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Current Directions for Geothermal Energy Development in Australia

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ABSTRACT

The geothermal sector in Australia fundamentally changed focus over the 2010s from electricity generation to direct-use, hot spring spas, and ground source heat pumps, driven by global energy market forces and trends in recreation and wellness. The Australian Geothermal Association (AGA) was incorporated in 2016 as a professional society and forum for the geothermal sector to present and exchange information about geothermal energy. One of the first activities of the AGA was to conduct a national census of geothermal projects, which revealed that ground source heat pumps and direct-use of geothermal heat are already providing significant benefits to Australia in terms of energy cost savings and offsets to greenhouse gas emissions. Natural hot springs occur in every state and territory of Australia, and a growing industry is providing significant boosts to local economies by commercializing the springs for tourism, recreation, relaxation and wellness. There appear to be abundant opportunities to grow the geothermal sector in Australia through direct-use, ground source heat pumps, and hot spring resorts.

1. INTRODUCTION

1.1 National context

The geothermal sector in Australia in the 2000s and early 2010s was dominated by private and publicly listed companies aiming to develop geothermal power plants. In spite of technical success by Geodynamics at Innamincka, South Australia, commercial success was not forthcoming and the geothermal power sector largely collapsed. The collapse took with it federal grant subsidy schemes and the industry representative bodies, AGEG (Australian Geothermal Energy Group) and AGEA (Australian Geothermal Energy Association). At the time of writing in October 2019, Australia has no state or federal level government incentive programs targeting geothermal development. This includes electricity generation, direct-use of geothermal heat, and ground source heat pumps (GSHPs).

Both domestic and global market forces, however, appear to be affecting Australian energy markets in favor of geothermal. Electricity market policies that reward (amongst other things) aggressive investment in transmission infrastructure have resulted in a steady increase in the wholesale electricity price. Domestic natural gas prices on the east coast have also been rising to meet global LNG (liquified natural gas) export price parity over the same period. The result is that many homes and established businesses have seen their energy costs rise dramatically. This has stimulated interest in ground source heat pumps and the direct-use of geothermal heat across the country. In most states, the production of geothermal energy for direct-use is explicitly excluded from geothermal energy legislation, regulated instead under existing frameworks for groundwater management, and the installation and operation of ground source heat pumps remains effectively unregulated anywhere in Australia.

The global growth of the ‘wellness’ sector is also having a positive impact on the growth of a geothermal hot springs industry in Australia, largely for recreation and relaxation. While natural spring water can be artificially heated for these operations, both the appeal of ‘natural’ hot water and the increasing energy costs noted above favor the use of natural geothermal resources.

Sustained interest in geothermal energy, but with a changing focus, justified the formation in 2016 of a new professional association covering all aspects of geothermal energy—the Australian Geothermal Association.

1.2 The Australian Geothermal Association

In the aftermath of the collapse of the Australian geothermal power sector in 2015, a refocus of the Australian geothermal sector was required. The Australian Geothermal Energy Group (AGEG) and the Australian Geothermal Energy Association (AGEA) were both deregistered in 2016, and the Australian Geothermal Association (AGA) inherited AGEG and AGEA assets and legacy material. Incorporated in 2016, the Australian Geothermal Association (AGA) is a professional society whose members are individuals working in industry, academia and government representing the full range of geothermal applications from ground source heat pumps to direct industrial heat supply, recreational bathing and wellness, and electrical power generation.

Affiliated with the International Geothermal Association (IGA), AGA was born to promote and encourage the science, technology and development of geothermal energy in Australia. It is not-for-profit, non-party political and non-sectarian. AGA aims to be the central point for information, discussion and communication on all things geothermal in Australia, covering all technologies and all applications. AGA provides a forum for individuals in the geothermal sector to meet and discuss matters of common interest, either casually or through formal AGA committees. The views and opinions of individual AGA members, however, are their own and not those of AGA, its membership, or the geothermal sector. AGA does not promote or endorse any particular supplier or technology used or supplied by any member or organization.

At the time of writing in October 2019, AGA has built a network of 59 financial members (plus 20 pending or non-financial) spanning the entire geothermal sector and location within the continent and abroad. AGA has also established a strong active and flexible

framework including communication, marketing and operations. To support the development of geothermal activities across all sectors and applications, AGA has reached out to its membership base and its network to establish three 'Special Interest Groups': (i) Ground Source Heat Pumps and Direct Use, (ii) Electricity Generation, and (iii) Bathing and Wellness. Early outcomes from these working groups have already started to be visible and are detailed in the next sections.

2. CENSUS OF AUSTRALIAN GEOTHERMAL ENERGY SYSTEMS

2.1 Background to the census

In July 2018, AGA launched a nationwide exercise to document and map the type, size and distribution of as many Australian geothermal energy installations and projects as could be identified. AGA relied on its members to spread word of the 'census' through their networks, and to help compile the results. The census covered geothermal electricity generation (including quantified estimates of future potential), 'ground source heat pumps' (GSHPs), direct use of geothermal energy including commercial hot springs, and (separately) non-commercial hot springs. Such a comprehensive exercise had never previously been undertaken in Australia. Data collected in the census included the following:

For electricity generation:

- Commissioning year
- Project name
- Ownership (commercial public, commercial private, or residential)
- Status (operating, under construction, investment committed, feasibility study, decommissioned, being commissioned, proposed, dormant, or undergoing maintenance)
- Location (latitude, longitude, town/post code, state)
- Maximum net electrical power output (kW)
- Geothermal water production system (production bore/s only, or production & injection bore/s)
- Maximum water temperature at surface (°C)
- Maximum flow-rate (L/s)
- Max ΔT [temperature IN - temperature OUT] (°C)
- Comments

For GSHPs:

- Commissioning year
- Project name
- Ownership (commercial public, commercial private, or residential)
- Status (operating, under construction, investment committed, feasibility study, decommissioned, being commissioned, proposed, dormant, or undergoing maintenance)
- Location (town/post code, state)
- Purpose (space heating, space cooling, space heating & cooling, bathing/swimming (heating), bathing/swimming (spa), aquaculture, greenhouses, industrial process, heat rejection, food drying, snow melting, other)
- Ground heat exchanger type (open-loop (production bore/s only, production and injection bore/s, dam/pond/lake), closed-loop (trench, borehole, pile, dam/pond/lake, waste treatment))
- Number of heat pump units installed
- Capacity per heat pump (kW)
- Max ΔT [temperature IN - temperature OUT] (°C)
- Comments

For direct-use including commercial hot springs:

- Commissioning year
- Project name
- Ownership (commercial public, commercial private, or residential)
- Status (operating, under construction, investment committed, feasibility study, decommissioned, being commissioned, proposed, dormant, or undergoing maintenance)
- Location (latitude, longitude, town/post code, state)
- Purpose (space heating, space cooling, space heating & cooling, bathing/swimming (heating), bathing/swimming (spa), aquaculture, greenhouses, industrial process, heat rejection, food drying, snow melting, other)
- Geothermal water production system (production bore/s only, or production & injection bore/s)
- Maximum water temperature at surface (°C)
- Maximum flow-rate (L/s)
- Max ΔT [temperature IN - temperature OUT] (°C)
- Comments

For non-commercial hot springs:

- Name
- Location (state)
- Water temperature (°C)

2.2 Census results

2.2.1 Summary

The census results, summarized on Figure 1, revealed that geothermal energy is already making a significant positive contribution to Australia's energy mix. The results showed that GSHPs and direct-use of geothermal energy are being adopted extensively in Australia with few government incentives. Small-scale geothermal electricity generation projects are also being developed in remote western Queensland as an economically competitive technology. Specific findings from the census include:

- GSHPs are already offsetting up to 4.5 MW_e of grid power demand during peak periods, relative to conventional air source heat pump air conditioners;
- 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 ~21,000 tonnes of CO_2 emissions 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 the planning stage in other locations.

2.2.2 Total installed capacity and energy

The installed capacity reported for all operating geothermal installations in 2019 was 94 thermal megawatts (MW_t). This is estimated to grow to 155 MW_t by 2025, according to planned future projects reported by census respondents. The estimated thermal energy produced by the installed geothermal systems is about 142 gigawatt-hours per year (GWh/yr), projected to grow to 220 GWh/yr by 2025. Figure 2 and Figure 3 show the breakdown in installed capacity and generated energy, respectively, according to application type. Direct-use and commercial hot spring installations typically operate at capacity factors of 0.4–0.6, (ie 3,500 to >5,000 hours per year), taking full advantage of the high availability of geothermal energy to sustainably produce large quantities of energy from relatively small capacities.

AGA considers the number of GSHP to be conservative because there was no standardized reporting of GSHP installations in Australia prior to 2000, particularly for residential scale applications. AGA estimates that in addition to the 65 MW_t of combined heating and cooling GSHP capacity captured by the census, up to 20 MW_t (heating and cooling) of additional GSHP capacity might have been installed prior to 2000 and not captured by the census (Burns et al., 2000).

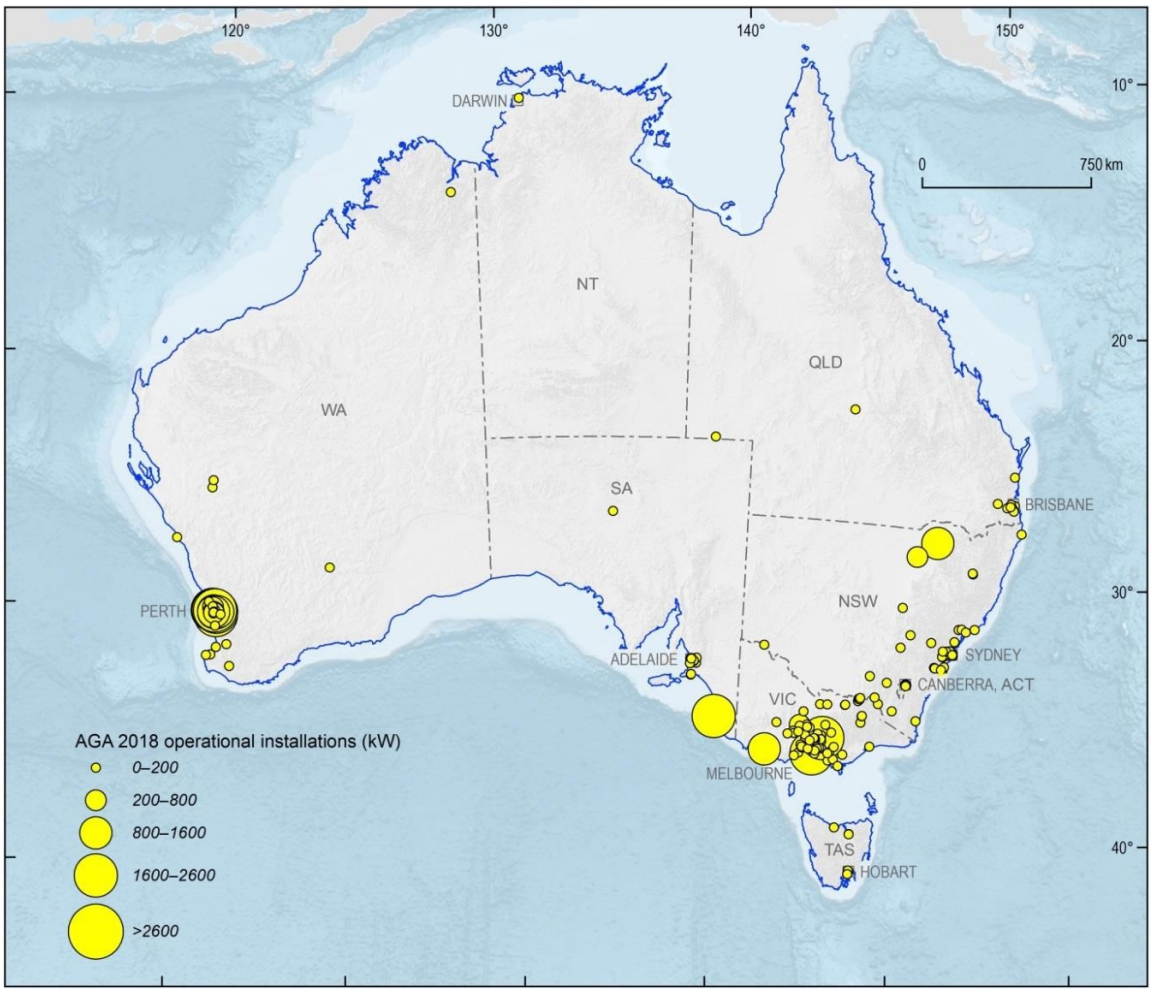

Figure 1. Summary of census results displaying locations and installed capacities of geothermal energy systems in Australia (Map source: Bridgette Lewis, Geoscience Australia)

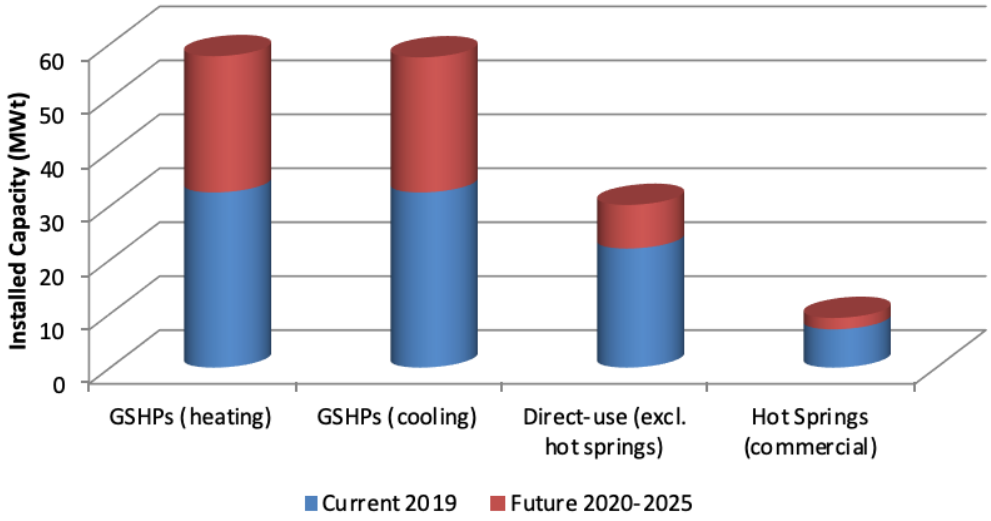

Figure 2. Summary of census results displaying current and planned installed capacity of geothermal systems according to application type in Australia

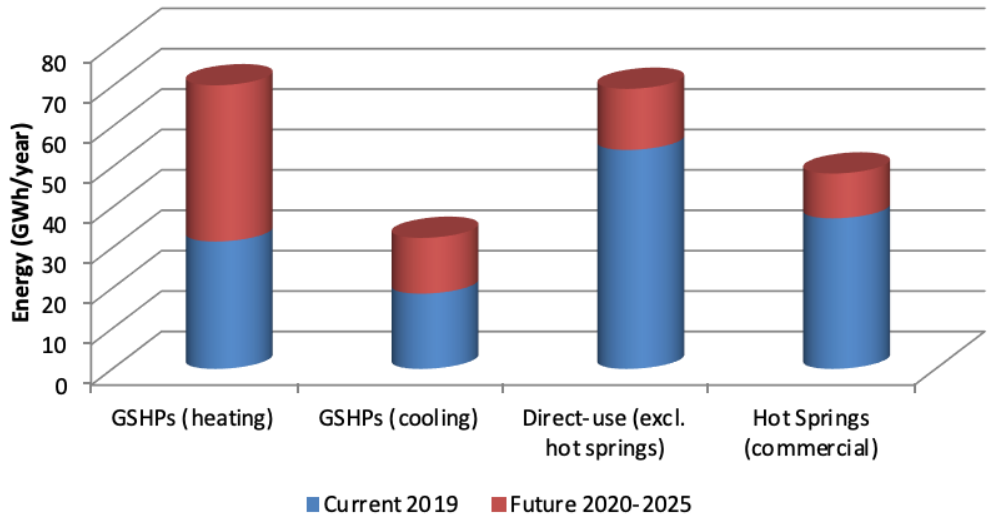

Figure 3. Summary of census results displaying current and planned annual thermal energy production from geothermal systems according to application type in Australia

2.3 Ground Source Heat Pumps

GSHPs accounted for 69% of the installed geothermal capacity in Australia in 2019, equally distributed between heating and cooling applications. GSHP installations produced an estimated 50 GWh/yr of thermal energy in 2019, accounting for 22% (heating) and 13% (cooling) of the total thermal energy produced by geothermal applications (142 GWh/year). Most GSHP systems are designed to provide both heating in winter (estimated average of 1,800 hour per year) and cooling in summer (estimated average 590 hours 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. 65% of GSHPs are installed in residential properties, 20% in public buildings (e.g. universities, libraries, etc.) and the remaining 15% in commercial premises (e.g. private schools, shops, etc.). They are most popular in NSW.

Australian GSHPs are typically installed in regions with shallow ground or aquifer temperatures in the range 15–25°C. They operate very efficiently with net system efficiency (the ratio of heating or cooling energy produced to electrical energy consumed) typically ranging from 3.15 (heating) to 3.85 (cooling), which is 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 AU$2.0 million per year at a retail electricity price of AU$0.30/kWh.

2.4 Direct-use

Direct-use geothermal applications (excluding hot springs) account for about 23% of the total installed capacity in Australia, but produce 38% of the thermal energy. The geothermal water is used (generally via a heat exchanger) in many of these applications to heat pools in large, energy-hungry leisure centres. These systems have mostly been adopted in Western Australia (for example Scarborough Beach Pool in suburban Perth, Figure 4) but are increasingly being considered elsewhere, particularly in Victoria. Other applications include aquaculture, meat processing, and cooling of supercomputers.

Figure 4. An aerial view of Scarborough Beach Pool, Western Australia, which has a geothermal heating system (photo source: Douglas Mark Black Photography, 2017)

2.5 Hot springs and tourism

Hundreds of hot springs, artesian bores and spas were reported across Australia. Most of them are remote, non-commercial sites, providing tourism destinations at minimal cost. Many are in the Great Artesian Basin which covers parts of Queensland, New South Wales, Northern Territory and South Australia. The Mataranka Thermal Pool in the Elsey National Park is a prime example. Although located more than 400 km southeast of Darwin in the Northern Territory, the thermal pool is visited by many of the >190,000 annual visitors to the national park.

A small proportion of hot springs, however, are commercial operations in populated places. Peninsula Hot Springs, in Victoria, is the most successful commercial example, receiving more than 500,000 visitors in 2019. These commercial operations represent the remaining 8% of the installed capacity and 26% of the thermal energy identified by the census. The proportion of thermal energy produced relative to the national total far exceeds the proportion of installed capacity because spa facilities operate at a high utilization factor, typically utilized for up to 14 hours a day year-round. This segment of the geothermal industry is tipped to grow quickly in coming years, as discussed in more detail below.

3. GEOTHERMAL HOT SPRINGS

There has been a big movement in the hot springs industry in the past couple of years with seven new projects well evolved in Victoria and a number more across the country in Western Australia, South Australia, Queensland, New South Wales and Tasmania.

A tourism project being developed by the Ewamian First Nations people at Talaroo Station in northwest Queensland is centered on natural mound springs. The Ewamian people are planning a both a day-visitation and accommodation facilities and have secured a grant of approximately AU$4.5 million (US$3.1 million) from a state government regional development fund. At the time of writing in October 2019, they are hoping to commence construction before the end of 2019 and anticipate opening for business in 2020. Also in Queensland, the town of Cunnamulla in the southwest of the state is planning a hot springs bathing facility to support year-round tourism in the township (Figure 5). This project has also been granted AU$5 million (US$3.4 million) from the state government regional development fund.

The town of Pilliga in New South Wales has also invested in the growing hot springs market, upgrading its camping facilities located next to artesian hot springs and bathing pools.

Many hot springs development projects are in different stages of planning and construction in Victoria (Figure 6). As an example, an existing hotel called Deep Blue Hotel and Hot Springs in Warrnambool is scheduled to open a AU$4 million (US$2.6 million) expansion to its pools and other facilities in late 2019. Saltwater Springs, Phillip Island, will shortly commence construction of a AU$20 million (US$14 million) facility, with an anticipated opening in December 2020. Peninsula Hot Springs opened a AU$13.5 million (US$9.3 million) expansion in July 2018 and is currently investing an additional AU$12 million (US$8.3 million) in infrastructure and anticipates launching on-site accommodation in November 2019. Peninsula Hot Springs anticipates spending a

further AU$60-80 million (US$41–55 million) over the coming 3–5 years to expand its accommodation and related services. The Great Victorian Bathing Trail strategy document (Sykes, 2019), released in September 2019, laid out a blueprint for the development of an integrated geothermal hot spring and bathing tourism industry in the state of Victoria.

Figure 5. An artist's impression of the planned Cunnamulla Hot Springs development in southwest Queensland.

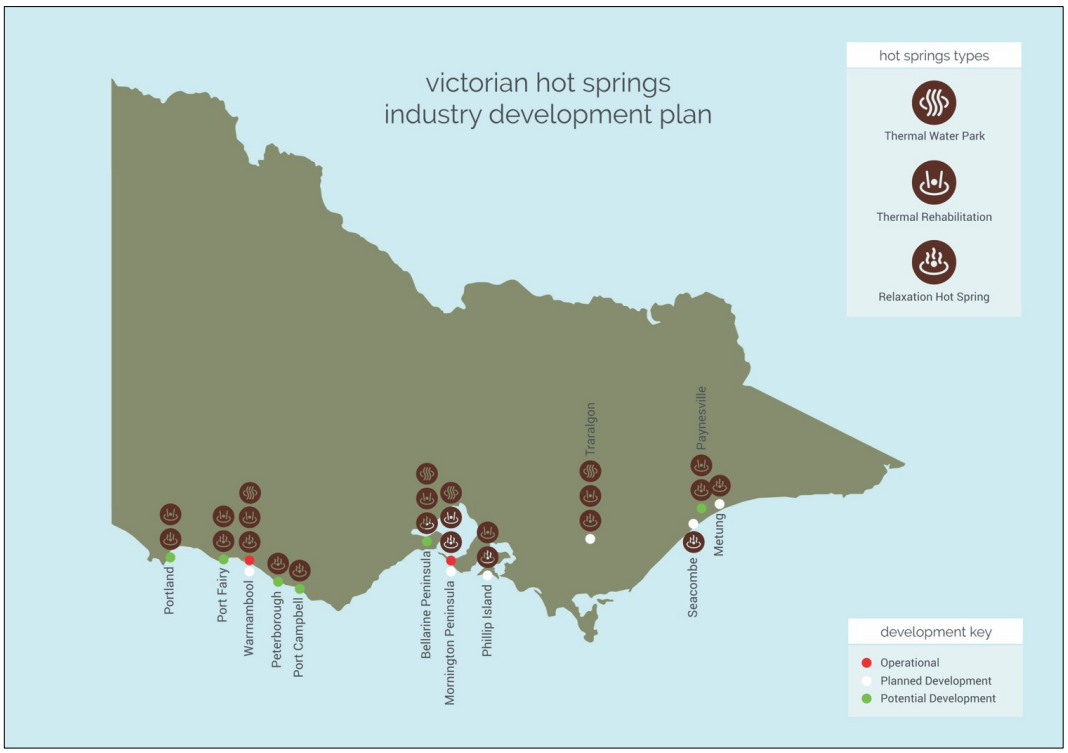

Figure 6. At least 12 geothermal hot spring developments are operating or are in planning or construction phases in the state of Victoria.

4. LOOKING AHEAD

4.1. Electricity generation

The positive aspects of geothermal power generation are well known within the sector, but must be actively communicated to those who are new to the concept. AGA therefore promotes the following attributes of geothermal power:

- Very low greenhouse gas emissions relative to fossil fuels;
- Sustainable if properly managed;
- High availability (typically >90%, compared to <30% for solar and <35% for wind in Australia);
- Can match demand (unlike solar and wind which require batteries to match demand);
- Small surface footprint and visual impact relative to wind and solar.

The 80 kWe (net) Birdsville Geothermal Plant in outback Queensland faithfully supplied electricity for over 25 years. In mid-2018, however, the state-owned electricity company that managed the plant made a strategic decision to decommission it. At the same time, plans by the Winton Shire Council, also in outback Queensland, were well advanced for a new 310 kWe geothermal plant. At the time of writing in October 2019, the Winton plant is in final commissioning stage. Both plants source thermal power from 87–99°C water at depths of 1 – 1.5 km in the Great Artesian Basin (GAB). Several more similar projects are currently at the planning stage for other small towns in the GAB.

A 2018 study commissioned by the Australian Renewable Energy Agency (Lovegrove et al., 2018) predicted that 'hot sedimentary aquifer' geothermal electricity generation (such as the Queensland projects) would have the lowest levelized cost of energy for fully dispatchable renewables; less than that of wind or solar with battery storage. While dispatchability is not yet financially rewarded in Australia, any such change in energy policy would be expected to provide a sharp incentive for geothermal power.

The future of 'engineered geothermal systems' in Australia is less certain. At the time of writing in October 2019, AGA is finalizing a position paper that examines recent global developments in geothermal power generation, and considers what impact these developments might have on the economics of geothermal power generation in Australia.

4.2 District heating and cooling

International examples demonstrate the opportunity to provide geothermal heating and cooling to entire neighborhoods via district networks as the local geothermal industry matures. The 50 MWt 'HKW Süd' cogeneration plant being developed in Munich, for example, will provide fully renewable heat to 80,000 Munich residents. That one plant will have more than twice the total installed thermal power capacity of Australia in 2019. This approach could be replicated in suitable locations in Australia, particularly where there is already a history of direct-use (e.g. WA and VIC).

4.3 Agriculture and aquaculture

A small number of facilities already utilize geothermal heat for aquaculture in Australia. However, the potential for wider use for agriculture and aquaculture in Australia is large, particularly if coupled with heat pumps to raise the temperature of geothermal water from (for example) 60°C to 100–130°C. The increasing use of geothermal energy in the Netherlands to provide heat to greenhouses is being studied closely by some Australian state agencies, with a view to replicating the success of such operations.

4.4 Food and fiber processing

There is currently at least one direct-use application of geothermal heat in Australia for food processing. A meat processing plant in western Victoria benefits from geothermal energy to preheat feed water for a steam boiler. In addition, geothermal heat was historically used in laundries and for wool scouring in Perth. International examples show the potential for more industrial use of geothermal heat to offset natural gas use in Australia, and increasing natural gas prices are driving industrial thinking down this path.

5 CONCLUDING REMARKS

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 air-source or natural gas technologies, with an added advantage of offsetting greenhouse gas emissions. A growing number of hot spring spa resorts are helping to raise the public awareness of geothermal energy for recreational and relaxation applications. New geothermal electricity generation projects are 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 in specific locations where they are shown to be cost-effective. This could include applications in heating, cooling, agriculture, aquaculture and food processing, taking full advantage of the characteristics of geothermal energy: clean, continuous, and low-impact.

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