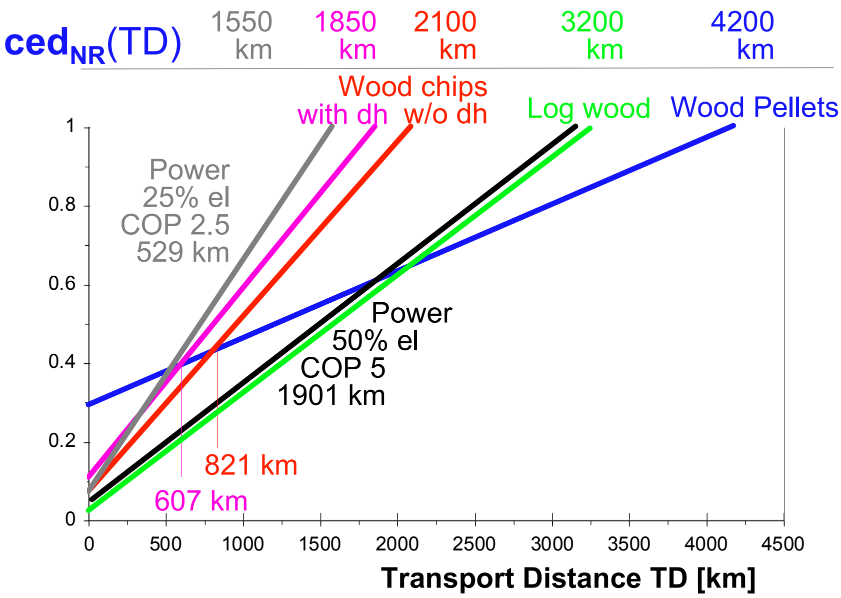
A report titled 'Evaluation of Biomass Combustion based Energy Systems by Cumulative Energy Demand and Energy Yield Coefficient' was prepared by Verenum, Switzerland. This report is also available at the Task 32 internet site. The study presents a method for a comparison of different energy systems with respect to the overall energy yield during the life cycle. For this purpose, the Cumulative Energy Demand (CED) based on primary energy and the Energy Yield Factor (EYC) are introduced and determined for different biomass fuels and combustion systems (both heat and CHP).



To enable a reasonable interpretation of the results, the energy demand related to the fuel consumption during plant operation is considered, which is often not the case for figures presented on non-renewable fuels in literature. The calculations are performed once with respect to all fuels used during operation (denoted as CED and EYC), and once with respect to non-renewable fuels only, hence without counting the energy content of the biomass (denoted as CED_{NR} and EYC_{NR}). The evaluation and comparison of both, EYC and EYC_NR, enables a ranking of energy systems without a subjective weighing of non-renewable and renewable fuels.

For a sustainable energy supply, it is proposed to implement renewable energy systems in the future which achieve an energy yield described as EYC_{NR} of at safely greater than 2 but favourably greater than 5. A parameter variation is performed for the plant efficiency, the transport distance, the fuel type for drying used for pellet production, and the heat distribution in case of district heat. A visualisation of the sensitivity of these parameters reveals a relevant influence on the ranking of the different scenarios and hence confirms the importance of these characteristics which are identified as key parameters.

For the reference scenarios and for an identical annual plant efficiency of 80%, an energy yield for non-renewable fuels of EYC_{NR} = 13.8 is achieved for log wood, of 13.0 for wood chips, of 9.0 for wood chips with district heating, of 8.3 for eco-pellets produced from saw dust with biomass used for drying, and of approximately 3.3 for wood pellets dried with fossil fuels. If the electricity from power production from biomass is used to drive local heat pumps for heating, similar or even higher energy yields are achievable than for direct heating with wood chips.



Road transport with driving distance = 2 TD

These results show, that all investigated scenarios based on biomass combustion are reasonable with respect to the overall energy yield. In comparison to heating with fossil fuels, biomass combustion enables CO_2 savings by approximately a factor of 10 for wood chips, eco-pellets and log wood, and by a factor of 4 to 5 for wood pellets, if fossil fuels are used for drying. It also shows that transportation of wood chips by truck still makes sense from an energy point of view up to transporting distances of at least 1500 km (depending on the type of woodfuel and combustion system).

The methodology developed and the scenarios described in this publication can be used as a basis for decisions to choose the most efficient energy systems based on biomass combustion in the future. The method can also be applied to other technologies for biomass utilisation and to other energy sources.

5. Determination of Efficiency for Automatic Biomass Combustion Plants and Comparison of Efficiency and Emissions for Different Operation Modes.

This study was initiated in 2003, and is continuing in the triennium 2004-2006. This study was started to evaluate different methods used in practise for the determination of efficiencies of automatic biomass combustion plants, using both theoretical and experimental investigations. This is particularly important for operators of relatively small automatic (woodfuel) combustion plants who have to pay fuel suppliers on the basis of the energy content of the fuel. In this case the costs of measuring efficiency can be significant in comparison to the price of the fuel. The following three types of efficiency are in use:

Combustion efficiency
The combustion efficiency can easily be determined with a fast and reliable measurement of the flue gas composition. Additional information about the fuel is needed, while no further information about the plant is necessary. Hence the combustion efficiency is often used for an instantaneous comparison of different furnaces and/or operation modes, since the influence of varying excess air or flue gas temperature can immediately be evaluated.

Boiler efficiency
The boiler efficiency is of interest for the plant operator, as it considers also losses of the boiler by radiation and by unburnt fuel in the ash. Although it is determined as instantaneous value, it must be considered that the boiler has a significant heat and fuel storage capacity. Hence a reliable information about the boiler efficiency can only be found during stationary conditions or as integrated value over a certain operation period.

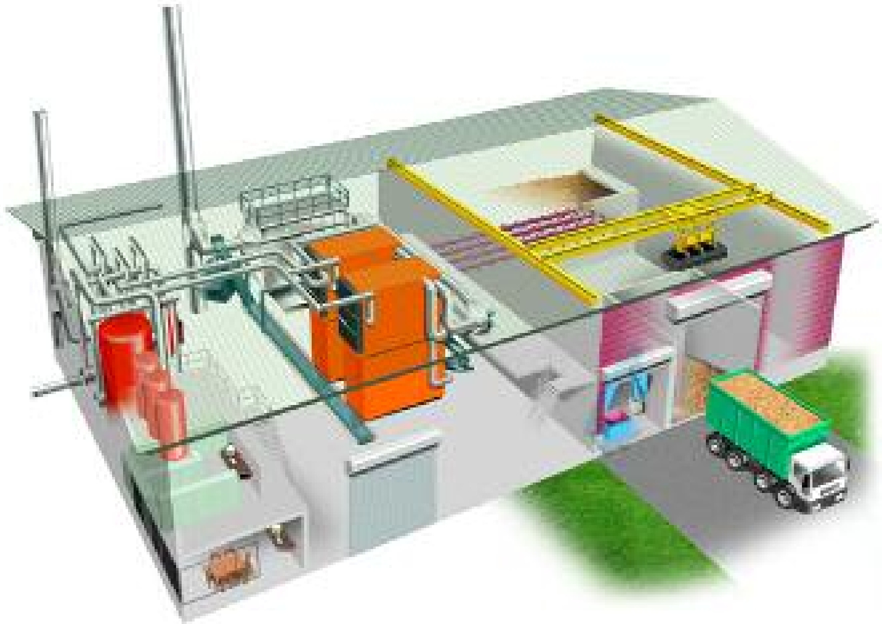
Annual plant efficiency
If the useful heat and the used fuel are determined during a whole heating season, the annual plant efficiency can be determined. In this case, additional losses from the system integration and during standby-mode of the boiler are also considered. The annual plant efficiency is of interest for the operator for economic reasons. However, it is not suited for a comparison of different furnaces, as the system integration has a major impact on the plant efficiency.

Since the efficiencies can be determined by different methods and since the three different types of efficiencies cannot be compared directly, an evaluation of the expected uncertainties is of interest. Furthermore, automatic biomass combustion plants are operated in different modes. The operation in part load influences the annual efficiency as well as the boiler emissions.

In this project, theoretical investigations of the appropriateness of using the different efficiencies have already been performed. For an assessment of the experimental determination of the three efficiencies, systematic measurements are being carried out in three automatic biomass combustion plants:

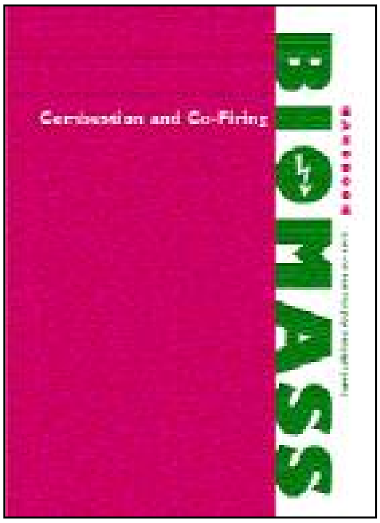
- a test bench in Belgium, which allows an independent operation for the measurements.
- two plants in practical operation in Switzerland.

This project is expected to provide hands-on tips for operators how to assess plant efficiency in a reliable and cost effective manner.



6. Handbook of biomass combustion and cofiring

The handbook on Biomass Combustion and Cofiring, prepared by Task 32 has been printed June 2002 in an edition of 600 copies. The first edition was sold out quickly and many positive reactions have been received from professional readers. It was therefore decided to produce a reprint of the first edition as a low-cost paperback edition (25€ only). This reprint has become available in 2003.



The handbook is mainly used by professionals such as equipment manufacturers, consultants and universities. 100 copies have been ordered by the Sustainable Energy Ireland Renewable Energy Information Office for distribution in Ireland. Further, the handbook will be used as course material by the University of Florence for two modules of the Master Course "Bioenergy and Environment" that will start in 2004.

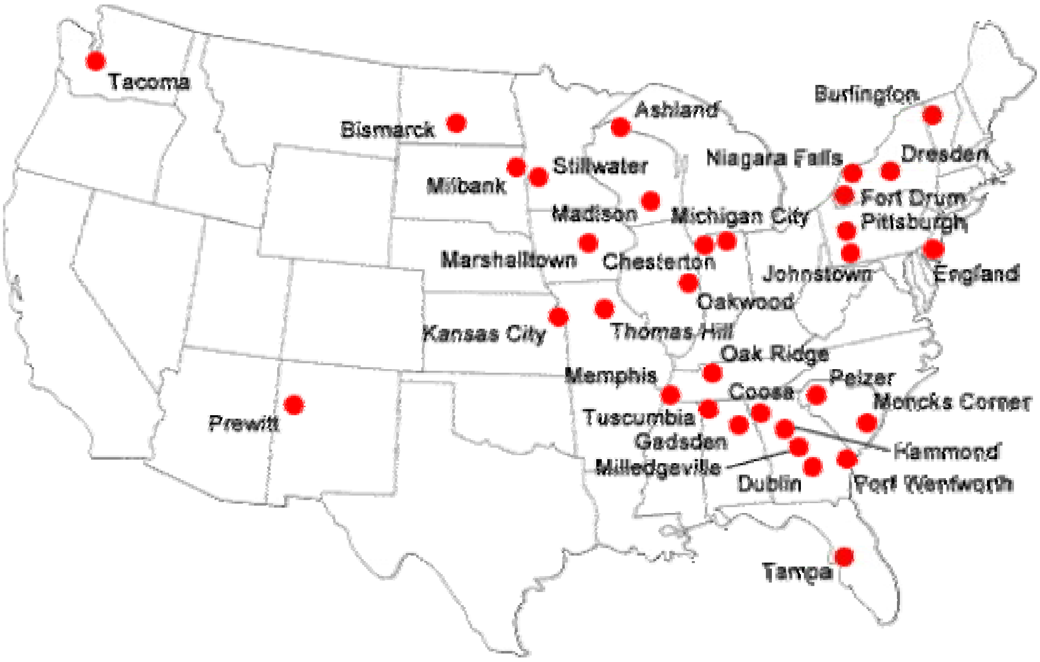
Because of the great success of this handbook it has been decided to evaluate if a second edition should be developed, and if so, what changes should be made in the contents. For this purpose, a critical review has been performed by two external experts.

7. Global overview of cofiring initiatives

After the preparation of an overview on biomass combustion based CHP installations was initiated, it was decided that the preparation of an overview of experiences with cofiring biomass in pulverised coal fired power plants could also significantly contribute to information exchange. This project was started 2003 by TNO. As of December 2003, approximately 150 coal fired power plants have been identified with experience with cofiring biomass. A database containing the below information has been prepared:

- Country and location of the plant
- Plant name and owner
- Type of cofiring (direct/indirect/parallel)
- Boiler type (pulverised coal/CFB/BFB/grate /….)
- If PF: burner arrangements (tangential/stoker)
- Output (MWth and MWe)
- Primary coal type
- Cofired fuel(s)
- Max cofiring% on heat or mass basis
- Duration of test or commercial operation
- Fuel preparation
- Technology supplier
- Contact information

The project will be continued in the new triennium, as a rapidly increasing number of power plants are performing trials and continue to commercial operation. For this purpose a web-based user interface of the database has been developed and will be put online in 2004.



8. Joint seminar with task 33 and EUBIONET on biomass cofiring

With inputs from Task 33 (biomass gasification) and the European Bioenergy Networks (EUBIONET), Task 32 organised a conference seminar on biomass cofiring at the 1st World Conference and Exhibition on Biomass for Energy and Industry in Amsterdam, 2001. This successful meeting was attended by around 75 participants. A report with a summary on the workshop and the contents of all presentations can be downloaded from the Task 32 internet site www.ieabcc.nl .

9. Seminar on 'Operating Experience and Techno-economic Benefits and Environmental Benefits of Energy Recovery from Renewable Waste Materials

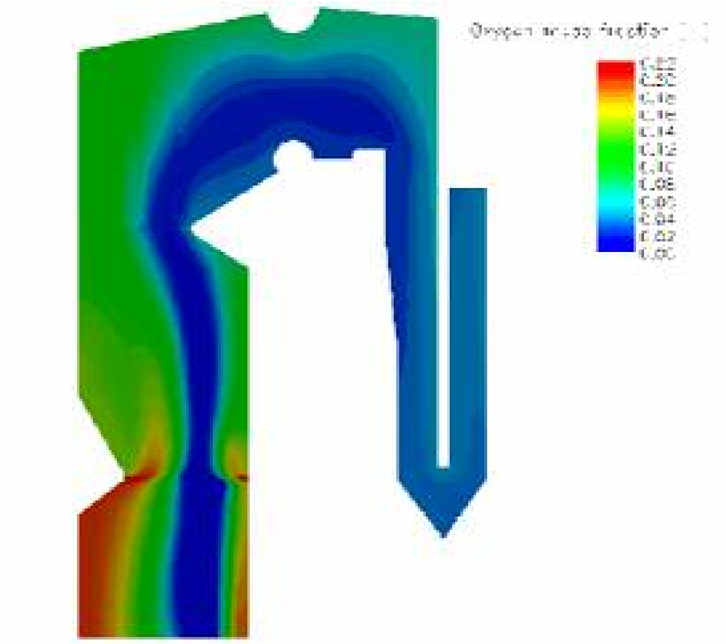
On Oct 28, 2003, a joint seminar was held with Task 33 (Biomass Gasification) and Task 36 (Energy recovery from MSW) on the topic of 'Operating Experience and Techno-economic Benefits and Environmental Benefits of Energy Recovery from Renewable Waste Materials'. This meeting was organised by the three tasks, the Japanese NEDO made practical arrangements for the meeting. There were 12 presentations covering different aspects of thermochemical conversion of biomass and waste. This varied from economic aspects of various plant configurations under different national conditions to prediction and mitigation of corrosion and ash deposition problems.

Participation in the meeting was open for all interested. The meeting was attended by The meeting was jointly chaired by the three individual Task leaders Niranjan Patal (task 36), Suresh Babu (Task 33) and Jaap Koppejan (Task 32).

The meeting was considered very successful by the approximately 30 participants. The overheads presented can be downloaded from the Task 32 internet site at www.ieabcc.nl .

10. Formation of Striated Flows During Biomass-coal Cofiring

Ash deposition, corrosion, NOx formation and other fire-side issues often influence maximum cofiring percentages in commercial boilers. In other cases, fuel preparation, storage, and handling limit the amount of cofiring. Such maximum cofiring percentages are almost always based on total coal vs. biomass feed rates. Many issues of substantial importance to short- and long-term viability of cofiring depend strongly on the amounts of coal and biomass in the boiler. However, biomass cofired at more than trivial amounts is most commonly fired through dedicated burners, in which case the cofiring percentage in that burner is 100%. Many (probably most) boilers poorly mix the flows, to the extent that individual burner performance is often inferred from grid-based oxygen measurements near the precipitators of boilers. In such boilers, the effective percentage of biomass at one region in the convection pass is often much higher than is suggested by the overall feed rate. Such boilers have the potential to experience failures from tube bank plugging, tube corrosion, etc. that might seen avoidable based on overall cofiring percentages.



Striated flows exist when local concentrations of biomass or coal and its combustion products are much higher or lower than the overall average concentration of the fuel and have the effect of producing conditions in a boiler that represent cofiring percentages in the combustor that differ markedly from the cofiring percentage inferred from total overall feed rates.

The objective of this project, which runs over the period 2003 – 2004, is to quantify the risks of such behaviour using the best available predictive technologies. For this purpose, state-of-the-art CFD models are being used, specifically adapted to biomass-coal cofiring conditions to predict the extent to which cofiring biomass with coal leads to the formation of striated flows in the convection passes or elsewhere in commercial boilers.

Within this project, simulations of two principal pc boiler designs, tangential firing and wall firing, are performed using existing CFD capabilities for describing such flows at Brigham Young University. Each simulation assumes an overall biomass contribution of 10-20% based on energy input (gross calorific values). The specific cofiring percentage is determined by the total number and the number of biomass-based burners. The boiler is assumed to be in overall balance (stoichiometric ratio of each burner identical). Biomass is assumed to be fed from dedicated burners located in the middle of the burner levels of the boiler, as is typical in commercial cofiring. The extent of mixing of biomass particles and their combustion products is predicted as a function of position in the boiler, with local calculations of the mixing extent.

The project will be finalised in 2004 and is expected to deliver a better understanding in to how striated flows originate, what influence they have on local ash deposition and corrosion mechanisms and how they can be avoided.

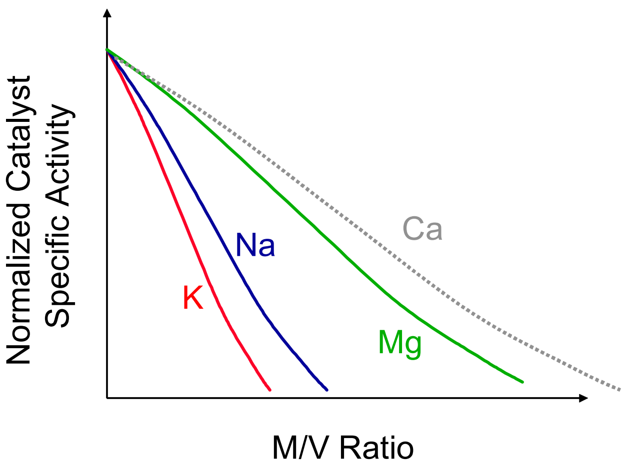
11. Biomass Impacts on SCR Catalyst Performance

SCR control systems for NOx control are being installed in most OECD countries. This technology represents the only commercially demonstrated option for NOx reductions beyond 70%, which are required by many new or pending environmental standards. However, biomass fuels appear to affect SCR catalysts deleteriously. Specifically, catalyst activation rapidly decreases when biomass flue gases pass through catalysts. Anecdotal evidence indicates this effect is more severe when biomass is fired under high-intensity conditions.

This project has been initiated to develop data from a variety of combustion systems on the impact of biomass and biomass cofiring on SCR catalyst performance. This work in this project is divided into two parts:

Part 1 Examination of exposed catalyst samples

This task will result in detailed comparisons of surface properties (composition, porosity, surface area, activity, etc.) for catalysts before and after exposure to combustion gases in commercial systems. Samples of initial and exposed catalyst materials from biomass or biomass cofired systems will be examined in BYU's catalysis characterization laboratory. A characterization of catalyst surface properties (composition, porosity, surface area, activity, etc.) before and after exposure to biomass-laden fuels in either dedicated or cofired facilities is conducted by BYU, using samples of real cofiring trials. Proprietary information concerning the deterioration of performance of commercially available catalysts will not be published, however when publishing the scientifically interesting and important information regarding deactivation, non-identifyable codes will be used. This work is be done in collaboration with an existing project on a similar subject but limited to US experiences and focused on slip stream measurements in which BYU is involved.



Part 2 Critical Technical Review

A review document will be produced, critically analyzing the impact of biomass on SCR catalyst behavior. A critical technical review of the impact of biomass on SCR performance on based on commercial and laboratory experiences from the member countries will be compiled in a single document.

Cooperation with Other Tasks

In the period 2001-2003, Task 32 has cooperated on several occasions with other IEA Bioenergy tasks (particularly Task 33 and Task 36) and networks outside IEA, e.g. EUBIONET, the EPRI Biomass Interest Group and the Advanced Combustion Engineering Research Center at Brigham Young University. This was mainly in the organisation of workshops and seminars, a list of events is given above.

Deliverables

The deliverables to date for Task 32 during the triennium 2001-2003 include:

- Organisation and minuting of task meetings.
- Audited financial accounts, reports for ExCo meetings and annual progress reports
- Preparation and distribution of the first and second print of the Handbook on Biomass Combustion and Cofiring
- Organisation of a seminar on aerosols from biomass combustion
- Distribution of a policy statement on the relevance of aerosols from biomass combustion
- A joint workshop with task 33 and 36 on 'Operating Experience and Techno-economic Benefits and Environmental Benefits of Energy Recovery from Renewable Waste Materials'.
- A joint workshop with EPRI/Biomass Interest Group on advances in biomass combustion and cofiring
- A joint workshop with the Advanced Combustion Engineering Research Center (ACERC) at Brigham Young University, USA
- A conference workshop with IEA Task 33 and EUBIONET on cofiring at the 1st World Biomass Conference in Amsterdam
- Preparation of an international overview of initiatives for biomass combustion based CHP plants
- A report on Energetic Assessment of Energy Systems with Biomass Combustion
- Continuation and expansion of task internet site with biomass fuel and ash database

In the next triennium, the below deliverables will be produced as a result of task supported projects initiated in the triennium 2001-2003:

- International overview of initiatives for biomass cofiring (by Netherlands)
- Determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operation modes (by Switzerland)
- Formation of Striated Flows During Biomass-coal Cofiring (by USA)
- Biomass Impacts on SCR Catalyst Performance (by USA)

TASK 32 MEMBERS DURING THE TRIENNIUM 2001-2003

EUROPEAN COMMISSION

Ms. Garbine Guiu
European Commission
DG for Science Research and Development
Rue de la Loi, 200
B-1049 BRUSSELS
Belgium
tel +32 2 2990538
fax +32 2 2993694
Garbine.GUIU@cec.eu.int

AUSTRALIA

Peter Coombes
Business Development Analyst
Delta Electricity
Level 12, Darling Park
201 Sussex Street
Sydney 2000
Australia
tel: +61 2 9285 2789
fax: +61 2 9285 2780
Peter.Coombes@de.com.au

Peter Costelloe
Technical Services Manager
C.S. Energy
Swanbank Power Station
MS 460
Qld 4306 Ipswich
Australia
tel +61 7 3810 8802
fax +61 7 3810 8777
pcostell@csenergy.com.au

Bob Saunders
Project Manager - Business Development
Stanwell Corporation Limited
Rockhampton Office - Suite 3
74-78 Victoria Parade
PO Box 6510
Qld 4702 Central Queensland Mail Centre
Australia
tel +61 7 4931 3017
fax +61 7 4931 3050
bob.saunders@stanwell.com

AUSTRIA

Ingwald Obernberger
Institute of Chemical Engineering
Fundamentals and Plant Engineering
Technical University of Graz
Inffeldgasse 25
A - 8010 GRAZ
Austria
tel +43 316 481300
fax +43 316 4813004
obernberger@glvt.tu-graz.ac.at

BELGIUM

Yves Schenkel
Département de Génie Rural
Centre de Recherche Agronomiques
Chaussée de Namur, 146
B 5030 Gembloux
tel. +32 81 61 2501
fax +32 81 61 5847
schenkel@cragx.fgov.be

Jerome Delcarte
Département de Génie Rural
Centre de Recherche Agronomiques
Chaussée de Namur, 146
B 5030 Gembloux
tel. +32 81 61 2501
fax +32 81 61 5847
delcarte@cragx.fgov.be

CANADA

Richard Logie
Department of Natural Resources
Renewable Energy Technology Group
Energy Technology Branch
580 Booth Street 7th floor
Ottawa, Ontario K1A OE4
Canada
tel. +1 613 9950283
Fax +1 613 9969416
email rlogie@nrcan.gc.ca

DENMARK

Henrik Houmann Jakobsen
dk-TEKNIK
Gladsaxe Mollevej 15
DK-2860 SOBORG
Denmark
tel +45 39 555999
fax +45 39 696002
hhouman@dk-teknik.dk

Anders Evald
FORCE Technology
Gladsaxe Mollevej 15
DK-2860 SOBORG
Denmark
tel +45 39 555999
fax +45 39 696002
aev@force.dk
www.force.dk

Jesper Werling
FORCE Technology
Gladsaxe Mollevej 15
DK-2860 SOBORG
Denmark
tel +45 39 555999
fax +45 39 696002
jwe@force.dk
www.force.dk

FINLAND

Heikki Oravainen
senior research scientist
VTT Energy, Fuels and Combustion
P.O. Box 1603
FIN-40101 Jyväskylä
Finland
tel +358 14 672532
fax +358 14 672596
Heikki.Oravainen@vtt.fi

Jouni Hämäläinen
Group Manager, Fluidized Bed Comb.
VTT-Processes
PO Box 1603
FIN-40101 JYVÄSKYLÄ
tel +358 14 672529
fax +358 14 672749
jouni.hamalainen@vtt.fi

Janne Kärki
Research Scientist, M.Sc. (Tech.)
VTT-Processes
PO Box 1603
FIN-40101 JYVÄSKYLÄ
tel +358 14 67 2676
fax +358 14 672 597
Janne.Karki@vtt.fi

NETHERLANDS

Sjaak van Loo (Task leader)
TNO-MEP
P.O. Box 342
7300 AH APELDOORN
Netherlands
tel +31 55 5493745
fax +31 55 5493740
S.vanLoo@mep.tno.nl

Kees Kwant (Operating Agent)
NOVEM
P.O. Box 8242
3503 RE UTRECHT
Netherlands
tel +31 30 2393458
fax +31 30 2316491
k.kwant@novem.nl

NEW ZEALAND
John Gifford
Forest Research Institute
Private Bag 3020
ROTORUA
New Zealand
tel +64-7-343-5899
fax +64-7-343-5507
john.gifford@forestresearch.co.nz

NORWAY

Øyvind Skreiberg, Ph.D.
Research Scientist
Department of Energy and Process Engineering
Faculty of Engineering Science and Technology
NTNU, N-7491 Trondheim
Norway
tel +47 73 592970
fax +47 73 598390
Oyvind.Skreiberg@tev.ntnu.no

Lars Sørum
SINTEF Energiforskning AS
Dept. of Thermal Energy
Kolbjorn Hejesvei 1A
NO-7465 TRONDHEIM
Norway
tel +47 73 59 29 65
fax +47 73 59 28 89
lars.sorum@energy.sintef.no

SWEDEN

Claes Tullin
Swedish National Testing and Research Institute
Box 857
S-501 15 BORAS
Sweden
tel +46 33 16 5555
fax +46 33 131979
claes.tullin@sp.se

SWITZERLAND

Thomas Nussbaumer (Task member)
VERENUM
Langmauerstrasse 109
CH-8006 ZÜRICH
Switzerland
tel +41 1 3641412
fax +41 1 3641421
thomas.nussbaumer@verenum.ch
www.verenum.ch

UK

William R. Livingston
Group leader - fuel technology
Mitsui Babcock Energy Limited
Technology Centre
High Street
Renfrew PA4 8UW
Scotland, UK
tel +44 141 8862201
fax +44 141 8853370
wlivingsto@mitsuibabcock.com

USA

Larry Baxter
Brigham Young University
Professor, Chemical Engineering
JJ Christensen Professorship of Thermochemical Science
350 Clyde Building
Provo, UT 84602
tel: +1 (801) 422-8616
fax: +1 (801) 422-7799
email: larry_baxter@byu.edu