SUPERGEN Bioenergy Hub

Report on the workshop for

# Gasification Technologies

# Delivering the Potential

This report was based on the outcome from the workshop on Gasification Technologies: Delivering the Potential, held in Newcastle University, Newcastle upon Tyne, UK on the 23rd October 2013, for the subproject 1.6 on Gasification Integration.

Written, compiled, reviewed and edited by the following members (in no particular order) of the SUPERGEN Bioenergy Hub:


| | | |
|---|---|---|
| Prof. Adam Harvey | Dr. Bea Jefferson | Dr. Dermot Roddy |
| Phillip Cozens | Dr. Chris Manson-Whitton | Dr. Patricia Thornley |
| Dr. Mook Tzeng Lim | | |

# Table of Contents

# Introduction

The SUPERGEN Bioenergy Hub aims to act as a focal point for engagement between industry, academia and other stakeholders to focus on research and challenges to increase the contribution of bioenergy to meet strategic environmental and energy security targets in a coherent, sustainable and cost effective manner.

One of the key enabling technologies for the successful uptake of bioenergy is gasification, a thermochemical process where biomass is converted into a mixture of gases that can be further utilized to generate heat or power or for the synthesis of chemicals or fuels. This process is highly versatile, and is applied in many forms. In fact, the technology is so versatile that no process or design within the gasification field is superior or dominant over the other [1] [2]. The types of gasifiers include the fixed bed (downdraft or updraft) gasifiers, fluidized bed gasifiers, entrained flow gasifiers (EFG) and plasma gasifiers. In fact, the fluidized bed gasifier category could be sub-divided further into several categories, such as bubbling fluidized bed gasifier systems, circulating fluidized beds, dual fluidized beds, internally fluidized beds, and triple fluidized beds.

The selection of the appropriate gasification technology is based largely on three essential criteria: the quality of the biomass feedstock, the downstream application (whether it is for heat, power or chemical/fuel synthesis), the cost and reliability of the system. Thus, no technology could claim to be an advanced version over the other, since each technology has an advantage in a specific niche market [2]. The outcome of this continuing period of experimenting and investigation (which became more active since the 1980s) is the existence of a large body of publications and patents on research and development work on various gasification technologies.

Though there seems to be no consensus for an efficient, cost effective technology to be commonly applied across the market, there still exist common issues and challenges that needs to be addressed for gasification to develop in a marketplace such as (but not limited to) the UK. The experience in the UK to date has been mixed and deployment slow. There are substantial technical, engineering and regulatory challenges that remain to be addressed. Key topic areas include gas cleaning and the integration of gasification systems, which fall into the purview of the SUPERGEN Bioenergy Hub.

To address these and other related issues with more depth and scope, the Hub organized a workshop on ‘Gasification -Delivering the Potential’, to gather and collate the experiences and expertise of significant players from industry and academia. Keynote speakers that attended the workshop include Dr. Chris Manson-Whitton (Progressive Energy Ltd.), Dr. Veronika Wilk (Vienna University of Technology (VUT)), and Dr. Bram van der Drift (ECN). Each gave a presentation on the following topics respectively, which are covered in more detail in the following chapters:

- Seizing the opportunities afforded by gasification in the UK
- Dual fluidized bed gasification: operational experiences and future developments

- Gas cleaning and conditioning

The summary of these talks are presented in the following sections respectively. These chapters are not exact transcripts of the presentations, and the reader is kindly referred to the presentation slides that can be found on the SUPERGEN Bioenergy Hub website, that complements the information found in these chapters.

In addition to these talks, a break-out session was facilitated for discussions among industrial and academics on the 'Current Experiences' of gasification technologies. Based on these inputs, participants were then asked to 'Underpin Future Developments' and identify an area of research that is a common challenge to the plethora of gasification technologies. A final section discusses these suggested projects. The full list of participants is included in the Appendix.

# Seizing the opportunities afforded by gasification in the UK

With a substantial generating capacity gap, and despite the potential of Shale gas, dwindling indigenous gas reserves, there is a pressing need to address the UK energy needs. The UK Renewable Energy Directives (RED) has also set a requirement for the amount of power, heat and transport fuels that needs to be supplied from renewable resources. At present, these requirements are not met.

Biomass has an important role to play. It should ultimately be stewarded to market sectors where there few other low carbon solutions, specifically heat, fuels or hydrocarbon-based chemicals. To do so, it needs to be converted to a fungible fuel. For different sectors, the UK has in place support mechanisms or policies to assist in the uptake of biomass as a renewable resource. Over the years, each support mechanism has evolved at a different rate, with the support policies for electrical production being the most mature, and also the most beneficial (refer to slide titled 'Policy Instruments – the bottom line'), especially if the Renewable Heat Incentive (RHI) is included with and the subsidies from the Renewable Obligation Certificates (ROC). The marginal benefit of producing liquid biofuels is currently lower compared to the producing electricity, heat, both, and synthetic natural gas (SNG).

The UK's biomass resource is lower (in terms of Mte pa) compared to that in Sweden which has a larger land area. Although there is a much higher municipal solid waste (MSW) in densely populated UK, its utilization is limited. Incentive support is limited for waste fuelled conventional technologies, but where gasification is used, even waste fuelled facilities can attract support; this is the key reason why waste gasification is of interest in the UK.

Gasification plants face some common challenges in upstream and downstream processes. Upstream, plants have issues in the quality of the feedstock, inconsistent gas evolution, ash removal. Downstream concerns include tar removal, effluents, airborne emissions. Other more general issues include control and monitoring of the process, insufficient financing to resolve arising issues, especially for long commissioning processes, and poor contracting strategies.

With that in mind, in today's workshop, there are key members from the industry, and also experts from ECN and VUT, who will be able to share their experiences on gasification and opinions on what issues should be addressed, which the academics can pick up to deploy resources in helping the industry address these issues.

Dr. Chris Manson-Whitton
Progressive Energy Ltd.

# Dual fluidized bed gasification: operational experiences and future developments

With Vienna University of Technology (VUT), two separate reactors are connected in a dual fluidized bed gasification plant (DFBG), with one reactor acting as combustor, the other as the gasifier. The DFBG is able to produce 40% $H_2$, with CO of 20%, while $CH_4$ was 10%. The gasification plant was able to be operated for a total of 7700 hours in 2012. Currently PhD students are working on optimization of the DFBG.

Bioenergy2020+ is a competence centre which is working with VUT on the conversion of the gas stream to mixed alcohols (for use as octane boosters, for example) and to liquid fuels through Fischer-Tropsch (FT) synthesis. The obtained FT diesel can be combusted with no soot formation, while the FT wax (solid by-product of the FT process) can be processed in a refinery hydrotreater. Other research includes using the gas stream to synthesise bio synthetic natural gas (bioSNG) as a transport fuel or for grid transmission, and biohydrogen.

The 100 kW pilot plant at VUT is being recommissioned. This can be used for investigating the fate of N, S and Cl contaminants and emissions of particulates for a range of feedstocks. The next-generation gasifier was described and also some of the larger-scale plants that have been built.

Dr. Veronika Wilk
Vienna University of Technology
Bioenergy2020+ GmbH

## Gasification: gas cleaning and gas conditioning

This talk covers topics such as the gas composition obtained from ECN's MILENA gasifier, tar removal, and ECN's bio-SNG system.

The MILENA gasifier is an indirect gasifier which has an internal loop to circulate the bed material between a fast fluidization reactor (gasification/ pyrolysis) and a bubbling fluidized bed combustor. This gasifier is able to produce 25 % of $H_2$, 32 % of CO, 15% of $CH_4$, 6% of ethylene and benzene, and 18% of $CO_2$. Their experimental results were not similar to the predicted results based simply on thermodynamic equilibrium. The thermodynamic equilibrium model is only applicable if the temperature in the gasifier is higher than 1000 °C (which is the case in EFGs).

Methane has a high energy density, and so do the other hydrocarbons such as ethylene and benzene. The sum of value of $CH_4$, ethylene, benzene, can payback the cost of the biomass feedstock (estimated to be 5 €/GJ). The energy penalty for generating $CH_4$ is the lowest from the MILENA gasifier. The advantage of this gasifier is that with decreasing temperature, more char is produced, and therefore can be used further for combustion. Char that is generated from the gasification reactor is recirculated for combustion to produce heat. The combustor can also be used to combust the tar stream that is removed from the gas stream via the OLGA oil scrubber (details of this system are shown in the presentation slides). With this process, the MILENA gasifier is also able to produce more $CH_4$. Entrained flow gasifiers (EFGs) have the highest penalty and lowest efficiency since it operates at such high temperatures generate more $H_2$.

There are three options to remove tar from the gas stream: preventing tar formation (multistage or HT process); help thermodynamics (catalysts); washing system (condensation, adsorption).

Catalysts are problematic as they are expensive and Nickel catalysts are prone to sulfur poisoning. To prevent sulphur poisoning, the selection of fuel becomes critical, since fuel bound sulphur are most likely to form sulphur oxide emissions. This then limits the ability of the process to handle the varying fuel quality that a feedstock-flexible system would encounter. Also, although catalytic tar reformers crack the tar into syngas, it also partially destroys desirable components in the gas stream such as methane.

Washing systems (such as the use of water scrubbers) are also problematic as there is still a need to treat the effluent from this process, and not many plants have waste water treatment plants readily available.

ECN's tar removal solution is their OLGA process, which is able to completely remove tar and particulates, without destroying methane. The tar is also able to be recycled for further use, for instance, for combustion in a gasifier (in ECN's case, the MILENA gasifier).

Dr. Bram van der Drift
ECN

# Collating Current Experiences

In this part of the chapter, the experiences of the participants in gasification were collated. This session provides us with an overview of the expertise and experiences that are already 'out there' in the industry. It also gives an overview of the solutions that are already being applied, e.g. those related to gas cleaning and tar removal. This session was also a chance for the participants to learn from each other and to showcase the capability of their respective companies.

- Xylowatt (represented by Jean Philippe-Damon) is a technology provider and has designed two 1 MW downdraft gasification plants. These plants have operated 15000 h. They face similar issues in gas cleaning and have performed R & D on gas cleaning, and have found that multistage downdraft gasifiers are able to reduce the tar content by oxidizing the pyrolysis gas. The tar content in the gas was able to be reduced to 100ppm with this system.

- Air Products (represented by Andrew Wright) are involved in gas separation and they are building a 49.9 MW gasification plant in Tees Valley, scheduled to start operations in 2014. The gasifier is a plasma gasification system, and is designed by Advanced Plasma Power (APP), who are also present in the workshop (represented by Richard Taylor). The plant is running on municipal solid waste (MSW). They are currently trying to identify potential issues that may arise from the operation, especially pertaining to the gas composition. The plant is equipped with three particulate removal systems.

- Cranfield University (represented by Dr. Kumar Patchigolla) have fixed and fluidized bed gasifiers that range from 75 to 150 kW.

- Sustainable Energy Ltd. (represented by Tom Milne) has an entrained flow gasifier that is used for gasifying feedstocks.

- University of Liverpool (represented by Dr. Xin Tu) have worked on heavy metal and dioxin emissions and they are interested in plasma gasification. They have also performed research into the removal of volatile organic compounds (VOC) and tars. They are also involved in $CO_2$ conversion processes (via catalysts and plasma).

- ECN (represented by Dr. Bram van der Drift) have been working on fluidized beds (as mentioned earlier) and they are also working on entrained flow gasifiers. Because the cost of electricity is cheaper in the Netherlands, with energy already being generated from other renewable resources (mostly from wind), the demand for biomass generated energy is not that great. Therefore ECN is now focusing on the extracting value added chemicals from biomass gasification, and therefore chemistry related research is being done.

- Newcastle University (represented by Dr. Kui Zhang) are performing research into coal and biomass conversion into liquid, and also the synthesis of ammonia.

- Jim Swithenbank (Sheffield University). Focus of the research group has been on waste gasification, particularly to produce hydrogen as this is a more efficient energy vector.It's less wasteful than production of electricity and can be transmitted via the gas grid (which is able to deal with load variation with less investment). An EFG is being used with approx. 80% efficiency so, if the gas is used for CHP, the overall efficiency is 80%x85%. The system will run at high pressures – pressurised at source using a method with good energy efficiency.

- Anh Phan (Newcastle University). Formerly worked with Jim at University of Sheffield on using different waste streams and tar production by different fuels. At Newcastle her work is around pyrolysis – particularly the use of catalysts.

- Rachael Hall (Alstom). Also formerly University of Sheffield – worked on gasification of molten metal. Now works on future technologies for Alstom – looks for new ideas and developments in academia of relevance to the industry. Industry currently perceives gasification as high level of risk.

- Abby Saddawi (Lincoln University). Formerly at Leeds University, working on combustion and pyrolysis – particularly metals in energy crops and pre treatments. She is now setting up a lab at Lincoln. Planned work will have strong tie-in with life science and will be looking at links between gasification and alcohol production as well as use of char in agriculture.

- Guy Thompson (Thompson Spaven). The company produces small scale gasifiers (300 to 500Kw) – currently at 'beta' stage with two units in the field – approximately 6 months from a commercial product. The gasifiers use a two stage process – pyrolysis followed by gasification stage – and produce gas with a fairly high hydrogen level (30-35%). The challenges are around flexibility to use different feedstocks and dealing with the gases from the pyrolysis process. The gasifiers use stainless steel – but this is at the border of what can be done with the materials.

- Mark Anderson (Ulster University). Mark's work is on small scale downdraft throated gasifiers. He has 2 lab-based gasifiers using wood and is currently working on a project on the use of poultry litter as a gasifier fuel source. Biochar for agricultural use is seen as the more important revenue stream from the litter gasification.

The table below shows the responses of the respective organizations to the themes or challenges.

Table 1: Responses of respective organizations to themes and challenges

| Themes | Organization | |
|---|---|---|
| Fuel flexibility | Xylowatt | Gasifying waste (contaminated) such as railway sleepers, cyprus and redwood, together with sewage sludge. |
| Applications | Xylowatt | Gas engines |
| | | 1-2 $MW_{th}$ systems for glass and brick manufacturing factories. |
| | Cranfield | Gas engines, chemical looping combustion, circulating fluidized bed gasifier. |
| | ECN | Extracting value added chemicals from benzene and ethylene. |
| Gas cleaning and conditioning | Xylowatt | Oil scrubber, mainly for particulate matter (PM) removal. |
| | | Developing dry PM removal process. |
| | | Also developing process for condensate removal. |
| | ECN | OLGA (an oil scrubber process) to remove tar. |
| Scale | Air Products | The Tees Valley plant will be running at 1000 tpd. |
| | Sustainable Energy Ltd. | 200 $kW_e$ entrained flow gasifier. |
| | Cranfield University | 25-50 kg/h |
| Operating hours | Xylowatt | Plants are running with 75 % uptime. |

# Underpinning Future Developments

**Group 1**

There are contrasts between small scale distributed and larger centralised production. The group also identified the potential importance of char as a useful output. There was also discussion on how to handle the pyrolysis gases. A potential issue is by treating it off-line so it poses less risk to assets downstream. However, there are challenges in such processes. An issue with the varying quality of feedstock was also identified (partly caused by seasonal variation), and the gasification process needs to be flexible in handling the varying quality in feedstock.

Different configurations of the gasifier were discussed and particularly the implications of the configurations on dealing with tar. The following priorities were also identified as potential research projects:

- Fundamental characterisation of pyrolysis and its interaction. Most tar compounds originate from pyrolysis gas (all produced "pre gasification", i.e. not as output in themselves but pre-cursors to gasification). Therefore a better understanding of the reactions in the gasifier is required. However, the challenge is to close couple the pyrolysis section to a gasifier and engineer it. The challenges associated with moving pyrolysis gas were acknowledged.

- A better feedstock preparation for achieving consistency of input particularly for fixed bed gasifiers – not just chemistry but also how it survives handling, form requirements etc. This could be done possibly through standardisation, building on 'G' codes used for woodchip.

- Modelling – particularly issues around scaling up – of physical, chemical and thermo-mechanical aspects of the gasifier. Sheffield University has produced a model (FLIC) but ran into problems resourcing support for external users.

- Consider best use for syngas/competing resources.

- Control systems for gasification plants. Gasifiers are 'living beasts' and control systems, especially using fuzzy logic are appropriate to allow the gasifier to adjust and 'learn'. This is especially important for the gasifier to be able to adjust operating conditions to varying parameters such as the quality of the feedstock.

**Group 2**

The participants in this group identified the issue of construction materials for the gasification system as being the most critical area for future research. There is not much research that has focused on materials specifically for gasification systems. The gases can be corrosive due to presence of contaminants such as alkali compounds [3].

A continuous supply of fuel is important to ensure that the gas supply for downstream applications is continuous, especially when the gas is to be combusted in a boiler or gas turbine. The interruption of fuel supply in an EFG is especially a safety hazard as this leads to a build-up of oxygen inside the reactor. This issue could be circumvented at a cost by having multiple feeders to provide a continuous supply of biomass. However, new ideas for extending the feed preparation stage into the gasifier feeding system aimed specifically at continuity of supply could make a big difference.

Another area of development is the online monitoring and instantaneous feedback of the feedstock quality in order to improve control. The aim would be to detect significant changes in fuel composition or bulk density earlier, allowing sufficient lead time for the gasifier operations to be adjusted accordingly.

A number of other topics were also discussed: use of feedstock additives for minimising tar formation; developing end markets for tars; oxygen-blown gasification at smaller scales; gasifiers in a CHP configuration; on-line calculation of bio content of input stream; fuel synthesis; tar conversion and gas purification.

**Group 3**

Information or experiences ('tricks of the trade') to prevent gasification project mistakes from being repeated are not readily available to practitioners. There were therefore suggestions to develop a portal for the information to be shared, which may be available through the BRISK website.

The following are mission orientated projects were identified by the group:

- Modelling and (understanding) of the gasification
- Fuel flexibility – making gasifiers accepting varying fuel feedstock without upsetting the process.
- Tar reforming for downstream application.
- Oil of low vapour pressures such that it does not condense in downstream applications.

In terms of gas clean-up processes, there were several potential developments that could involve process intensification of downstream applications:

- Solvents for tar removal
- Plasma related technologies
- Intensified technologies such as microwaves

In-situ tar prevention or removal is another area of development. Plasma gasification was suggested as a technology best suited for this purpose with the high temperatures that it is possible to generate. Addition of catalytic bed materials such as dolomite can also reduce the tar content.

# Discussion and conclusion on suggested future projects

A few of the suggested projects are being addressed by the SUPERGEN Bioenergy Hub. For instance, the effects of pre-treatment on emissions from biomass combustion of biomass are being investigated in Leeds University. Though this is mainly meant for biomass combustion, the investigation would partially address the effects of pre-treatment on the emissions.

Tar removal and reforming have been well investigated [11-16], as has shown by the work performed in ECN, the technology exists to condition and clean the gas for further downstream applications [17].

Simulation and modelling work to better understand the fundamentals of gasification came up as another future project identified by the participants. There exist theoretical work on gasification in literature [6-10], and these improve the fundamental understanding of the process, thus improving the control and design process

Operation and control of the plant was a common theme that emerged from the majority of the suggested areas of research. These include: improving the fuel flexibility of the gasifier, development of a new control system for better control of the gasification plant, improvement of the feeding system for a continuous feedstock supply, and the development of a monitoring system of the feedstock quality, equipped with instantaneous feedback loop. These are essential investigations that if pursued, could be used to outline the engineering design of a large scale gasification plant. These challenges were recently highlighted in the *Power Engineering International* and are being addressed by several companies [23].

Among the above mentioned areas of research, fuel flexibility was identified as one of the main challenges encountered by gasification plants. As mentioned by Chris Manson-Whitton (ref. page 3, *Seizing the opportunities afforded by gasification in the UK*), in the UK, the supply of biomass is finite, and therefore there needs to be a process that can handle the various properties and quality of biomass, such that there is an optimal use of the feedstock in the gasification plant. As shown in Table 1, Xylowatt has addressed this issue by gasifiying contaminated waste.

Plasma gasification has been used to treat municipal solid waste (MSW) to generate power [18-24]. If the varying quality and properties of MSW can be used successfully with plasma gasification, then it is possible that the varying properties of biomass do not pose a problem in a plasma gasification plant. From this perspective, plasma gasification will be effective in addressing the issue of feedstock supply and quality.

# References


1. Piterou, A., S. Shackley, and P. Upham, Energy Policy, 2008. **36**(6): p. 2044-2050.
2. Kirkels, A.F. and G.P.J. Verbong, *Biomass gasification: Still promising? A 30-year global overview.* Renewable and Sustainable Energy Reviews, 2011. **15**(1): p. 471-481.
3. Woolcock, P.J. and R.C. Brown, *A review of cleaning technologies for biomass-derived syngas.* Biomass and Bioenergy, 2013. **52**(0): p. 54-84.
4. Yang, Y.B., et al., *Combustion of a Single Particle of Biomass.* Energy & Fuels, 2007. **22**(1): p. 306-316.
5. Nemtsov, D.A. and A. Zabaniotou, *Mathematical modelling and simulation approaches of agricultural residues air gasification in a bubbling fluidized bed reactor.* Chemical Engineering Journal, 2008. **In Press, Corrected Proof**.
6. Xu, Q., S. Pang, and T. Levi, *Reaction kinetics and producer gas compositions of steam gasification of coal and biomass blend chars, part 2: Mathematical modelling and model validation.* Chemical Engineering Science, 2011. **66**(10): p. 2232-2240.
7. Chen, J.-S. and W.W. Gunkel, *Modeling and simulation of co-current moving bed gasification reactors — Part II. A detailed gasifier model.* Biomass, 1987. **14**(2): p. 75-98.
8. Nemtsov, D.A. and A. Zabaniotou, *Mathematical modelling and simulation approaches of agricultural residues air gasification in a bubbling fluidized bed reactor.* Chemical Engineering Journal, 2008. **143**(1–3): p. 10-31.
9. Gómez-Barea, A. and B. Leckner, *Modeling of biomass gasification in fluidized bed.* Progress in Energy and Combustion Science, 2010. **36**(4): p. 444-509.
10. Miao, Q., et al., *Modeling biomass gasification in circulating fluidized beds.* Renewable Energy, 2013. **50**(0): p. 655-661.
11. Dayton, D., *A Review of the Literature on Catalytic Biomass Tar Destruction*, 2002, National Renewable Energy Laboratory (NREL).
12. Fjellerup, J., et al., *Formation, Decomposition and Cracking of Biomass Tars in Gasification*, 2005, Agency DE.
13. Han, J. and H. Kim, *The reduction and control technology of tar during biomass gasification/pyrolysis: an overview.* Renewable and Sustainable Energy Reviews, 2008. **12**(2): p. 397-416.
14. Houben, M.P., H.C. De Lange, and A.A. Van Steenhoven, *Tar reduction through partial combustion of fuel gas.* Fuel, 2005. **84**(7-8): p. 817-824.
15. Houben, M.P., et al., *An analysis and experimental investigation of the cracking and polymerisation of tar.* Proceedings of the 12th European Conference on Biomass for Energy, Industry and Climate Protection, 2002: p. 581-584.
16. Rabou, L.P.L.M., et al., *Tar in biomass producer gas, the energy research Centre of the Netherlands (ECN) experience: an enduring challenge.* Energy and Fuels, 2009. **23**(12): p. 6189-6198.
17. Zwart, R.W.R., et al., *Oil-based gas washing: flexible tar removal for high-efficient production of clean heat and power as well as sustainable fuels and chemicals.* Environmental Progress and Sustainable Energy, 2009. **28**(3): p. 324-335.
18. Hlina, M., et al., *Production of high quality syngas from argon/water plasma gasification of biomass and waste.* Waste Management, (0).
19. Van Oost, G., et al., *Pyrolysis/gasification of biomass for synthetic fuel production using a hybrid gas–water stabilized plasma torch.* Vacuum, 2008. **83**(1): p. 209-212.
20. Byun, Y., et al., *Hydrogen recovery from the thermal plasma gasification of solid waste.* Journal of Hazardous Materials, 2011. **190**(1–3): p. 317-323.

21. Rutberg, P.G., et al., *On efficiency of plasma gasification of wood residues.* Biomass and Bioenergy, 2011. **35**(1): p. 495-504.
22. Schubert, P. *Plasma torch for biomass pyrolysis*. 2008.
23. Taylor, R., R. Ray, and C. Chapman, *Advanced thermal treatment of auto shredder residue and refuse derived fuel.* Fuel, 2013. **106**(0): p. 401-409.
24. Zhang, Q., et al., *Gasification of municipal solid waste in the Plasma Gasification Melting process.* Applied Energy, 2012. **90**(1): p. 106-112.

# Appendix

List of participants during the Gasification Workshop on the 23rd October 2013.

| First name | Surname | Affiliation |
|---|---|---|
| Richard | Taylor | Advanced Plasma Power |
| Andrew | Wright | Air products |
| Rachael | Hall | Alstom |
| John | Oakey | Cranfield University |
| Kumar | Patchigolla | Cranfield University |
| Ben | Anthony | Cranfield University |
| Bram | van der Drift | ECN |
| Dermot | Roddy | Five-Quarter Energy |
| Andrea | Jordan | ITI energy |
| Chunfei | Wu | Leeds University |
| Jurgen | Sitzmann | Lignogen |
| Abby | Saddawi | Lincoln University |
| Xin | Tu | Liverpool University |
| Bea | Jefferson | Manchester University |
| Anh | Phan | Newcastle University |
| Mooktzeng | Lim | Newcastle University |
| Adam | Harvey | Newcastle University |
| Chris | Manson-Whitton | Progressive Energy |
| Phillip | Cozen | Progressive Energy |
| Jim | Swithenbank | Sheffield University |
| Mathew | Smith | SKM |
| Gabriel | Gallagher | Sustainable Energy Limited |
| Tom | Milne | Sustainable Energy Limited |
| Guy | Thompson | Thompson Spaven |
| Martyn | Newton | UEA |
| Mark | Anderson | Ulster University |
| Veronika | Wilk | VUT |
| Jean-Philippe | Damon | Xylowatt, AS |