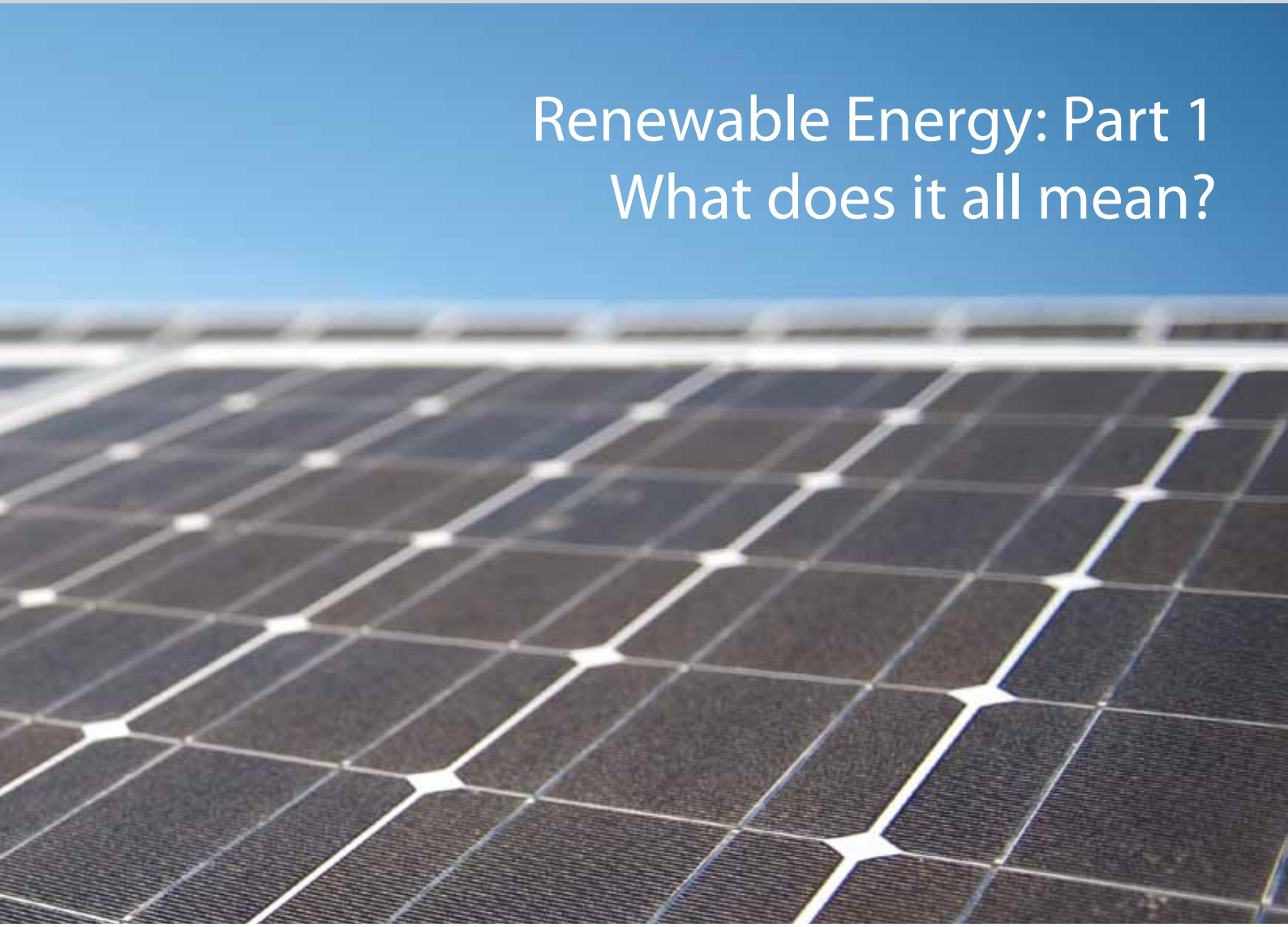
Issue #62 - December 2011

Technical News

INDUSTRIAL ELECTRICAL AND AUTOMATION PRODUCTS, SYSTEMS AND SOLUTIONS

Renewable Energy: Part 1
What does it all mean?



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Sustainability and Engineering Projects Manager

INTRODUCTION

Each year the Sun delivers approximately 1.12 Exa kWh of energy to the Earth's surface, completely free of charge. That is, 1,120,000,000,000,000,000 kWh per year or approximately 21,000 times the annual human energy production and consumption, based on 2010 figures[1]. Clearly sunlight is Earth's primary source of energy.

Our current civilisation is based on plentiful supplies of inexpensive energy. Our daily lives have become much more energy intensive. The trend below (Figure 2) clearly shows this. Primitive humans only had a requirement for food energy, about 2kWh per day. Today we each require about 267kWh per day to support our civilisation. Compounding this two order of magnitude increase is a corresponding increase in the Earth's human population.

Petroleum products power our transportation systems. Electricity from coal fired power stations power our industries and homes. Even high yield agriculture makes extensive use of energy in the form of petroleum based fertilisers. Finding enough energy to continue to support our civilisation is a challenge.

Solar energy can be harnessed by a variety of natural and synthetic processes. Photosynthesis by plants captures the energy of sunlight and converts it to a chemical form. The energy stored in petroleum and other fossil fuels was originally converted from sunlight by photosynthesis in the distant past.

The Carboniferous Period was a geologic time that extended from about 360 to about 300 million years ago. It is important to realise that the vast majority of fossil fuels that we now use were formed during this period. Their formation is not a process that continues today.

Synthetic processes such as direct heating or electrical conversion by solar cells are important ways that we can harness solar energy directly. This will be increasingly important if we wish to continue with our current lifestyles and sustain our economies. For Australia:

"Clean energy is one of the world's fastest-growing sectors. In Australia the national Renewable Energy Target will deliver 20 per cent of the country's electricity from renewable sources such as solar and wind by 2020. It will unlock more than $20 billion in investment and create more than 55,000 jobs, in addition to more than 8000 existing jobs. Much of this growth will be in regional Australia, creating employment opportunities and an economic boost for towns and communities. In 2009-10 alone, clean energy in Australia generated just under $1.8 billion in investment. The Renewable Energy Target is projected to avoid 380 million tonnes of greenhouse gas emissions, making it the most significant climate change initiative in Australian history".

- Clean Energy Council Australia, 2010.

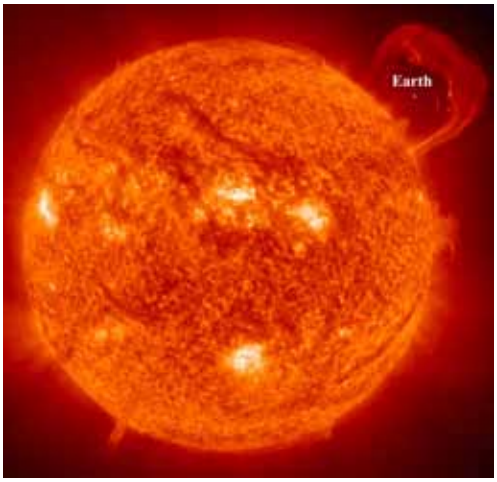

Figure 1: The Sun dwarfs everything that we do (1).

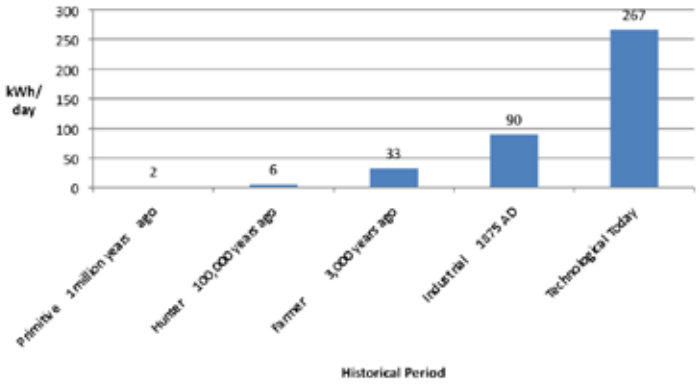

Figure 2: Estimated historical energy consumption per capita (2).

NHP has recognised the importance of renewable energy and has recently started to offer renewable products. A demonstration of NHP's belief in the importance of these technologies can be seen in the construction of the Sustainability Centre, which is located adjacent to our National Manufacturing and Distribution Centre in Laverton, Melbourne. This considerable investment is intended to showcase NHP's renewable energy product offering in a live, working and interactive display. It will provide a platform for education, training and testing of renewable energy products.

This two-part edition of technical news is intended to provide a brief insight into renewable energy and to introduce the new NHP Sustainability Centre. The Sustainability Centre will be a constantly evolving installation and will change as new ideas and products are devised.

In addition to renewable energy the centre will endeavour to promote sustainability in general, with an emphasis on how NHP's other products can help customers monitor and reduce energy consumption. Currently the focus of the display is on renewable energy.

From an engineering perspective, renewable energy technologies are fascinating. For example, being able to produce electricity directly from sunlight is technologically impressive. No moving parts, no noise and with quality equipment, a system is likely to continue working, without maintenance, in excess of 20 years. All this powered directly by the sun. An endless "renewable" energy source. (But is it really?) What is the difference between renewable and non-renewable energy? What other sources of renewable energy are available?

Figure 3: An artist's impression of the Carboniferous period. Most of the Earth was covered by such forests during this time (3).

NON-RENEWABLE AND RENEWABLE ENERGY SOURCES

Typically when we think of non-renewable energy we immediately think of oil and other fossil fuels. We have access to a finite amount of these fuels and there is no way of replacing them once they are used. Nuclear fission is another non-renewable energy source. There is a limited amount of uranium (and other elements) that we can access. While these reserves may be large, once they are spent there is no more available.

Strictly speaking, the Sun is a non-renewable energy source. The Sun is 'only' expected to shine in its current form for about 5 billion more years (5). Of course, by any human measure 5 billion years is essentially forever, so therefore we generally consider the sun to be an endless source of energy.

The energy from the sun supports almost all life on Earth either directly or indirectly by photosynthesis. It also drives the Earth's climate and weather. Most renewable energy sources are directly derived from the sun. For example:

- Direct heating
- Hydro-power generation
- Bio-mass (either burnt or decomposed)
- Wind
- Photo voltaic solar energy

However, there are also obvious exceptions:

- Tidal power is driven by the effects of gravity
- Geothermal power is driven by the thermal energy stored in the Earth's structure

For the remainder of this edition of technical news we will briefly discuss these sources of renewable energy. Included under each of these headings there are two numbers. These represent the contribution of the renewable energy source to the world's and to Australia's and New Zealand's energy production. These figures come from Australia's Clean Energy Council and New Zealand's Ministry of Economic Development, and are based on 2010-11 figures. Currently, worldwide, renewable energy sources contribute 13% (6) or our energy requirements.

We may imagine renewable energy sources to be leading-edge sources of energy. Generally they are not. We have been using these sources of energy for a long time. We will start with one of the simplest and most often overlooked sources of renewable energy - Direct Heating.

Figure 4: Burning fossil fuels releases billions of tons of CO_2 (4)

DIRECT HEATING

Simply standing in sunlight to warm our bodies must be one of the oldest conscious methods humans have used to make direct use of the sun's energy. Today, using clever architecture we are able to maximise the sun's energy to help heat and cool our homes and other buildings. Known as passive heating and cooling, the design of the building alone helps regulate the indoor temperature, reducing the requirements for external sources of energy such as gas or electricity.

The Australian Bureau of Meteorology offers some simple explanations of architectural steps that can be taken to design passive heating and cooling in buildings (See Figure 5).

Another popular direct heating method is Solar Hot Water. This simple technology can reduce residential energy costs for heating water by 60% (8) (See Figure 6).

A more complex, larger scale method of generating energy from the heating effect of the sun is known as Solar Thermal. Here an array of reflectors or lenses concentrates sunlight. The concentrated energy is used to heat a fluid which in turn powers a turbine that generates electricity. A number of large scale solar thermal projects are planned for Australia, which will be capable of producing 125MW (9) (See Figure 7).

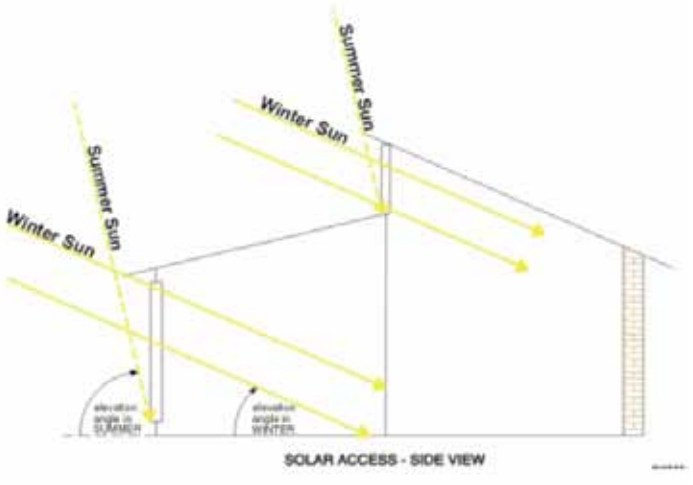

Figure 5: A simplified diagram showing how placement of windows can help with passive solar heating and cooling of a home (7)

Figure 6: A typical residential solar hot water system with natural gas back up.

Figure 7: A reflective solar concentrator located in Mildura Australia.

HYDRO POWER GENERATION - 800,000MW WORLD, 8,000MW AUSTRALIA, 5,252MW NEW ZEALAND

The first use of hydro power is typically credited to the ancient Greeks and Romans approximately 2,000 years ago (10). Free flowing water turned the familiar bladed or bucketed wheel, providing motive power to operate a grain grinding mill or similar application.

Today, using the same basic principles, flowing water rotates a turbine connected to a generator to produce electricity. In 1949 Australia undertook a massive engineering project known as the Snowy Mountains Hydro Electric Scheme. This system took 25 years to complete and is still on line today. It is capable of generating 3,800MW and typically produces 4,500GWh of electricity per year (Figure 8).

Snowy Hydro currently provides around 40% of all renewable energy that is available to the eastern mainland grid of Australia, as well as providing fast response power to light up the morning and evening rush hours of Sydney, Brisbane, Canberra, Melbourne and Adelaide (11).

An interesting academic question is: would Australia undertake such a project today? Today's general public is much more aware of the environmental impact of such projects. Tasmania's proposed Franklin Dam project was cancelled after huge public outcry over its environmental impact. Even ignoring the financial costs and the difficulty of finding suitable sites, a Snowy Hydro scale project may no longer be possible.

Figure 8: The Tumut 3 power station which forms part of the Snowy Mountains Hydro Electric Scheme.

Figure 9: The photograph *Morning Mist, Rock Island Bend, Franklin River*, by Peter Dombrovskis was used by the Tasmanian Wilderness Society in advertising against the Franklin dam's construction (12)

GEOTHERMAL POWER - 9,700MW WORLD, 80KW AUSTRALIA, 720MW NEW ZEALAND

Cooking in naturally occurring pools of hot water is an ancient practice most notably performed by the indigenous peoples of New Zealand. Here, volcanically or tectonically active regions heat naturally occurring ground water, often with spectacular steam geysers being the result.

Today, New Zealand continues to make extensive use of geothermal energy. There is 720MW of installed geothermal capacity, a massive figure when taking into account New Zealand's relatively small population.

Geothermal energy production can also make use of the increasing temperature with increasing depth below the Earth's surface in areas *away* from regions of tectonic activity. In such areas the average ground temperature increases by 25-30°C for every km of depth (International Geothermal Association, 2004). This heat comes from two sources: residual heat from the formation of the Earth and from the radioactive decay of various elements.

A typical geothermal energy plant uses technology borrowed from the oil and gas industry. One or more holes are bored into the "hot rock". Water is pumped into the rocks to return to the surface as steam. This steam spins a turbine, in turn, generating electricity.

It is claimed that Australia has some of the best, most accessible hot rock sites suitable for power generation. Over fifty companies are currently exploring for suitable sites (14).

Currently there is one functioning geothermal plant in Australia. Located in the remote, non-grid connected community of Birdsville this 1200m deep, 80kW system provides 25% of the community's power requirements, supplementing the local diesel generators. This system has been in operation since the 1960's and in 2004 produced 520MWh of electricity (15).

The Birdsville installation is somewhat unique among geothermal power plants. Water is not injected into the ground. Instead, hot, pressurised water emerges from the artesian basin without the need for pumping. The water emerges at 98°C and is used by an Organic Rankine Cycle turbine system to produce electricity. Once the water leaves the power plant it is fed into the town water supply.

Geothermal energy sources have a major advantage over many other renewable energy sources because they are continuously active and can support base load supply.

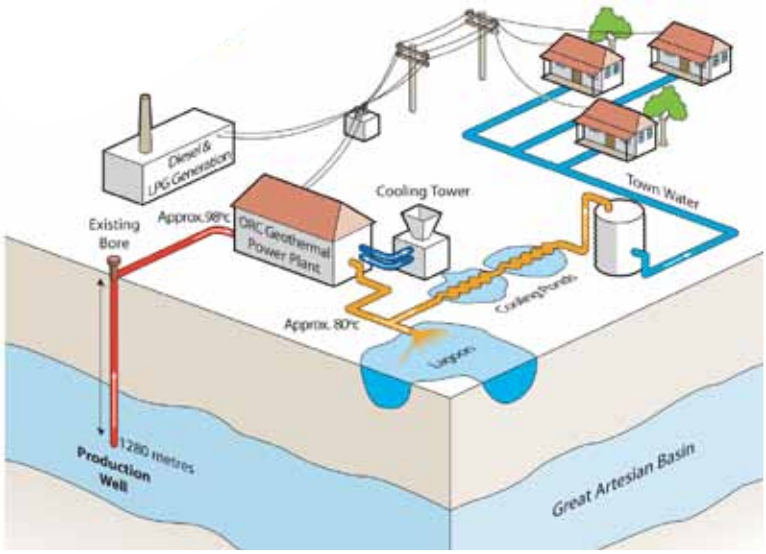

Figure 10: A diagram of the Birdsville geothermal power system.

BIO-MASS - 52,000MW WORLD , 867MW AUSTRALIA, 65MW NEW ZEALAND

Burning wood for heat is another ancient source of renewable energy. It is generally accepted that humans have been controlling fire for at least 400,000 years (16). It is estimated that even today energy from bio-mass contributes 10% of the world's total energy requirements, mostly in the form of heat from burning plant material (note that the figures shown in the heading above refer to electricity production from bio-mass). Typically, waste products from agriculture are burnt to produce steam. This, in turn, powers a turbine generator.

Bundaberg Sugar's factories obtain over 95% of their energy requirements by burning waste products from the manufacture of sugar (17). The fibrous remains of the sugar cane plants are burnt to power steam equipment, generate electricity and for process heating. If the furnace is properly designed and operated it is possible that the emissions from burning waste plant material can be less harmful than those of simply letting the material rot or by burning it in the open air.

An alternative to direct burning is to make use of the natural decomposition products of waste bio-mass. Landfills emit carbon dioxide and methane gases as the biological waste in the landfill decomposes. The methane can be harvested and following some very simple processing, burnt in internal combustion engines connected to generators to produce electricity (See Figure 12). Methane can be commercially extracted from a landfill site for 15-20 years after the site's closure (19).

Methane can also be extracted from sewage. Melbourne Water's Werribee sewage treatment plant captures much of the methane emitted by the sewage treatment process, with 95% of the entire plant's energy requirement coming from the collected methane (20).

Figure 11: A Bundaberg Sugar steam generation plant.

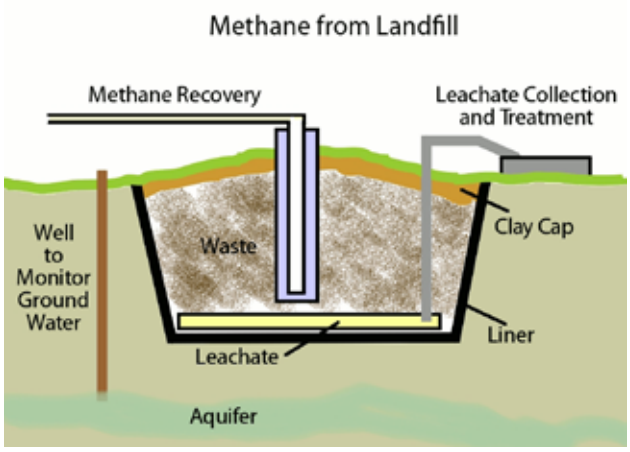

Figure 12: If the waste goes to landfill, the organic material in it will eventually decompose, producing methane gas. This gas can be captured and used to fuel an electricity generation plant (18)

TIDAL POWER - 300MW WORLD, 0.75MW AUSTRALIA, 200MW APPROVED FOR CONSTRUCTION NEW ZEALAND

Much like other sources of renewable energy tidal power is not new. Grain was milled using tidal power on the coasts of France and Britain as early as the 11th century (21). The rise and fall of coastal tidal waters is caused primarily by the gravitational effects of the Sun and Moon. A tidal power station is often part of a dam or barrage, built across a narrow bay or river mouth. As the tide flows in and out, it creates uneven water levels on opposite sides of the barrage. Water flows from the high side to the low side through turbines to generate electricity.

The tide moves vast quantities of water twice per day. The potential energy stored in a typical high tide varies enormously by geological location.

For example: On average, at high tide in Port Phillip Bay, Melbourne, there is 1.29 million kWh of energy stored in the potential energy of the water[11]. Or, about 2% of the state of Victoria's daily electricity usage (22). While this is not so impressive, consider the Bay of Fundy in Canada. At high tide there is 2.66 billion kWh of energy stored in the potential energy of the water[111].Or, about 17 times Victoria's daily electricity usage. This is definitely impressive.

Of course this example ignores the engineering challenges of harvesting this energy, the social impact of changing the nature of the associated ports and towns and the environmental impact on delicate tidal areas. However, it certainly highlights the importance of site selection.

Australia currently has one tidal power station located at San Remo in Victoria. This installation makes use of tidal currents flowing in and out of Western Port Bay. It is a research and development system capable of 150kW that has been exporting power to the national grid since 2006.

Figure 13: The tidal current turbine at San Remo, Victoria.

SUMMARY

In this edition of technical news, we have briefly examined the various sources of renewable energy which have included:

- Direct heating
- Hydro-power generation
- Geothermal
- Bio-mass
- Tidal power

In the next edition of technical news, we will provide part two which will discuss photo voltaic (PV) and wind energy sources.

SUSTAINABILITY CENTRE OPENS UP A BRIGHTER FUTURE

After close to 18 months of design and construction, NHP is proud to announce that our 'Sustainability Centre', located adjacent to our National Manufacturing and Distribution Centre in Laverton, Melbourne, is officially open.

To coincide with the opening on November 24, an Australian Industry Group 'Environmental Solutions Forum' was held on-site, with many invited guests, Ai Group officials and NHP staff attending the event.

Today is a significant day for not only NHP but for our industry in general as we enter a new phase in the way we do business", offered Damian Jones, NHP's Sustainability and Engineering Projects Manager, shortly after the opening.

"Sustainability is now of paramount importance in our industry, and this construction demonstrates that we are well placed to embrace this new approach moving forward", he continued.

NHP's Sustainability Centre offers an interactive display allowing visitors to view and experience this cutting edge technology in an environment that is suitable for use as a meeting and presentation facility. The centre showcases a variety of sustainable technologies including;

- Horizontal axis wind generator
- Photo-voltaic solar collectors
- Bio-diesel back up generator
- Energy management and control systems
- Grid interactive systems
- Off grid systems
- Dual axis solar tracker

"In the past a lot of businesses have let renewable energy development pass on by and considered it more of a household or government responsibility," said Ai Group's Tennant Reed, Senior Adviser – National Public Policy. "But that is definitely changing and this NHP initiative is a great example of that", Reed says.

This centre will ensure NHP remain at the forefront of the sustainable energy industry and are leaders in providing alternative energy solutions for domestic, commercial and industrial applications.

NHP are committed to understanding and minimising any adverse impacts that their operations and their products have on the environment and recognise that the education of others is a big step towards achieving this. The Sustainability Centre encourages the use of alternative energy solutions and demonstrates what is possible with sustainable energy technologies.

The centre is now open to the public (via appointment) and visits can be arranged through your local NHP Representative.

Damian Jones (Sustainability and Engineering Projects Manager), Jason Walker (Ai Group Manager - National Environment Services), Alex Coslovich (Director - Product Quality, Engineering & Manufacturing), Daniel Harris (Business Development Manager - Renewable Energy) and Tennant Reed (Ai Group Senior Advisor –National Public Policy).

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[1] Based on mean Earth radius of 6371km, solar energy incident on the ground of 1kw/m2 cloud cover is ignored and BP Statistical Review of World Energy, June 2011.

[11] Based on 0.7m tide and tidal volume of 1.351Gm3.

[111] Based on 17m tide and tidal volume of 104billion metric tonnes.

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