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Australian
Geothermal
Energy
Association (Inc)

Position Paper: *Direct Use* Geothermal Applications

DRAFT

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Executive Summary

While most of the focus of the emerging geothermal energy industry in Australia has been on producing electricity (see the companion AGEA paper), there is also increased attention on the benefits of "*Direct Use*" geothermal. *Direct Use* describes the use of Geothermal Heat Pumps (GHPs) as well as Circulating Hot Water (CHW) for heating and drying applications. The former uses a static arrangement for heating and cooling with boreholes usually less than 50m deep. The latter involves the active extraction of hot water from an aquifer to take it to the place of use, before later re-injection at some other point.

The *Direct Use* of geothermal energy has significant economic and greenhouse benefits, chiefly because it reduces electricity demand and, ultimately, generation as it replaces electric-driven heating and cooling appliances. It is also a more efficient form of energy as the fuel undergoes only one energy conversion (absorption or radiation of heat), rather than the several that occur in electricity generation and usage, with each step losing a percentage in conversion.

Direct Use applications exist on a scale ranging from households (heat pumps, hot water supply) to large industrial and institutional buildings (hospitals, factories, universities).

AGEA encourages the Federal Government to consider new *Direct Use* geothermal applications, along with incentives for the roll out of existing technologies. *Direct Use* makes significant international energy savings and a significant reduction in greenhouse gas emissions. The global (Australian) installed capacity of Direct Use geothermal is 28,266 (110) MW_{th} compared with 9,732 (0.1) MW of geothermal electricity production. GHPs constitute 54.4% of the global installed capacity [8].

Purpose

The purpose of this paper is to outline the AGEA industry position on Geothermal *Direct Use* technology, including Geothermal Heat Pumps (GHPs). In doing so, we outline the potential benefit to Australian public interest including a key role in meeting Australia's new Mandatory Renewable Energy Target (MRET) and combating Climate Change.

Key Recommendations

- Institute a rebate scheme for GHPs at least matching the existing solar photovoltaic rebate (Climate Ready);
- Develop the Green Building Fund and open eligibility to geothermal energy companies to work with process end users to examine industrial scale *Direct Use* applications, including feasibility studies. Unlike electricity generation projects, *Direct Use* projects undertaken by geothermal companies will almost always be done in direct partnership with the process end user, for instance a public institution, manufacturing plant or large building. The benefits will be quantifiable in projection and measurable in application.
- Include funding for GHPs and other *Direct Use* geothermal applications in the funding allocation for commercial buildings (Climate Ready) and extend Climate Ready eligibility to state government controlled institutions and buildings working in partnership with geothermal energy companies.
- Issue Renewable Energy Certificates (RECs) for *Direct Use* installations. *Direct Use* and in particular GHPs are presently not allocated RECs despite Solar Hot Water heaters receiving RECs.

Geothermal Energy

Geothermal energy is a renewable and sustainable energy source that is stored as heat in the earth. It is derived from a combination of solar energy that is stored in the immediate surface of the crust, heat radiated from radiogenic granites in the crust, and the molten core of the Earth. The latter makes only a very small contribution to the energy ultimately flowing through the surface of the Earth.

Geothermal energy applications in Australia can be broken into three categories, the first two of which are known as *Direct Use* and which we describe in this paper:

1. **Geothermal heat pumps**: Operates in the upper few tens of metres of the earth - heating & cooling buildings and fluids.

2. **Circulating hot water**: Sourced from the upper few hundreds of metres of the earth– industrial heating and drying, space and district heating, aquiculture.

3. **Electricity Generation**: Sourced from between three and five kilometres **-** convert heat to electricity by using steam to drive turbines.

Circulating Hot Water (CHW) *Direct Use*

Circulating Hot Water (CHW) *Direct Use* involves hot fluids being extracted from a relatively shallow aquifer (usually less than 1km, but possibly deeper) and the heat being used in heating and drying applications. The fluids are then returned elsewhere in the aquifer. In these applications, the *Direct Use* of the fluids substitutes for the use of electricity, thus saving on electricity consumption and ultimately generation.

The temperature of CHW geothermal fluids can vary from as low as 30℃ to over 200℃; in some overseas locations where contemporary volcanism is present, temperatures can exceed that, but in Australia they are unlikely to exceed 200℃. Furth ermore, temperatures approaching 200℃ are unlikely to be common in close proximity to the surface but where they are, their use for electricity generation is probably more likely.

It should be noted that one of the major differences in approach between CHW geothermal and GHPs (see below) is that the former is likely to require a geothermal license to be issued by the state regulating authority, usually the 'Mines Department'. Such tenure usually begins with the issuing of an Exploration License and ultimately, some form of Production License allowing regulated economic exploitation. Geothermal heat pumps usually do not need a 'production license'.

Figure 1 illustrates the range of uses and temperatures of *Direct Use* geothermal fluids up to 200℃.

Advantages of CHW *Direct Use* geothermal energy

Direct Use geothermal is a highly desirable substitute for electricity use due to:

- Widespread occurrence
- Shallow depths (i.e. lower cost)
- High efficiency (no energy conversion)
- Conventional plant and equipment utilised
- Relatively easy to set up
- Can be small to industrial scale

Current usage and installed capacity

Approximately 70 counties around the world currently employ CHW *Direct Use* geothermal. In 2006, excluding geothermal heat pumps, installed capacity was over 12,800 MW_{th} and energy use was over 180,000 TJ/year (51,000 GWh/year) – enough to heat 2.3 million homes. This energy usage was enough to save 1.4 million tonnes of oil (1.4 days of global consumption) [8].

The most common uses of CHW *Direct Use* geothermal fluids are:

- Space and district heating (buildings, greenhouses);
- Aquaculture and balneology;
- Food, timber and industrial process drying;
- Industrial processing;
- Hot water for bathing (e.g. spas)

Space and district heating

In 2006, 33 countries used geothermal space heating, mostly district heating (reticulated hot water into a neighborhood) and greenhouse warming. The largest deployment was in Iceland, Turkey, France, China and the USA.

In Iceland, district heating commenced in 1930 and now services all of Reykjavik - approximately 200,000 people - with geothermal fluids supplied from both wells around the city and, more recently, 'effluent' from geothermal power stations.

In Australia, geothermal space heating is most applicable to large industrial and office sites, such as factories, university campuses, hospitals etc. and could have very wide application, especially in green-field construction sites.

The city of Portland in Victoria has operated a district heating system since 1983. The city water supply is drawn from a number of bores between 1,200 and 1,500m deep, which deliver water to the well heads at between 55℃ and 60℃. One bore services approxima tely 19,000m^2 of (mainly public) building floor space. The annual energy savings were estimated in 1995 to be about 8,900 GJ per year, or $570,000 worth of natural gas, at the prices prevailing then. Converting this into CO_2 abated, it would correspond to an annual saving of approximately 530 tonnes of CO_2 [6].

Greenhouse warming is used extensively in Iceland and Eastern Europe. In Australia, its application is probably limited due to the milder climate, but applications may probably be found in Tasmania and Victoria.

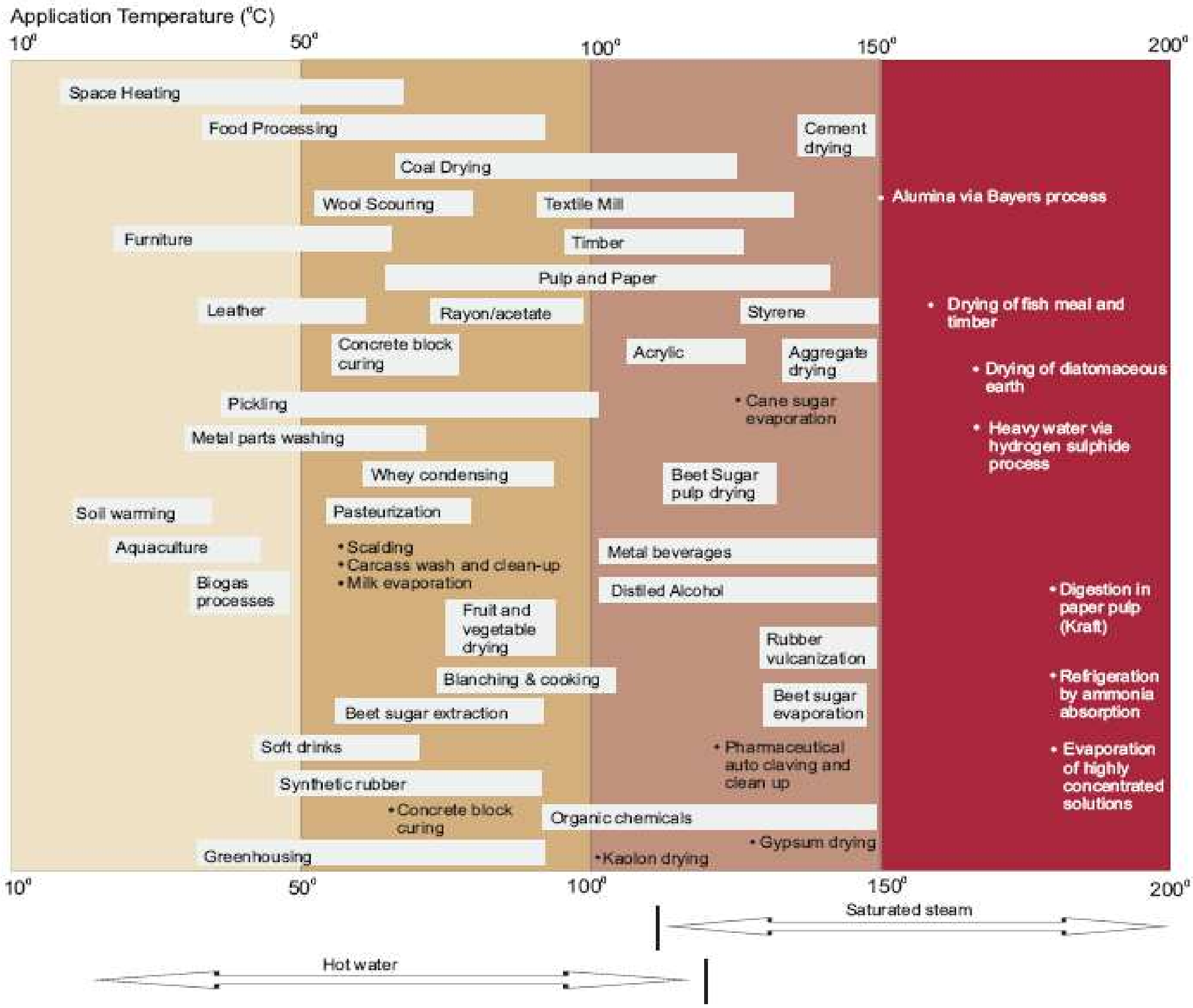

Figure 1 - Direct use applications sorted by Temperature

Aquaculture and balneology

About 17 countries use geothermal heating for aquaculture, with the leaders being Iceland, China, the USA and Italy. In Australia, geothermal warming for aquaculture purposes may be a by-product of other upstream, hotter applications.

Agricultural produce drying

Geothermal heat to dry agricultural produce is dominated by New Zealand, China and the USA, out of the 15 countries where it is practiced. It is applicable to drying grains, vegetables and fruit.

Industrial drying

Eastern Europe and Iceland make extensive use of geothermal heat for industrial processes, such as concrete curing, milk pasteurization, diatomaceous earth drying, chemical extraction, pulp and paper processing, and timber drying.

Industrial geothermal applications will be attractive to those industries with a large carbon footprint. In Australia, suitable applications would be the production of alumina using the Bayer process, digestion in paper pulp (Kraft type), drying of agricultural products and timber, possibly desalination plants, and coal drying for supply into coal-fired power stations.

Hot water for bathing

Geothermal waters, or hot springs, have been used by mankind for hygiene and therapeutic purposes for millennia. 'Spa' tourism is worth hundreds of millions of dollars (at least) and occurs in many countries around the world.

At the Mornington Peninsula, Victoria, a spa operates by sourcing 50℃ waters from a bore at 630 metres. In NSW bores from 500 to 1,000 m source geothermal 'spa' waters at between 37℃ and 41℃ at several locations.

New uses for CHW *Direct Use* geothermal

As all types of energy are becoming more expensive, geothermal fluids are being directed into new applications that make more efficient use of existing resources.

Combined usage

A new trend in CHW *Direct Use* geothermal is for the still-hot 'effluent' water from a geothermal power station to be 'cascaded' down for several *Direct Use* applications, improving efficiency and economics. For instance, fluids may enter a geothermal power station at 200℃ and exit at 120℃. Before being re - injected, the 'waste' fluids might be used in food processing (120℃ - 100℃), then for space heating (100℃ - 50℃) and finally for fish farming (50℃ - 20℃).

In 2006, New Zealand had about 310 MW_{th} installed capacity of *Direct Use* geothermal (in addition to 435 MW_{th} of geothermal power production). The main uses are industrial (67%), agricultural drying (9%), bathing and balneology (9%), space heating (8%), farming and aquiculture (6%), and greenhouses (1%). Most of the fluids for these applications were from the effluent of geothermal power stations [7].

Geothermal power station spent fluids are used for space and district heating in new projects in Iceland and Germany (Landau).

Co-generation or pre-heating

Natural geothermal fluids at (say) 50℃ to 150℃ ca n be brought to the surface and used as pre-heated starting fluids for other energy production systems, such as solar and even coal. Much more efficient use of the other energy sources can be made if the boilers are fed naturally heated hot water.

Geothermal Heat Pumps

Geothermal Heat Pump (GHP) technology has gained a well-deserved reputation as a proven, reliable, efficient, and cost-effective choice for space heating, cooling, and water heating in a plethora of building types. GHPs achieve extraordinary energy efficiency by using the Earth rather than ambient air as a heat source and sink. Ground temperatures are cooler than the ambient air in the summer and warmer during winter, so GHPs benefit from pumping heat over smaller temperature differences—and therefore more efficiently—year round (Figure 2). The U.S. Environmental Protection Agency (EPA) has identified GHPs as a technology that significantly reduces greenhouse gas and other air emissions associated with space heating, cooling, and water heating. The EPA has determined that GHP's are the most energy efficient and environmentally friendly while saving consumers money, compared to conventional technologies. With over 50,000 being added annually, there are over a million GHPs installed in the U.S.A, notably including a 49kW unit at president George W. Bush's Texas ranch.

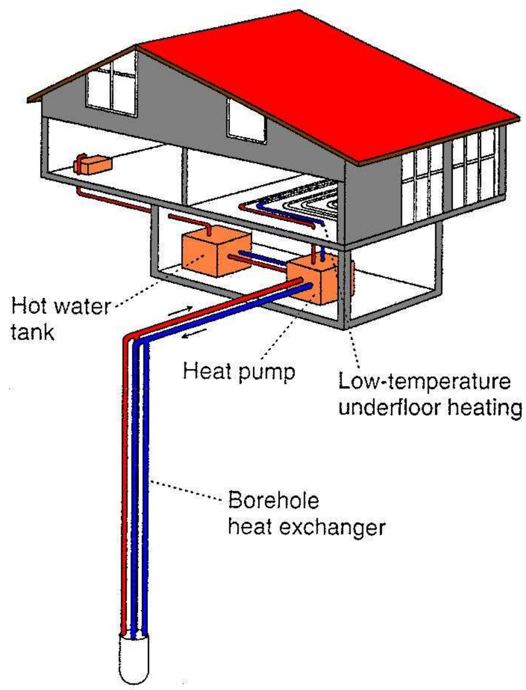

Figure 2 - Household Geothermal Heat Pump

Vertical, closed-loop GHPs (such as shown in figure 2) require less than two square meters of ground space for the ground-loop installation and are thus suitable to urban households. Furthermore, they can be retrofitted to existing heating & cooling installations. GHPs can play a key role in meeting Australia's emission-reduction targets. They use up to 75% less electricity than conventional heating & cooling systems – a significant amount considering that heating & cooling are the majority of electricity use. GHPs also reduce peak electric load, thus mitigating brownout risk.

In a 4000-home comprehensive GHP retrofit at the U.S. Army's Fort Polk in Louisiana annual electrical energy savings of approximately 25.6 million kWh (6,400 kWh per house) or 32.4% of the pre-retrofit electrical use were obtained, and summer peak electric demand on the base reduced by 6.7 MW, or over 40% [1]. Besides their intrinsic efficiency, GHPs operate reliably and quietly, provide better humidity control, and provide better zone-level temperature control than conventional equipment. GHPs are adaptable to almost any type of building, and their popularity for use in schools, office buildings, town halls, barracks, and factories is growing quickly.

Australian residential buildings can benefit from GHP technology but lack of awareness, infrastructure, and the up-front costs, have limited activity to date. Through Climate Ready and the Renewable Energy Fund, a rebate scheme such as the $8,000 photovoltaic (PV) rebate program and various GHP rebate schemes internationally is the required stimulus to raise awareness, promote the development of infrastructure, and encourage domestic GHP uptake. A 1 kW solar PV installation generates 1,825 kWh (5 hr/day effective sunlight) annually compared with an average of 6,400 kWh energy savings per house for GHPs. On a dollar-per-kWh basis, a GHP rebate would lead to more energy savings than the existing PV rebate. If solar PV installation rates (figure 3) are matched, 4,000 Australian GHPs, saving 25.6 GWh/yr could be installed annually. GHP energy savings compare favorably with other renewable energy solutions (table 1).

Type	Solar*	Wind#	Solar Hot Water	GHP
Capacity	1kW	1kW	2kW	14kW
Energy (saved)/year	1,900kWh	2,400kWh	2,500kWh	6,400kWh
Installation Cost ($)	14,000^	15,000	4,000	8,000
Payback (years)	18	30	10	3-10

^ $6,000 net of PV rebate.
* 5 hr/day effective sunlight
\# 7 – 8 m/s annual average wind speed
14c/kWh electricity price assumed

Table 1 - Comparison of Renewable Installations

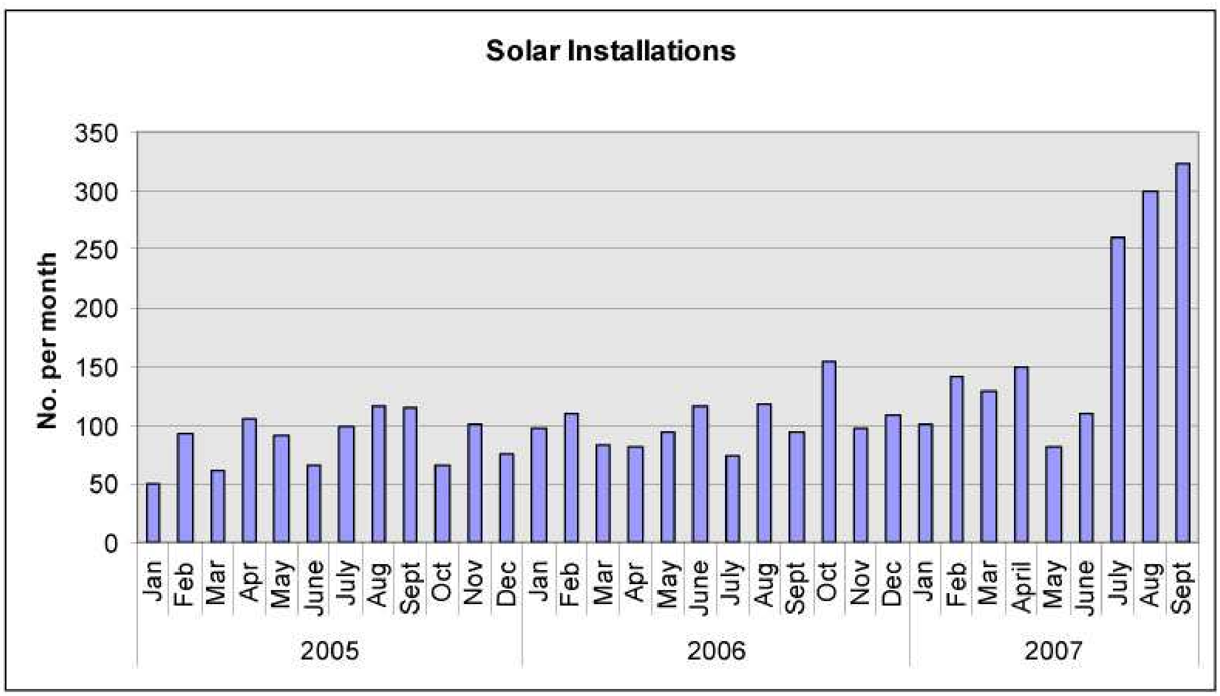

Figure 3 - Solar Installations by month (Australian Greenhouse Office)

Australia's Existing GHPs

In Australia, GHPs have been installed at several non-residential locations, including Geoscience Australia's office building in Canberra, the Integrated Energy Management Centre, the Antarctic Centre in Hobart, and the Hobart Aquatic Centre. Geoexchange Australia, founded in 1988, and the longest standing Australian GHP company, has installed water-loop GHPs in 200 residential and about 30 commercial and government projects. Present GHP capacity is estimated to be 5.5 MW_{th} or 10 GWh/yr.

Direct GeoExchange, refrigerant-based, closed-loop GHP systems are now available in Australia through EnergyCore (Dandenong, Victoria) who have 4 operating installations in Victoria, and Earth-to-Air Systems (Lane Cove, NSW). Direct geoexchange systems are generally more viable for the residential market because instead of 15-cm wide, 100-metre deep bore holes (as required for water-based systems), only 5 - 7-cm wide, 15 - 30-metre deep bore holes are required. The drilling cost is about $8,000 for the average, 20-square household. Once the ductwork, compressor, heat exchanger, and air handler; all required for a conventional air-conditioning; are included, the average price is $20,000. A rebate of $8,000 would bring these GHPs into line with conventional heating and cooling systems.

Closed-loop, water-based geothermal heat pump systems are generally more viable in larger commercial and institutional buildings because of the larger capacity of a single unit.
Direct Use of geothermal energy in Australia currently includes building and district heating systems (e.g.: Portland, Victoria), spa developments (Mornington Peninsula, Victoria and Mataranka, Northern Territory), artesian baths (Moree, Lightning Ridge artesian baths, and Pilliga Hot Artesian bore, inland New South Wales) and swimming pool heating (Challenge Stadium, Western Australia) [4]. Australia's installed capacity for direct geothermal heat use was 110 MWth or 830 GWh/yr in 2000 [2]. Australia's GHP capacity is only 5% of its total geothermal direct-heating capacity, compared with 54.4% internationally.

Carbon-Emission Reduction

Australia's new Mandatory Renewable Energy Target (MRET) requires that the equivalent of at least 20% of Australia's electricity supply - approximately 60,000 GWh/yr - be generated from renewable sources by 2020. Meeting this target will involve multiple renewable technologies including solar photovoltaic panels, wind turbines, solar hot-water heating and geothermal energy. GHPs play a key role internationally in the reduction of electricity demand and can make a significant contribution to Australia's MRET. The present air-conditioning market is outlined below. If a GHP is installed in each of Australia's eight million households, then the energy savings would be 51,400 GWh/yr almost enough to single-handedly meet Australia's MRET!

Impact

Residential

The Australian Heating Ventilation and Air Conditioning (HVAC) market has been expanding rapidly. Air-conditioner penetration has increased from 35% to 65% (figure 4) over the last decade. Well over a million units are sold for over $1 billion and the market is growing at over 20% annually (figure 5).

GHPs are a negligible component of the current HVAC market in Australia as compared with about 2% of the USA HVAC market with over 50,000 GHPs installed annually [4]. The renewable energy revolution that will be catalyzed by Australian carbon trading will accelerate the GHP market. However, stimulus in the form of a rebate is required by the government in order to kick start GHP residential HVAC market penetration.

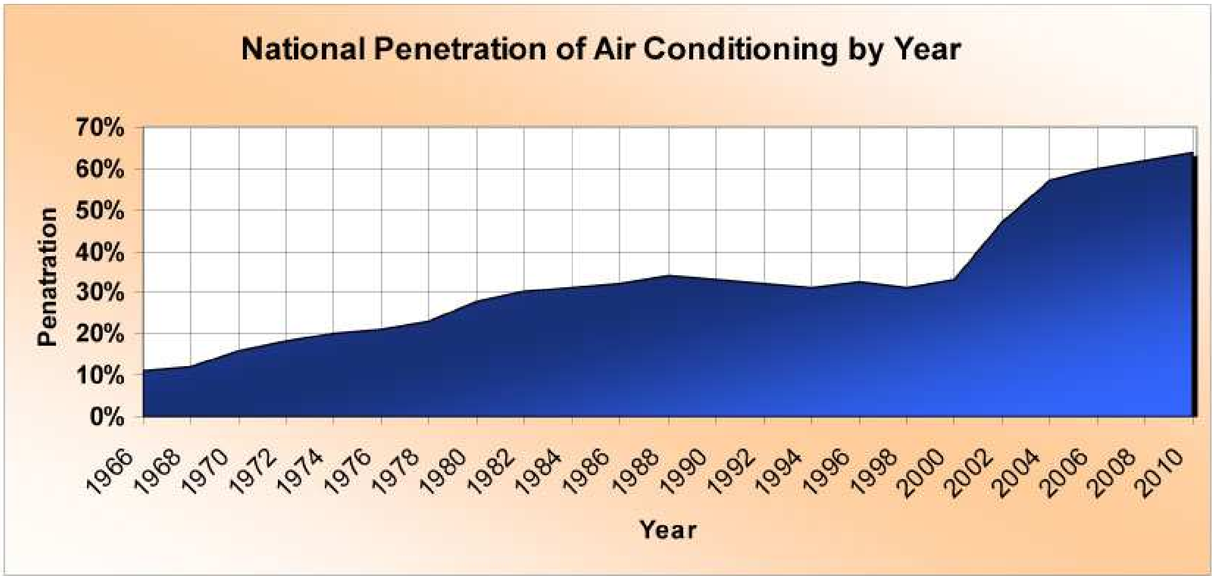

Figure 4 - Air Conditioner Penetration [5]

Figure 5 - Air Conditioner Supply [5]

Commercial & Government

The Commercial HVAC industry (also referred to as the Climate Control Industry) services at least 120 million square metres of nonresidential space, employs at least 95,000 people and accounts for direct spending of at least $7.1 billion per annum. Energy consumed by HVAC services in the non-residential sector in Australia is on track to produce at least 21 million tonnes, or more than 3.5% of total national greenhouse gas emissions in 2010 [3]. HVAC services outside the residential sector presently consume an estimated 9% of all electricity generated in Australia and hence are a major target for Governments looking to reduce greenhouse emissions in cost-effective ways.

Demand for HVAC services is growing by an estimated 20% per annum as a result of natural economic expansion and new building completions, as older building stock has HVAC services added, and as more significantly hot days, and longer sequences of hot days, are experienced. Additionally, as the installed base of HVAC systems expands and ages, it becomes less efficient and consumes more energy. HVAC services are very electricity intensive. As a result, energy demand from HVAC services in Australia is a significant contributor to electricity demand growth and greenhouse gas emissions growth.

Policy Statements

Federal Government

The Rudd government made several policy commitments during their campaign that may relate to Direct Use geothermal. These include:

- Renewable Energy Fund: $500 million to develop, commercialise, and deploy renewable energy in Australia. It may be used for GHP and CHW geothermal demonstration projects.

- Clean Business Fund: $240 million to help business and industry deliver energy and water efficiency projects, with a focus on productivity and innovation.

    - Green Building Fund: $90 million to provide 50% cost of retrofitting buildings up to $200,000 per building -priority to buildings over 5,000 sq. m & higher energy savings per Commonwealth dollar.

    - Climate Ready: $75 million to support development and introduction of products that save energy: reduce energy used by appliances, cutting emissions and household power bills.

- Energy Innovation Fund: $150 million to keep our world leading scientists and researchers in Australia, rather than losing them overseas.

    - $50 million for general clean energy research and development, including energy efficiency, energy storage technologies and hydrogen transport fuels.

- Green Loans of up to $10,000 each to make 200,000 existing homes more energy and water efficient, with subsidised environmental audits and free Green Renovations packs. Households only pay back 2% of annual income with a minimum of $300 per annum.

- Implement Carbon Emissions trading by 2010, a commitment that may be brought forward so that the scheme has some live time before the 2010 federal election.

- Improve the six-star Energy Rating Label scheme so that up to ten stars could be awarded to an expanded list of products. This would give manufacturers incentives to continually improve their products and give consumers more accurate information to help with their choices. GHP technology would presumably be awarded a ten star rating.

- Introduce Greenhouse and Energy Minimum Standards (GEMS) that ensure greenhouse benefits as well as energy savings are factored into standard setting. This builds upon the Minimum Energy Performance Standards (MEPS) for air conditioners, set out in AS/NZS 3823.2-2001, that were introduced on 1st October 2001. Again, GHP technology will undoubtedly meet these standards.

State and international Direct Use policies are summarised in the appendix.

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Appendix

State Government (Victoria)

In early 2006, the Victorian Government formally endorsed the deployment of Advanced Metering Infrastructure (AMI) to all Victorian electricity consumers taking supply of less than 160 MWh per annum. Starting at the end of 2008, more than 2.5 million new AMI meters (often referred to as “smart meters”) will be installed over a 4-year period. Smart meters will allow power distributors to reduce power supply to avoid brownouts. High-drawing air conditioners may be switched out automatically. To avoid this, households may look to GHPs.

The Victorian Energy Efficiency Target (VEET) sets a target for energy efficiency savings, initially in the residential sector. The scheme, due to commence in 2009, will play a role in achieving the Victorian government’s target of reducing greenhouse gas emissions from households by 10 per cent by 2010 and Victoria’s overall emissions to 60 per cent below its 2000 level by 2050.

The VEET scheme involves the creation, acquisition and surrender of Victorian energy efficiency certificates (VEECs) in order to meet the legislative objectives of:

- Reducing greenhouse gas emissions,
- Encouraging the efficient use of electricity and gas, and
- Encouraging investment, employment and technology development in industries that supply goods and services that reduce the use of electricity and gas by consumers.

Under the scheme, accredited persons will be eligible to create certificates when a residential customer undertakes prescribed energy saving activities. Large electricity and gas retailers in Victoria will be required to surrender certificates to the Commission on an annual basis in proportion to their annual acquisitions of gas and electricity. A penalty will be imposed upon entities that fail to surrender sufficient certificates to offset their liability.

Clearly GHPs satisfy the requirements of VEET and will benefit greatly from them.

Present GHP funding is only for demonstration projects via the Renewable Energy Support Fund (RESF) administered by Sustainability Victoria, for example.

International GHP Rebates

USA: The Federal government allows a personal tax credit for the installation of heat pumps. Various states and electric utilities have also adopted incentives. For example in Minnesota, Minnesota Power offer rebates of $57/kW$_{th}$ for a closed loop system (a typical house requiring a heat pump in the 14 18 kW range). In Indiana, the rebate is $114/kW$_{th}$, with the maximum rebate capped at $2,000, which is part of the Indiana Office of Energy & Defense Development (OEDD) rebate program. The new system must be a closed-loop system that is certified by EnergyStar.

United Kingdom: The Business Enterprise & Regulatory Reform funds the Low Carbon Buildings Programme which provides grants for 30% of costs up to AU$3,000 for GHP installation for householders, and 50% of the cost up to AU$75,000 for community organisations, schools, the public sector, and businesses. This is mirrored in the Scottish Community & Household Renewables Initiative (SCHRI).

Canada: The EcoENERGY program offers GHP rebates of up to $3500. In Ontario, a home energy retrofit program has been created. It provides homeowners with grants of up to $3,500 for home energy improvements from the province and mirrors the federal ecoENERGY program of up to $3,500. This makes residents eligible for up to $7,000 for the installation of a qualifying GHP.

Switzerland: GHPs have spread rapidly in Switzerland because of the local utility electricity rebates that are offered [4].

The question is not really whether a rebate should be given clearly it should but rather how much should the rebate be such that it is comparable with rebates for similar scaled wind and solar energy systems.