

Renewable energy use in Australian public hospitals

Hayden Burch
MD/MPH Student
The University of Melbourne
Faculty of Medicine Dentistry and Health Sciences
Melbourne Medical School
Melbourne, Victoria, Australia

Matthew H Anstey
Intensivist
Sir Charles Gairdner Hospital
Department of Intensive Care
Perth, Western Australia, Australia

Forbes McGain
Consultant
Western Health
Intensive Care Unit
Footscray, Victoria, Australia

Associate Professor
The University of Melbourne
Department of Medicine
Medical Faculty
Melbourne, Victoria, Australia

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Australian public hospitals' energy choices are at odds with 'first do no harm'.

The healthcare sector faces many of the consequences of climate change, but is lagging behind in tackling its own contribution to this health threat (1). Increases in extreme weather are contributing to adverse physical, mental and intergenerational health outcomes in Australia and beyond (2, 3). Despite these health implications, healthcare itself pollutes, being responsible for 7% of Australia's total carbon footprint (4). Coal-generated electricity and natural/fossil gas are considerable sources of healthcare's CO₂e (CO₂ equivalent) emissions (4), and also contribute to local air particulate matter with cardiorespiratory consequences (3).

Hospitals have large energy demands due to continuous operation, primarily from heating, ventilation and air conditioning (5). The demand is so large that public hospitals consume over half of public-sector energy in most Australian states and territories (6, 7). Hospitals should therefore be key stakeholders in Australian state/territory decarbonisation efforts.

Internationally, healthcare institutions have recognised and are acting on their energy choices, signing on to 100% renewable electricity targets for their healthcare facilities (5). It remains unclear, however, how rapidly Australian hospitals are moving towards renewable energy alternatives. We aimed to evaluate the total energy use, electricity use, fossil (natural) gas use, and renewable electricity generation/purchase by Australian public hospitals and compare this to international healthcare leaders and the Australian university sector.

We examined Australian state/territory public hospital direct energy data for the decade 2010-19, obtaining prospective ethics approval (Western Health QA2019.41). Although we sought 10 years of data, we were only able to obtain complete data for all states/territories for three consecutive years 2016/17 – 2018/19. There were 693 public hospitals in Australia in 2018/19 (Australian Institute of Health and Welfare data) (8).

We sought data from two sources: Australian State/Territory Health Departments, and the Australian Clean Energy Regulator (responsible for National Greenhouse and Energy Reporting (NGER)). In Australia, since 2017 public hospitals have been included in both the National Built Environment Rating System (NABERS) (9) and NGER schemes (10). Under NABERS, 274 of 693 Australian public hospitals are included in 2018/19 NABERS analysis, though none are publicly disclosed (9). Under NGER, hospitals must report if energy consumption is 100TeraJoules or more per year and/or if emissions equal 25kt CO₂e emissions/annum (i.e. hospitals with approximately 200 acute beds) (10).

We wrote to Australian state/territory Health Departments in August-October 2019 seeking annualised data for public hospital direct energy use. We also wrote to three health services in Western Australia (East, North and South Metropolitan regions) as no renewable electricity data could be identified by the WA Health Department. Hospital-level information was amalgamated into state-based calculations to avoid inadvertent identification of individual hospitals. Tertiary education was selected as a comparator with similarly large multi-building institutions, and considerable energy demands (6).

The following Australian public hospital data were requested for 2010-2019: total energy use, fossil/natural gas use, renewable and non-renewable electricity (produced or purchased, e.g. rooftop solar photovoltaic (PV), GreenPower (purchased renewable electricity) in kilowatt-hours (kWh), natural gas (gigajoules, GJ), Liquefied Petroleum Gas (LPG) (kilolitres, kL), co/tri-generation (kWh).

In order to establish the active contribution of the healthcare industry to reducing fossil fuel use, we focused upon renewable electricity generated/purchased by the healthcare sector. Only health sector purchased GreenPower was attributed to hospital renewable energy calculations. That is, we only included production/purchase of renewable electricity beyond the state's/territory's grid electricity. We did not include diesel fuel use (used either for transport, back-up power or in smaller rural hospitals for electricity generation) due to poor data access.

From November 2019 to February 2020 we received responses from all state/territory Health Departments and from metropolitan Western Australian health services. Data were robust for the three consecutive years from 2016/17 to 2018/19 inclusive. Data prior to 2016/17 were: unavailable, unreliable or not inclusive of all hospitals. Data supplied under NGER (the Clean Energy Regulator) were not reliable (high energy reporting thresholds, and heavily redacted due to concerns about revealing individual hospitals).

Total Australian public hospital energy use was stable for the three years (2016/17 to 2018/19) (Table 1). Renewable energy production/purchase increased from 14/ 4,132 GWh to 94/ 4,122 GWh (from 0.3% to 2.3% of power consumed). Australian renewable grid electricity uptake grew by 8.3% (from 15.7% in 2016/17 to 24% in 2018/19).

On a national level, grid electricity use was the majority of total hospital energy consumed (range 2,495-2,507 GWh [59-61% of total energy]), incorporating GreenPower certificates (range 1-72 GWh [0.02-2%]). Natural gas use was also large (range 1,444-1,522 GWh [35-36%]), followed by liquid propane gas (range 95-107 GWh [2%]), co/tri-generation (range 62-74 GWh [1.5-2%]), and rooftop solar PV (range 13-21 GWh [0.3-0.5%]). No biofuels were used according to discussions with state health representatives, nor was feedback that renewable electricity supply may be a limiting factor.

The large increase in renewable energy in 2018/19 was a result of Queensland Health being a benefactor of a whole-of-government GreenPower purchase (71.4 GWh purchased by Queensland Health). Renewable energy uptake by healthcare elsewhere was small (range 0 – 1.2%, 2018-19).

Figure 1 represents each state/territories relative contribution to Australian national public hospital energy consumption and the percentage of renewable energy use. Victoria and New South Wales combined consumed 60% of total Australian public hospital energy (1,288 and 1,206 of 4,122 GWh respectively, 2018/19). Queensland public hospitals consumed 778/4,122 GWh [19% of total energy] and produced/purchased the most renewable electricity (74/778 GWh [9.5%]) of all state public hospitals in 2018/19. In Victoria, the ACT, and SA half of total energy consumption was by natural/fossil gas. Large hospital heating loads are required particularly overnight in cooler states, thus Victorian public hospitals had higher total energy use than NSW.

Our study shows that just 2.3% (14-94 GWh/yr) of Australian public hospital energy use was sourced from renewables between 2016/17 to 2018/19. The vast majority of hospital efforts over-and-above national grid renewable electricity supply arose from a single state, Queensland Health's GreenPower purchase in 2018/19 which contributed $\frac{3}{4}$ of all Australian public hospital renewable electricity. Over the same period, public hospitals consumed 4,122-4,132 GWh/yr of energy, enough to power 630,000 average Australian homes each year.

Increasing renewable energy use in the healthcare sector will require a number of approaches. Firstly, state/territory net zero emissions and renewable energy targets need to be more uniform and stronger. Appendix 1 outlines the state health sector specific targets, which remain piecemeal (online at mja.com.au). In contrast, the NHS has a national Sustainable Development Unit that coordinates a national roadmap for net zero healthcare emissions by 2040 (11).

Secondly, while hospital energy efficiency may be a reasonable first step, in order to achieve the emissions reductions targets required, we need to transition to renewable electricity sources. (6). Co- or tri-generation electricity are energy-efficiency variants relying on fossil/natural gas. Victoria illustrates the difficulties of hospital energy efficiency as a sole strategy, as while their efficiency improvements achieved a 9% reduction in CO_{2e} emissions/m² of hospital floor-space between 2005-2018, demand driven energy use grew 22% and carbon emissions 32%. (12). For Victoria to achieve the state's legislated 2050 net zero target, large change will be required. Natural/fossil gas consumption contributed 48% of Victorian hospital energy use in 2018/19, and only 'getting off gas' will ultimately solve this.

While some Australian hospitals are putting on roof-top solar panels, this will be insufficient to supply virtually all medium to large hospitals. Australia's public hospitals are using about 4,100 GWh p.a., and solar panels can generate approximately 4kWh per m² per day (a conservative average for Australian capital cities (<https://pvwatts.nrel.gov/>)). Allowing for 50% inefficiencies for cloudy days and battery storage, we would need a solar farm at Sydney's latitude of approximately 4 km² (two km long, by two km wide) to power all of Australia's public hospitals (our calculations). Comparatively, in the United States, the world's largest integrated healthcare system, Kaiser Permanente has achieved renewable energy self-sufficiency via a 180MW power purchase agreement (13). A power purchase agreement enables the construction of utility-scale solar and wind farms, and large battery-energy storage systems to directly supply clean and often cheaper energy to hospitals. In the UK, England's National Health Service (NHS) will purchase 100% renewable electricity for its 3,500 buildings (hospitals, GP surgeries, etc.) by December 2021 (11). In Australia, Queensland may demonstrate a pathway for other state/territory health systems through their large-scale GreenPower purchasing. This approach increased purchasing power, although renewable energy remains expensive (hospitals' 24-hour operations demand both on- and off-peak electricity).

GreenPower purchasing, however, may not suit all states/territories. For example, the ACT, Tasmania and South Australia have already achieved high grid renewable electricity penetration, with ACT and South Australia reducing state-wide grid carbon intensity by more than 50% over the past decade (14, 15). This may explain why relatively little renewable electricity has been produced/ purchased by public hospitals in these states/territories (range 0.4 - 1.2%, 2018/19). Purchasing hospital renewable electricity over-and-above a high state background renewable electricity proportion will yield lower sustainability returns than

focusing on states that have much lower renewable grid penetration. Further, Victoria, South Australia, and ACT, with proportionally high gas consumption should focus on replacing this gas with renewable electricity. For the same amount of energy, gas (at best) has approximately 1/3rd the CO₂e emissions compared with coal (16). Gas, by definition, is not the pathway to zero emissions healthcare.

When healthcare compares itself to comparative economic sectors in Australia, such as tertiary education, it is woefully behind. Many universities have set 100% renewable electricity targets, with the investment by individual universities occurring at a scale equal or larger than entire state/territory public hospital efforts (17). Monash University (Melbourne) purchases fivefold the renewable electricity each year of all Victorian public hospitals combined (55 GWh of GreenPower; and from 3.8 to 6.3 GWh of solar PV, 2015/16 to 2018/19). Other universities (Swinburne University 90 GWh/yr; University of New South Wales 124 GWh/yr) have entered long-term renewable Power Purchase Agreements (like Kaiser Permanente in the U.S) that eclipse the efforts of the entire Australian public hospital system.

All renewable energy solutions need investment, and routine cooperation with other government sectors. We recognise these solutions will require a degree of financial investment to kickstart (and expect a future return), and this can be difficult when hospitals are under pressure to balance their yearly budgets just to provide patient care. Nevertheless, the healthcare sector could use its market influence to purchase increasing amounts of renewable energy.

Our study has limitations. We calculated the best-case scenario for the percentage of renewable energy produced/purchased, often based on peak-solar output per kW of solar panels. Underreporting of total hospital energy data was possible in WA, NT, ACT, and Queensland with very small rural/regional facilities not included in the supplied data. Centralised management systems of public hospital energy are non-existent in some jurisdictions. We did not consider indirect hospital energy consumption, such as procurement of services, equipment and consumables not directly controlled or owned by the hospital, which we realise form the majority of healthcare's carbon footprint (scope 3 emissions) (4). We also did not examine private hospital energy use due to commercial-in-confidence concerns. Future analyses should consider data collection methodology in the absence of robust state-wide energy management systems.

We describe the first quantitation of how rapidly Australian hospitals are moving towards renewable energy as a source of electricity supply and compare healthcare's performance with international leaders and other economic sectors. The ancient Hippocratic principle '*Do No Harm*' is central to the practice of medicine. Evidence-based medicine is also now integral to our practice. Level 1 evidence from our planetary science colleagues tells us that we need to act now to reduce harm from climate change. To decouple hospital energy from contributing to climate change, hospitals must move to renewable electricity, and get off gas.

Table 1. Australian national and state/territory baseline grid renewable electricity levels, public hospital total energy consumed, renewable energy purchased/produced, and percentage of total energy that is renewable over-and-above grid supply, 2016/17 to 2018/19.¹

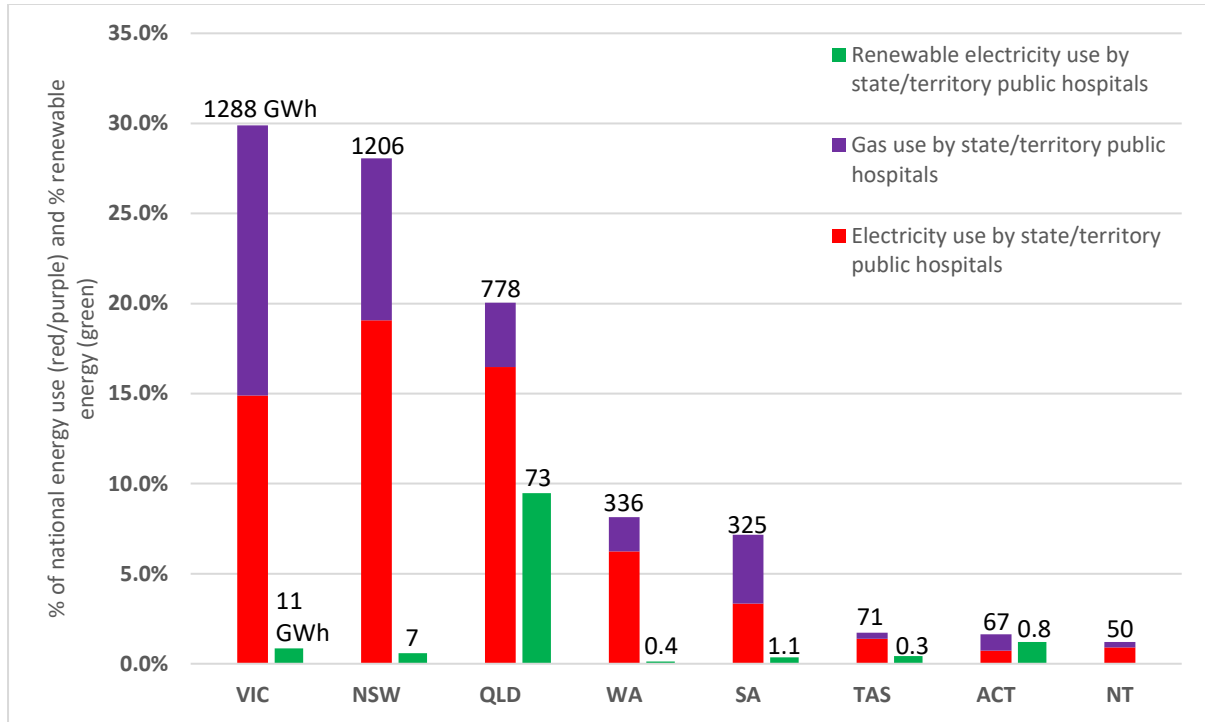
State	Energy (MWh)	2016/17	2017/18	2018/19
AUSTRALIA	National baseline renewables	15.7%	17.0%	24.0%
	Total hospital energy consumed	4,132,162	4,213,694	4,121,911
	Hospital renewable energy produced	13,651	18,350	94,415
	Hospital energy % renewable	0.33%	0.44%	2.29%
VIC	State baseline renewables	12.0%	15.2%	23.9%
	Total hospital energy consumed	1,305,587	1,310,008	1,288,292
	Hospital renewable energy produced	3,288	7,679	11,057
	Hospital energy % renewable	0.3%	0.6%	0.9%
NSW	State baseline renewables	16.0%	15.7%	17.1%
	Total hospital energy consumed	1,194,657	1,218,509	1,206,019
	Hospital renewable energy produced	7,053	7,036	7,007
	Hospital energy % renewable	0.6%	0.6%	0.6%
QLD	State baseline renewables	6.5%	7.2%	14.1%
	Total hospital energy consumed	773,111	770,317	778,595
	Hospital renewable energy produced	2,136	2,121	73,694
	Hospital energy % renewable	0.3%	0.3%	9.5%
WA ²	State baseline renewables	7.5%	7.7%	20.9%
	Total hospital energy consumed	336,494	354,698	335,783
	Hospital renewable energy produced	-	-	396
	Hospital energy % renewable	0.0%	0.0%	0.1%
ACT	State baseline renewables	18.1%	28.2%	43.9%
	Total hospital energy consumed	70,196	70,311	67,426
	Hospital renewable energy produced	549	829	811
	Hospital energy % renewable	0.8%	1.2%	1.2%
TAS	State baseline renewables	91.3%	91.3%	95.6%
	Total hospital energy consumed	71,839	70,987	71,396
	Hospital renewable energy produced	415	429	300
	Hospital energy % renewable	0.6%	0.6%	0.4%
NT	State baseline renewables	2.9%	3.5%	6.0%
	Total hospital energy consumed	54,282	56,415	49,613
	Hospital renewable energy produced	-	-	-
	Hospital energy % renewable	0.0%	0.0%	0.0%
SA	State baseline renewables	47.0%	46.6%	52.1%
	Total hospital energy consumed	325,997	362,450	324,789
	Hospital renewable energy produced	210	256	1,149
	Hospital energy % renewable	0.1%	0.1%	0.4%

¹We converted all energy data into kWh for simplification, i.e. for fossil/natural gas; 1 GJ = 278kWh, for LPG; 1kL= 6,900kWh (18). Solar PV data supplied as kilowatts/kilowatt-peak were multiplied by the hourly daily solar average per state/territory capital city for 365 operating days (19). Peak-watts were used to calculate a best-case scenario. If raw gas co-generation electricity data were not provided, we multiplied total kilowatt-peak capacity by the minimum annual running time to justify operation as per a NSW government approach (3,300 hours p.a. or 38% total time usage) (20). Solar

hot water production was included in Queensland supplied data, and approximated by researchers in South Australia as 2kWh/panel/day (6) and not reported elsewhere.

²Blue - data sourced directly from Western Australian health services.

Figure 1. State/Territory public hospital total energy consumption as % of Australian total public hospital energy use, and % of state/territory total energy use that was renewable in supply, 2018/19.



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Appendix 1. National, state and territory renewable electricity generation, renewable electricity, and net zero CO2e emissions targets, and health sector specific ambitions

Jurisdiction	% Grid renewable electricity (2019)	2030 target	Net zero emissions target	Health sector targets
Australia	24	None	26-28% reduction on 2005 levels	None at the Federal level
Australian Capital Territory	97	100%	2045	Achieve zero emissions from the public health sector by 2040
Tasmania	96	100%	Achieved 2018	None
South Australia	52	Removed	2050*	None
Victoria	24	50%*	2050*	5% of hospital electricity from on-site renewables by 2023; Work with Health Purchasing Victoria regarding state-wide power purchase agreements with renewables
Queensland	14	50%	Aspirational 2050	New health facilities shall <i>target</i> 20% of power sourced from alternative energy sources (<i>including fossil gas</i>) (2017)
New South Wales	15	None	Aspirational 2050	All non-Local Health District's (LHD) facilities purchase 6% GreenPower; LHDs to complete at least one renewable energy installation/year <i>if</i> internal rate of return >12% can be achieved over life of project
Western Australia	21	None	Aspirational 2050	None
Northern Territory	8	50%	Aspirational 2050	Assist government facilities (including health centres) to have more flexible financing options to enter into renewable energy projects

*Legislated targets. Sources: (1-6)

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