VOLUME 29 NO. 2 – JUNE 2011

ENERGY NEWS

OFFICIAL JOURNAL
OF THE AUSTRALIAN
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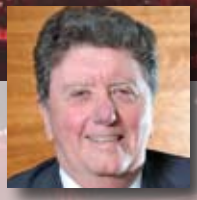

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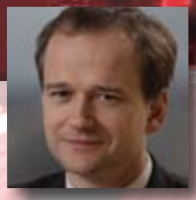

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ISSN 1445-2227
(International Standard Serial Number allocated by the National Library of Australia)

THE AUSTRALIAN INSTITUTE OF ENERGY
ENERGY NEWS

Journal Correspondence
Joy Claridge
PO Box 298
Brighton, VIC 3186
email: editor@aie.org.au

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Subscription Information

ENERGYNEWS is published by The Australian Institute of Energy and is provided to all members as part of the membership subscription. Non-members may obtain copies of this journal by contacting either the Secretariat or the Editor.

Contributions Welcome

Articles on energy matters, letters to the editor, personal notes and photographs of those involved in the energy sector are most welcome.

Published By

The Australian Institute of Energy
ABN 95 001 509 173

Registered Office
Level 1/613 Canterbury Road,
Surrey Hills VIC 3127

Postal Address
PO Box 193
Surrey Hills VIC 3127

Telephone Toll Free: 1800 629 945
Facsimile: (03) 9898 0249
email: aie@aie.org.au

Web Address
http://www.aie.org.au

Print Post Approved No. PP 32604/00001

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Cover: F-CELL World Drive in Sydney
Courtesy Mercedes-Benz

President's Message

Illuminating statistics

Tony Vassallo FAIE, President
Australian Institute of Energy

Keeping up with the flow of new information, data and trends is an important part of any profession. For the energy industry, this flow is becoming a torrent, with its position at the centre of studies concerned with mitigating carbon emissions, providing ever growing energy services and maintaining secure and affordable energy supplies. Close to home, the Australian Government recently released *Energy in Australia 2011*. This is a handy reference for anyone with an interest in Australian energy issues, with its detailed overview of energy in Australia from production to consumption.

For those that do not follow these numbers regularly, this update is well worth a look. For example, at A$57.5 billion, energy exports accounted for 34% of the value of Australia's total commodity exports in 2009–10, despite being down by 26% from $78 billion in 2008–09. Coal, at A$36 billion, is by far the largest contributor by dollar value. The major energy using sectors of electricity generation, transport and manufacturing, together accounted for more than 75% of Australia's energy consumption of 5.7 exajoules (1 exajoule equals 1000 petajoules). Australia is the now the world's ninth largest energy producer, at 17.8 exajoules, accounting for around 2.4% of world energy production.

The transport sector is the largest user of final energy in Australia. Around 34% of Australia's final energy use is employed moving people and goods around the country. The energy supply for this sector relies heavily on imported oil and fuel, costing the Australian economy more than A$15 billion in 2009–10, largely as a result of about 70% of refinery feedstock being sourced from imports.

Despite Australia's enviable fossil fuel resources such as coal, gas and coal seam methane, the challenges for our policy makers are signficant. All near-term and long-term energy supply options have their difficulties. With coal and gas, there is a need to deal with carbon dioxide emissions, escalating global resource prices and, ultimately, finite reserves. With nuclear there are issues of cost, proliferation and waste disposal. With renewables the issues are scale, intermittency and cost. In addition, uncertainty over the future of a carbon price and uncertainty over the future of nuclear power after the Fukushima disaster continue to frustrate energy planners and investors in Australia. There are no easy solutions.

The role of renewable sources of energy in Australia will most certainly expand strongly in the coming decade and beyond. According to the US Energy Information Administration, the capital cost of renewable technologies is coming down, with estimates that onshore wind and geothermal power coming onstream in 2016 will be cheaper than new nuclear or advanced coal, and about the same as new conventional coal plant. Photovoltaic module prices have dropped to below US$1.50/watt much sooner than many in the industry anticipated, substantially lowering the lifetime cost of electricity from PV.

Given the likely growth in renewable sources of electricity, we had better start planning to manage the issue of intermittency. While some in the industry see intermittency as an ongoing downside for renewables, others believe that energy storage is the obvious solution, even if the technology is still in its infancy. The achievement of affordable, effective, large-scale grid-connected storage is becoming one of the great scientific and engineering pursuits of this decade.

Globally, energy consumption is set to increase strongly. As Shell has shown in its updated *Shell Energy Scenarios to 2050 – Signals and Signposts*, underlying global demand for energy by 2050 could triple from its 2000 level if emerging economies follow historical patterns of development. To meet this growth, "New energy technologies must be demonstrated at commercial scale and require 30 years of sustained double-digit growth to build industrial capacity and grow sufficiently to feature at even 1–2% of the energy system." The article goes on to point out, "The policies in place in the next five years shape investment for the next 10 years, which largely shape the global energy picture out to 2050. Speed and direction are significant. How fast will tensions rise? How fast can we make the right choices? And how quickly can positive developments happen?"

Some in the industry believe that our energy policy makers at both the state and federal levels have been asleep at the wheel. While this might be a harsh view, the industry needs a strategic approach more than ever before.

Tony Vassallo FAIE

Australian Government energy announcements

- A forum of Climate Change Commissioners met in Parliament House on 24 May 2011 to discuss climate change policy. The Commissioners are Members of Parliament, Senators and invited members of the public.
  www.climatechange.gov.au
- GM Holden received A$40million in grant funding the Green Car Innovation Fund for the 'greener' Holden Commodore upgrade project. Applications have closed due to reallocation of budget to the Flood Levy.
  www.innovation.gov.au
- The Climate Commission has released its report *The Critical Decade: Climate science, risks and responses,* which is a comprehensive synthesis of the most recent climate change science, with a focus on the Australian context.
  www.climatechange.gov.au
- Shell has decided to proceed with the development of Prelude – the world's first floating LNG project. This will be the largest floating structure ever built and the project will add over A$45 billion to Australia's GDP.
  www.ret.gov.au
- Terms of reference have been released to guide the development of a new strategy aimed at making household gas appliances safer.
  www.mce.gov.au
- CSIRO has provided cost-effective technologies to support the Nissan Motor Company development of the LEAF electronic car in Dandenong, Victoria.
  www.csiro.au
- The seventh meeting of the Multi-Party Climate Change Committee met to discuss: stakeholder engagement process, updated Treasury modelling and agreed to release a number of papers prepared on the debate.
  www.climatechange.gov.au
- A Household Assistance Working Group, hosted by the Parliamentary Secretary for Climate Change and Energy Efficiency, looked at the design of a package that the government will deliver with a price on carbon.
  www.climatechange.gov.au
- A review of the potential benefits and risks associated with the Carbon Farming Initiative has been undertaken by CSIRO.
  www.csiro.au
- A$5 million in funding has been awarded to James Cook University in Townsville as part of a package under the A$20 million Australian Biofuels Research Institute to look at algae as a source of biofuels.
  www.ret.gov.au
- Members of the Establishment Council of the Australian Biofuels Research Institute have been announced.
  www.ret.gov.au
- An *Emerging Renewables* program, with A$100 million in funding, has been established to provide lower cost, emissions-free energy for Australian businesses.
  www.acre.gov.au
- Two venture capital fund managers are being sought to lead the Renewable Energy Venture Capital Fund, which will assist Australian high-potential renewable energy start-up companies by making critical early-stage equity investments.
  www.acre.gov.au
- Two nuclear facilities in NSW will be safely decommissioned with funding of A$8.7million to ensure safety.
  www.innovation.com.au
- Funding of A$3.2 million has been set aside to help demonstrate how coastal communities can adapt to climate change. The investment supports local governments, infrastructure operators and utilities make planning and investment decisions.
  www.climatechange.gov.au
- Blacktown City Council has unveiled a 50 kilowatt grid connected electricity system at the council depot. Funding has been provided through the Solar Cities program.
  www.climatechange.gov.au
- A Land Sector Working Group has been established to review the impact of climate change on farmers and landholders in rural and regional Australia.
  www.climatechange.gov.au
- An Australia–China alliance is underway to increase the efficiency of photovoltaic solar cells and make them cheaper. Funding has been provided through the Australia Solar Institute.
  www.australiansolarinstitute.com.au
- Evans and Peck has been awarded the contract to undertake the Western Australia Regional Renewable Energy Assessment. The assessment will look at renewable opportunities, including providing a solution to rural properties.
  www.acre.gov.au
- The Home Insulation Safety Plan will wind down once a minimum of 150 000 homes with non-foil insulations is reached – expected in mid 2011.
  www.climatechange.gov.au

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Project Spotlight

Kogan Creek Solar Boost Project

Carbon-free capacity expansion

CS Energy's coal-fired supercritical Kogan Creek Power Station near Chinchilla in southwest Queensland will add a solar thermal array to boost the electrical output by 44 MW. For the same amount of coal, the Kogan Creek Solar Boost Project will increase the output of the power station from 750 MW to 794 MW – the maximum continuous overload capacity of the existing steam turbine. This solar project is the largest in the southern hemisphere and the world's largest solar integration with a coal-fired power station.

CS Energy – a Queensland Government-owned electricity generation company – owns and operates four power stations that together can generate more than 3000 MW of electricity from a combination of black coal, natural gas and landfill gas. (Total capacity will change from 1 July 2011 with the reallocation of assets from three state-owned generating companies to two.)

Kogan Creek Power Station is the newest of CS Energy's generating assets. It contains the largest single generating unit in Australia and has one of the lowest environmental impacts, with low levels of water consumption and relatively low greenhouse gas emissions.

Kogan Creek Power Station

CS Energy – with the support of the Australian and Queensland Governments – is working on reducing carbon emissions across its portfolio. CS Energy's Carbon Management Plan, aimed at significantly reducing the greenhouse gas emissions of its operations, includes the Callide Oxyfuel Project – demonstrating how carbon capture and storage can be applied to an existing coal-fired power station – and the Kogan Creek Solar Boost Project – showing how renewable and conventional electricity generation technologies can be successfully integrated. After the addition of the solar boost, the already high overall efficiency of Kogan Creek Power Station will be further improved.

SPECIFICATIONS

Project location:	SW Queensland
Output capacity	44 MWe (peak)
Technology	AREVA Compact Linear Fresnel Reflector (CLFR)
Cost of construction	A$104.7 million
Completion date	2013

AREVA's CLFR technology uses modular flat reflectors to focus the sun's heat onto elevated receivers, which consist of a system of tubes through which water flows. The concentrated sunlight boils the water in the tubes, generating high-pressure superheated steam for direct use in power generation.

AREVA's solar CLFR technology

At Kogan Creek Power Station, the solar array will produce steam that will be used directly in the turbines. Although the steam from the solar array is under high pressure, it is not sufficiently high to be used in the high-pressure turbine. The solar-generated steam will join the steam as it returns from the high-pressure turbine to the boiler for reheating, before continuing on to the intermediate-pressure stage.

This direct use of steam in the turbine (rather than using the steam to heat feedwater as it enters the boiler) makes this project both innovative and challenging. Engineering, management and technical specialist Aurecon has been appointed Owner's Engineer for CS Energy to review the design and oversee the construction of the steam cycle integration with the existing power plant.

ENERGYNEWS asked Aurecon's Power Generation Leader for Queensland, Dr Prabir Halder, why CS Energy chose this design option and how these challenges will be met?

Q. Firstly, what will Aurecon's role be in the Kogan Creek Solar Boost Project?

A. Aurecon will be providing CS Energy with owner's engineer services, which will include a range of design reviews, as well as project and contract management services during the construction phase. This will include mobilising staff to site for the construction and commissioning phases, coordinating and inspecting the works and conducting witness testing with CS Energy.

Q. Why has CS Energy chosen to feed the solar field steam directly to the turbine?

A. Channelling the solar field high-pressure steam directly into the main turbine raises the overall efficiency of the plant by making the best use of the steam output from the solar field. The operating cost for the solar array is minimal – all the costs are up-front. So the aim is to reach the maximum capacity of the power station turbine while minimising capital expenditure on the solar array. That means feeding in steam directly into the turbine cycle, which is a more challenging engineering task. It is also why power stations around the world are watching this project. It is the first of its kind and there is a lot of interest in the successful integration of the 44 MW boost with fewer solar units and at a lower cost.

Q. Why is steam such a challenge?

A. Simply, working with steam is always more difficult than working with water. However, it is the integration with the existing power station that is such an engineering challenge. If we were building a stand-alone solar thermal power station, we would match the turbine to the solar array. At Kogan Creek, it is the other way round – the conditions of the steam coming from the solar array must be matched to the existing coal-fired steam turbine cycle. As part of the design review, improvements have been made to the design during the preparation for the construction phase.

Q. Is this the only integration challenge?

A. No. We also have the issue of where, when and how to connect the solar system to the existing power station. Kogan Creek is an operating power station and it cannot shut down for a long time. Everything will be kept ready, with redundancies in the system, so that when the shutdown occurs, everything can be connected at once. This is being addressed by the design team. The aim is to connect very quickly.

Further, the control system is crucial. The power station and the solar array need to 'talk to each other' as the solar output varies. The power station has to be controlled for intermittency, and this all has to be worked out in advance of commissioning.

Q. How will Kogan Creek's control system cope?

A. Kogan Creek is a new power station – one of the most efficient in Australia – and it has control system to match. This project would not be possible without a modern control system that allows the two systems to communicate and work together.

aurecon

Kogan Creek Power Station site with artist's impression of solar field

continued from page 31

- The National Greenhouse Accounts, including Accounting for the Kyoto Target 2009 have been published by the Department of Climate Change and Energy Efficiency.
  www.climatechange.gov.au
- CSIRO has discovered the first known detrimental impact of ocean warming on a fish species. These findings were published in the *Nature Climate Change* journal.
  www.csiro.au
- Energy Ministers from around the world have agreed to proposals to help speed global deployment of carbon capture and storage.
  www.mce.gov.au
- Australia elected to the International Renewable Energy Council.
  www.ret.gov.au

ENERGY IN THE FEDERAL BUDGET

OUT

- National Solar Schools Program, which has supported over 2,600 schools, will close two years early.
- The Fringe Benefits Tax scheme has been modified to remove the tax incentive for extended driving promoting high carbon pollution.
- Reduction in funding for the Carbon Capture and Storage Flagships program.
- Cancellation of the Green Start program to support householders reduce energy consumption.
- Early end to the Green Car Innovation Fund.
- End to the 'cash for clunkers' program.

IN

- A$53.2 million in additional funding over four years for the Office of the Renewable Energy Regulator to administer the new responsibilities under the Renewable Energy (Electricity) Act 2000.
- Additional funding of A$13.7 million for the Solar Cities program to complete the program objectives.
- A further A$20.2 million to support the delivery of the National Greenhouse and Energy Reporting Act responsibilities.
- A$13 million to support energy efficiency initiatives identified under the National Strategy on Energy Efficiency.
- A$100 million for the Renewable Energy Venture Capital Fund through to 2024.
- Additional funding of A$40 million for the Emerging Renewables program.

From our Canberra correspondent, Anntonette Joseph MAIE, Environmental Resources Management

Energy 2031
WA Strategic Energy Initiative

Seminar and workshop hosted by AIE Perth Branch and the Western Australia Office of Energy on 19 April 2011.

Western Australia's energy consumption has doubled during the past two decades and how we meet our growing energy needs in the future is a critical issue.

In August 2009, Minister for Energy Peter Collier announced that the government would outline a vision and broad plan for the energy sector for the next 20 years. The Strategic Energy Initiative project – *Energy2031* – is now well along the path towards achieving this aim.

Energy2031 has four strategic goals:

1. **Secure Energy** – making sure investment in Western Australia's energy supply resources and infrastructure is sufficient to meet the future needs of our economy and our community.
2. **Reliable Energy** – making sure our energy supply is of a consistently high quality and delivered with minimal disruption.
3. **Competitive Energy** – ensuring a transparent, stable, market-based regulatory environment to deliver competitive energy prices for consumers and an attractive environment for energy investors.
4. **Cleaner Energy** – means energy production and consumption that minimises carbon emissions and is compatible with sound environmental stewardship.

An Issues Paper was released in December 2009 to seek the views of community and industry stakeholders on the key issues affecting the energy sector. This was followed by an extensive consultation process which resulted in 67 written submissions and 14 workshops held across the state.

Among the main issues and challenges raised were:

- removing impediments to, and promoting, alternative fuels and technologies
- ensuring ongoing gas availability in a globally competitive market
- managing climate change mitigation measures and impacts on the energy sector
- coordinated planning of energy infrastructure investment
- ensuring the reliability of energy supply across the supply chain
- limiting exposure to energy cost increases
- slowing the growth of energy demand and improving energy efficiency
- ensuring that regulated prices reflect the costs of supply to support the ongoing availability of those services
- providing transparent support mechanisms to secure social and regional objectives without market distortion.

The issues were considered and assessed and developed into the next important stage – the *Energy2031 Directions Paper*, released in March this year. This paper outlines a vision of a smarter energy future. In this future, energy use in our homes and businesses is more efficient; we make use of intelligent technology; and more energy is derived from low carbon sources. In addition, the paper points toward a more competitive energy marketplace, and a more efficient transmission system linking energy sources to consumers.

Smart energy supply

Consumption starts with end users, but the supply chain starts with the way in which we obtain our energy from its source. Western Australia is unique in the wealth and diversity of its energy resources and also in its distance from other energy networks. Over the coming years, our energy system will continue to operate largely in isolation from other energy networks. Our choice of energy sources will determine the security and cleanliness of our energy system. The key initiatives to achieve smart supply are diverse sources and competition.

Smart energy delivery

Significant gains can be made with the critical linkages between our homes and businesses and the sources of our energy supply. In most cases, our energy is usually consumed some distance from where it is produced. It must be conveyed to users either in its physical state (gas, liquid fuel) by pipeline or vehicle or in its transformed state (electricity) by wires. In the future, the electricity to power our buildings, and increasingly our transport, will be supplied by a network based on more sophisticated technology. The key components to achieve this are:

- two-way interaction in both energy flow and information flow
- dispersed embedded generation within the grid
- capacity for new transport technology such as electric vehicles.

Smart energy use

Real change starts with the way that we use energy. In the future, consumer choices about use of energy in the home, businesses and for transport will be strengthened by knowledge and technology that allow us to make decisions on energy use that minimise the cost and consumption of energy. The key requirements to achieve this are:

- inform users
- link prices to costs
- spread the load
- reduce the demand.

Smart energy planning

Lasting benefits come from being adaptable and innovative. Our future involves larger population and economic growth serviced by smarter energy systems. We need to ensure that investment in our energy infrastructure is targeted to service these changing needs. The keys to achieving this are:

- coordination of long term infrastructure provision
- education and training in the delivery of energy and energy services
- efficient, flexible regulation and policy frameworks equitably administered within a market environment.

Project leader Dr Paul Biggs says that the Office of Energy understands that this vision will require actions right across the energy chain. "We need to develop smarter systems for the supply, delivery, use and planning of our energy resources," he said. The directions paper proposes a series of strategies structured around six major themes:

- promoting security and diversity in energy supply and fuels
- ensuring efficient provision and utilisation of energy infrastructure
- improving the energy efficiency of the Western Australia economy
- maintaining continuity of downstream energy supply
- ensuring effective and efficient downstream energy markets
- ensuring universal access to essential energy supplies.

From March to May 2011 the Office of Energy has been actively seeking feedback on the to help inform the government in deciding upon the final strategies to be included in the 20-year plan. The second round of consultations included a range of community and industry forums. Sessions were held with the Chamber of Minerals and Energy, Chamber of Commerce and Industry; Western Australian Council of Social Services; Australian Institute of Energy; Economic Regulation Authority; Sustainable Energy Association of Australia; Australian Petroleum Production and Exploration Association; the Western Australian transport sector and Sustainable Energy Now.

Regional perspectives have been actively sought with forums and video conferences held in Albany, Esperance, Geraldton, Kalgoorlie and Port Hedland. Regional Development Commissions have also been an important source of advice.

An Office of Energy project team is now reviewing the results of the recent forums and analysing formal submissions received. The team will continue to work with an Industry Reference Group and an Inter-Agency Group of cross-government representatives in order to develop the final strategic plan for Western Australia's energy future. The final strategy is due for release by the end of 2011. For more information visit www.energy.wa.gov.au/energy2031 or contact the Office of Energy on (08) 9420 5600. EN

Biofuels: Future energy source?

Presentation by Dr Victoria Haritos, Stream Leader–Biofuels, CSIRO Ecosystem Sciences; Richard Marshall, Director Energy and Environment, GM Holden; and Mathew Nelson, Partner–Climate Change Team, Ernst & Young, to AIE Melbourne Branch on 30 March 2011.

Article written by Joy Claridge, based on presentations.

TECHNICAL OVERVIEW

In Australia, biofuels comprise less than 1% of total fuel needs. First generation technologies, although mature, are limited by capacity constraints and concerns over their impact on food prices. However, they represent a platform for the development of second generation technologies.

The major drivers towards the development of alternative fuels are:

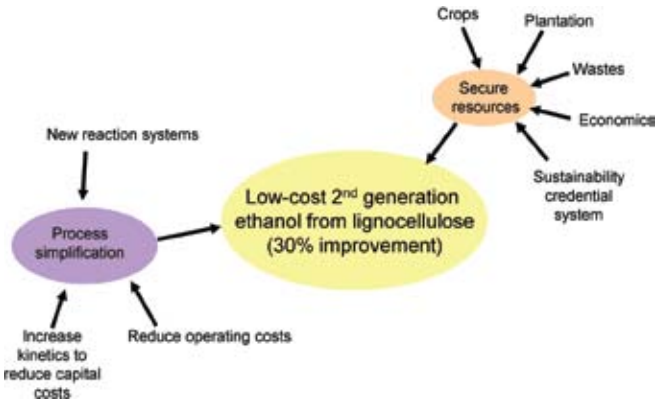
- fuel security – according to work by CSIRO, current lignocellulosic stocks could supply 34% of Australia's fuel requirements.
- environmental benefits – reduced greenhouse gas emissions of at least 80%, depending on source of biomass; other benefits include salinity reduction; biodiversity and air quality improvements.
- import replacement – annual petroleum import costs will rise from A$14 billion now to currently to A$70 billion by in 2030 unless alternative sources are deployed.

The biofuels energy value chain is more complex than for petroleum fuels. Second generation lignocellulosic technologies to generate liquid fuels from agricultural residues; wood waste, newsprint, grasses, and municipal waste involve pre-treatment and conversion prior to fuel production. Similarly, microalgae are harvested, converted to lipids, which are processed to make fuel by transesterification, catalysis or other methods. The process challenges are costs and energy requirements. Although successful at pilot scale in the United States and Europe, there are barriers to commercial scale development including:

- volatility around the crude oil price
- availability of capital for investment
- government policy support
- uncertainty in new technology
- competing technologies for investment
- biomass availability and industry sustainability
- technological and efficiency barriers.

CSIRO research focuses on technology, biomass feedstocks and sustainability, drawing on expertise across the organisation. The aim is to improve costs associated with ethanol from lignocellulose by 30%, while addressing issues of sustainability (land use change, water use, carbon offsets and tradeoffs, costs of production, biodiversity, social issues).

Research includes methods to improve enzyme conversion of Australian lignocellulosic sources through novel enzymes from fungi and termites. The recently formed biofuels research cluster (comprising CSIRO's Energy Transformed Flagship, Australian National University, RMIT University, University of Queensland and University of Manchester) is developing third generation enzyme-based processes for generating safe and sustainable transport fuels from waste plant material.



CSIRO research to reduce the cost of lignocellulosic fuels
Source: CSIRO

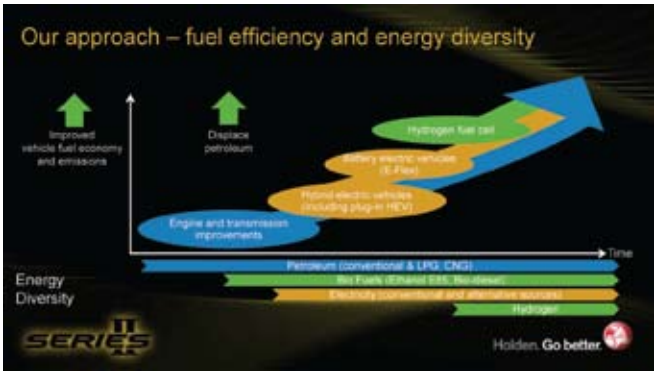
Australia has some competitive advantage in algal fuels – sunshine, salt water, non-arable land and unique genetic resources. CSIRO is addressing the major technical barriers of scaling up production. The focus is on yield, simplifying the process and costs. The challenge is in selection, growth and optimisation of algae for biomass and oil production. The National Algal Collection is housed at CSIRO Marine and Atmospheric Sciences in Hobart.

The work of the CSIRO extends to integration of knowledge and predictive modelling for future fuels, such as the recently published *Flight Path to Sustainable Aviation*. This report predicts that, over the next 20 years, a new sustainable Australia–New Zealand aviation fuels industry could cut greenhouse gas emissions by 17%, generate more than 12 000 jobs and reduce Australia's reliance on aviation fuel imports by A$2 billion annually.

Looking forward, some next generation fuels will be available at commercial scale in 5–10 years. Depending on the trajectory of the crude oil price, they are likely to cost competitive with oil within that period. However, the United States and parts of Europe are well ahead in research, development and implementation of advanced biofuels.

BIOFUELS IN CARS

According to the International Energy Agency, we need to find six Saudi Arabias by 2030 to meet ever increasing demand. Holden's approach combines fuel efficiency with energy diversity. We are bringing the Volt to Australia in 2012. GM has the largest fleet of fuel cell vehicles in the world (over 100 vehicles; accumulated more than 3 million miles). However, we see no silver bullet to solve the problem of sustainable transport. Many technologies will coexist in the market. Petrol and diesel will still be the main transport fuels up to 2030. LPG, LNG and CNG use will increase, and biofuels and electric vehicles will contribute to energy diversity.



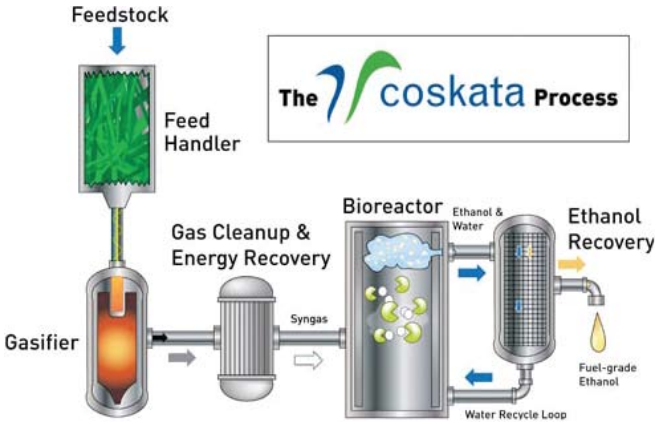
Fuel efficiency and energy diversity
Source: GM Holden

Australia has advantages in LPG, ethanol and CNG/LNG. LPG is readily available, with low running costs and reduced carbon dioxide emissions. CNG is also widely available, with even lower running costs, and reduced carbon dioxide and noxious emissions. Bio-ethanol (or E85 – up to 85% ethanol, 15% petrol) can be produced from household waste with no impact on food supply. For Australian-produced ethanol, E85 lowers emissions by up to 40%.

Fuel security is not given the attention it deserves. Holden envisages that ethanol could displace up to 30% of Australia's petrol requirements by 2030. This would require the production of up to 10 billion litres of ethanol.

In September 2010, GM Holden launched the Flex-Fuel Commodore, which can run on unleaded petrol, premium unleaded or any combination of ethanol–petrol from E10 to E85. The customer is the 'average Australian family'. Research indicates that, even though they want to help the environment, they don't want to pay more. The appeal is highest when there is no change to behaviour or increase in cost. Bio-ethanol is flexible, with no additional cost to purchase or service the vehicle. The higher octane when using E85 delivers more power and torque. E85 is sustainable when the ethanol is produced from agricultural and household waste.

To facilitate the development of the supply of E85, Holden has formed an alliance with Caltex Australia, Moltoni Energy, the Victorian Government and US-based Coskata to construct a plant capable of converting rubbish into 200 million litres of ethanol annually.



Coskata production process
Source: www.coskata.com

The Coskata process converts waste material to synthesis gas; ferments the syngas using anaerobic bacteria in a bioreactor; then separates and recovers ethanol. The process accepts a wide variety of feedstocks (municipal waste, tyres, agricultural residue, forest waste, bio-solids) producing fuel-grade ethanol that competitive with petrol.

Caltex has been marketing E85 as Bio E-Flex since September 2010, with dedicated pumps in Melbourne, Sydney, Brisbane, Adelaide and Canberra. There are now 35 participating service stations, increasing to 100 service stations by the end of 2011.

Holden is confident that the consortium will demonstrate second generation production and marketing. There is a lot of technology racing to commercialisation and the capital is there. There is no single solution to the complex challenge of supplying long-term sustainable mobility. Holden is taking a multi-path approach to finding solutions that address the issues of energy security, climate change, emissions and customer requirements.

THE ETHANOL MARKET

Within the next five years, ethanol demand in Australia is projected to grow by four to seven times. Conservatively, the market in the eastern states of Australia could be 1200 ML by 2014. Even after accounting for increases in capacity at existing plants, there will be a shortfall of about 300 ML. It is unlikely that this shortfall can be economically met without imports or the implementation of a second generation facility. Government support for the industry is still critical to drive demand and provide a basis for the competitiveness of Australian production.

Australia's ethanol production is concentrated in the eastern states, in particular New South Wales and Queensland. This is where the greatest growth in consumption has occurred due to the mandates in these states. Growth will be even faster if the proposed mandates of 5–10% are implemented, alongside the targets of 5% by 2013 in Victoria and Western Australia.

Based on projections by Ernst & Young, Australia could have a shortfall in fuel grade ethanol of between 329 ML and 619

ML within the next few years. This shortfall is only eased when new projects come onstream around 2014 and possible expansions at existing plants are progressed.

Australia is not alone in implementing biofuel targets (see Table 1).

Table 1: Targets for renewable content in transport fuels

United States	36 billion gallons per year by 2022
Canada	5% blend in gasoline by 2010; 2% in diesel fuel by 2012
France	10% renewable blend by 2010
Germany	8% biofuels content by 2015
United Kingdom	5% of transport fuel sales by 2010
China	10% ethanol blend by 2020
India	20% biofuels by 2017 (under consideration)
Japan	50 million litres of domestic production by 2011
Brazil	20–25% ethanol blend; 2% biodiesel

Source: Renewable Fuels Association, OECD and USDA
First published in "Destination ahead: the automotive industry in the era of climate change and sustainability –Asia spotlight edition" by Ernst & Young

The supply and quality of feedstock represents a defining factor in the ability to successfully develop ethanol production. Traditional feedstocks present issues of sustainability. Second generation plants that use different feedstocks are therefore critical to future production growth. In particular, new technologies to convert waste to biofuels are critical. Australia is not a priority market and international supply may not be available. For domestic production the location of waste is important – need to move it and process it.

EN

Advanced Nuclear Power Systems for Long-term Energy and Climate Security

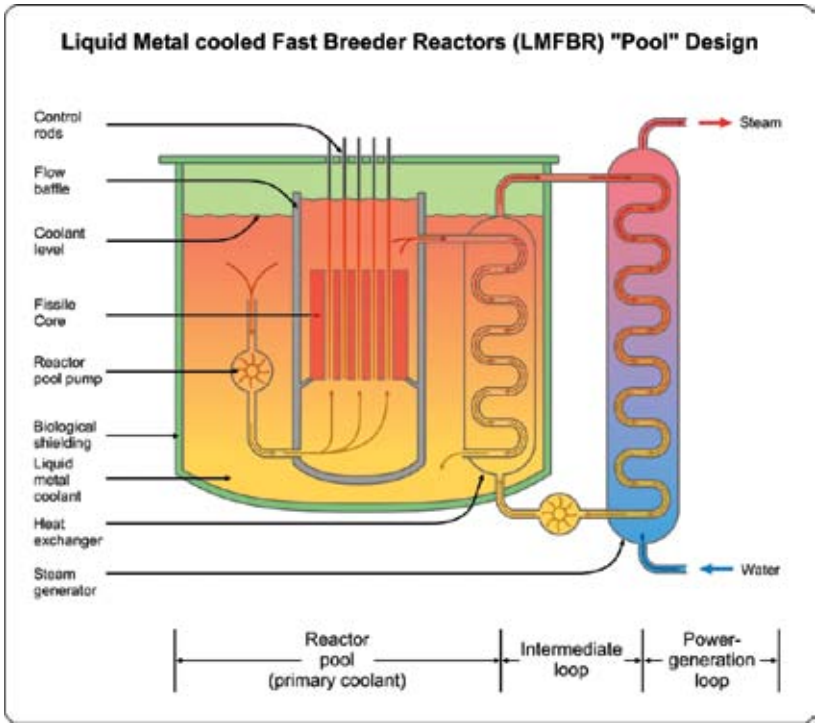
Presentation to joint event (Engineers Australia Sydney Division, the Academy of Technological Sciences and Engineering, Australian Nuclear Association, Nuclear Engineering Panel of Engineers Australia, Australian Young Generation in Nuclear, and AIE Sydney Branch) by Prof. Barry Brook, Centre for Energy Technology, University of Adelaide, on 10 March 2011.

An exciting new development in the nuclear power industry is the Integral Fast Reactor (IFR). This reactor differs significantly from the vast majority of the world's 440 commercial nuclear power plants that use light water as the coolant – Light Water Reactors (LWRs). The IFR design is the result of years of research work from an expert team of scientists assembled following the 1984 Three Mile Island accident. The research work aimed to solve the issues of public concern over nuclear power generation: safety, nuclear waste, proliferation, economics, fuel supply, fabrication and construction.

In a conventional LWR, the fuel source used is enriched reactor-grade uranium, which is the commonly occurring uranium U–238 enriched to about 3.5% uranium U-235 (the fissile content). The fission process in the reactor occurs when neutrons split the uranium U-235 atom into two smaller highly radioactive atoms releasing more neutrons and setting up a chain reaction. The chain reaction is controlled by using a moderator and control rods to regulate the number of neutrons in the reactor and absorbing any excess neutrons when the fission process becomes too fast. Once the uranium U-235 is used up, the fuel rods require replenishment and the highly radioactive spent fuel rods together with high-level waste must be removed and safely stored. The current uranium enrichment technology used

Pressurised Water Reactor, Gösgen Nuclear Power Plant, Switzerland

to produce reactor grade uranium fuel results in about 8–10 kilograms of depleted uranium (DU) for every kilogram of power plant fuel. As a result, the United States alone has large unwanted stockpiles of DU in excess of half a million tons. The IFR offers a reliable and certain way of utilising the energy remaining in these vast waste resources as well as spent fuel rods, as well as handling and safely storing the final waste, the radioactivity of which is significantly lower than with waste material from conventional nuclear reactors.



Schematic of a typical liquid metal cooled fast reactor

The quandary of long-lived nuclear waste is a non-issue since the fission products will decay below the radioactivity level of uranium ore within a few hundred years yet they will be embedded in a stone–glass matrix that will not leach into the environment for thousands of years. The long-lived actinides that cause so much consternation to the public when considering spent nuclear fuel will never leave the site of the IFR power plant (except in the case where new fuel is moved to start up a new IFR), but will instead be recycled back into the reactors, repeatedly, to produce prodigious amounts of clean energy, gradually all being transmuted into either electricity or fission products that pose no troublesome disposal problems. Moreover, all of the spent fuel that has accumulated from operation of past, present and future LWRs can also be consumed as fuel in an IFR; in short, they 'eat' nuclear waste.

The IFR design builds on earlier research work into fast nuclear reactors (breeder reactors). In a fast reactor, the neutrons are allowed to move at a considerably higher speed, and for this reason the fissile content of the fuel must be higher, at about 20%. Fast reactors usually use liquid sodium metal as the coolant, at or near atmospheric pressure, which avoids the need for pressure vessels. And because the boiling point of sodium is quite high, fast reactors can operate at a considerably higher outlet temperature of about 550°C, compared with LWRs. This results in a higher efficiency in the power generation loop.

In a breeder reactor, the reactor core is configured so that more fissionable fuel is created than is consumed with fuel replenishment only requiring the occasional addition of relatively abundant uranium U-238 (see Figure 1).

One of the most important features of the IFR is the use of the metal fuel consisting of uranium, plutonium and zirconium. Fuel fabrication is straightforward and if an accident occurs causing the core to overheat, the metal fuel would expand causing neutron leakage to terminate the chain reaction. Thus this type of reactor is inherently safe and this feature has been demonstrated on earlier experimental breeder reactors.

IFRs are capable of using spent LWR fuel and weapons grade uranium and plutonium as fuel as well as the millions of tonnes of depleted uranium that are available throughout the world. It is estimated that if humanity were to rely only on IFRs for all final energy, there would be no need to mine any more uranium for about 1,000 years!

The economics of IFRs will be attractive as the plants are less complex than conventional nuclear reactors. The expectation is that they will be competitive with almost any other type of power generation at a likely cost of less than the US$1200 per kilowatt (estimated by General Electric in 2000 for their more complex Advanced Boiling Water Reactor). IFRs could be standardised using a modular construction, which would allow their rapid introduction across the world within a relatively short time frame. There would be many advantages with this approach including low carbon footprints, energy security, impressive safety features of the new nuclear power plant designs, control of spent fuel and the use of the vast amounts of depleted uranium.

This opportunity should be a top priority in the coming decade if we are serious about replacing fossil fuels worldwide with sufficient pace to effectively mitigate climate change and other environmental and geopolitical crises of the 21st century.

For more information, see Prof. Brook's climate change and energy options blog/website at http://bravenewclimate.com

EN

Bottling Electricity

Presentation by Prof. Tony Vassallo, President, Australian Institute of Energy, and Delta Electricity Chair in Sustainable Energy Development, University of Sydney, and Dr Geoff James, Principal Research Scientist, CSIRO Energy Transformed Flagship, to AIE Sydney Branch on 4 April 2011.

Prof. Vassallo and Dr James focussed on integration of renewable energy into the electricity grid, 'peak shaving', and smart ways in which storage technology can be utilised for these applications at a relatively low cost.

Electricity is the only major form of energy that cannot be stored in large quantities. Therefore, electricity supply systems have to be designed to cope with maximum demand, even though this may only occur for a few hours every year. The lack of storage means that wholesale electricity prices in the NEM (National Electricity Market) can go as high as the current cap price of A$12 500/MWh.

Interest in energy storage has grown in recent years due to:

- advances in energy storage technologies
- increasing fossil-fuel prices
- deregulated markets for high-value ancillary services
- challenges in building and operating transmission and distribution networks
- development of mini-grid technologies and applications
- opportunities with intermittent renewable generators.

One of the limitations of renewable energy sources is that their output is highly variable. Using a storage capability in conjunction with a renewable energy source could reduce short-term fluctuations of output; allow dispatch during times of higher demand and prices; enable greater deployment of renewables without need for 'shadow supply'; and allow for lower transmission line costs by increasing line utilisation.

Possible future 50 MW facility using UltraBatteries
Source: Ecoult

The feasibility of using storage with renewables depends on factors such as electricity prices and the capital costs required to build and operate the storage facility. An example of an integrated battery and wind farm includes the Rokkasho Wind Farm in northern Japan.

The other main application of storage is managing peak demand (peak shaving). Peak demand is rising faster than average demand, and expensive network augmentation is required to meet fewer than 100 hours a year.

A 6400 MWh battery could meet the needs of the top 10% of demand in New South Wales. Importantly the storage facility does not need to be one large unit; it could be distributed across the network, as is the load. For example, New South Wales has approximately 650 zone substations, The 6400 MWh of storage could be met by each substation having 10 MWh of storage. If it were distributed across all distribution substations then barely 30 kWh of storage at each unit would be required.

Distributed storage really starts to get interesting with the potential to use the batteries in the growing electric vehicle (EV) market as a mechanism for managing peak demand. Assuming that EVs have 40 kWh batteries, it could take as few as 25 000 vehicles to supply 300 MW of power to the grid. Considering that Sydney alone has approximately 1.8 million vehicles, this represents a relatively small fraction of the potential EV population.

Five interacting components need to be considered in power systems that have a significant energy storage infrastructure: intermittent generation; despatchable generation; transmission and distribution; demand; and storage. The variability and correlation of renewable resources on regional, national, and international scales will determine reserve capacity requirements, some of which may be met by energy storage at supply-side or demand-side locations. Yet widespread adoption of energy storage is inhibited by the limited range of workable business models that presently exist for storage. The relatively high cost of energy storage is offset by the multiple applications that may be served by each installation: renewable energy and demand peak shifting, ancillary services, reserve capacity, market arbitrage, multiple network support roles, contingency support, and others. It is not easy in present deregulated energy systems to capture the benefits of these applications as a revenue stream for investors in energy storage. This situation is developing, as regulators and proponents recognise the importance of energy storage in low-emission power systems, and over the next few years the business case for storage should improve significantly through 'stacking' multiple benefits.

AIE Sydney Branch thanks the New South Wales Government Department of Trade and Investment, Regional Infrastructure and Services for its support in providing the venue for this event.

EN

Australia's future transport fuel options: Will South Australia have a role?

Presentation by Mike Cochran, CEO, Ecco Consulting Pty Ltd, to South Australia Branch on 14 April 2011.

Ecco Consulting provides marketing and commercial consultancy services to the oil, gas and resource industries, specialising in the oil, gas liquids, petroleum, biofuels and alternative fuels sectors.

Whether or not one is a believer that world oil production has or is about to peak, developed countries around the world are examining more closely their ability to meet future demand for transport fuels. Countries that have plentiful supplies of other energy resources such as natural gas, coal, biomass or oil shale are seriously reviewing their options for ensuring a sustainable supply of alternative fuels, that is, fuels and resources that can replace or supplement supplies of conventional transport fuels of diesel and petrol. Australia is fortunate to have access to alternative fuel sources. However, fuel imports continue to increase, and could soon reach as much as 45% of Australia's demand with the closure of the Clyde refinery. South Australia imports all its transport fuels, yet it has access to a range of alternative fuel resources.

Why alternative fuels?

The three key reasons for the development of alternative fuels are:

1. Fuel security and sustainability
   - Australia is becoming too dependent on conventional imported fuels
   - Australia has significant natural resources, such as gas, coal and shale, which should be utilised
2. Emissions advantages
   - Fuels should save on emissions
   - Preference for renewable fuels
3. Social and regional development
   - Assisting local industry and employment
   - Social benefits
   - Regional growth.

In terms of transport fuels security, Australia is self-sufficient in LPG but relies on imports of diesel and petrol. Imports increased after the Mobil refinery at Port Stanvac in South Australia was closed in 2003. They are set to surge with the pending closure of Shell's Clyde refinery in New South Wales. Although petrol sales are fairly stable, sales of automotive diesel increased 20% in the past four years, with imports growing rapidly to make up the shortfall of demand.

Alternative fuels

This presentation focuses on competitive alternative liquid fuels (see Table 1).

Table 1: Transport fuel classification

Engine/fuel type	Base conventional fuels	Competitive alternative fuels*
Spark/petrol	Petrol	Ethanol blended with petrol LPG
Compression/ diesel	Diesel	Biodiesel Synthetic (Fischer Tropsch) diesel from CTL, GTL, STL CNG LNG

** Excludes electric, hydrogen, DME and methanol alternatives*

BIOFUELS

There are two major types of biofuel – ethanol and biodiesel – and both are used primarily as transport fuel. Ethanol is an alcohol produced from sugars, starches, biomass or cellulose and is usually blended with petrol from 10% (E10) to 85% (E85). E10 can be used in most modern petrol engines without modification, while E85 is used in flex-fuel engines. Ethanol has a much lower energy content by volume than petrol. It is an oxygenate and, therefore, an octane enhancer. Australian ethanol production capacity in 2010 was 350 ML and production was 307 ML. APAC biofuel consultants estimate that E10 comprised nearly 15% of total petrol sales in 2010.

Biodiesel can be an ester for blending that is produced from oil crops, waste oil, animal fats, oil seeds (canola, palm, pongamia, jatropha) and (in the future) algae. However, this cannot be used as an aviation fuel. Biodiesel (or renewable diesel) can also be produced through a hydrogenation process from the same feedstock. Hydrogenated biofuel can be used for aviation. Biodiesel (ester) is blended with petroleum diesel in ratios from 2% (B2) to 100% (B100). Australian production capacity in 2010 was 286 ML, but domestic production was only 85 ML and 20 ML imported.

Of most interest are the next generation of biofuels – biodiesel from algae, which has high yield and generates valuable byproducts, and ethanol from lignocellulosic mass, such as crop residues, timber and municipal waste. Australia is very active in researching and developing next generation biofuels.

SYNTHETIC FUELS

Synthetic fuels are produced from syngas (coal/gas gasification), which is converted into a variety of products

including diesel, petrol/naphtha and jet fuel using the Fischer–Tropsch process. These fuels are sulphur-free, low in particulates and low in nitrogen oxides. FT fuels also have other quality characteristics that make them an attractive and valuable alternative to conventional fuels.

Coal-to-liquids (CTL) technology is unlikely to flourish in a carbon-constrained economy without some form of carbon capture. Underground coal gasification (UGC) is a process for storing CO_2 in the coal cavity after gasification. There are a number of CTL projects under development in Australia, but it remains uncertain if and when the projects will be realised and the actual volume of liquids that would be produced.

Gas-to-liquids (GTL) is based on the same technical path as CTL, and competes with LNG. There are no planned GTL projects in Australia, despite several being researched in the past.

Shale-to-liquids (STL) face the challenges of greenhouse gas emissions and environmental management in mining and processing spent shale. Oil shale is a light organic-rich shale that contains kerogen, which (when heated) yields a liquid hydrocarbon. Oil shale deposits in Eastern Australia contain a very large resource of recoverable hydrocarbon in accessible locations. Queensland Energy Resources is developing its Stuart deposit near Gladstone, with the aim of producing 100–200,000 bpd by 2030. QER's technology extracts oil at relatively low cost. The pilot plant is under construction and should commence production mid-2011.

In summary, synthetic diesels could build a foundation capacity to meet diesel demand between 2025 and 2040. However, according to ABARE, it is not anticipated that GTL and CTL technologies will significantly add to liquid fuel supplies in the period out to 2030. The barriers to entry for synthetic fuels include carbon management, customer acceptance; high investment costs; supply chain logistics; resistance by conventional fuel and transport chains; oil price risk, technical risks; government policy; and environmental issues.

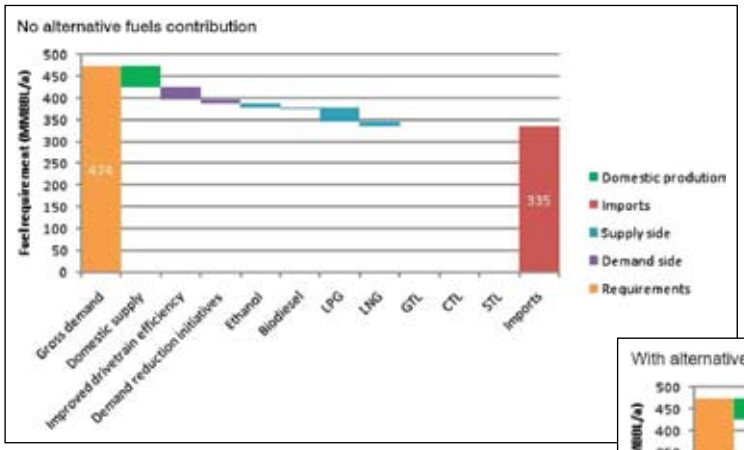
CNG

Australia large gas reserves and compressed natural gas (CNG) is an existing fuel used as a diesel substitute in some commercial vehicles fleets. CNG vehicles have a shorter range than diesel-fuelled vehicles, and refuelling is more complex. In Australia, more than 1200 buses in capital cities currently run on CNG.

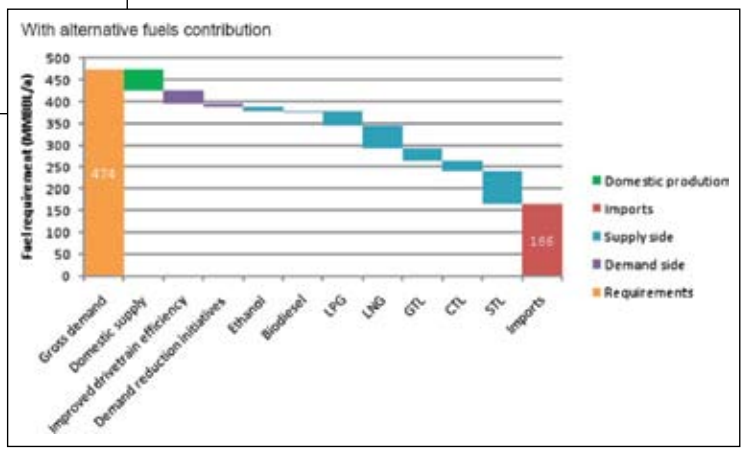
LNG

Natural gas in liquefied form (LNG) as an auxiliary or substitute fuel for diesel is a more recent development in Australia with the evolution of 'mini' LNG plants. There are currently three sources of domestic LNG accessible for line haul application – Wesfarmers in Western Australia, APA in Victoria and BOC in Tasmania. There are plans for the construction of additional 'mini' LNG plants in Australia. There is also a small network of refuelling stations in WA and Tasmania. Currently, there are about 240 trucks converted to LNG (mainly dual fuelled). Expansion has been slow, although one estimate indicates that, by 2030, LNG could replace as much as 30% of diesel in line haul applications.

The development of alternative transport fuels could halve Australia's imports of petroleum by 2030.



Fuel security in 2009



Fuel security in 2030

Source: EnergyQuest, ACIL Tasman, RARE, Purvin & Gertz, "Australia's Future Transport Fuel Supply Options", Study for Queensland Energy Resources, April 2009, with permission

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Retail Electricity Contestability: A Tasmanian perspective

In May 2005, the Tasmanian Government introduced competition for retail electricity sales in that state. Contestable customers are able to source their electricity from a retailer of their choice. Retail contestability has been progressively rolled out depending on annual electricity consumption, ranging from the state's large electricity users to business such as restaurants, large offices and service stations.

The government has yet to decide whether to extend retail contestability to residential and smaller business customers, and the issue has become topical both in the media and politically. The Australian Institute of Energy's Tasmania Branch is hosting a series of presentations that present the perspectives of retailers, regulators and customers.

30 March 2011 Cameron O'Reilly, Executive Director, Energy Retailers Association of Australia, provided a retailer perspective on the issue. Mr O'Reilly presented lessons learned at interstate and international levels and their potential applicability to the Tasmanian market.

Cameron O'Reilly, Executive Director, ERAA

20 April 2011 Chris Lock, Director, Economic Policy Branch, Tasmanian Department of Treasury and Finance, and Jane Hyland, Director, Office of the Tasmanian Economic Regulator, presented a regulator perspective on contestability in the Tasmanian retail market. This included the drivers for retail contestability in, the regulator's 2008 examination of the costs and benefits of full retail contestability, the outcome of the OTTER (Tasmania) survey of retailers in 2010, and the latest on the new tranche of contestability that will take effect on 1 July 2011.

Chris Lock and Jane Hyland answering questions

28 June 2011 Marc White, Goanna Energy, will provide a customer's perspective.

For further information regarding AIE events in Tasmania or membership please contact Patrick Burke, Tasmania Branch Chair at tas@aie.org.au

EN

Aussies win UK energy awards

The UK-based Energy Institute – sister association of the Australian Institute of Energy – awarded its EI Individual Achievement Award 2010 to Prof. Martin Green, Executive Research Director, Australian Research Council Photovoltaic Centre of Excellence, University of New South Wales (UNSW), and its Technology Award to UNSW/Suntech Power Holdings for Pluto technology – the world's most commercially successful solar cell.

The individual achievement award recognises that the dedication of one individual can make a tremendous impact on the industry and provide inspiration. In make this energy award to Prof. Green, the Energy Institute described him as "the father of modern photovoltaics", with the real world outcomes of his research revolutionising solar cell technology.

Prof. Martin Green

An extract from the publication, *EI Awards*, published in 2011, follows. For more information on these energy awards, visit http://www.energyinst.org/events/ei-awards

"He (Prof. Martin) has made unparalleled contributions to solar cell design, the uptake of photovoltaics technology and to the realisation of its benefits. His fundamental research achievements, as well as his incitement of major investment in the technology, has resulted in vastly improved cell performance and radically reduced production costs. The impact of his work is profound, with greatly increased expectations as to what is commercially possible with solar technology. Through his research and industrial application, photovoltaics has been transformed from a marginal technology to being the only truly viable alternative to fossil fuels to meet the growing global demand for energy in the next century.

"Martin's work has provided a viable solution to the greatest challenge of climate change –the delivery of a cost effective technology that has the ability to rival, and ultimately usurp, human reliance on fossil fuels. With the burning of fossil fuels and the resulting greenhouse gases now almost universally acknowledge as the cause of global warming, the need for an immediate change in our energy production/usage behaviour is imperative, with affordable, efficient solar cells being an important part of the answer.

"Whilst many of the innovations in alternative energy production worldwide remain experimental, Martin has had a 'real' impact in providing an alternative to coal-derived energy. This has been achieved not only by innovative design and development of cost effective solar cell technology, but by taking this technology out of the laboratory and into the factory. He has set many records for solar cell efficiency, but it is the major links with industry that has seen this work commercialised, put into real-world applications and start to make an impact upon fossil fuel reliance.

"As commercialisation has flourished through his innovations, Martin has maintained close, strategic partnerships with former students/research colleagues and forged strategic relationships with companies including BP Solar, the Centre's first major licensee; Pacific Power, a large local utility investing in his thin-film work; Q-Cells, who headed a European consortium to commercialise this technology; Roth and Rau, offering turn-key plant based on his recent work; and China-based JA Solar, Solarfun, Sunergy, Trina, Yingli and, most importantly, Suntech, who have revolutionised the photovoltaic industry and demonstrated how China can be a major force in the green industries of the future.

"None of this would have been possible without Martin's outstanding capacity to lead, influence and work closely with other researchers and industry leaders."

This EI Individual Achievement Award was sponsored by Expert Alumni. Chief Executive Jon Glesinger made the award, which was collected by Nicole Kuepper from UNSW. The EI Technology Award was sponsored by Premier Oil. The Australian Institute of Energy congratulates Prof. Martin Green, UNSW and Suntech Power Holdings.

EN

Having fun on the F-CELL World Drive

Mercedes-Benz F-CELL World Drive arrived in Australia on 29 March 2011. Your editor took one of the cars for a spin when the 'drive' visited Melbourne.

On 29 March 2011, after Europe and the USA/Canada, the third section of the F-CELL World Drive with the B-Class F-CELL cars commenced. Before flying to Australia the cars each covered around 10 000 kilometres on North American soil, with 18 driving days, three days of local events and numerous excursions for film and photo shoots. During this tour the participants were able to reduce the average fuel consumption of the B-Class F-CELL from the 1.18 kg of hydrogen per 100 kilometres achieved in Europe to just 1.15 kg. The fuel consumption record for the USA was 0.88 kg per 100 kilometres, corresponding to a diesel equivalent of less than 3 litres per 100 kilometres. Mercedes-Benz also used the tour to visit partner companies in North America. On 10 March the F-CELL World Drive paid a visit to the electric car manufacturer Tesla Motors, and also made a stop at the Automotive Fuel Cell Cooperation (AFCC) in Vancouver (Canada), which is developing the fuel cell stack for the B-Class F-CELL in cooperation with the Daimler research and development department in Germany. Mercedes-Benz also took this opportunity to announce future intentions in the field of electromobility: from 2013 the company will produce fuel cell stacks in its own plant in Vancouver (Canada).

During the F-CELL World Drive, three Mercedes-Benz B-Class F-CELL vehicles are passing through 14 countries and 4 continents – to drive around the globe once. Organised by Mercedes-Benz, the circumnavigation of the world started on 30 January 2011 in Stuttgart and was scheduled to last 125 days, until the vehicles return to Stuttgart again at the beginning of June, after covering a distance of some 30 000 kilometres. The aim of the tour is to demonstrate the technical maturity and suitability for everyday use of electric vehicles with fuel cells, and at the same time highlight the need for a comprehensive hydrogen infrastructure. The Stuttgart-based automotive manufacturer is being supported on the tour by Linde AG, which is responsible for supplying the hydrogen.

This is the second time that Mercedes-Benz brought fuel cell powered cars to Australia, as this locally emission-free technology was already used in Perth as part of the HyFLEET:CUTE STEP project. Three Mercedes-Benz Citaro buses with fuel cell drive were in operation in the city's urban public transport system between 2004 and 2007, where they demonstrated their reliability and performance potential by covering a total of over 261,000 kilometres in Down Under. "One major advantage of fuel cell technology is that it can be used in a wide variety of vehicles, from passenger cars to buses. Moreover, it is not only suitable for short distances that are for example covered in public transport, but also for longer distances," says Prof. Herbert Kohler, Head of E-Drive & Future Mobility in the Research and Pre-Development department, and Chief Environmental Officer of Daimler AG. "Fuel cell vehicles therefore have a great potential for CO_2 reduction over a wide range of mobility needs."

Mercedes-Benz B-Class F-CELL technical data

Drive	Electric motor with fuel cell
Rated output (kW/hp)	100/136
Rated torque (Nm)	290
Maximum speed (km/h)	170 (limited electronically)
Consumption (NEDC) (l of diesel equivalent/100 km)	3.3
Total CO2 (g/km min.–max.)	0.0
Range (km) NEDC	385
Capacity of lithium-ion battery (kWh/kW)	1.4/35
Cold-start capability:	to -25 °C

After a 13-day journey across the south of Australia, including detours to the famous Great Ocean Road, the stage of the F-CELL World Drive which is most distant from the final destination, ended in Perth on 10 April.

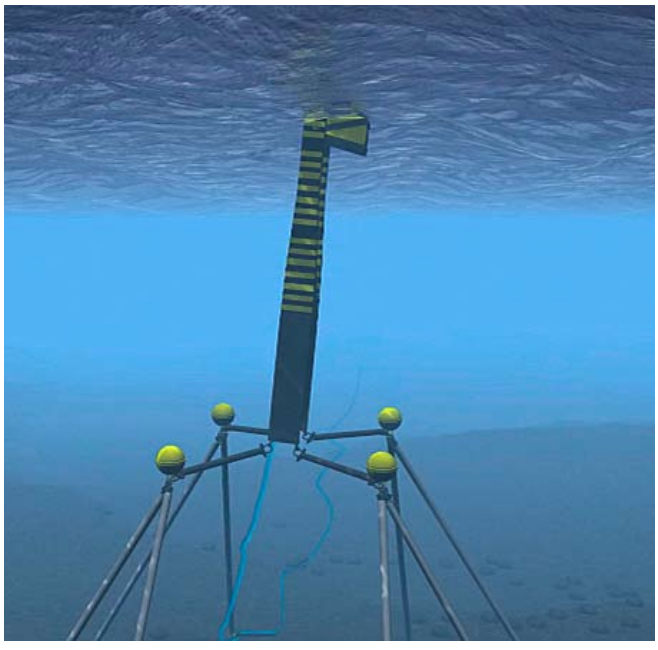
One of the objectives of the F-CELL World Drive is to draw attention to the need for the development of a global hydrogen infrastructure that will make the widespread introduction of locally emission-free fuel cell vehicles possible. To date there are only very few public hydrogen fuelling stations in the world, and this presents a major challenge involving great logistical effort during this unique round-the-world tour. Public fuelling stations have so far only been available at the starting point in Stuttgart and in Los Angeles. Therefore refuelling procedures for the F-CELL World Drive required very precise planning. Two refuelling teams accompanying the tour ensure that the mobile fuelling station is available for the B-Class F-CELL cars at around midday and in the evenings. The hydrogen required is directly transported to the fuelling station by Linde AG. It is fed into the mobile fuelling unit, where it is compressed to the nominal 700 bar pressure under which it is filled into the B-Class F-CELL. EN

New Zealand device points to the future of wave energy

*By Jeremy Cavanagh MAIE**

Just across the 'ditch', New Zealand has been quietly forging its own steady development of marine energy with six active projects so far. One such local project under development for eight years has the potential to extend existing wave energy extraction designs, attracting US Government funding for further testing and development of the project's point absorber wave energy converter design.

Point absorber designs have been around for a number of years, for example the mooted wave energy farm array for Portland in Victoria, where a partnership between Leighton Holdings and Ocean Power Technologies (OPT) plans to use OPT's point absorber wave energy device. However, point absorbers have always faced limitations in how much energy they can extract from sea waves due to limits on reciprocal movement between components from each passing wave. WET-NZ (http://www.wavenergy.co.nz/), a partnership between Wellington energy consultancy, Power Projects Limited (PPL), and Industrial Research Limited (a government funded research company) has found a novel way to extend these limits. Like other point absorbers, WET-NZ's wave energy converter consists of a spar and a buoy that generate reciprocating movement from passing waves so extracting energy. John Huckerby, a director of PPL, said that the difference is that in the partnership's design the buoy is able to move like a swing in 360 degrees in either direction enabling more movement and hence more energy to be gathered from each passing wave.



Artist's impression of full-scale WET-NZ wave energy device

WET-NZ has progressed from ocean testing two quarter-scale 2 kW devices in 2008 to building a half-scale device that will begin sea testing around August 2011. Under construction in New Zealand, it is 17 metres long by 3.5 metres in diameter, with a power output of 20 kW, and is designed to be deployed in under two days if conditions are good. Initial testing will take place off Wellington.

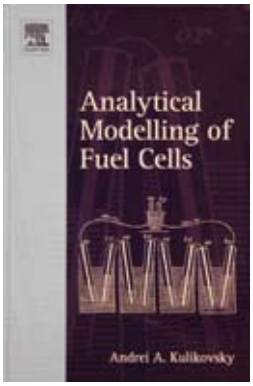
But it is WET-NZ's successful participation in a US Department of Energy Funding Opportunity Application in 2010, partnered with Pacific Energy Ventures of Portland, Oregon, that has attracted attention. Totalling over NZ$2 million, the joint venture – named Northwest Energy Innovations – will use the funding to carry out tank testing of 1:50 scale models in the US, as well the building of a separate half-scale device for ocean testing off the US. The resulting data will be used to guide and optimise the design for the eventual full-scale device.

On ocean survivability, WET-NZ had a statement of feasibility in 2010 from Det Norske Veritas, the global marine risk management experts. This has fed into design work, for example the half-scale device will be deployed with eight mooring points rather than four as originally envisaged. Manufacture can take place anywhere as most of the structure is relatively simple except for the proprietary power pod which will be built in New Zealand. WET-NZ's aim is to have the full-scale device operate in as broad an ocean wave environment as possible. New Zealand's west and south coasts have very reliable underlying wave swell resources under normal conditions giving, according to Huckerby, the prospect of base load generation.

Mr Huckerby said, "While the design of the full-scale wave energy converter device is yet to be finalised, the expected power output of 200 kW is a nominal figure, but I would expect it to be larger than that eventually as the development team realises efficiencies as the design evolves." Huckerby could not quote expected cost per kW but said, "… clearly we have to be competitive with other similar device developers and our ultimate objective is to have a device that is both survivable and maintainable and also produces electricity within the ball park that our competitors might do". He envisages that markets for the full-scale device would include both ocean arrays and deploying small or single wave and tidal power installations in remote coastal and island communities in Australian and New Zealand. Electricity generated from diesel in such communities in New Zealand can cost around NZ$0.80/kWh. Mr Huckerby was reluctant to give a timetable for commercial readiness of their design, expressing the cautious view that much work remained and no developer had a fully commercial ready machine in the sea yet.

* *Jeremy Cavanagh is an engineer undertaking research into marine energy at postgraduate level.* EN

Book Review



Analytical Modelling of Fuel Cells

By Andrei A. Kulikovsky, Elsevier BV, 2010, hardback, ISBN: 978-0-444-53560-3, 312 pages, list price A$194.95 (incl. GST), discounted price for ENERGYNEWS readers A$165.70 (incl. GST) – see page 44

Progress in the development of fuel cell technologies in the second half of the 20th century was driven largely by experimental and empirical research. Our understanding of fuel cells has required the application of electrochemistry and physics, as well as mechanical and chemical engineering. And one of the reason fuel cells have taken so long to emerge in the commercial world has been our inability to model the complex systems involved. Since a fuel cell is both an assembly of chemical reactors and an electrochemical device, the modelling of fuel cells has always appeared far too complex. The situation is fortunately changing and over the past decade, with increasing computer power at our disposal, analytical modelling of fuel cell systems has become a rapidly growing area of research.

Considered only from a chemical engineering point of view, analytical modelling can confirm material and energy balances within a fuel cell; fluid flows and heat transfer rates can be calculated; and the kinetics of the various reactions can be analysed with a view to understanding the reaction mechanisms occurring within each domain (anode, cathode and electrolyte). From an electrochemical perspective, the voltage delivered by the cell can be analysed in terms of voltage losses, or 'overpotentials', that occur in the different regions of the cell. This analysis may lead to ways of improving cell performance and reducing cell degradation. Needless to say that analytical modelling has been a challenge for all types of fuel cell and fuel cell configurations, partly because no two systems are the same. The Solid Oxide (SOFC) and Proton Exchange Membrane (PEM) fuel cells operate at very different temperatures and employ entirely different materials for the anode, cathode and electrolyte. Indeed different fuels can be used in the various fuel cell types meaning that the electrochemical reactions are different in each case.

This book is a well-written introduction to the modelling of fuel cells that the reader will no doubt want to supplement by referring to published research articles (a comprehensive bibliography is included). It is written by a physicist, but is clearly influenced by engineering rather than science. For example chapter 2 analyses in some detail oxygen-reduction at the cathode catalyst layer, without any reference to the reaction mechanism, which is still poorly understood. This is the essence of the book. It uses 'simplified' models based on idealised systems, basic geometries and minimal assumptions, enabling the qualitative understanding of the causes and effects of system phenomena. In this way it shows how analytical modelling can be applied to real fuel cell systems. It focuses on the low temperature PEM fuel cell and related Direct Methanol Fuel Cell (DMFC) and the high temperature SOFC. The PEMFC is perhaps the most challenging in terms of modelling on account of the thee phases (gaseous oxygen, liquid water and solid catalyst) that coexist at the cathode/electrolyte interface in this type of cell.

The opening chapter, which reviews fuel cell basics, explores the contributions to voltage losses that occur in operating fuel cells, and introduces mass conservation in the fuel cell channels, mass transport in the catalyst layers and ionic transport in the electrolyte.

Chapter 2 is substantial and considers in detail the anode and cathode catalyst layers. The 'macro-homogenous approach' taken by the author ignores the physical structure of the electrode layers and considers only the catalyst layer as a homogenous domain for providing transport for ions, electrons and gas/liquid (in the catalyst voids). This assumption is good for predicting local current distributions and species concentrations both of which can be measured fairly easily, at least in the PEMF and DMFC. Heat balance in the catalyst layer is also considered, and this is expanded more in chapter 3 in which a one-dimensional model of a fuel cell is described. This considers the all important issues of fluid and heat flow in the different gas diffusion layers as well as the catalyst layers and electrolyte. The usefulness of the 1-dimensional model is illustrated by showing how, by measuring temperatures in a working cell, the thermal conductivity of the MEA can be determined.

Analysis gets more interesting when moving from a 1-dimensional to a 2-dimensional model, and this is explored in chapter 4. In this chapter, the author examines fluid flow, local concentrations and voltages developed within flow channels, and water cross-over in the case of the PEMFC. Also the 2-dimensional model is able to be validated against working fuel cells (and stacks) and can be used to gain insight into cell ageing. Chapter 4 also provides more discussion of SOFCs. The final chapter explores the modelling of fuel cell stacks, even to the extent of introducing a hybrid 3-dimensional SOFC concept. Unfortunately the book does not explore issues of modelling an internal reforming SOFC stack. This would have been quite a challenge and perhaps beyond the scope of the first textbook to appear in this subject area.

Dr Andrew Dicks FAIE
Adjunct Senior Research Fellow
School of Chemical Engineering
The University of Queensland

Membership Matters

The members' section of ENERGYNEWS

ENERGYNEWS welcomes contributions to Membership Matters, including member profiles, corporate member profiles, anecdotes, and advertising. Send ideas and contributions to editor@aie.org.au

New Members

New Members

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Around the Branches

Melbourne

- Huw Wilkinson, Strategic Market Executive, Silver Spring Networks; John Nachef, Business Development Manager – Connected Energy, Cisco Systems; and Mark Kealy, Victorian Department of Business and Innovation, explained "Smart Meters" to AIE Melbourne Branch on 24 May 2011.

Perth

- Lyndon Rowe, Chairman, Western Australian Economic Regulation Authority, presented "The Strategic Energy Initiative – Energy 2031" on 19 April 2011.
- Allan Dawson, Chief Executive Officer, IMO, presented "Competition in the Wholesale Electricity Market on 17 May 2011.
- Perth YEPs hosted a free technical presentation on 26 May 2011.

Tasmania

- Chris Lock, Director, Economic Policy Branch, Tasmanian Department of Treasury and Finance, and Jane Hyland, Director, Office of the Tasmanian Economic Regulator, presented "Contestability in the Tasmanian Retail Market: A regulatory perspective" on 20 April 2011.

South Australia

- Prof. Paul Stevens, Chatham House, London, presented "The Shale Gas Revolution: Hype and Reality" on 10 March 2011.
- Mike Cochrane, CEO, Ecco Consulting, presented asked "How vulnerable is Australia's fuel supply?" and "Will South Australia have a role in Australia's future transport fuel options?" in his presentation on 14 April 2011.
- Adelaide YEPs hosted "An after-work Lowdown on Demand Management" on 4 May 2011.
- Prof. Barry Brook, Director of Climate Science at the University of Adelaide's Environment Institute, presented "Advanced Nuclear Power Systems for Long-term Energy and Climate Security" on 12 May 2011.

Sydney

- Prof. Tony Vassallo, University of Sydney, and Dr Geoff James, CSIRO, presented "Bottling Electricity: The need for energy storage" on 4 April 2011.
- Rod Sims, Chairman of the Independent Pricing and Regulatory Tribunal (IPART) in NSW, presented "Greenhouse Policy, Investment Certainty and Electricity Prices" on 16 May 2011.

2011 Study Scholarship

The Australian Institute of Energy is pleased to be able to offer Institute members the opportunity to win an energy study scholarship of up to A$6000 for 2011–12.

The aim of the scholarship is to assist a young AIE member to further his/her knowledge in an energy-related discipline through study and/or visits to relevant organisations and facilities. The knowledge gained should be applied to the benefit of the individual undertaking the scholarship, the AIE and the community in general.

Scholarships may be used for:

- official enrolment fees for an approved course, seminar or conference;
- approved expenses in relation to attending a course, seminar or conference;
- approved expenses incurred in association with a planned study tour; and
- other appropriate areas of expenditure approved by the selection committee.

To be eligible for selection a person must be a current member of the AIE aged 35 years or less and have been a financial member in any category, including Student, for at least 12 months.

Applications must be in writing and include the *Summary Application Form*, which is available on the website (www.aie.org.au) under 'AIE Scholarship'. Applicants must submit a realistic planned program covering the itinerary and expected activities to be financed, including airfares and accommodation if applicable. Applicants must also submit a budget for the proposed scholarship. Other important conditions are also on the website.

Within six months of return to Australia, the scholarship recipient will be required to present a paper to an AIE technical meeting and/or a written paper, which the AIE shall have the right to publish in its nominated journal. The recipient may be required to present his/her paper to other groups, at the AIE's expense. Previous winner Mark Kealy's article appeared in the April 2011 issue of **ENERGY**NEWS.

Applications close 31 August 2011

Aurecon

Aurecon is a global company that provides engineering, management and specialist technical services to government and private sector clients across many industries. With more than 6000 staff and over 80 offices worldwide, Aurecon has a presence in Australia, New Zealand, Africa, Southeast Asia, China, and the Middle East. In Australia, energy is one of Aurecon's key markets, and Aurecon is involved in some of Australia's most innovative energy projects. This gives Peter Hulbert, General Manager – Energy – Asia Pacific, a unique insight into the Australian energy sector. **ENERGY**NEWS asked Peter about the key issues in the energy space.

"I think the biggest issue in the industry right now is that of carbon certainty because it pervades every aspect of the sector," he said.

"It affects everyone from electricity generators to energy consumers. Nearly all of the challenges facing the industry come down to carbon. For example, the discussion about the cost of electricity transmission and distribution in both the privatised and public sectors partly comes down to the price of carbon.

"We hear a lot of numbers being bandied about, but it is not really about the number; it's about certainty. Even the big resource companies are campaigning for a price on carbon sooner rather than later. Pricing this into their project development calculations and negotiations with customers is essential as customers need to know what the real cost will be – whether it is going to be A$20 per tonne or A$100 per tonne! Even though customers may prefer the lower price to the higher amount, what is most critical is everyone knows, with some certainty, what the costs will be.

"Uncertainty is having a direct impact on investment decisions. It will not only affect the cost of supply; it will also alter consumer behaviour. It will change the way people use energy, in particular electricity. As service providers to the industry, offering design, construction and project development support, many of Aurecon's clients are holding back on the final sign-off. A lot of projects are lined up waiting for carbon certainty because if the carbon price is high enough, it will change the way people use electricity in a significant way. Many are in the renewables space, including quite a few wind power projects. That being said, some projects, such as those supported by the Solar Flagship program, as well as Kogen Power Station's Solar Boost Project [see "Project Spotlight" in this issue of **ENERGY**NEWS, ed.], are going ahead regardless.

"We are also finding that globally the market is picking up, with a lot of enquiries from clients overseas. Although there are still new coal projects in Asia and Africa, new coal projects in Australia have been all but shelved."

ENERGYNEWS asked Peter Hulbert about Aurecon's corporate membership of the Institute – why join the AIE?

"Aurecon's corporate membership of the Australian Institute of Energy is part of our broader engagement in the energy sector," said Peter.

Peter Hulbert

"We have a strong history in the electricity industry and are members of specific electricity industry associations. However, over recent years we have seen that the energy sector's interaction with other sectors has become increasingly complex. It is no longer just about building power stations, transmission lines and substations. We are now involved in how end users use their energy – working with clients on energy efficiency is a key part of our business. More broadly, clients are looking for ways to manage their existing assets more effectively for longevity and financial performance.

"In the future, electricity will be more integrated. We are now talking about smart grids and smart buildings (with cogeneration and trigeneration feeding back into the system); and soon electric vehicles will be connecting to the grid. The future is about an intergrated, connected holistic approach to energy. That means we have become engaged in a much broader discussion and we want to engage more broadly with the energy community. So, our membership and support of the AIE is part of this broader engagement.

"This integrated and holistic approach is also reflected in how we engage with clients. We bring teams together from across the Aurecon group to address clients' broader issues. We have also found that customer service is a lot more important nowadays in terms of making sure the service is right, with the right deliverables, on time with excellent quality assurance. It is no longer enough to be a good engineer or a good project manager. All of our professionals undergo client relationship training and we place a lot of emphasis on delivering a good experience transactionally as well as technically."

For more information about Aurecon visit www.aurecongroup.com

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SECRETARIAT
Candice Pribil
aie@aie.org.au
Tel: 1800 629 945
Fax: (03) 9898 0249

MEMBERSHIP
Colin Paulson
aie@aie.org.au

WEB MASTER
Tony Forster
webmaster@aie.org.au

EDITOR
Joy Claridge
editor@aie.org.au

Branch Secretaries

Brisbane
Leigh Morpeth
brisbane@aie.org.au

Canberra
Ross Calvert
canberra@aie.org.au

Melbourne
Glenne Drover
melb@aie.org.au

Newcastle
Behdad Moghtaderi
newcastle@aie.org.au

Perth
Kylie Wilkie
perth@aie.org.au

South Australia
Graeme Atwell
adel@aie.org.au

Sydney
Gwen Cant (Secretariat)
syd@aie.org.au

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Melissa Jackson
tasmania@aie.org.au

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Aurecon provides engineering, management and specialist technical services for public and private sector clients globally.

Aurecon's energy team delivers effective, tailored solutions for clients across the power generation, transmission and distribution, and renewable energy sectors.

Drawing on the talents of a global team, Aurecon has expertise in all areas of the energy sector, including power systems and power generation engineering; industrial and process engineering; and energy advisory and asset management consulting services.

www.aurecongroup.com

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Electricity, Gas and Carbon

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CQ Partners is committed to providing commercial solutions in the areas of electricity, gas, carbon, fuel and greenhouse gas abatement.

www.cqpartners.com.au

Ph: 08 8464 0300

Calendar

Forthcoming AIE Events

17–18 August 2011	Energy in WA Conference 2011 Jointly with Western Australian Government Office of Energy http://www.energy.wa.gov.au/ewa2011

For all forthcoming AIE events, see http://www.aie.org.au

If your branch has organised an event in 2011, send details to editor@aie.org.au to promote the event in the ENERGYNEWS.

Other Events 2011: Australasia

25–28 July in Sydney	Australian Energy & Utility Summit 2011 http://www.acevents.com.au/energy2011/
10–11 August in Brisbane	Gas Generation World 2011 http://www.activebusinesscommunications.com/gasgen/
23–25 August in Perth	Offshore Convention: Australasia 2011 http://www.neoventurecorp.com/oc/aus/
29–31 August in Hobart	Tasmanian Energy http://www.tonkincorporation.com
4–7 September in Brisbane	Ecogen 2011 http://www.ecogen2011.com/
18–21 September in Sydney	Chemeca 2011 http://www.chemeca2011.com/
19–21 September in Perth	Global Gas 2011 http://www.globalgas.info/
26–27 September in Perth	Smart Transport http://newurbanism-smarttransport.com/home
5–7 October in Darwin	Southeast Asia Australia Offshore Conference 2011 http://www.seaaoc.com/
12–13 October in Melbourne	All-Energy Australia 2011 http://www.all-energy.com.au
19–20 October in Melbourne	12th Annual Australian Gas Turbines Conference http://www.informa.com.au/gasturbines
25–27 October in Melbourne	Retrofitting for Energy Efficiency http://www.retro-fitting.com.au
31 October–1 November in Sydney	Australia Gas 2011 http://www.cwcaustraliagas.com
8–10 November in Sydney	Smart Utilities Australia and New Zealand 2011 http://www.smartutilities-ausnz.com
8–11 November in Gold Coast	International Conference Energy & Meteorology http://www.icem2011.org
17 November 2011 in Melbourne	Energy Efficiency Council National Conference 2011 http://www.eec.org.au/events/National_Conference_2011

Other Events 2012: Australasia

31 January–2 February in Brisbane	Retrofitting for Energy Efficiency http://www.retro-fitting.com.au
17–19 April in Sydney	Retrofitting for Energy Efficiency http://www.retro-fitting.com.au
20–23 May in Broken Hill	Resources & Energy Symposium 2012 http://www.symposium.net.au
26–28 July in Perth	Retrofitting for Energy Efficiency http://www.retro-fitting.com.au

Please note that the events listed here are based on information provided by event organisers. The AIE does not necessarily endorse the views of the speakers. The events are brought to the attention of members as potentially contributing to discussion on relevant energy issues. If you know of any conferences or other major events in our region that would be of interest to AIE members and will be held in 2011 or 2012, please email date, location, title and web link to editor@aie.org.au

Other Events 2011–12: International

For global energy events, see the following websites:

http://www.conferencealerts.com/energy.htm
http://www.energyiq.co.uk/Energy.aspx
http://www.eia.doe.gov/calendar/meetings.htm
http://www.econference.com.au
http://www.ieee.org
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