

PERSPECTIVES ON BROWN COAL

THE NEWSLETTER OF BROWN COAL INNOVATION AUSTRALIA

July 2013 : Number 7



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CEO's Update: Accelerating a Low Emissions Future

In June I attended the Clearwater Clean Coal Conference in Florida. This was an opportunity to see the latest research, hear industry presentations on current developments, and renew acquaintances with those in the global community working towards a lower emissions future for coal.

This year, however, there was a growing sense of frustration from some in the audience about the cost and pace of development and deployment, especially in light of the announced changes in EPA regulations for emissions from new coal fired power plants in the USA. It is clear that there is a real role for applied RD&D to play in accelerating the development to lower emissions coal technologies.

Here in Australia, the CCS flagship program, part of the Australian Government's Clean Energy Initiative, has been established to accelerate the construction and demonstration of large-scale integrated carbon capture and storage (CCS) projects.

CarbonNet, one of the two projects with funding from the Flagships program, is seeking to create the conditions required for commercial deployment of CCS. On page 4 you can read about CarbonNet's plans for the next phase of its activities. A major challenge in accelerating the development of any emerging industry is providing the skills and training required.

On pages 2 and 3, Stephen Zitney from the AVESTAR project in the USA tells us how an immersive virtual reality environment is helping to train the next generation of coal gasification engineers. In fact, by putting computer games technologies in the right hands, the AVESTAR facility is even helping researchers analyze gasification performance, and establish safe practices for plant operators.

Accelerating the deployment of low-emissions coal technologies will require ongoing cost reductions. On pages 5 and 6, Sharmen Rajendran introduces his BCIA funded project on Chemical Looping Combustion (CLC), a potentially lower cost means of providing oxygen for coal combustion. This project, which forms part of a larger collaboration with Kyushu University in Japan, aims to determine the right conditions for application of CLC to brown coal.

Accelerating the adoption of new coal technologies will involve a wide range of stakeholders, from industry and government to research and finance. BCIA's seminars and membership programs are designed to bring together these people, and to help them understand what is possible for today, and what is coming for the future. BCIA is delighted to announce Mantle Mining Corporation Limited as our latest member (see profile on page 12).

In the last 12 months, over 350 people have attended a BCIA seminar. BCIA's upcoming seminars for 2013 include a community forum in the Latrobe Valley, a seminar on deployable CCS technologies, a one-day course on gasification and a seminar on coal-to-products technologies.

See page 7 for a write-up on our latest seminar on coal drying and handling, and page 8 for dates of upcoming BCIA events. We would love to see you at one of our upcoming events, and hope you enjoy this issue of *'Perspectives on Brown Coal'*.

PAGES 2 & 3

AVESTAR® Center for Operational Excellence of Coal-Fired Power Plants using Dynamic Simulation and Virtual Reality Technologies

By Stephen E. Zitney, Director, AVESTAR Center, Advanced Virtual Energy Simulation Training and Research Office of Research & Development, U.S. Department of Energy, National Energy Technology Laboratory (NETL)

How can virtual reality and computer games technologies help to address the skills requirements for clean energy deployment and provide an environment for advanced R&D on safe plant operation? Read on to find out more....

The Advanced Virtual Energy Simulation Training and Research, or AVESTAR®, Center at the U.S. Department of Energy's National Energy Technology Laboratory (NETL) is dedicated to accelerating progress toward achieving operational excellence for smart energy systems ranging from smart power plants to modern grid applications.

Attaining operational excellence requires that energy producers maximize the efficiency and profitability from their operations through excellent process automation and control, while also improving safety and reducing negative environmental impact. Driving people excellence via the development, training, and empowerment of a highly-skilled engineering and operations workforce is another critical component of operational excellence.

The NETL AVESTAR Center is addressing all of these challenges by bringing together advanced dynamic simulation and virtual reality technologies, state-of-the-art training facilities, and leading industry experts to focus on the optimal operation of clean energy plants in the smart grid era.

The AVESTAR Center was launched in March 2011 with deployment of a high-fidelity, real-time dynamic simulator and operating training system (OTS) for a coal-fired integrated gasification combined cycle (IGCC) power plant with carbon capture.

The IGCC dynamic simulator is designed with dual-train entrained-flow gasifiers producing shifted, high-hydrogen synthesis gas. CO₂ capture and desulfurization of the sour syngas are accomplished by a two-stage physical solvent-based acid gas removal process.

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In the combined cycle, the high-hydrogen syngas is combusted in two gas turbines (GTs) which are partially integrated with an air separation unit (ASU) which supplies nitrogen for syngas dilution to reduce NOx emissions. The ASU also produces high-purity oxygen for use in the gasifiers. The exhaust of each GT is sent through a heat recovery steam generator and produces steam that is supplied to a steam turbine for additional power generation.



Figure 1. Trainees use IGCC dynamic simulator/OTS in AVESTAR's control room environment

The full-scope OTS recreates the look and feel of the operator station in the IGCC power plant control room (Figure 1), thereby providing much-needed hands-on experience with plant operations and control.

Based on first-principles dynamic models, the OTS enables engineers, operators, students, and researchers to analyze IGCC performance over a wide range of operating scenarios, including normal full-load operation, plant startup, shutdown, power demand load following, and variable CO₂ capture rates.

The IGCC dynamic simulator also lets users analyze the plant's response to disturbances (eg. fluctuating coal flowrate and composition) and malfunctions (eg. pump failure, valve stuck open). In addition, the dynamic simulator allows for switching and co-firing of different types of feedstocks, including various coals, petroleum coke, and biomasses.

For use in training IGCC field operators and engineers, the AVESTAR Center also offers a first-of-a-kind, 3D virtual immersive training system (ITS). As shown in Figure 2, users can navigate avatars (field operators) through the virtual IGCC plant using the same gesture-sensitive handheld devices used as the primary means of interacting with most modern video games.

Plant equipment interactions include opening/closing valves, starting/stopping pumps, and reading pressure and temperature gauges. ITS users can also experience equipment sound effects (e.g., pump engines) and malfunctions (eg. gas/liquid leaks, fires), as well as augmented reality features such as transparent views (eg. liquid levels in tanks, gasifier internals showing slag flow and gasification animations (Figure 3), CO₂ capture column internals showing liquid holdup and vapour flow), pop-up trends (eg. gasifier temperature over time), and web pages providing additional training content (eg. NETL's Gasifipedia).



Figure 2. Field operator (avatar) in AVESTAR 3D virtual IGCC power plant



Figure 3. Transparent view of gasifier operation in AVESTAR 3D virtual IGCC power plant

Using the virtual reality technology, IGCC field operators can coordinate activities with control room operators. The virtual environment is fully interactive in real time with the dynamic simulation models, so actions taken by a field operator have an impact on the process and actions performed in the control room change the information visible to the field operator.

As a result, field and control room operators can coordinate their activities and perform collaboratively as a team. Additional uses include training for safety-critical tasks, rare abnormal situations, and emergency shutdowns.



Figure 4. Trainees interact with the AVESTAR 3D virtual IGCC immersive training system

The principal applications of the high-fidelity IGCC virtual plant simulator include realistic hands-on industry workforce training, engineering education, and advanced research on the safe, reliable, and efficient operation and control of clean gasification-based power plants with CO₂ capture.

Future AVESTAR plans include development and deployment of dynamic simulators for other pulverized coal-fired power plants, namely subcritical-, supercritical-, and oxy-combustion technologies.

For detailed information on AVESTAR's virtual energy plant development, training, education, and research programs, please visit www.netl.doe.gov/avestar.

PAGE 4

CarbonNet Industry Consultation to Pave Way to Commercial Model



How do you develop a commercial model for a government-led project when no precedent exists and a range of industries could be involved? This is the unusual challenge faced by the CarbonNet Project (CarbonNet); a challenge the project has developed a 'bespoke' solution for.

CarbonNet is a Carbon Capture and Storage (CCS) project that is investigating the potential for a shared, large-scale CCS network in the Gippsland region, Victoria, Australia. It is envisaged that the network will integrate the supply of a number of CO₂ capture projects within the region and transport the CO₂ via pipeline to offshore geological storage formations to be stored, permanently, deep underground.

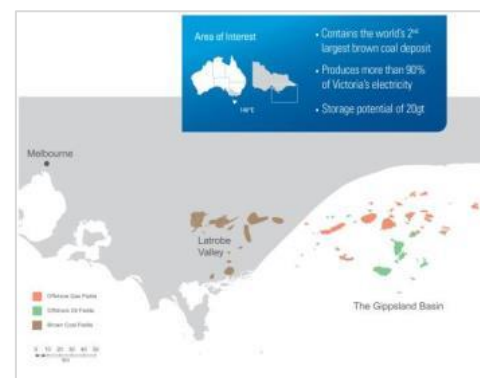
To develop and then gain acceptance for a new commercial model, CarbonNet's solution is to engage with the market to develop a model that works for all parties.

"CarbonNet is taking a structured two-stage market engagement approach - one that reflects the complexities of CCS - and the project - and is underpinned by a solid stakeholder engagement strategy," says Project Director Richard Brookie.

"It's important that we have a solid understanding of the market for the project to meet its underlying objectives. Those objectives include scalable infrastructure to underpin the roll-out and growth of a CCS network, to enable an emerging CCS industry to evolve once market conditions are supportive."

Stage 1 of the market engagement, Industry Sounding, was conducted late last year. It sought to understand how other CCS projects, globally, are progressing and highlighted the need for continued engagement with the market to help inform the model.

Stage 2, Industry Consultation, is in the pipeline. CarbonNet seeks to understand the needs of current and future potential users (CO₂ emitters) of its network, and what is



required for these parties to participate in the project. *A Request for Industry Submissions* supporting document will be available as part of the Industry consultation, which will include meetings with some parties.

“The Industry consultation will provide an opportunity to reinforce the Victorian and Australian Governments’ commitment to consider CCS and for CarbonNet’s investigation of a viable CCS network. That commitment is an important message for our target market, as it involves international participants unfamiliar with the potential of the Victorian industry,” Mr Brookie said.

At the end of the Industry consultation, CarbonNet will have:

- A more informed understanding of the network’s potential users, and appetite for CCS
- Information and market views around commercial business models
- An understanding of how different commercial options might impact private sector participation in CarbonNet.

Organisations wishing to make enquiries about participating in the industry consultation can email carbonnet.industry@DPI.vic.gov.au.

The industry consultation is being funded by the Victorian and Australian Governments and the Global CCS Institute.

To find out more about the CarbonNet Project, visit www.dpi.vic.gov.au/carbonnet.

PAGES 5 & 6

Postgraduate Research Updates: Chemical Looping Combustion of Victorian Brown Coal

By Sharmen Rajendran, PhD Student in Energy, Fuels and Reaction Engineering Group, Department of Chemical Engineering, Monash University

Combustion of brown coal in an oxygen atmosphere can produce a pure stream of CO₂ suitable for sequestration. In the second issue of *Perspectives on Brown Coal* we heard about a BCIA funded project looking at pilot scale oxy fuel combustion. In this issue, Sharmen Rajendran provides an overview of his BCIA-funded research into chemical looping, an alternate (and potentially lower cost) means of providing oxygen for combustion.

Victorian brown coal is an economical and important source of energy for the state of Victoria and accounts for approximately 85 per cent of all generated electricity. At the current rate of consumption, these brown coal reserves are expected to last for more than 500 years.

Victorian brown coal is an excellent fuel as it contains low levels of ash and is highly reactive. However, the use of this low energy density fuel has a significant drawback in that it generates high levels of greenhouse gases, particularly CO₂, which are responsible for global warming.

There is therefore a strong incentive for the research and development of technologies which will allow for cleaner utilisation of Victorian brown coal. This can be accomplished in combination with

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Carbon Capture and Storage (CCS) technologies which aim to produce a concentrated stream of CO₂ which can be sequestered, mostly geologically, to reduce the impact on the atmosphere.

It is possible to produce a concentrated stream of CO₂ by firing the coal in an oxygen-rich atmosphere. In oxy-fuel combustion, oxygen is provided by an Air Separation Unit (ASU), however this has a high operating cost as it involves cryogenic separation of oxygen from air.

Chemical Looping Combustion (CLC) is an alternative way to provide oxygen for combustion, and shows potential to reduce the relative cost of oxy-combustion. The CLC process has been significantly researched for use with gaseous fuels such as natural gas and synthesis gas and is a relatively simple process to implement, but investigation with solid fuels, coal in particular, was initiated only recently.

However, the vast majority of fossil fuels are in the form of coal, and the use of solid fuels in the CLC process brings about an extra level of complexity.

The operating principle of the CLC process is shown in Figure 1. The process utilises two reactors which are known as the Air Reactor (AR) and Fuel Reactor (FR), compared to a single reactor typically found in power plants. The most important facet of this technology is the oxygen carrier which is typically a transition element metal oxide such as NiO, CuO and Fe₂O₃.

The fuel is fed into the FR together with the oxygen carrier and is fluidized by gasification agents such as CO₂ or steam. The CO₂ or steam then reacts with the coal and forms gasification products consisting predominantly of CO and H₂. These gases then react with the oxygen carrier causing it to be reduced and subsequently generate CO₂ and H₂O which then exit the FR. This flue gas stream is then cooled down to condense the steam to generate a concentrated stream of CO₂ which is sequestration ready.

Once the oxygen carrier has been reduced, it enters the AR, fluidized by air, and undergoes oxidation to return to its initial higher oxidation state. The oxidized oxygen carriers are then recirculated into the FR for another reaction cycle.

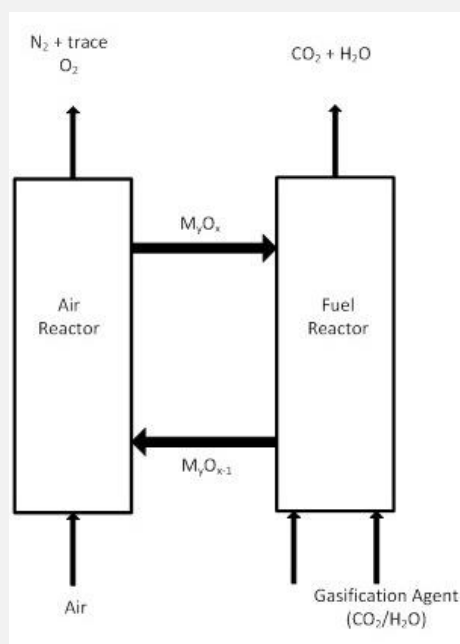


Figure 1: Schematic representation of the CLC process

My postgraduate degree is titled Chemical Looping Combustion of Victorian Brown Coal and is supervised by Associate Professor Sankar Bhattacharya at the Department of Chemical Engineering, Monash University, and Professor Klaus Hein.

The main focus of my research is to determine the applicability of the CLC technology with Victorian Brown Coal, and this involves investigation of a number of aspects of the process:

- What is the appropriate ratio of oxygen carrier to Victorian brown coal?

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- What is the CO₂ capture efficiency of the process? Would it be close to 100% or towards the other end of the spectrum?
- How reusable is the oxygen carrier with Victorian brown coal?
 - What is the rate of loss of oxygen carrier, or attrition, with time?
 - What is the rate of oxygen carrier reactivity degradation with respect to time?
 - What factors affect the reactivity of the oxygen carrier?
- Would commercial metal oxides provide sufficient reaction rate for the CLC process or would synthetic oxygen carriers be necessary?
- What are the optimum operation conditions with respect to temperature, fluidization gas concentration, fluidization velocity etc.?

While there has been increasing research into coal fuelled CLC in recent times, very little literature exists for brown coal and even lesser for Victorian brown coal. My research will serve to fill in this knowledge gap and will be accomplished through my scope of study as follows:

- Chemical looping combustion of Victorian brown coal on various experimental scales starting with a Thermogravimetric Analyzer (TGA) followed by a small bench scale fluidized bed and ultimately with a large four metre tall bench scale fluidized bed reactor. The TGA was used for kinetic studies to obtain the parameters of CLC with Victorian brown coal. The small scale fluidized bed reactor is used to assess the performance of Victorian brown coal fuelled CLC.

Lastly, the large fluidized bed reactor can be used to study not only the performance but the scale up characteristics, drawing on the work done using the small fluidized bed reactor. Figure 2 shows the large bench scale fluidized bed reactor which will be used in this project.



Figure 2: Large four metre tall bench scale fluidized bed reactor configuration

- The oxygen carrier is characterised using various analytical instruments such as Scanning Electron Microscope (SEM), Electron Dispersive X-Ray (EDS), X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF) as well as X-Ray Photoelectron Spectroscopy (XPS). These are conventional analytical techniques that are typically employed in this field of study whereby the oxygen carrier is subjected to ex-situ analysis.

Recently, a synchrotron application was approved and CLC experiments were performed in an in-situ manner to shed more light with regards to the reduction of the oxygen carrier with temperature and time. A photograph of the beamline can be found in Figure 3.

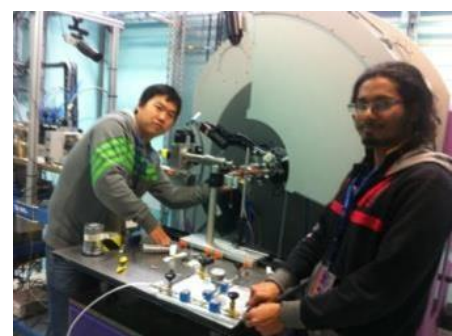


Figure 3: X-Ray Diffraction beamline at the Australian Synchrotron (Shuai Zhang, visiting PhD student from Southeast University, China (left) and Sharmen Rajendran (author) right)

- Performance of different oxygen carriers, in particular synthetic materials, in terms of reduction and oxidation reactivity. Current preliminary findings suggest that whilst synthetic oxygen carriers have a higher reactivity, the cost of manufacturing such materials will render them unfeasible even in a large scale application.

An exchange student from Southeast University, China is also working on this project. This student is presently at Monash for a total duration of one year at our laboratory investigating the performance of synthetic oxygen carriers, which is part of the research scope.

This project has also hosted four students undertaking their final year project with the Department of Chemical Engineering. Two students have undertaken their summer research with this project which qualifies as working experience needed for their graduation. These two students were selected to present their research at Monash-Warwick International Conference on Undergraduate Research.

Finally, this project has allowed me to perform some experiments at Southeast University, marking the initiation of collaborative work between the two universities in this research front. Additional collaborations in this project include Chalmers University, University of Alberta and the Huazhong University of Science and Technology.

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BCIA Coal Drying & Handling Seminar proves strong interest in low-emissions brown coal use

BCIA's seminar series aim to show what is possible today, and what the future might hold for developments in brown coal applications.

Strong domestic and international interest in low-emissions brown coal utilisation was evident with more than 120 people registering to attend a recent BCIA one-day seminar and mini exhibition on coal drying and handling.

The Melbourne seminar showcased state-of-the-art coal drying, from research through to commercial operation, together with a mini expo which provided for interaction and networking opportunities among participants and companies working in the area.

BCIA Chief Executive, Dr Phil Gurney, told seminar registrants that coal drying, and the ability to handle and work with dewatered coal, was a necessary precursor to any future low-emissions brown coal development.

"Seminars like these are needed to bring together interested parties, build knowledge in what is now possible for brown coal drying and other low emissions technologies, and to explore next steps required for the expansion of low-emissions brown coal utilisation", Dr Gurney said.

A broad range of local, national and international presenters from across industry, research and technology development provided the audience with an insight into what is possible in coal drying and handling. The seminar was held in June as part of BCIA's 2013 seminar series.

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Dr Fedir Woskoboenko, General Manager, Technical at HRL Limited (New Ventures) opened the seminar with a plenary session focussed on the unique opportunities and challenges for the utilisation of Victorian brown coal.

Prof. Robin Batterham, Kernot Professor of Engineering at the University of Melbourne examined the history of brown coal drying and Assoc. Prof. Andrew Hoadley, a senior lecturer in Chemical Engineering at Monash University provided an update on the BCIA funded project 'Improved Handling Properties of Lignite-based Products'.

Participants also heard from a number of speakers with experience in coal drying technologies, processes and engineering services to support technology deployment, as well as the latest research in this area including:

- **Ashley Moore**, Managing Director, Environmental Clean Technologies - *Coldry: Low Cost, Zero Emission Lignite Drying*
- **Slade Wormington**, Director/Technical Development Manager, Exergen - *Exergen's Continuous Hydrothermal De-Watering of Low Rank Coal*
- **Paula Murphy and Kate McCowan**, J.C Steele & Sons Australia - *The Merits of Brown Coal Extrusion*
- **Chris Johnston**, Principal Mechanical Engineer Service Line Leader – *Plant Engineering, GHD - Delivering Coal Drying Projects in Latrobe Valley*
- **Jan Wolff**, Sales & New Business Manager, Mines Engineering Centre, RWE Power AG - *WTA Coal Drying Technology – An Update*
- **Dr Len Humphreys**, Chief Executive Officer, Ignite Energy Resources - *Lignite, a Pathway to drop in Fuels*
- **Mark Frecheville**, Chief Executive Officer, Torrefco Pty Ltd - *Torrefaction Technology as applied to Brown Coal Upgrading and other Beneficial Uses*
- **Shigeru Kinoshita**, Process Engineer, Coal & Energy Technology Department, Kobe Steel, Ltd. - *Prospects for UBC (Upgraded Brown Coal) Technology*
- **Dr Nawshad Haque**, Research Scientist (Process Modelling)/Project Leader (Environmental LCA), CSIRO Process Science & Engineering - *Use of Life Cycle Assessment (LCA) to Evaluate Drying Technology and Mineral Processing*
- **Rohan Zauner**, Principal, Power and Energy Strategic Consulting, Sinclair Knight Merz - *Dried Brown Coal Project – How the "Due Diligence" Reviewer will look at it*
- **Arash Tahmasebi**, Visiting Research Fellow from the Key Laboratory of Advanced Coal and Coking Technology at University of Science Technology Liaoning, China - *China & Australia Research: Microwave and Steam Fluidized-Bed Drying of Low-Rank Coals*
- **Rod Touzel**, Global Director Power Networks, WorleyParsons (and Great River Energy) - *Evaluation of the DryFining™ Technology for Existing Power Units Firing Brown Coals*

A post-event survey amongst participants identified other topic areas of strong interest in low-emissions brown coal utilisation and endorsed the information sharing and international networking opportunities provided by BCIA's seminar series.

A seminar focussed on developments in Carbon Capture and Storage, to be held in early October in Melbourne, will be the subject of BCIA's next open seminar.

2013 BCIA Seminar Series

BCIA is a private, not-for-profit company with a mandate to co-invest with stakeholders in brown coal innovation and emissions reduction technologies, with the aim of securing a sustainable future for Australia's world-class brown coal resource.

As part of this activity, BCIA runs seminars on areas of interest to our membership and the broader community in regard to brown coal technologies and developments.

Following on from the success of BCIA's Coal Drying and Handling Expo, held in July, BCIA is planning three more seminars this year.

- **8 August, 2013**
BCIA Community Forum, Century Inn, Traralgon
Update on progress of R&D and skills activities
- **8 October, 2013 (TBC)**
Carbon Capture and Storage Seminar, Melbourne
"Reducing Emissions from Brown Coal Use – What's Possible and What's Coming"
- **5 - 6 December, 2013 (TBC)**
Gasification Course & Seminar, Melbourne
"Value-Added Products from Brown Coal – Gasification, Pyrolysis and Beyond" followed by a one-day course on gasification technologies

BCIA's Community forum will provide an update on BCIA's activities and programs. It will provide an opportunity for the community to see what may be possible for brown coal use in the future, and to highlight issues and opportunities that they see. Speakers will be BCIA Chair, Gerry Morvell and Chief Executive Officer, Dr Phil Gurney.

BCIA's aim in running the remaining two seminars is to both educate and inspire a range of brown-coal stakeholders in what is possible today, and what the future may hold with regard to low-emissions coal developments.

It is hoped that these seminars can be a focal point to bring together the right people to envision the next generation of low-emission brown coal developments. The seminars will include a broad mix of industry speakers and researchers, and will explore what could be deployed today, what is coming, and what the future will hold for utilisation of Australia's brown coal.

We will keep you updated on these events as information becomes available.

PAGES 9 & 10

What's News at BCIA?

SKILLS, NETWORKS AND STAKEHOLDER RELATIONS

BCIA seeks to engage with the community on new developments in brown coal utilisation. In addition to running our own seminars (see article page 7), during July BCIA sponsored the screening of the documentary movie "Switch" at the University of Melbourne. Switch is intended to provide a balanced view of the various energy sources available and their potential for large-scale deployment to achieve a low-carbon economy.

One of the key messages in Switch is that there is no general energy solution that will work in every country. For example, Norway relies 100 per cent on hydroelectric power and France uses 80 per cent nuclear power. In the USA, it was suggested that a combination of shale gas, nuclear, solar and wind energy could replace the coal and oil used for energy production in about 50 years. In each case, the energy mix depends on the natural resources available, strategic security concerns and an ability to pay for innovation.

Another message in Switch is that no one technology can provide a complete solution to the problem. Renewables are mostly intermittent, so we need reliable sources of energy such as fossil fuels in the mix as well. It was also made clear that transitioning to a low-carbon economy will be very expensive, no matter which option is chosen. If we wish to make the transition as quick and painless as possible, we need to look at how we can leverage our most abundant natural resources.

RESEARCH AND DEVELOPMENT

BCIA supports research on technologies that can help the Latrobe Valley transition to a low-carbon economy, preferably while preserving the welfare of the local community.

Our focus is on promoting technologies that can use brown coal in an environmentally responsible fashion. This includes increasing the efficiency of brown coal power production to reduce CO₂ emissions, and coal-to-power options that are more flexible and suited to integration with renewables.

We also have a strong focus on development of new, value-added products from brown coal that can support new job-creation opportunities beyond power generation. The future development of brown coal is likely to be strongly linked more to these new opportunities.

A key part of our strategy is to link the use of brown coal with permanent sequestration of the resulting CO₂ emissions. The International Energy Agency (IEA) has stated that "No more than one-third of proven reserves of fossil fuels can be consumed prior to 2050 if the world is to achieve the 2 degree Celsius goal, unless carbon capture and storage (CCS) technology is widely deployed."

In Victoria, we are fortunate in having the largest and best potential CO₂ storage reserve in Australia, in the Gippsland Basin; very close to the power stations in the Latrobe Valley.

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The State government is supporting the development of commercial-scale carbon capture and storage (CCS) in the Gippsland Basin through its CarbonNet project (see article page 4).

With 90 per cent of Victoria's electricity produced from only four brown coal-fired power stations, the transition to a low-carbon economy could be relatively straightforward. There is potential to maintain continuity of electricity supply while progressively reducing Victoria's greenhouse gas emissions.

BCIA is supporting the development of CCS technology by funding research on a number of projects involving CSIRO, the CO2CRC and the local power generators. The aim of these projects is to help reduce the cost of CCS, so that it will be commercially viable more quickly. These projects also serve to train our local engineers in the skills needed for large-scale implementation of CCS in our power stations.

There is no good reason why brown coal cannot continue to be part of Victoria's low-emissions future, but this will only be achieved by embracing the opportunity offered by our local geological resources and actively developing our local expertise in CCS technologies.

BCIA will be holding a seminar on CCS on 8 October 2013 in Melbourne as part of our 2013 seminar series – see page 8 for further details.

COMMUNICATIONS

BCIA's e-newsletter, Perspectives on Brown Coal, continues to be well received. The second edition for 2013 was released at the end of May, featuring articles on the Australia-China workshop on Novel Carbon Capture, the Direct Injection Carbon Engine (DICE) project, and BCIA's workshop for early career researcher amongst others.

As part of BCIA's annual research seminar program, an update was provided on a number of BCIA-funded research projects during May at CSIRO in Clayton.

The seminar included presentations from Dr Abdul Qader, CO2CRC; Dr Trina Dreher, Process Group and Dr Lian Zhang and Assoc Prof Sankar Bhattacharya, from Monash University, covering the following topics:

- Dr Abdul Qader, Capture Facilities Manager, CO2CRC: 'Operation of the PCC pilot plant at GDF SUEZ Australian Energy's Hazelwood Power Station'
- Dr Trina Dreher, R&D Manager, Process Group: 'Pilot-scale results with the WES frother absorber'
- Dr Lian Zhang, ARC Future Fellow, Monash University: 'Pilot-scale oxy-fuel combustion of Victorian brown coal'
- A/Prof Sankar Bhattacharya, Associate Professor Chemical Engineering, Monash University: 'Development of chemical looping combustion for Victorian brown coal'

A Community Forum will also be held in the Latrobe Valley on 8 August to provide an update on how BCIA is funding research to drive the future of brown coal, highlights from BCIA's R&D program and an update on the outcomes of our recent skills activities. Go to BCIA's News and Events homepage for more details about the forum.

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BCIA hosted its first seminar and mini-expo on Coal Drying and Handling in June as part of a series of like seminars for 2013. The event was very successful with 125 registrations and great positive feedback, which will be used to assist in the delivery of future events.

Work is underway on the next event in this series on Carbon Capture and Storage to be held in Melbourne early October this year (details to be confirmed).

Chief Executive, Dr Phil Gurney, addressed the 38th International Technical Conference on Clean Coal and Fuel Systems held in Florida, United States in June, regarding challenges and opportunities for Australian brown coal development. Informally known as the Clearwater Clean Coal Conference, BCIA's low-emissions brown coal research and development was featured at the Florida forum for the first time last year.

As part of a large Australian contingent, BCIA-funded researchers, Dr Erik Meuleman and Dr Louis Wibberley, from CSIRO Energy Technology, and former BCIA Research Fellow and Conference Co-Chair, Dr Klaus Hein, also address the conference.

BCIA also sponsored the 10th Clean Coal Forum held in Beijing, China, on June 13 to 14. The Clean Coal Forum is Asia's premier event for low-emissions coal utilisation and the biannual conference attracts more than 300 domestic and international delegates and 40 exhibitors.

BCIA Membership

As a member-based company, BCIA undertakes a range of programs of interest to brown coal stakeholders including industry, research and education providers, governments and international coal technology organisations.

BCIA industry stakeholders encompass a broad range of sectors including coal-fired energy operators, original equipment manufacturers, companies involved in the conversion of brown coal to value-added products and services companies operating in the brown coal sector.

Membership enables BCIA's stakeholders to work with like-minded organisations to drive the future of the brown coal sector through active participation in our skills, networking and R&D programs.

BCIA is delighted to announce that Mantle Mining has joined as a member, extending BCIA's partner network.

On the next page, you can read about this edition's new member in the spotlight, Mantle Mining.

For more information about BCIA membership, contact info@bcinnovation.com.au

BCIA has updated our membership programs for 2013. Our current members include:



SPOTLIGHT ON BCIA MEMBER

Mantle Mining Corporation Limited

Mantle Mining Corporation Limited (Mantle) is an Australian based minerals exploration company focused on the exploration and development of coal and gold deposits in Eastern Australia. Mantle was incorporated in 2003 and listed on the ASX in 2006. Mantle's senior management has been directly involved in the Victorian brown coal industry for over 10 years and the Australian black coal industry for over 30 years. Mantle's contacts for the Victorian projects are:



Ian R. Kraemer – B.Sc., M.Sc., FAusIMM, Managing Director

Ian has an extensive background in the resources sector with over 20 years' professional experience in the exploration, acquisition, construction and operation of diverse mining projects in the coal, gold and nickel sectors. Ian has had lengthy experience in Australian and US coal mines and holds First and Second Class Coal Mine Manager's Certificates in QLD and NSW.



Mark Maxwell – B.Sc., M.E.C., MAusIMM, Exploration Manager Coal

Mark has over 20 years' experience in the operation and maintenance of coal fired power stations and more recently 9 years' experience in the coal mining industry and Geological Survey of Queensland as a coal geologist, technical services manager and project leader (geothermal and carbon geo-sequestration drilling).

Mantle's principal activities are to acquire exploration tenements and locate economically developable deposits of coal and gold. It is Mantle's intention to progress these mineral deposits through feasibility and into mining operations, to the benefit of all stakeholders. The Company has 6 exploration projects spread across Victoria and Queensland (Figure 1).

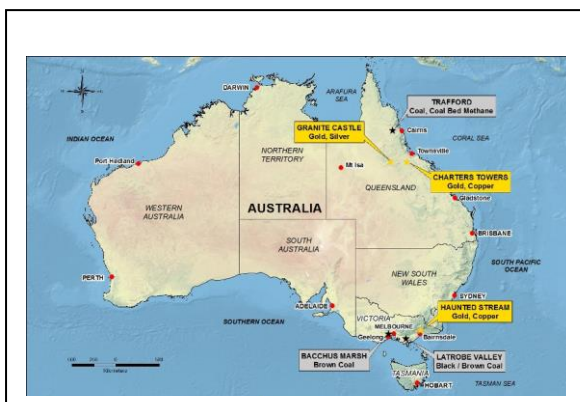


Figure 1 – Mantle's project locations

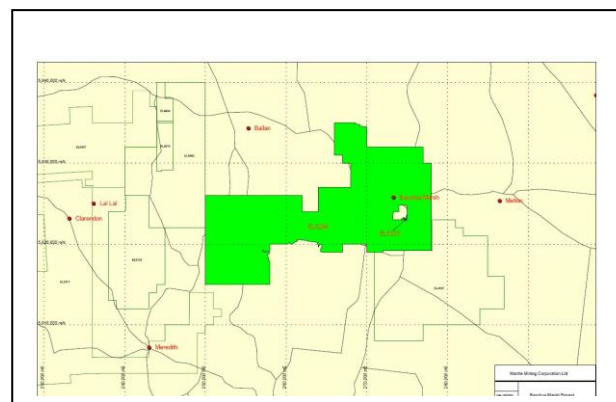


Figure 2 – Bacchus Marsh tenements

PERSPECTIVES ON BROWN COAL

THE NEWSLETTER OF BROWN COAL INNOVATION AUSTRALIA

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Two of these projects are focused on reduced emission, domestic and export, brown coal upgrading in Victoria. The Bacchus Marsh coal project, located approximately 50 km north of the port of Geelong, and the Latrobe Valley coal project, located approximately 150 km east of Melbourne, are considered by Mantle as being high priority pre-development projects of global significance.

Bacchus Marsh

At the Bacchus Marsh Coal Project, Mantle is focused on developing Australia's first brown coal upgrade and export project. Mantle completed a 15 hole diamond drilling program in June 2012, along with the associated sample analysis and resource modeling for the project. To accomplish its project goals at Bacchus Marsh, Mantle has also entered into a joint venture with Exergen Pty Ltd, a private Australian technology company. Mantle and Exergen now each hold a 50% interest in Exploration Licences 5294 and 5323.

Exergen has developed a breakthrough brown coal dewatering and upgrade technology called Continuous Hydro-Thermal Dewatering (CHTD). CHTD upgrades low rank coal with high moisture content in an economic and efficient manner, thereby adding significant value to those resources. Potential products from the CHTD process include upgraded pulverized fuel for local use, Direct Injection Coal Engine (DICE) fuel and upgraded coal/water slurry suitable for long distance transport or briquetting via a secondary pressing operation.

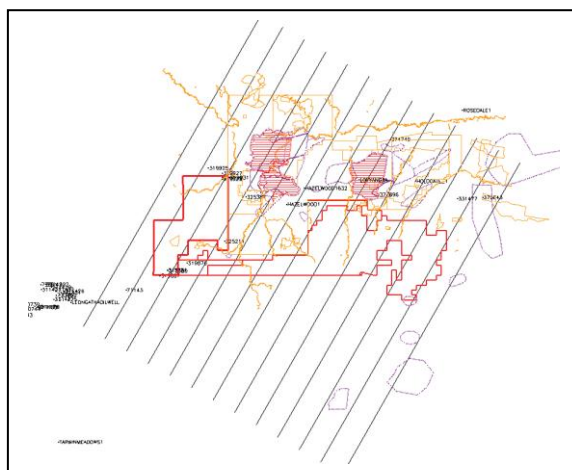


Figure 3 – Latrobe Valley tenements

Latrobe Valley

Mantle's Latrobe Valley Project tenements (outlined in red in Figure 3) are highly prospective for deposits of brown coal as well as containing deeper black coal deposits. Mantle seeks to partner with brown coal upgrading technology companies and apply that technology to develop domestic and export coal market opportunities from the resources available in the Latrobe Valley.

The Latrobe Valley brown and black coal deposits have been modeled with cross sections constructed for the section lines also shown in Figure 3. This data will assist in the current planning underway for exploration on the first granted tenement and for future work in the other tenements.

This work is leading into a holistic approach to exploration in the Latrobe Valley by accessing both near-to-surface brown coals and deeper underground black coals.

For more information visit www.mantlemining.com

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UPCOMING EVENTS

Calendar of Events

8 August 2013

Latrobe Valley Community Forum, The Century Inn, Traralgon, Victoria, Australia

Update on progress of R&D and skills activities. For more information visit BCIA's News and Events homepage.

14-16 August 2013

COAL-GEN 2013, Charlotte Convention Centre, Charlotte, North Carolina USA

COAL-GEN 2013 presents eight conferences in one. COAL-GEN is a dynamic event covering the latest topics affecting the design, development, upgrading, operation and maintenance of coal-fuelled power plants. Visit <http://www.coal-gen.com/index.html>

16-19 September 2013

Pittsburgh Coal Conference, Beijing International Convention Center, China

The 30th Annual International Pittsburgh Coal Conference focuses on environmental emissions issues and technologies surrounding the continued use of coal and the development of future coal-based energy plants to achieve near-zero emissions of pollutants, reduced costs, and high thermal efficiency while producing a suite of products to meet future energy market requirements. Visit <http://www.engineering.pitt.edu/PCC/>

24-26 September 2013

BIT's 2nd Annual International Symposium of Clean Coal Technology 2013, Xi'an Quijang International Conference Center, China

The theme of this conference is 'Changes from Black to Green'. Find useful creative strategies for the R&D of new technology; meet research workers from a variety of fields, and hear about latest research achievements concerning IGCC, CFBC, PFBC, coal conversion technology and clean coal technology. Visit <http://www.bitcongress.com/cct2013/>

29 Sept-3rd October 2013

International Conference on Coal Science and Technology, Pennsylvania, USA

This conference will look at all aspects of coal science and technology including, combustion, oxy-combustion gasification, liquefaction, coal-to-liquids, biomass co-firing, co-gasification, CO₂ sequestration, carbon capture, coal structure, coke, coal tar, coal bed methane, coal chemistry, and ash chemistry. Visit <http://www.iccst.info/live/index.php>.

8 October 2013

Carbon Capture and Storage Seminar, Melbourne

"Reducing Emissions from Brown Coal Use – What's Possible and What's Coming". Details to be confirmed.

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9-10 October 2013

All-Energy Australia 2013, Melbourne Convention & Exhibition Centre, Australia

This conference will co-locate with Australian Sustainability Conference & Exhibition and Waste Expo in 2013 to form Australia's most significant showcase for the clean energy, sustainability, waste and recycling industries. BCIA's CEO Dr Phil Gurney will be a panelist. Visit www.all-energy.com.au

22-23 October 2013

4th Annual Global CCUS Summit 2013, Beijing, China

Asia Carbon Energy announces its Global Carbon Capture Utilization and Storage Summit in Beijing, China. Over 150 major CCUS stakeholders will participate to address progress that has been made and challenges to be tackled in China and around the globe. Visit <http://www.a-carbon.com/incoming-events>

18-19 November 2013

10th Australian Coal Science Conference, Sofitel Brisbane Central Hotel, Brisbane, Australia

Hosted by the Australian Institute of Energy, the theme for this year's Conference is 'Solutions for Industry'. For all who are interested in the future of energy supply and the role of coal, this Conference will be a major event in the energy calendar. The Conference will bring together leading speakers from governments, industry and academia from around the world. Visit <http://www.coalscience2013.com/>

21-22 November 2013

11th Coal Deep Processing Forum 2013, Beijing, China

Large Scale Modern Coal Chemical Projects: Update and Planning Outlook - understand regulatory aspects for coal conversion and utilization and learn about new initiatives, projects and techniques to develop a deep understanding of the China coal industry and worldwide. Visit <http://www.cdmc.org.cn/2013/CDPF/index.asp>

4-6 December 2013

12th Clean Coal Forum Indonesia, Jakarta, Indonesia

This conference will keep you informed of the latest trends in Indonesia's coal market and understand where the smart money is headed. The conference will address the most critical industry issues affecting your performance objectives in Indonesia and globally, and will aim to help you gauge the pulse of this dynamic industry, and stay abreast of the most advanced clean coal technologies. Visit <http://www.cdmc.org.cn/2013/ccfi/index.asp>

5-6 December 2013

Gasification Course & Seminar, Melbourne

"Value-Added Products from Brown Coal – Gasification, Pyrolysis and Beyond" followed by a one-day course on gasification technologies. Details to be confirmed.

28 April – 1 May 2014

3rd International Low Rank Coal conference, Melbourne, Australia

This high level industry symposium will focus strongly on the issues, opportunities, challenges and project drivers facing the low rank coal industry globally. To register your interest contact symposium.2014@dpi.vic.gov.au