Advanced solar biofuels aim to innovate fuel landscape

At the Solar Biofuels Research Centre at the University of Queensland, an advanced solar biofuels pilot plant designed to develop microalgae-based systems as a source of clean fuel, food, bioproducts and bioremediation, has been developed by the University's Institute for Molecular Bioscience.

Director of the University of Queensland's Solar Biofuels Research Centre, Professor Ben Hankamer, recently caught up with *EcoGeneration* to discuss the Centre and its on-site Pilot Plant, as well as some of the key fuel supply issues Australia and the globe faces in coming decades.

Solar Biofuels Research Centre (SBRC)

The SBRC is a result of a partnership of the University of Queensland with the Queensland Government, KBR, Neste Oil Corp, Cement Australia Pty Ltd, Siemens, Bielefeld University and the Karlsruhe Institute of Technology in Germany.

It is designed to provide an international research hub to build synergy between industry and university partners skilled in biology, engineering and systems development.

The SBRC's advanced pilot-scale test facility and ancillary laboratories will focus on the development of advanced microalgae systems for the production of food, fuels, bioproducts and bioremediation.

"Broadly speaking our population is set to grow from 7 billion to more than 9 billion people by 2050. By that time it is estimated that we're going to need 70 per cent more food, around 50 per cent more water, and around 50 per cent more fuel," says Prof. Hankamer.

"There is a pressure on food, fuel and water, as well as a whole range of chemical feedstocks that we obtain from oil. Ultimately, what we need to do is move away from fossil fuels and move across to renewable energy and production systems.

"The best way to do that is to harness the huge solar energy resource available to us. Globally we receive about 2,500 x more solar energy annually than we use globally in the form of fossil fuels. What we're trying to do at the SBRC is develop systems to capture this solar energy and CO_2 and convert it into chemical energy, and that is basically in the form of biomass. The biomass can be used to make food, fuel and a range of chemical feed stocks (e.g. to make bioplastics). Microalgae (single-celled green algae) can also be used for the generation of fresh water and to provide a process for CO_2 capture."

The SBRC will focus on advanced biofuel production systems based on algae, instead of first generation of biofuel systems such as those that produce ethanol from corn.

A key issue for first generation biomass systems was that they were using arable land and fresh water for the production of fuel instead of food.

Algae systems are more advanced and can be produced on non-arable lands, often using saline or waste water streams.

"Algae-based systems can assist with a transition from food versus fuel concerns towards a more sustainable food and fuel future," says Prof. Hankamer.

Pilot project

The $3.5 million *National and International Research Alliances Program* pilot project supported the development of the SBRC, which has the potential to benefit regional and rural communities through developing economically viable methods of producing biofuels and other commodities, including animal feeds.

The pilot plant will compare the potential of different types of algae and cultivation methods and test the results of laboratory-scale work under real-life conditions.

Producing algae as a feedstock for biofuels cost-effectively is a major challenge facing the sector, and this project is designed to provide answers to key questions.

"This facility combines biology, engineering and economics to allow us to identify the best algae strains, production conditions and system designs that are the most effective in producing affordable biofuels for the future," says Prof. Hankamer.

"There's a lot of work going on at the lab-scale at the moment, and there is a lot of interest from industry for commercial systems. The SBRC sits at the pilot scale and is focused on the optimisation of systems prior to demonstration scale deployment."

Energy supply issues

"A key thing to consider is the time scale," says Prof. Hankamer.

"We have a finite amount of fossil fuel that we can burn before we exceed the 2 °C temperature rise limit identified by the International Panel on Climate Change for being 'safe'. Our best modelling would suggest that within the next 20 years we need to achieve a massive shift towards CO_2-free systems if we are to stay in this limit."

"At the SBRC, we bear in mind that currently ~80 per cent of our energy is used in the form of fuel, and ~20 per cent is used in the form of electricity.

The bulk of renewable energy systems under development, such as wind turbines and solar photovoltaic systems – are all focused on that ~20 per cent electricity market. Solar fuel systems and our work is focused on the ~80 per cent fuel market.

"If the international community seriously wants to deal with climate change, it must do so very rapidly and on a much larger scale, and within a well-coordinated and well-thought out context," says Prof. Hankamer.

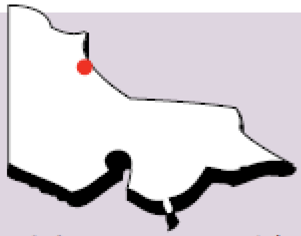
"To achieve this we need both excellent science and excellent policy frameworks. Scientists can and are developing solutions. Industries are actively developing systems for deployment. Our hope is that internationally, government will increasingly seize these opportunities and assist with improved policy frameworks to support a renewable *fuel and fuel* future and the building of new industries." –eco

In 2002, Ben Hankamer moved from Imperial College London to take up his position as a Principle Investigator at The University of Queensland's Institute for Molecular Bioscience. Here he focused on the development of environmentally friendly, high-efficiency microalgae biofuel production systems. In 2006, he established the Solar Biofuels Consortium, which has grown to include seven international teams, ~100 researchers and has worked with ~10 industry partners.

In 2009, Prof. Hankamer was awarded a prestigious Eisenhower Fellowship, awarded to individuals identified as international leaders in areas of energy technology and supply. In 2013, Prof. Hankamer was also awarded the Discovery of Outstanding Researcher Award from the Australian Research Council.

Australian Tartaric Products Biomass Power Plant

A project in Colignan, near Mildura, Victoria, is the first in Australia to use grape marc as a biomass fuel source, and the largest biomass Organic Rankine Cycle installation in Australia.



Project name:	Australian Tartaric Products Biomass Power Plant
Location:	Colignan (near Mildura), Vic
Distance from nearest capital city:	600 km from Melbourne
Demographic:	Rural
Owner, developer, operator:	Australian Tartaric Products Pty Ltd
Capacity:	600 kWe 8 MWth boiler capacity
Commissioned:	November 2013
Capital cost:	$7.5 million
Fuel source:	green Thermal Energy Technologies (ORC generator)
Construction contractor:	Bono Sistemi, Italy (biomass boiler)
Fuel source:	Post-processed spent grape marc (residue from regional wineries)
Prime mover:	green Thermal Energy Technologies (ORC generator) (as above)
Prime mover type:	600 kWe Organic Rankine Cycle generator
Technical details:	The auto-feed biomass boiler produces 8 MWth of 180 °C steam. 5 MWth of steam is used for consumption by the plant process. 3 MWth is used by the ORC power generator, producing 600 kWe of power.
Number of equivalent full time employees:	20 (during construction) 3 (ongoing)

The site

Australian Tartaric Products (ATP) is located in Colignan, approximately one hour south-east of Mildura. It is a rural area at the extremity of the Victorian power grid. As a result, the area is subject to high electricity distribution charges and transport charges.

The project

The primary objective for the project was to eliminate liquefied petroleum gas (LPG) used to generate steam by utilising a renewable fuel source – namely grape marc produced from ATP's tartaric acid manufacturing process – and as a consequence, reduce energy costs.

The project provides substantial economic benefits to the plant by reduction in waste removal, elimination of the requirement for freighted-in LPG, and a substantial reduction in grid power usage.

At the same time, it provides significant reductions in carbon emissions through reduction in methane-producing landfill, reduction in grid power use, and elimination of the need for an LPG-fired boiler. It also provided substantial employment opportunities during installation and ongoing operation.

The plant is expected to produce approximately 2.9 gigawatt hours of electricity per annum, and save more than 10,000 tonnes per annum of greenhouse gas emissions.

Flexible, scalable, and financially beneficial

Project developer, owner and operator ATP says that the project will demonstrate the great flexibility and scalability of Organic Rankine Cycle (ORC) technology for other sources of biomass.

"The ATP biomass power plant installation is an excellent example for businesses to achieve significant economic benefits from biomass process waste, while also providing significant CO_2 emission reductions created by reductions in grid power usage, LPG usage and landfill," says ATP Program Manager Sam Testa. →

Technical innovation

Key innovative features of the ORC generator include:

- **A high tolerance to biomass boiler load variation.** The site's processes and steam usage are seasonal, so this tolerance to consume less steam in peak periods and more steam in off periods is critical
- **An electronic inverter drive** to transfer the power generated from the high speed turbo-alternator to the grid connection. This technology benefits the site by providing high 'turn-down' and improving the electrical power factor.
- **A fully-automated biomass fuel handling system** – from process to boiler management
- **Environmental control systems** include **a cyclonic filtration and bag house filter system**, achieving EPA requirements
- **Integrated air cooled condensing**, eliminating the need to use scarce water supplies in the installation's rural location for generator cooling
- **Elimination of process waste to landfill**, providing significant methane emissions reductions.

The Australian Tartaric Products Biomass Power Plant's boiler at 80 per cent completion.

> "The project will demonstrate the great flexibility and scalability of this technology for other sources of biomass."

Power purchase and consumption

Power generated from the project is consumed on site under a connection agreement with PowerCor. The generator produces approximately 50 per cent of the site's baseload power requirements in peak season, and most of the site's baseload power requirements in off-season.

Funding

The ATP installation has been supported by the AusIndustry *Clean Technology Investment Program* and Victorian Government *Regional Infrastructure Development Fund*.

The installation is also an accredited generator under the Clean Energy Regulator for Large-Scale Generation Certificates. –eco

About green Thermal Energy Technologies

green Thermal Energy Technologies (gTET) is an Australian owned business specialising in turn-key solutions in energy efficiency for thermal processes. gTET has delivered solutions in heat transfer, cryogenic refrigeration, co- and trigeneration, as well as its core Organic Rankine Cycle power generators, which are used to convert thermal energy into electrical power and are designed and fabricated by gTET in Melbourne.

gTET's ORC generators use world-leading, turbo-alternator technology supplied by its US-based partner, resulting in increased reliability, reduced complexity and more competitive economics than imported competitors.

The company is applying the ORC generator technology to other biomass applications in the timber industry, incineration plants and food industry, both domestically and internationally.

For more information visit **www.g-tet.com**