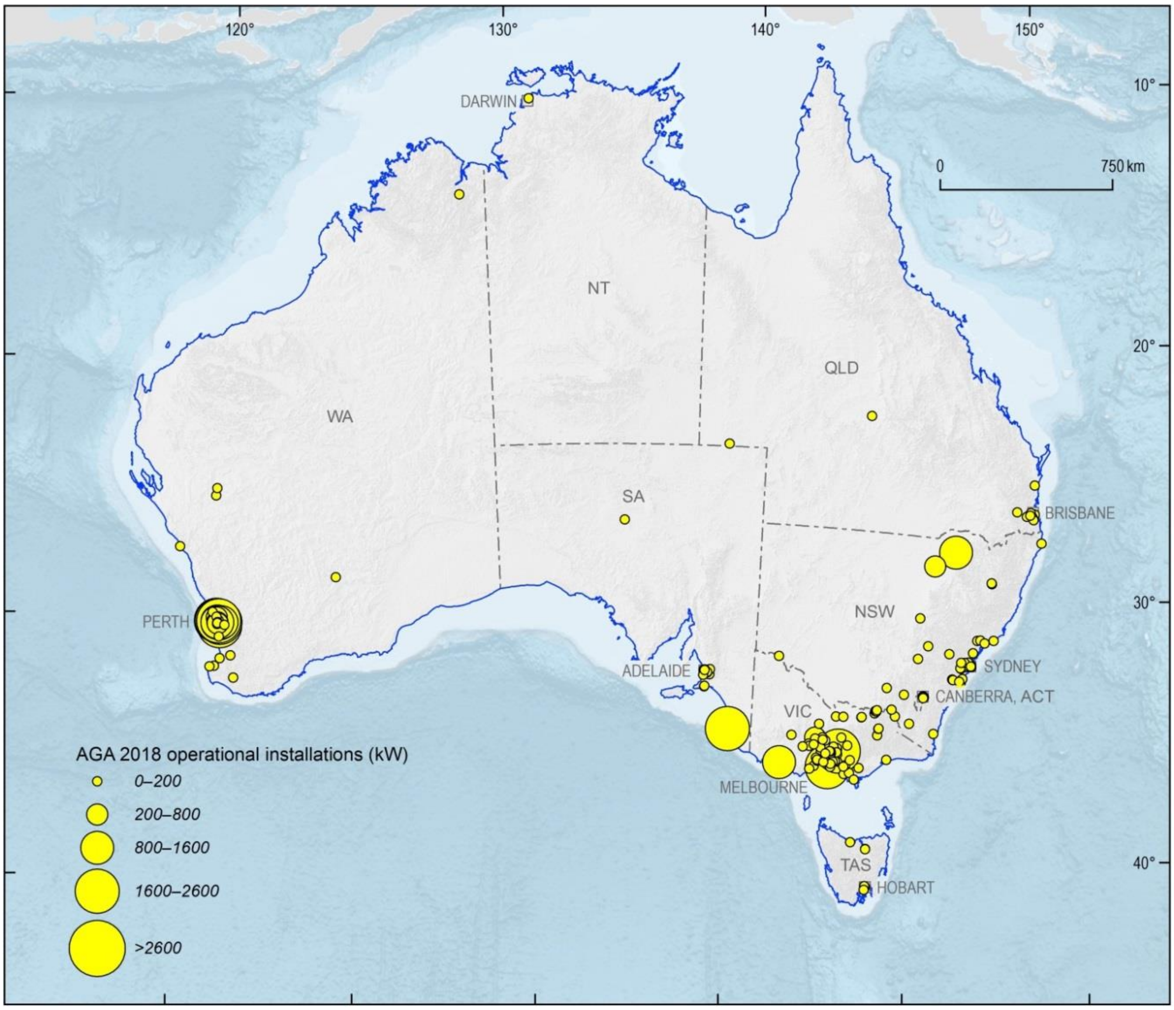
April 2019

Australian Geothermal Association

Geothermal energy is already a clean, cost effective and reliable 24/7 energy solution for Australia

In July 2018, the Australian Geothermal Association (AGA) launched a comprehensive Census to map the type, size and distribution of Australian geothermal energy installations and projects. Such an exercise had never previously been comprehensively undertaken. Preliminary results, summarised on the map below, indicate that geothermal energy is already making a significant positive contribution to Australia's energy mix.

AGA's Census shows that low temperature uses of geothermal energy are being adopted extensively in Australia and working out well while small-scale geothermal electricity generation projects are being developed in remote Queensland. Both are sustainable 24/7 sources of energy.



The Census results show that current geothermal projects are already having a positive impact:

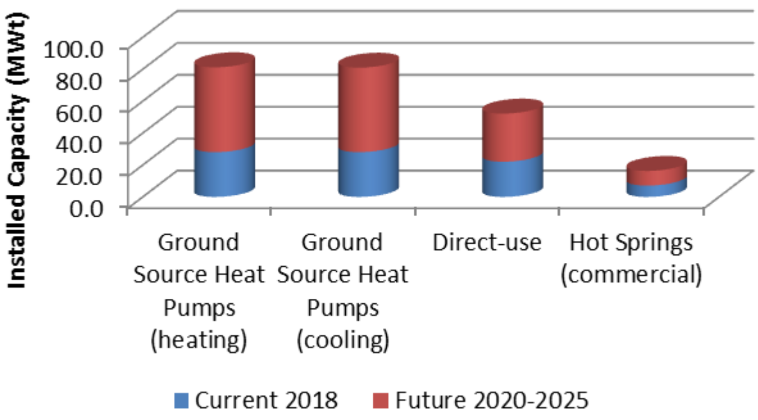
- **Ground Source Heat Pumps (GSHP)** are providing domestic and commercial scale air conditioning with 25-50% greater energy efficiency than conventional air-conditioners, already offsetting up to 4.5 MW_e of grid power demand during peak periods.
- **Direct-use** of geothermal heat has become the standard for large heated swimming pool facilities around Perth in Western Australia, offsetting demand for about 0.35 PJ of natural gas and averting an estimated ~21,000 tCO_2 per year.
- **Commercial Hot Springs** are an increasing tourism drawcard for Australia with one facility in Victoria reporting more than 500,000 visitors in 2018 and up to a dozen new projects in other locations in the planning stage.

Future development opportunities include low temperature electricity generation, large direct-use applications for industry and agriculture, district heating and cooling network for new green suburbs. AGA is working to further analyse the Census results to deliver a more detailed presentation of the data and an outlook on the opportunities for further development.

Total Installed Capacity and Energy

The installed thermal capacity reported for all operating geothermal installations in 2018 was 85 megawatts (MW_t[1]). This is estimated to grow to 146 MW_t by 2020-2025 based on future projects reported by Census respondents. The chart below shows the breakdown in installed capacity according to application type.

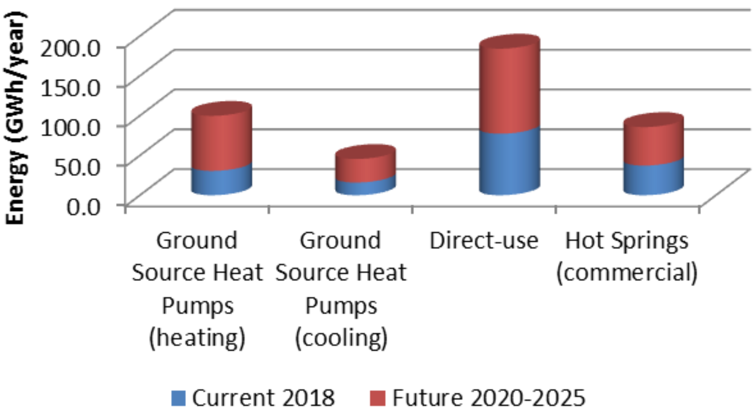
AGA considers the GSHP numbers to be conservative because there was no standardised reporting of GSHP installations in Australia prior to 2000 particularly for small residential scale applications. AGA estimates that in addition to the 56 MW_t of known installed GSHP capacity post-2000 captured in the Census, up to 20 MW_t (heating and cooling) of additional GSHP capacity installed prior to 2000 might not have been captured by the Census[2].



[1] "MW_t" denotes megawatts of thermal power, whereas megawatts of electrical power are denoted by "MW_e"

[2] Burns, K.L., Weber, C., Perry, J., & Warrington, H.J., 2000, Status of the Geothermal Industry In Australia, WGC 2000, https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2000/R0559.PDF

AGA estimates the produced thermal energy from the installed systems to be about 156 gigawatt-hours (GWh)/year, with the chart below showing the breakdown according to application type. Direct-use and commercial hot spring installations typically operate 40 to 60% of the year (ie 3,500 to over 5,000 hours per year) and thus take full advantage of the baseload nature of geothermal energy to produce large sustainable quantities of energy from relatively small capacities.



Ground Source Heat Pumps

Ground Source Heat Pumps (GSHPs) represented 66% of the installed geothermal energy capacity in Australia in 2018 equally distributed between heating and cooling applications. GSHP installations accounted for 19% (heating) and 10% (cooling) of the produced thermal energy (47 GWh/year) with most systems designed to provide both heating in winter (up to 1,800 h per year) and cooling in summer (up to 590 h per year). Their use is mostly for heating, ventilation and air-conditioning (HVAC) applications (space heating and cooling) although there are some reported applications for residential pool heating. GSHPs are installed primarily in residential properties (65%), with 20% installed in public buildings (e.g. universities, libraries…) and the remaining 15% in commercial premises (e.g. private schools, shops etc..). They are most popular in NSW.

GSHPs rely on stable shallow ground / aquifer temperatures typically in the range 15-25°C. They operate very efficiently with net system efficiency[3] typically ranging from 315% (heating) to 385% (cooling). This is about 25 to 50% more efficient than conventional air-conditioners. As a result, AGA estimates that GSHPs offset up to 4.5 MW_e of grid power demand at peak times, and a total of 6.9 GWh of electricity per year. That equals to total savings of about $2.0 million per year at a retail electricity price of $30c/kWh.

Direct-use

Direct-use of geothermal heat represents about 26% of the total installed capacity in Australia but 48% of the produced thermal energy (77 GWh/year). In many of these applications, the geothermal water is used (generally via a heat exchanger) to heat pools in large energy-hungry leisure centres. These systems have been primarily developed in Western Australia (for example Scarborough Beach Pool in suburban Perth) but are increasingly being considered elsewhere, particularly in Victoria. Other applications include aquaculture, meat processing, and cooling of supercomputers.

[3] 'Net system efficiency' is the ratio of the amount of heating or cooling produced to the electrical energy consumed

Direct-use systems operate very efficiently since energy input is limited to electricity supplied to the submersible pumps in the geothermal bores. Conventional heating systems often rely on gas boilers for heat, which can be only up to 80% efficient. As a result, it is estimated that direct-use geothermal systems offset about 0.35 PJ of gas use in Australia in 2018. This is enough to heat more than 9,700 new apartments. Furthermore, it represents savings of about $5.2 million per year at a retail gas price of $15/GJ, and avoidance of about 21,000 tCO_2 emissions associated with the displaced gas use.

Scarborough Beach Pool in Western Australia uses a geothermal heating system

Hot Springs and Tourism

Hundreds of hot springs, artesian bores and spas were reported in Australia, primarily in the Great Artesian Basin which covers parts of Queensland, New South Wales and South Australia. In addition to these often remotely located hot springs, new developments are proposed near tourist destinations in Western Australia and Queensland. Peninsula Hot Springs in Victoria is the most successful example, having received more than 500,000 visitors in 2018. In the Northern Territory, the Mataranka Thermal Pool is visited by many of the more than 190,000 annual visitors to the Elsey National Park.

These commercial operations represent the remaining 8% of the installed capacity identified by the Census, but 23% of the thermal energy (37 GWh/year) because the facilities are often used all year round for up to 14 hours a day. This segment of the industry is tipped to grow quickly in coming years.

Testing of an artesian bore in the Great Artesian Basin

Opportunities for further development

Electricity Generation

In addition to heating and cooling, geothermal energy is also used to generate electricity in many parts of the world. Key benefits of geothermal electricity generation include:

- Clean and sustainable
- 24/7 availability and baseload (typically 90% compared to 30% for solar and wind)
- Can match demand (unlike solar and wind which require batteries to match demand)
- Relatively low surface footprint compared to other renewables

Here in Australia, the 80 kilo-watt[4] (kW_e) Birdsville geothermal plant in Queensland faithfully supplied electricity for over 25 years. While the state-owned electricity company that managed the Birdsville plant recently made a strategic decision to decommission it, a new 310 kW_e geothermal plant is due to be commissioned by the Winton local government in another part of Queensland in 2019. Both of these plants are powered by 87-100˚C water from depths of 1 – 1.5 km in the Great Artesian Basin, and similar projects are currently at the planning stage (e.g. bore testing in photo above) in other parts of the basin.

A 2018 study commissioned by the Australian Renewable Energy Agency[5] found that 'Hot Sedimentary Aquifer' geothermal electricity generation (such as the Queensland projects) have the lowest Levelised Cost of Energy for dispatchable renewables available 24/7. This means that lifecycle cost of geothermal electricity generation is less than that of solar and battery storage combined.

The AGA is currently working on a ***position paper*** that examines recent global developments in geothermal power generation, and considers what areas in Australia might be best suited to this type of geothermal development. For details please get in touch with AGA at australiangeothermal@gmail.com.

District Heating and Cooling

International examples demonstrate that there are opportunities to provide heating and cooling via district networks to entire neighbourhoods as the GSHP and direct-use geothermal industries reach a mature stage.

The Thalkirchen plant currently being built in Munich, for example, plans to use 100% renewable sources to power its newly built district heating network by 2040, with geothermal providing the bulk of the energy. This plant will alone have a capacity of 50 MW_t (about 2 to 3 times the total installed direct-use capacity in Australia) and deliver heat to at least 80,000 people. This approach could be replicated in suitable locations in Australia particularly where there is already a history of direct-use projects (e.g. WA and VIC).

Agriculture and Aquaculture

There are already a few direct-use projects in Australia that utilise geothermal heat for aquaculture. However the potential for a wider use of geothermal energy in Australia is large

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[4] The plant had a gross capacity of 120 kW_e, with 40 kW_e parasitic load from the fans and pumps.

[5] K Lovegrove, G James, D Leitch, A Milczarek, A Ngo, J Rutovitz, M Watt, J Wyder, 2018, Comparison of Dispatchable Renewable Energy Options, ITP report for ARENA, https://arena.gov.au/assets/2018/10/Comparison-Of-Dispatchable-Renewable-Electricity-Options-ITP-et-al-for-ARENA-2018.pdf

particularly when coupled with modern high temperature heat pumps which are capable of raising modest geothermal temperatures from say 60°C to 100-130°C.

For example, in the Netherlands geothermal energy is increasingly used for the purpose of providing heat to greenhouses. The government there plans to produce 15 PJ/year by 2030 from direct-use projects (about 40 times the current direct-use thermal energy produced in Australia) to entirely displace current natural gas usage.

Manufacturing industry

There is already at least one direct-use project in Australia that utilise geothermal heat for meat processing. In addition geothermal heat was used historically in laundries and for wool scouring in Perth.

Overseas, large geothermal projects have been developed to displace gas use. For example, in New Zealand, timber is dried using geothermal heat and plans are to further increase geothermal energy use by 7.5 PJ/year by 2030. Geothermal has the potential to be applied in the same way in Australia.

What does the future of geothermal energy look like?

AGA's Census has revealed that the geothermal industry in Australia has undergone a decade of quiet growth, particularly for space heating and cooling and pool heating. The growth has been driven by lower lifecycle costs when compared to conventional technologies, with an added advantage of lowering CO_2 emissions. A growing number of geothermal spa resorts are helping to raise the public awareness of geothermal energy for recreational and relaxation applications. Electricity generation has been technically demonstrated in South Australia and is being commercially pursued in Queensland.

With better education and communication on the benefits of geothermal energy, AGA believes that the future of the geothermal sector in Australia will feature scaling up of GSHP and direct-use projects. This could include applications in the manufacturing industry and agriculture and other contributions to the energy mix, taking full advantage of the characteristics of geothermal energy: clean, cost effective and reliable.

Regards

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