The UQ Energy Initiative was established in the second half of 2012 to provide a strategic framework for energy research at UQ. We aim to bring multidisciplinary research capability together on some of the significant energy challenges facing today’s world and connect that capability with industry and government partners.

The global energy challenges are quite enormous. As the energy demands of a growing population soar, especially in developing regions, in a setting of increasing cost of energy resources, heightened community scrutiny and environmental risk (particularly climate change), science and innovation are paramount.

This Newsletter, to be released bimonthly, seeks to brief the UQ community and its partners on current energy sector issues along with energy technology insights and research activities at UQ. And for those who find the whole energy space a bit confusing, we’ll have a regular Energy 101 page introducing some basic concepts and statistics.

We welcome comments and feedback from all and look forward to engaging with you on global energy challenges.

Professor Chris Greig
Director, UQ Energy Initiative

Socio-economic outcomes tend to be focussed on affordability of domestic supplies for both households and businesses. But just as important to the economic resilience of Australia are the energy resources it exports, including coal, gas and uranium, and energy technologies that can also be exported.

Observations of the past decade suggest that Australia has lacked a consistent purpose or vision to underpin an energy strategy and drive the trade-off decisions. This lack of clarity of purpose and the politicisation of energy and climate issues has left us exposed on all three elements of the energy trilemma. Potential gas shortages in NSW, an aging power generation fleet and an increasing reliance on imported liquid fuels reflect declining energy security. High domestic prices for electricity and gas are impacting energy affordability at the household level but also driving the manufacturing sector out of Australia. And finally environmental regulation and climate policies are plagued by duplication, inconsistency and uncertainty. In this setting, investment confidence along with innovation in the energy sector has stalled.

Two reasons for the above failures are front of mind at the UQ Energy Initiative. First is the failure of scientists and innovators to provide technology solutions that would make the trade-off decisions easier. We simply haven’t yet found a low-carbon energy solution that meets the economic and reliability expectations of society. Moreover, there is no guarantee that a single technology panacea even exists; it is far more likely to be a portfolio of technology solutions. The second is the lack of awareness around energy concepts in society, something we have termed a lack of energy literacy. So long as those empowered to develop Australia’s energy strategy are lobbied by vested-interest advocates and elected by an uninformed public, the situation is unlikely to improve.

Time will tell whether the new Energy White Paper will in fact provide the necessary clarity of purpose, vision and a blueprint for Australia’s energy strategy. This is going to remain difficult though unless both industry and environmental policies are effectively integrated with energy policy. In the meantime, we must strive to deliver technology advances and inform the broader society, which will allow those who govern to take a long-term, strategic approach.

Figure 1: The energy trilemma & trade-offs

Editorial

THE NEED FOR AN ENERGY STRATEGY

Energy is fundamental to the economic and social well-being of any society. When we talk about energy, we are referring to electricity, gas and liquid fuels and their use in lighting, heating, cooking and transport for both homes and business. But energy resources are also a critical feedstock for a vast array of vital industrial products such as plastics, fertilisers, steel, and cement. The energy strategy of nations, corporations and even households therefore has a critical bearing on productivity and prosperity.

In a year when the Queensland government released its 30 year strategy for the electricity sector and the Commonwealth government is developing a new Energy White Paper, along with a review of its Renewable Energy Target, we thought it useful to reflect on the key strategic issues for our energy economy. We often hear references to the requirement for more sustainable energy, cleaner energy and cheaper energy in connection with energy strategy. But what is an energy strategy and how is it related to energy policy?

Perhaps the first and most critical issue is the recognition that there are multiple drivers, not necessarily complementary and that there are inevitable trade-offs. In essence the goal of an energy strategy might best be described by the energy trilemma illustrated in Figure 1.

It is the job of those who govern to design and implement policies that can deliver a desired balance between energy security, socio-economic outcomes and environmental performance.

In Australia, energy security tends to be focussed on the reliability and quality of energy supplies. Environmental performance tends to be focussed on the impact of energy systems on the ecosystems - land, air and water resources - and increasingly, climate change.
BP releases latest statistical review of world energy

The latest edition of the BP annual review, now in its 63rd year, indicates that oil, gas and coal will continue to dominate and drive the energy landscape over the next decade. Consumption grew for all three of these fossil fuels during 2013, which combined accounted for a staggering 86.7% of global primary energy consumption, which overall grew by 2.3%.

Oil consumption grew by 1.4%, but as a result of disruptions in Libya and Syria, production growth was only 0.6%. Natural gas consumption also grew by 1.4%, but this was below the decade-long average of 2.6%, partly as a result of EU gas consumption falling to the lowest level since 1999. Gas production increased by 1.1%, with the US still the leading producer of gas.

Coal consumption fell in Australia by 4.7% but globally grew by 3% over the last year with 88% of the growth coming from China and India. These two countries also accounted for 86% of the growth in electricity generation. In energy terms coal continues to be the fastest growing energy source supplying 30.1% of the total primary energy demand – the highest percentage since 1970. On the export scene, Australia’s coal exports increased by 7.3% and Indonesia’s by 9.4%.

On the low carbon front, non-hydro renewable energy (wind, solar, geothermal and bioenergy) consumption continued its rapid increase, growing by 16.3% in 2013, but still represented just 2.2% of global primary energy demand. Other low carbon energy resources hydro (up 2.2%) and nuclear (up 0.9%) also grew in 2013, to provide 6.7% and 4.2% of global energy demand respectively.

The Australian Energy Market Operator (AEMO) has released its latest forecasting report for the National Electricity Market (NEM). The key message is that electricity consumption is declining in Australia, and will continue to do so for the next three years. The only exception is Queensland, which will see a small increase in consumption as a result of LNG projects. However, this gain is likely to be offset by growth in rooftop PV installations, which impacts consumption levels.

Key factors reducing residential and commercial grid consumption are robust growth in rooftop PV installations in QLD and VIC, (estimated at 24% annually), energy efficiency savings (estimated at 10% annually), and a decline in industrial consumption due to the closure of energy-intensive industries, for example aluminium smelters, all driven in part by rising electricity costs.

The graph below illustrates the future challenges for electricity generators. Consumption is currently well below the 2013 annual energy consumption forecast (black line). It will continue to decline for all scenarios, primarily as a result of industrial and manufacturing plant closures. QLD’s LNG projects are considered the only source of industrial growth to boost consumption (yellow line). Eliminating LNG consumption and reduction/ closure of NEM-connected aluminium smelters would see further declines.

IEA estimates $48 trillion in investment required to meet our 2035 global energy needs

The IEA’s World Energy Investment Outlook estimates that approximately $40 trillion is required for energy supply from now to 2035. Broken down, that’s $23 trillion for fossil fuel extraction, transport and oil refining; almost $10 trillion for power generation, including $6 trillion in renewables and $1 trillion in nuclear; and a further $7 trillion for transmission and distribution. Another $6 trillion goes towards energy efficiency, mainly in the growing EU, North America and China markets, of which 90% is for transport and buildings sectors.

The jump from current 2013 annual investment levels to required levels is staggering i.e. ramping up from $1,600 billion to $2,000 billion annually for energy supply, and $130 billion to $550 billion annually for energy efficiency. And more than half the total energy-supply investment is needed merely to sustain current production levels.
GLOBAL ENERGY NEWS: TRENDS AND TECHNOLOGIES

CHINA COMMENTS ON ENERGY DIRECTION, FOCUS ON ENERGY-SAVING POLICIES TO ADDRESS ENERGY CONSUMPTION LEVELS

In the wake of the $400 billion gas deal with Russia, President Xi Jinping has outlined key pillars in China’s energy revolution. At a recent meeting for the Party’s Central Leading Group on Financial and Economic Affairs, the President focused on energy security, drawing attention to irrational energy use and energy-saving policies to address energy consumption levels. His comments, if translated to policy action, will have implications not just for China but for global energy markets:

- Safeguard energy demand and security by incorporating a diverse range of energy suppliers and sources
- Explore and develop new sources of energy beyond coal and petroleum including natural gas, renewable energy (solar and wind) and nuclear power
- Consider opportunities in Central Asia, the Middle East, Americas and Africa and increase international cooperation for energy production
- Establish a competitive energy market through market-oriented pricing reform
- The renewable energy sector has a role to play in the broader strategy to upgrade the country’s industrial structure.

HYDROGEN: ENERGY STORAGE OPTION IS GETTING CLOSER

Hydrogen is becoming increasingly recognised as an important ally for intermittent energy sources. The benefit of hydrogen is that it can be generated, stored and used without producing any hazardous chemicals or emissions.

One of the concepts of hydrogen energy storage is the use of decentralised installed electrolysers, which operate when excess energy is available in the grid. AREVA (more commonly known as a major nuclear power company) has recently installed its hydrogen-based Greenery Box energy storage and management system at the MYRTE test platform in Corsica, France. It enhances the existing solar PV installation, which has been in operation since early 2013, and increases the grid output from the energy stored in hydrogen to 150 kW, strengthening the quality and reliability of grid operations. The system, which includes an electrolyser and a fuel cell, increases the potential storage of the electricity produced.

The system stores hydrogen and oxygen generated by water electrolysis when power demand is low and recombinates them to generate electricity when required again. The new system also offers greater flexibility for grid operations.

IVANPAH SOLAR ELECTRIC GENERATING SYSTEM

The first unit of the world’s biggest concentrated solar thermal power plant was commissioned in March 2014. The Ivanpah Solar Electric Generating System (ISEGS), located in California’s Mojave Desert, will consist of three solar thermal units, each with a 140 meter high solar power tower. These units are surrounded by 170,000 heliostats (sun-following mirrors), which focus sunlight onto boilers located on the towers to create steam, and in turn drive turbines to generate electricity. The total area of the plant is 14km².

The auxiliary gas-fired boilers warm the fluid in the turbines in the early morning, keep it at an optimum temperature through the night, and boost production during the day when the sun is partially blocked by clouds. In order for ISEGS to operate at full efficiency, the plant’s gas-fired auxiliary boilers need to run an average of 4.5 hours a day, burning 42 million m³ of natural gas per year. Notably, the carbon footprint of the plant is around 90,000 tonnes of CO₂ per year, which corresponds to roughly 10% of the carbon emissions from a comparable gas fired power plant.

The facility, owned by NRG Energy, Google and BrightSource Energy, has an official net capacity of 377 megawatts. The plant capacity factor is calculated to be approximately 31%.

Total project costs are estimated to be $2.2 billion, and the project received a $1.6 billion loan guarantee from the U.S. Department of Energy. The project also provided a boost to the local economy by creating 2,650 construction jobs at its peak, and 86 operations and maintenance jobs. It also supports 76 supply-chain jobs across 17 states.

FAST NEUTRON REACTORS DEPLOYMENT

The newest fast breeder reactor, Beloyarsk 4, is expected to start-up within weeks. Beloyarsk 4 is a first-of-a-kind BN-800 unit. At 789 MWe, it will become the most powerful fast reactor in operation.

Fast neutron reactors are typically fuelled using a mixture of oxides of uranium and plutonium (MOX fuel) and can vastly increase the efficiency of the nuclear, fuel cycle by using the uranium-238 recovered from recycling nuclear fuel after use in conventional nuclear power reactors. They can also be used to burn the long-lived actinides found in high-level nuclear wastes and to dispose of ex-military plutonium.

Fast reactors feature in Russia’s long-term nuclear energy plans, which envisage a move to inherently safer nuclear plants using fast reactors with a closed fuel cycle and mixed-oxide (MOX) fuel.

SHENHUA COAL-TO-OLEFIN CAPACITY TO DOUBLE

China’s largest coal producer, Shenhua Group is planning to double its coal-to-olefins production capacity upon the completion of the second phase project at Baotou, Inner Mongolia.

The first phase started commercial operation in early 2011 with a production capacity of 1.8 million tonnes for coal-to-methanol and 600,000 tonnes for methanol-to-olefins. The total cost of the project was US$ 3.6 billion. The second phase, sanctioned in May this year, will add 2 million tonnes coal-to-methanol and 700,000 tonnes methanol-to-olefins.

Overall the coal-to-chemical industry in China is a rapidly developing sector, with a threefold increase in coal-to-methanol production capacity since 2009. There are currently 53 coal-based methanol and 34 coal-based ammonia and fertiliser production plants operating in China producing approximately 30 million tonnes of methanol and 11 million tonnes of ammonia per year, with a large number of plants in various stages of planning.
ENERGY POVERTY RESEARCH GROUP

Access to affordable, clean and efficient energy services is crucial for human well-being and facilitating social and economic development. Energy poverty denies billions of people in the developing world access to modern energy services, sentencing them to live in abject poverty. In the IEA's 2013 World Energy Outlook it estimated that 2.6 billion people - 38% of the global population - did not have access to clean fuels for cooking and heating (in 2011). And that number includes 1.3 billion people with no access to electricity. It is vital to appreciate that energy poverty presents a complex challenge; it encompasses household poverty, unsustainable lifestyles and negative impacts on local and regional environments. Providing scalable energy solutions that are secure, reliable, affordable and sustainable will have far reaching implications and can help bring affected societies out of impoverishment.

Under the UQ Energy Initiative a multidisciplinary group is investigating how poverty and energy are interconnected in the developing world. The Energy Poverty Research Group explores sustainable energy solutions that are tailored to regions and societal conditions. The program involves engineering, modelling, analysis, behavioural science, social change, data management, and scenario and policy formulation for the development of holistic solutions that are reliable and affordable.

Link to Energy Poverty Research Group

ALGAE ENERGY FARM COMPLETED

The Algae Biotechnology team headed by Professor Peer Schenk (Faculty of Science) has now completed the construction of all three raceways of the small-scale Algae Energy Farm at Pinjarra Hills. This 1 hectare, off-grid algae farm uses solar power and Brisbane River water to cultivate and harvest microalgae for production of feed, fuel and high-value health compounds in large raceway ponds. This farm implements lower-cost approaches for cultivation and harvesting of algae. Cost-savings were achieved by an airlift system to assist algae mixing, harvesting by foam flotation with Jameson Cell, and settling and solar drying. Industry partners include Meat & Livestock Australia and XT (formerly Xstrata Technology).

Initial products are focussed on animal feed and high-value products, with biodiesel and biogas to be integrated in 2015.

Link to the Algae Biotechnology Lab

CO2 CAPTURE AND GEOSTORAGE

Earlier this year Shenhua Geological Exploration Co Ltd (a subsidiary of the Shenhua Group, China’s largest coal producer) hosted Professor Andrew Garnett to present “experiences and lessons on CO2 capture and geostorage from coal fired power plants”. Accompanied by Dr Xingxin Wang, an Honorary Professor at the China University of Geoscience and Managing Director at Austar Gas, who acted as interpreter, Professor Garnett presented to a number of people from the company, including Zhengwu Zhou, the chief engineer, Guangyan Kong from the office of the chief engineer, and Jianming Zhang from the department of technology development.

UQ’s engagement with Shenhua is focused on characterisation and development of CO2 storage resources - particularly offshore saline aquifers - and providing guidance on the execution of integrated CCS projects. Ultimately we hope to pave the way for forthcoming collaborations between China and Australia in this area.

COLLINSVILLE SOLAR-GAS HYBRID PROJECT: COMBINING PROVEN TECHNOLOGIES WITH EXISTING INFRASTRUCTURE

RATCH Australia and UQ’s Energy Economics Group are researching the potential of a hybrid gas-concentrated solar power (CSP) plant using Linear Fresnel Reflector (LFR) technology to replace the coal fired power station at Collinsville, in Queensland. The project is supported by the Australian Renewable Energy Agency (ARENA) and administered by the Global Change Institute at UQ.

Gas generation and LFR are demonstrated technologies, with both boiling water to drive a generator to produce power. The combined-gas-solar hybrid maintains a constant electricity output because the gas-fired boiler operates when sun does not shine, avoiding intermittency issues and therefore operating as a base-load plant.

Capital investment savings are considerable as the same generator for the solar boiler and gas boiler can be used, as well as the existing transmission lines at Collinsville. Forecasting lifetime yield, revenue and dispatch of the solar plant is now underway, which will help to determine financial feasibility and power purchase agreements for this type of project.

Link to the Energy Economics and Management Group

CENTRE FOR COAL SEAM GAS WELCOMES CHAIR IN PETROLEUM ENGINEERING

Professor Brian Towler has joined the Centre for CSG as inaugural Chair in Petroleum Engineering. Previously with the University of Wyoming, where he was Professor and CEAS Fellow for Hydrocarbon Energy Resources in the Department of Petroleum Engineering, he has returned to his alma mater where he extends the Centre’s petroleum engineering research program and manages the University’s Master of Science (Petroleum Engineering) coursework program.

Wyoming was at the centre of the US coal bed methane boom in the early 1990s and Brian conducted research in CBM/CSG at that time. He is widely published across many technical areas of petroleum engineering. His research interests include reservoir engineering and simulation, well-bore integrity and enhanced oil recovery. He has authored three text books including a very highly regarded (by the Society of Petroleum Engineering) reservoir engineering text. His latest book "The Future of Energy" discusses the sources, technologies, and trade-offs of the options available to meet the world’s energy needs - including existing fossil fuels and emerging renewable energy sources.
**ENERGY 101: CONVERSION, SOURCES & UTILISATION OF ENERGY**

**OVERVIEW**
Energy can not be created nor destroyed. It can only be transformed from one form to another.
- The sun is a major source of energy; along with fossil fuels, nuclear fuels and geothermal springs
- These sources can be converted into thermal, mechanical or electrical energy
- About 20% of the total energy consumed is used to generate electricity
- Total energy is always conserved but during conversion, the amount of useful energy remaining is reduced due to inefficiencies
- We use energy for space heating & cooling, lighting, cooking, transportation, manufacturing & industrial processing

**ENERGY FORMS**

- **FOSSIL FUELS**
  - Coal
  - Oil
  - Gas

- **NUCLEAR FUELS**
  - Uranium

- **RENEWABLES**
  - Solar, Thermal
  - Wind, Hydro
  - Biomass, Geothermal
  - Tidal, Bioenergy

**ENERGY SOURCES**

- **Fossil Fuels**
  - Coal: 30.1%
  - Oil: 32.9%
  - Gas: 23.7%

- **Renewables**
  - Solar: 2.2%
  - Wind: 1.1%
  - Bioenergy: 4.4%

- **Nuclear**
  - 0.8%

**ENERGY CONSUMPTION**
While it varies from region to region, energy consumption is dominated by industrial and then transport applications.

- **Residential**
  - Space heating/cooling, lighting & cooking for houses & apartments
- **Commercial**
  - Space heating/cooling, lighting & cooking for offices, schools, hospitals, malls, churches, etc.
- **Transportation**
  - Energy used by trucks, cars, airplanes, ships, etc.
- **Industrial**
  - Energy required for manufacturing, processing farming, mining, construction, etc.

**ENERGY SOURCES**
Today, the vast majority of energy consumed is supplied by coal, oil and gas.

**DISCLOSURE STATEMENT**
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Questions or comments can be directed to uqenergy@uq.edu.au

**UQ IN EVENTS**

**UQ Energy Express Seminar**
11 August, at The University of Queensland
The first seminar in the UQ Energy Express Seminar series, hosted by The UQ Energy Initiative, with keynote speaker Professor Andrew Garnett who will share his views on “The modern energy landscape and scenarios – the trends, frameworks and choices that drive our energy future”.

**National AIE Energy Conference, incorporating the 14th Energy in Western Australia Conference**
27-28 August, in Perth
This year’s conference theme of ‘Energy Markets: Disruption, Transition and Transformation’ reflects the sector’s rapidly evolving business environment across Australia and the world.

**National Carbon Capture and Storage (CCS) Conference**
31 August – 2 September, in Sydney
A biennial, Australian-based event providing a focus for CCS as an essential part of the global greenhouse gas mitigation portfolio. Early bird registration closes 15 July; standard registration closes 19 August.

**Rio Tinto-UQ Energy Exchange Series Breakfast**
11 September, in Brisbane
The breakfast series is designed to facilitate broad industry discussion of global energy issues, with guest speakers chosen on the basis of their recognised expertise and leadership related to energy.

**International Conference on Greenhouse Gas Technologies (GHGT)**
5-9 October, in Austin, TX, USA
The GHGT conference series has established itself as one of the principal international conferences on greenhouse mitigation technologies.

**McDonnell Academy 5th International Symposium**
16-19 October, in St Louis, MO, USA

**SPE Asia Pacific Oil & Gas Conference and Exhibition (APOGCE)**
14-16 October, in Adelaide
This year’s theme of ‘Changing the Game: Opportunities, Challenges, and Solutions’ considers the continued changes affecting the oil and gas industry.

**GTC TECH Conference**
October 29-31, in San Diego, CA, USA
The conference will provide updates on gasification processes and other relevant topics.