International Energy Agency
Bioenergy Agreement
Task 32, Triennium 2004 - 2006
Biomass Combustion and Cofiring

Working Group Meeting
Arranged by:

Bill Livingston, Doosan Babcock, UK
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Content:

Minutes of the 6th Task Meeting, triennium 2004 - 2006
Working Group Meeting-Biomass Combustion and Cofiring

19-21 September, 2006
Glasgow, UK

IEA Working Group Meeting Task 32
Biomass Combustion and Cofiring
19-21 September, 2006, Glasgow, UK

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09:15	Report of last meeting
09:20	Revision of handbook (2nd edition)
	Presentation of final drafts by chapter coordinators
10:30	*Refreshment Break*
10:00	Revision of handbook (2nd edition)
	Presentation of final drafts by chapter coordinators
11:30	Short country reports (facultative)
13:15	*Lunch break*
14:00	Results of BIO-CHP project by Anders Evald
14:15	Work plan for next triennium
15:00	Proposals for Task supported projects
15:30	*Refreshment Break*
16:00	Determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operation modes (Task project)
16:15	Planning of workshops, synergy with other networks
17:30	Next meetings
17:00	Closing
20:00	*Task 32 dinner in Glasgow*

Wednesday, 20 September 2006: Field trip

From	Topic
8:30	Depart from Jury's Inn, Glasgow
8:35	Pick up people from Marriott
9:30	Arrival in Longannet, visit to large pulverised coal fired power plant, cofiring sewage sludge and wood biomass
12:00	*Lunch near Longannet*
13:30	Continue to Mitsui Babcock Technology and Engineering, Renfrew
14:30	Arrival in Renfrew, visit to MB facilities
16:30	Return to Glasgow
17:00	Arrival in Glasgow, back to hotels

Thursday, 21 September 2006: Workshop on biomass ash issues

Location: ThermalNet conference, Marriot Hotel, Glasgow

Chairpersons: Bill Livingston and Sjaak van Loo

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9:20	Overview of biomass ash characteristics, Bill Livingston, Doosan Babcock, UK
9:50	Ash related problems when cofiring biomass with coal in PF burners, Rob Korbee, ECN, Netherlands
10:10	Test rig and ash deposit characterisation for biomass cofiring Fraser Wigley, Imperial College, UK
10:45	Coffee break
11:00	Biomass ash deposition and corrosion processes Bill Livingston, Mitsui Babcock, UK
11:20	Ash related problems in wood fired boilers and effect of additives Håkan Kassman, Vattenfall Power Consultant AB, Sweden
11:40	Experience with ash deposition in poultry litter boilers David Bowie, Mitsui Babcock, UK
12:00	Experiences with wood/sludge cofiring in Sweden Claes Tullin, SP, Sweden
12:20	Discussion and conclusions, Bill Livingston, Doosan Babcock, UK
12:30	Closing

Attendance list

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Task 32 meeting, Tuesday 19 September, 2006

Opening

Sjaak van Loo opened the sixth and final meeting of IEA Bioenergy Task 32 in the triennium 2004-2006 and welcomed everyone participating in meeting, which was held in the Jury's Inn hotel in Glasgow. No delegates from Belgium, Germany and Norway were present at the meeting. For this meeting, Thomas Brunner represented Austria instead of Ingwald Obernberger. For Australia, Brett Corderoy was represented by Peter Cameron. The overhead sheets used by Sjaak van Loo to present several issues on the agenda of this task meeting are included as Annex 1.

In addition to a one-day task meeting on Tuesday 19 sept where progress was discussed, a field trip was organised on Wednesday 20 Sept to a pulverised coal fired power plant cofiring wood pellets and sewage sludge as well as the R&D facilities of Mitsui Babcock in Renfrew, Glasgow. A workshop was organised together with the European ThermalNet project on Thursday 21 Sept on the topic of ash related issues in biomass combustion. Local logistical arrangements in Glasgow were made by Bill Livingston.

News from IEA Bioenergy ExCo

On request of the IEA Bioenergy Executive Committee, input was provided to a paper by Andre Faaij (Task 4) on the global potential for bioenergy. This work is funded with part of the '10% of the task budget' earlier agreed for ExCo support. It is the intention to finalise the paper after the task meeting, before the end of 2006.

A technical coordinator is currently being identified to run day-to-day affairs to implement and enforce the decisions taken by the ExCo and smoothen communication between Tasks and ExCo

Earlier Sjaak van Loo presented a proposal for prolongation of Task32 at ExCo57. Here, a number of individual countries expressed their interest in continuing their participation in the next triennium and gave comments. At ExCo58, a final decision for participation will be taken.

Report of last meeting

The precirculated minutes of the previous Task meeting, held May 2006 in Jönköping, Sweden, were approved after including a few changes in contact details. The report will be finalised and distributed.

Revision of handbook (2nd edition)

Chinese translation

After agreement with Sebnem Madrali (Canada), the final draft of the Chinese translation of the first edition of the Task 32 produced Handbook of Biomass Combustion and Cofiring is currently being read by Chinese employees working at NRCAN. After this process the book will be printed in China.

Second edition
The second edition of the Handbook of Biomass Combustion and Cofiring is currently under preparation. Based on an external peer review carried out in 2003, a revised Table of Contents and the division of work was agreed upon in 2004. In 2005 the actual work on rewriting individual chapters has started. While a number of chapters have been submitted already, a few chapters are still missing. During the Task meeting, the progress in revision of the handbook was presented by the coordinators of the respective chapters. The current status per chapter is described below.

Chapter 1 (Introduction)
This introductory chapter will be written based on the contents of the other chapters. As the other chapters have not yet been submitted, this work has not yet started.

Chapter 2 (Basic Combustion Theory)
This chapter has been thoroughly edited under coordination of Norway, with key inputs from Austria. A discussion on converting emission units, held at the previous task meeting, has culminated in some modifications in a draft submitted earlier. The current version is considered as final.

Chapter 3 (Biofuel production and supply)
This chapter is almost ready. Fernando Preto promised to deliver information earlier promised on cubing technology for inclusion in the chapter. Information on system perspectives is also still lacking but will be delivered shortly by Chalmers University from Sweden.

Chapter 4 (Domestic wood burning applications)
A first draft, prepared by Canada was revised using input from Sweden. Canada intends to redraw a number of graphs after which the manuscript should be ready.

Chapter 5 (Industrial combustion)
Chapter 5 was already finalised before the previous meeting.

Chapter 6 (Power generation and cogeneration)
Comments provided by Austria shortly after the previous meeting were included by Thomas Nussbaumer. It was noted that a number of suggested modifications with regard to the definition of efficiencies should be processed.

Chapter 7 (Co-combustion)
There has been a significant delay in the preparation of this chapter, which is coordinated by CCSD of Australia, with inputs from USA and UK. Shortly before the meeting a first draft was distributed. It was mentioned by Bill Livingston that the plant examples included are outdated and new examples should be included.

Chapter 8 (Corrosion and ash deposition)
A first draft for this new chapter related to ash deposition and corrosion was submitted by UK shortly before the meeting. Ingwald Obernberger has several comments to this draft and will discuss this bilaterally with Bill Livingston. A key concern is that the contents of chapters 8 and 2 are well adjusted.

Chapter 9 (Environmental aspects)
Anders Evald (Denmark) is responsible for the editing of the existing chapter on environmental aspects. New environmental data (emission limits) from individual countries is needed. A first draft will be available by October 2006.

Chapter 10 (Policy aspects)
A first draft for this new chapter is under preparation by Netherlands and will contain different (support) policies related to biomass combustion in the member countries of IEA Bioenergy Task 32.

Chapter 11 (R&D Needs)
This draft is available, key inputs from the IEA Bioenergy ExCo book on R&D needs was taken into account.

It was concluded that our aim to have all chapters available in a final form at this meeting was not achieved and finalisation of the chapters should be postponed by another month to October 2006, so that TNO can finalise the editing by the end of 2006. The aim is to have the book available in print at the Bioenergy Conference in Berlin. It will be discussed with the publisher if this is possible with the revised timeframe for preparation of the individual chapters, editing of the manuscript, layout and printing as indicated below:

- Finalisation of revised chapters by authors (Oct 31, 2006)
- Editing of the revised handbook to a revised draft (Nov 30, 2006)
- Finalisation and submission to publisher, based on comments received (Dec 31, 2006)
- Layout and printing of the revised handbook (Jan 2007 – May 2007)
- Presentation of printed version (Task meeting, spring 2007)

Short country reports (facultative)

Austria:
In Austria a new feed-in tariff for electricity from biomass is expected by October 2006. In January 2008 the second mid-European Biomass Conference will be held in Graz. The first conference, held March 2005 was very successful.

Canada
Rob Lyng of Ontario Power Generation (OPG) presented a cofiring case study from Canada in one of OPG's coal fired power plants (see Annex 2). The Nanticoke Generating Station consists of 8 units of 500 MW_e each and provides around 75% of electricity needs in the province of Ontario. Driven by an expected government imposed carbon constraint for 2008-2012 and the opportunity to resolve a local disposal problem, OPG considered cofiring wheat shorts, wood pellets, grain screening pellets and dried corn distillers' grain. In March 2006 a proof of concept for burning wheat shorts was done, and in autumn 2006 additional short tests are planned. Spring 2007 OPG aims to perform an engineered test burn of approx 4% on energy input on two units to evaluate impacts on equipment, supply and handling of biomass, after which the biomass fuel handling system should be expanded and cofiring capability realised on a third unit. The tests have yielded a lot of insight in regulatory and economic issues, as well as detailed knowledge on the local availability of suitable biomass for cofiring. Also, the Ontario Govt has announced that they plan to close coal fired power plants, however there is not alternative option yet.

Denmark
Anders Evald provided information on recent developments in Denmark related to biomass combustion. Regretfully the current government policy is not very much in favour of supporting bioenergy, and there is little interest in industry to perform R&D on solid biomass combustion. Some R&D is done on conversion of lignocellulosic biomass to ethanol and production of other liquid biofuels.

Force Technology is involved in ultrasonic stimulation of combustion to improve combustion quality. Further, Force has a database with 400 samples of biomass fuels with background information. Anders Evald mentioned he could find out if it were possible to include this information in the existing Task 32 fuel database which is available on the T32 website.

Finally, a research programme is ongoing in Denmark to generate good quality information on the optimal selection of pre-treatment in combination with bioenergy systems.

Switzerland
Thomas Nussbaumer provided recent information from Switzerland related to PM emissions from biomass combustion. In Feb 2006, the immission levels for PM have been exceeded in Switzerland during 3-4 weeks. This is largely due to small scale biomass combustion devices, which emit about 1200 ton of PM per annum (about the same order of magnitude as diesel soot). User influence is much more important in reducing PM emissions from small scale biomass combustion devices than improving designs. Another measure currently examined in Switzerland is small scale ESP and fabric filters. A report is available on www.verenum.ch.

Sweden
Some highlights from Sweden were given by Claes Tullin:
- an R&D programme on small-scale heating by biomass (including solar heating) is in preparation by the Swedish Energy Agency.
- As for Switzerland, several studies are currently done on emissions from small scale biomass combustion
- Projects are done to assess the fire safety of wood fuel storages and how to safely design large storages in order to avoid self-ignition
- With increasing wood prices, agricultural residues are getting more attention as a potential source of energy. Due to the higher ash content and the composition of the ash, there is a potential risk for increased PM emissions.
- The recently announced ambition of Sweden for 2020 is to achieve developments in renewable energy and energy conservation to make it possible to be completely fossil-free. The currently high energy price of oil help to achieve this goal.

European Commission
Erich Nägele provided information on the 7th Framework Programme of the European Commission. Topics are currently prioritised and by November 2006, the work programme and call text can be expected. While the R&D budgets for energy are only slightly increased as compared to FP6, this will have been tripled from today's level by 2013.

Australia
The interest in cofiring is regretfully decreasing in Australia due to a lack of commercial justification. While the 2% Renewable Electricity target assures retailers of a price of 4-5 AUSct/kWh, the costs of generation are around 3 AUSct per kWh_e (in Queensland even

lower). For Delta Electricity for example, the amount of biomass cofired dropped from 28.5 kton in 2005 to 5 kton in 2006.

Bagasse based cogeneration in sugar industries remains about constant, however it is difficult to set up new projects in this sector due to the seasonality of the sector (6 m/y operation, no other biomass available). In addition, large quantities of wood residues are exported to Japanese paper industries.

UK

Bill Livingston provided an overview of biomass combustion related developments in UK. There is increased interest in wood fired boilers and stoves in the UK, particularly imported equipment such as pellet stoves.

On industrial scale there are three significant projects supported by the Renewables Obligation:

- E-On Lockerby, a 35 MW_e biomass power plant fired with forest residues and energy crops
- Welton Ten in Redcar, a 35 MW_e biomass power plant fired with wood waste
- Newport, a biomass power plant in the range of 20-30 MW_e.

All coal fired power plants are cofiring biomass today, with currently about 2.5-3 TWhe/y of installed capacity. The accumulative biomass based generation amounts to over 5.5 TWh_e.

The average plant load factor today amounts to approx. 40%, but this restriction is largely due to limitations in the Renewables Obligation in time and percentage. Industry can in principle generate much more than the current cap.

One reason to start cofiring was to develop fuel supply infrastructure. In practise however the quantities required are so much larger than what can be delivered from national sources, that most power plants obtain all of their biomass fro overseas.

A recent energy review recognises that cofiring should have a firm position in long term renewable energy policies, since coal will remain to be used for the long term. With approx 10,000 GBP/MW_e, the investment costs of biomass cofiring are up to 200 times lower than for dedicated biomass combustion (about 2,000,000 GBP/MWe for straw fired power plants).

A design study is currently performed for Ultra SuperCritical (USC) power plants with 45% generation efficiency, 25% biomass cofiring ability and capture storage.

The Netherlands

Jaap Koppejan shared some important news from the Netherlands. As the government very recently concluded that with the available projects, the 2010 target for 9% renewable electricity generation would be met, subsidy on the generation costs was suddenly stopped for new projects. This was a showstopper for several biomass combustion projects. It is anticipated that with the new government, another support policy will be introduced to replace the abandoned one.

Results of BIO-CHP project by Anders Evald

Anders Evald presented the key results of the European project "European Biomass CHP in Practice" (BIO-CHP). The BIO-CHP project was initiated to assess the actual efficiencies and availability of 67 different types of power plants using biomass and/or waste. The several technologies and a diverse range of biomass fuels. Data collection consists of a long range of operational parameters on a monthly basis, which is combined with basic key data, collected in the beginning of the project period. It is interesting to see that actual efficiencies and availabilities of power plants are usually significant lower than nominal efficiencies. More information can be downloaded from http://bio-chp.dk-teknik.dk .

Work plan for next triennium

The work plan for the next triennium, as presented at ExCo57 and presented by Sjaak van Loo at the previous meeting, was again discussed in detail after a brief introduction. Two proposals for specific task co-funded projects which were received, were discussed during the meeting in more detail:

- Thomas Nussbaumer presented the proposal for a Task co-funded project on aerosols from biomass combustion. As this can be considered as the number one problem for small scale combustion, there is a need for a thorough evaluation on the sources of origin and how it can be mitigated. With the proposed methodology we can only describe the impact of improved stoves on aerosol concentrations and immissions. It was agreed that everyone should indicate their interest in participation, after which the proposal will be made final.
- Thomas Brunner elaborated on the plans for a pellet handbook. It was emphasised that the project should be a cooperative project, with involvement of individual countries and possibly even other IEA Bioenergy Tasks. Denmark and Sweden already have collected national expertise in their own handbooks, which is beneficial. In other countries such as Canada, pellet production is also done in large quantities. It was concluded that it should be a cooperative project, and as the total budget is rather high, Sjaak will ask the ExCo if this project could be supported under the 10% ExCo funding.

Determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operation modes (Task project)

Thomas Nussbaumer presented the results of the task supported project on *"Determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operation modes"*. The presentation is attached as Annex 3. In this project, laboratory measurements were combined with measurements from a real installation to evaluate the accuracy of different measures to evaluate the efficiency of heating plants. The key result of the project is that the indirect method for evaluating efficiency is more accurate than the direct method. The report will be made available on the Task 32 website.

Planning of workshops, synergy with other networks

An overview of all task 32 (co)organised workshops in this triennium is shown below

Topic	Organizing country	Date
Co-firing	Netherlands	May 2004
Public perception	Canada	August 2004
Aerosols	Austria	March 2005
Modelling grate furnaces	Netherlands	September 2005
Small scale systems	Netherlands	October 2005
Fuel flexibility	Sweden	May 2006
Corrosion and deposit formation	UK	September 2006

Next meetings

The next meeting is also the first meeting of the next triennium, and will be held in combination with the 15th European Biomass Conference and Exhibition, Berlin, 7-11 May 2007. As stated in the work programme, effort will be made to organise a workshop on pre-treatment and system perspectives of biomass combustion as part of the conference.

It is yet unknown where the second meeting of the next triennium will be held. Suggestions are welcome.

Field trip

Longannet power station

A field trip was organised to the Longannet power station of Scottish Power (4 x 576 MW_e), see Annex 4 for an overview. This plant is the second largest power station in UK, commissioned in 1972. Each unit has 8 coal mills, of which 7 are typically used. Each mill is connected to four low-NOx burners. River water is used for cooling purposes, so there are no cooling towers.

Longannet was the first station to obtain ROCs for its cofiring activities. The plant cofires 50-55 kton/y of thermally dried sewage sludge (knowns as WDF) on two of its boilers. This is brought by closed tankers from western Glasgow, and locally stored in dedicated storage facilities. WDF is injected at the PF mill coal feeder bunker.

It has been concluded that the plant should operate under the Waste Incineration Directive, however the plant cannot comply with these limits. Therefore it will be allowed until a new, dedicated plant (approx 20 MW_e) will be put into operation.

As a second biomass fuel, wood pellets are used. A dedicated shed was built to handle the pellets and meter them on the coal conveyor belt. Pellets are premixed with the coal up to a level of 5% on mass basis.

Mitsui Babcock Technology and Engineering, Renfrew

A visit was paid to the Mitsui Babcock Technology and Engineering in Renfrew. This location avails of extensive research and development facilities where in-depth research can be performed on material sciences, plant design, as well as burner development and testing for the power sector.

Workshop on Ash Related Issues in Biomass Combustion

Opening and welcome - Sjaak van Loo, IEA Bioenergy Task 32

Sjaak van Loo welcomed all participants to this workshop, which was co-organised by ThermalNet and IEA Bioenergy Task 32. Most of the practical organisation was arranged by Bill Livingston of Mitsui Babcock.

Overview of biomass ash characteristics -Bill Livingston, Mitsui Babcock, UK

Bill Livingston provided an overview of the major ash related issues in biomass combustion. Within ThermalNet, WP2D particularly focuses on ash related issues in biomass combustion. A key deliverable is a report summarizing the issues, which is currently available in draft for comments.

In the ash one can distinguish inorganic components contained in the biomass, as well as extraneous inorganic material such as sand. Inside a boiler, ash is related to various issues such as the formation of fused or partly-fused agglomerates and slag deposits, accelerated metal wastage of furnace and boiler components due to gas-side corrosion under ash deposits, and due ash particle impact erosion or ash abrasion of boiler components and other equipment. Ash may also result in the formation and emission of sub-micron aerosols and fumes, and have various impacts on the performance of flue gas cleaning equipment. Finally, ash contained in biomass has consequences on the handling and the utilisation/disposal of ash residues from biomass combustion plants, and of the mixed ash residues from the co-firing of biomass in coal-fired boilers.

Ash related problems when cofiring biomass with coal in PF burners - Rob Korbee, ECN, Netherlands

Rob Korbee explained the major ash related issues in biomass cofiring. In the Netherlands there is already significant experience with cofiring several types of biomass with pulverised coal. Following the agreement between the Dutch government and the power sector, cofiring biomass should lead to avoidance of some 3.2 Mton CO_2 by 2012, which is equivalent to 475 MWe biomass capacity.

Power plants have plants to cofire up to 35% on mass basis; when applied in combination with ultra super critical (USC) boilers this poses great ash related challenges on boiler operation. When compared to coal ash, biomass ash typically contains more chlorine and alkalines but less sulphur, minerals and total ash.

An experimental study on ash formation and deposition from various types of biomass and coal was performed at ECN. Major inorganic elements are mineral and organic calcium as well as potassium in salt and mineral forms. Biomass ash components that evaporate to over 80% are Na, K, Cl, S, Zn, Pb; other inorganics such as Ca, Mg, Mn, P, Ti are released for 20-50%. The release of minerals from coal however is much less in absolute terms, and also largely determined by the mineral composition (predominantly S and Cl).

The deposition chemistry of devolitalised ash elements may pose significant challenges for reliable boiler operation. Fuel preparation, quality control and blending may be needed to avoid problems. Such measures can be applied in combination with smart cleaning of membrane walls and superheaters, using a water jet that is controlled by a heat flux sensor.

Test rig and ash deposit characterisation for biomass cofiring - Fraser Wigley, Imperial College, UK

Fraser Wigley presented an assessment of ash deposits, produced on temperature controlled coupons by combustion of Miscanthus, palm kernels and Russian coal and at various process conditions in a combustion test facility of RWE npower.

The tests showed that the deposits with Miscanthus were slightly thicker and stronger than the deposit from Russian coal. The deposits with palm kernel were smoother, and significantly denser and stronger. At higher temperatures, deposits from all three fuels became denser, stronger and CCSEM analysis confirmed a significant increase in degree of sintering with increased temperature. This is particularly true for palm kernel, which increases the rate of sintering significantly if cofired with coal.

It was interesting to see that bulk iron oxide concentration in deposits from all three fuels increased with increasing temperature, especially for the deposits with palm kernels. Both the concentration of iron oxide in the aluminosilicate deposit material and the proportion of more iron-rich material in the deposit increased. This was probably caused by the biomass component in the ash creating a 'stickier' deposit surface – retaining more impacting iron-rich particles, increasing the iron content of the deposit and causing a further reduction in deposit viscosity.

Biomass ash deposition and corrosion processes - Bill Livingston, Mitsui Babcock, UK

Bill Livingston explained the mechanisms of ash deposition and corrosion on heat transferring surfaces, ash melting in the fuel bed and the consequences for the design and operation of biomass combustors and boilers.

In general, biomass materials and their ashes tend to be less erosive and abrasive than more conventional solid fuels. However, slag formation may significantly increase in comparison to coal, leading to less heat transfer and increased flue gas temperatures downstream of the superheater in the convective section, which may then cause unexpected ash deposition there. Increased formation of hard deposits and subsequent shedding may in turn lead to damage to grates and boiler ash hoppers.

Severe boiler fouling may occur on the surfaces of superheater, reheater and evaporator banks at flue gas temperatures less than around 1000ºC. If formed at temperatures around 600-700°C, these deposits are relatively easy to remove, however for higher temperatures these deposits may be difficult to remove on-line or off-line. Fouling may also result in increased flue gas temperatures and boiler efficiency losses.

Corrosion of relatively hot heat exchanging tubes when cofiring biomass is often a result of high alkali metal and chloride contents of biomass. This can for example be mitigated by introducting sulphur. Higher chrome alloys are also more corrosion resistive.

Although there are online monitoring and cleaning (sootblowing) systems available commercially today, the key to avoidance of serious deposition and corrosion in biomass combustion plant is in the design phase. It can be very difficult to compensate for poor design after the plant is built. The designer of the combustion equipment and boiler plant must have the appropriate fuel assessment and design tools.

Ash related problems in wood fired boilers and effect of additives - Håkan Kassman, Vattenfall Power Consultant AB, Sweden

Håkan Kassman of Vattenfall Power Consultant AB presented the effect of additives on ash related problems in wood fired boilers. It is well known that K and Cl in biomass may cause KCl in deposits, leading to accelerated corrosion. Additives in the fuel or gas phase may either

1. reduce the release of gaseous KCl, e.g. by adding Al_2O_3 or SiO_2 K-alumino silicates are formed, and/or
2. react with KCl in the gas phase and form less corrosive components, e.g. by adding sulphur, potassium sulphates may be formed and Chloride removed as HCl.

In the strategy of Vattenfall, the concentrations of KCl, NaCl and SO_2 in the flue gas are monitored online using an In-situ Alkali Chloride Monitor (IACM). This information is used to inject a sulphur containing additive (ammonium sulphate, brand name ChlorOut ®) to obtain the latter effect. Ammonium may also lead to reduced NO_x emissions.

The effect of ChlorOut was successfully demonstrated at various biomass fired power plants, varying from grate, BFB and CFB. These demonstration showed that ChlorOut could effectively reduce deposit growth and Cl contents in deposits. At the same time, NOx could also be reduced using the ammonium in the additive.

Experience with ash deposition in poultry litter boilers - David Bowie, Mitsui Babcock, UK

David Bowie of Mitsui Babcock shared some results on the operating performance of a 40.6 MW_{th} chicken litter fired BFB installation and particularly the ash related impacts. Several severe operational problems were experienced in this installation, such as agglomeration of fuel ash in the bed, fouling of furnace walls, primary and secondary superheaters, the convective section and economiser. It appeared that the deposition of ash on superheaters led to higher superheater exit temperatures, and increased entrance temperatures to downstream convective and economiser sections. Since the ash deposits become more hard and difficult to remove using installed sootblowers at elevated temperatures, manual cleaning was frequently required, resulting in plant availability of 80%, vs. 90% as design availability.

Design changes have been proposed for the installation, including elimination of refractory slopes, extended support firing at start-up, on-load water washing of the furnace, large platen superheating surface and increased tube pitch.

Experiences with wood/sludge cofiring in Sweden - Claes Tullin, SP, Sweden

Claes Tullin explained the results of combustion trials where wood waste was cofired with sewage sludge. Sewage sludge contains relatively high concentrations of S, Al, Si, Fe, Ca and P, which may help in preventing the formation of alkali chlorides formed from relatively high concentrations of alkali metals in the wood.

While deposit formation increased when adding ZnO to wood fuel (as present in waste wood), adding sludge substantially reduced deposit growth and reduced corrosive alkali chloride concentrations in the deposit as potassium is sulphated. Adding sewage sludge also lead to reduced emission of aerosols (< 1 μm), this is explained by transportation of mainly KCl and K_2SO_4 in aerosols to larger particles.

Discussion and conclusions

In the discussion that followed, it was concluded that ash related issues such as deposition and chloride based corrosion are important for reliable operation of biomass fired boilers. Particularly when biomass is used in a boiler that is originally designed for another fuel, availability may be seriously hampered. The challenges increase with more challenging fuels and steam conditions.

It is therefore essential that proper fundamental understanding exists of the ash chemistry in a boiler, and that particularities of a fuel are taken into account seriously when designing or modifying a new boiler.

Future actions of Task 32

- Finalisation of chapters for revised handbook by authors (Until October 2006)
- Editing of the revised handbook to a revised draft (December 2006)
- Finalization and printing of the revised handbook (Next task meeting in Berlin, May 2007)
- The next meeting of Task 32 will be held in Berlin in the week of 7-11 May 2007, in combination with a field trip and workshop on system perspectives

Annex 1. Overhead sheets presented by Sjaak van Loo

Annex 2. Country presentation for Canada, Rob Lyng

Annex 3. Determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operation modes, Thomas Nussbaumer

Annex 4. Practical Large Scale Co-Firing Experience at ScottishPower, Scottish Power