



Powering a sporting nation: Rooftop solar potential for Australian soccer 🌱



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Introduction

Nearly 2 million Australian adults and children played football (association football or soccer) in 2019 [1], giving the sport the highest participation of Australia's football codes. But, as climate change brings increasing extreme temperatures and bigger, more frequent and more intense bushfires, it will affect the enjoyment of participants and spectators alike.

Football was significantly impacted by 2019-20 bushfires, with high level games postponed due to poor air quality caused by bushfire smoke¹ and community clubs advised to replace games and training sessions with indoor activities². At the peak of the fire season, playing football in Australia was likened by Sydney FC's Alexander Baumjohann to "smoking 50 cigarettes a day"³. The physiological effects of playing or training in bushfire smoke, particularly when exacerbated by high temperatures and humidity, are described on Football NSW's website:

*"When these fine particles penetrate deep into the lungs, the consequences can be more severe and may trigger asthma and other respiratory ailments. In more serious cases, particularly where chronic pre-conditions exist, this can aggravate heart and lung conditions resulting in cardiac arrest or heart failure."*⁴

In January 2020, Football Australia (FA) convened a National Bushfires Working Group⁵, with a focus on raising money for first responders and to rebuild communities, but with no mention of the contribution made by climate change to the scale of the devastation. Similarly, climate change, carbon emissions or environmental sustainability do not appear in the FA's 2020 Annual Review [1] and, although some of the state football federations have installed solar photovoltaics (PV) on some of their buildings (as described below), there is a lack of any coherent plan to make the sport more sustainable.

Internationally, many football clubs are showing more leadership in the fight against climate change. In the UK, Forest Green Rovers has been certified by the UN's "Climate Neutral Now" initiative⁶ as carbon neutral across all its operations and has been fully powered by Green Energy since 2011, including 180 rooftop solar panels that provides 10% of the club's electricity use⁷. In Spain, Juventus and Real Betis have also joined the UN initiative offsetting 100% of their scope 1 and scope 2 emissions. Real Betis has also launched the "Forever Green" sustainability platform and plans to install solar on Benito Villamarín Stadium⁸, recognising football as *"a worldwide loudspeaker and we see it as a great opportunity to create conscience about environmental problems."*

¹ <https://www.reuters.com/article/australia-bushfires-sport-idINKBN1Z809G>

² <https://footballnsw.com.au/2019/11/21/the-impact-of-poor-air-quality-and-high-temperatures-on-the-football-player/>

³ <https://www.foxsports.com.au/football/a-league/aleague-news-australian-bushfires-alexander-baumjohann-sydney-fc-playing-conditions-fires-smoke-latest-updates/news-story/a40bbb38ca09f198bfc579bd42f6e549>

⁴ <https://footballnsw.com.au/2019/11/21/the-impact-of-poor-air-quality-and-high-temperatures-on-the-football-player/>

⁵ <https://www.a-league.com.au/news/football-federation-australia-convenes-national-bushfires-working-group>

⁶ <https://unfccc.int/climate-action/climate-neutral-now>

⁷ S. Morris, "Forest Green Rovers named world's first UN certified carbon-neutral football club", The Guardian, <https://www.theguardian.com/football/2018/jul/30/forest-green-rovers-named-worlds-first-un-certified-carbon-neutral-football-club>

⁸ <https://www.laliga.com/en-GB/news/real-betis-launches-forever-green-a-sustainability-platform-for-companies-through-football>

In the Netherlands, the Johan Cruyff Stadium has installed 4,200 lightweight, thin film solar panels and 2.8 MWh of battery storage⁹. In Germany, the 1270 kW of solar installed by Werder Bremen generates good will and great publicity as well as enough energy to power 400-500 homes¹⁰.

In general, the best financial returns for rooftop solar are achieved by consuming as much of the generated electricity as possible on site. In a football stadium, powering floodlights for evening matches is challenging without battery storage, but some venues have significant daytime consumption, including lighting, heating and cooling for offices, clubrooms and other facilities. Not all commercial electricity tariffs include a feed-in-tariff (FiT) – payment for electricity exported to the grid – so solar systems on commercial properties are often designed to avoid any export. However, large commercial customers are in a strong position to negotiate a tariff structure that enables them to enjoy the full value of their solar system, exporting during the day and offsetting the export payment against their evening consumption.

Football Australia and the state and territory Football Federations don't have direct influence over football stadia, but most own or operate training facilities as well as their administrative headquarters. The potential solar systems installed on the rooftops of these facilities, as described in this report, would generate relatively modest amounts of electricity, but could send a clear message about the urgency of climate action through the Australian football community.

Moreover, the federations produce guidelines for, and direct strategic funding towards, development of community football facilities, providing an opportunity to drive deployment of solar generation and energy efficiency infrastructure throughout every Australian community.

This report explores the possibilities for solar installations on football infrastructure throughout Australia, with a focus on the headquarters of the state football federations.

At the peak of the fire season, **playing football in Australia was** likened by Sydney FC's Alexander Baumjohann to **"smoking 50 cigarettes a day"** 🌿

⁹ <https://www.weforum.org/agenda/2018/07/netherlands-football-johan-cruyff-stadium-electric-car-batteries/>

¹⁰ <https://enviropaul.wordpress.com/2015/09/12/bremens-solar-stadium/>

Football Australia (FA)

As Australia does not have a dedicated national stadium, the national teams, the Socceroos and the Matildas, play at different stadia across the country, including Stadium Australia, Hunter Stadium and the Marvel Stadium. Football Australia (formerly Football Federation Australia), whose membership comprises the various state and territory football federations, is the governing body for men’s and women’s football in Australia, although the professional A-League and women’s

W-league are no longer under FA’s governance. FA’s administrative base is at One Oxford Street in Sydney, a multi-occupancy office building owned by Memocorp. Like most high-rise office buildings, the solar generation potential of the roof area is small compared to the electricity consumption of the buildings, but Figure 1 shows the modest 41 kW solar system that could be hosted on the building.

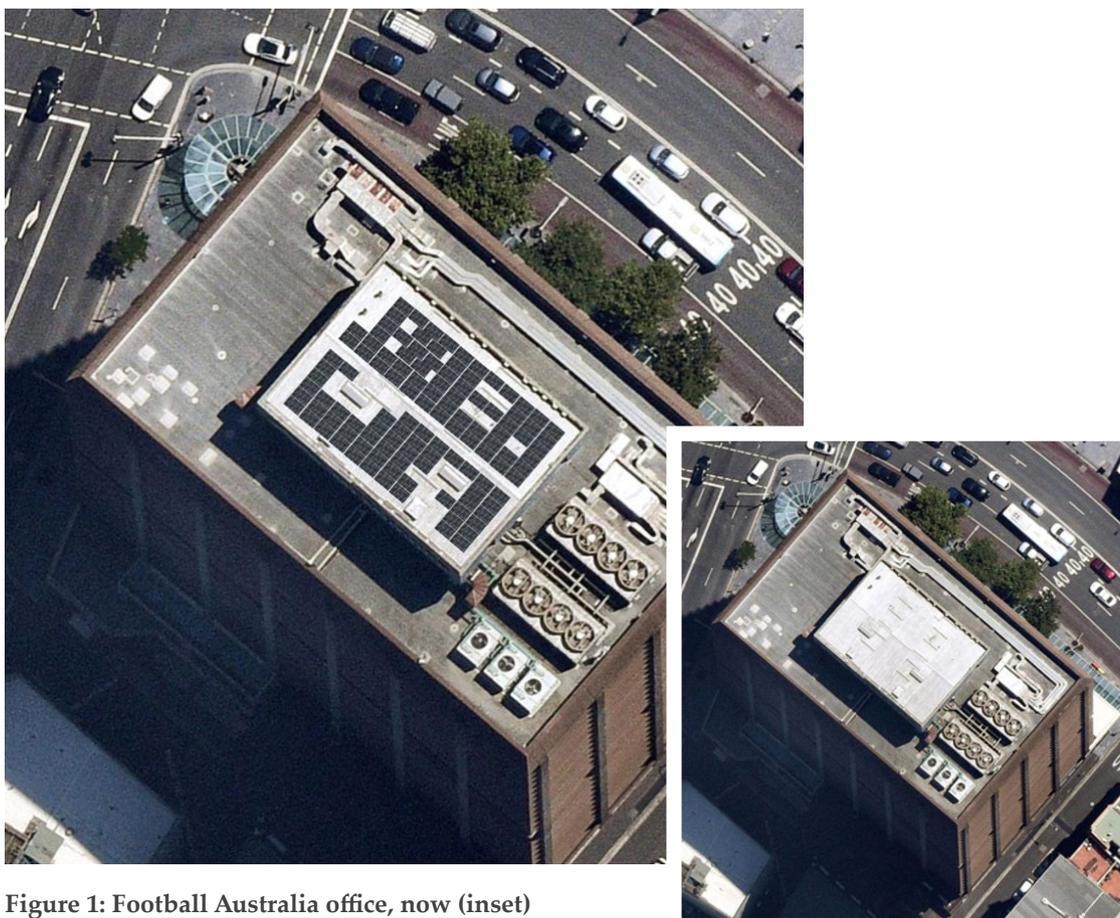


Figure 1: Football Australia office, now (inset) and with a potential 41 kW solar array

State Football Federations summary results

Analysis was carried out on the roof areas of the state football federations to determine the size of the potential solar system that could be installed.

Different federation headquarters comprise office buildings, stadia, training facilities or a combination of these. Figure 2 shows a representation of the solar potential on the roofs of each federation’s facilities.

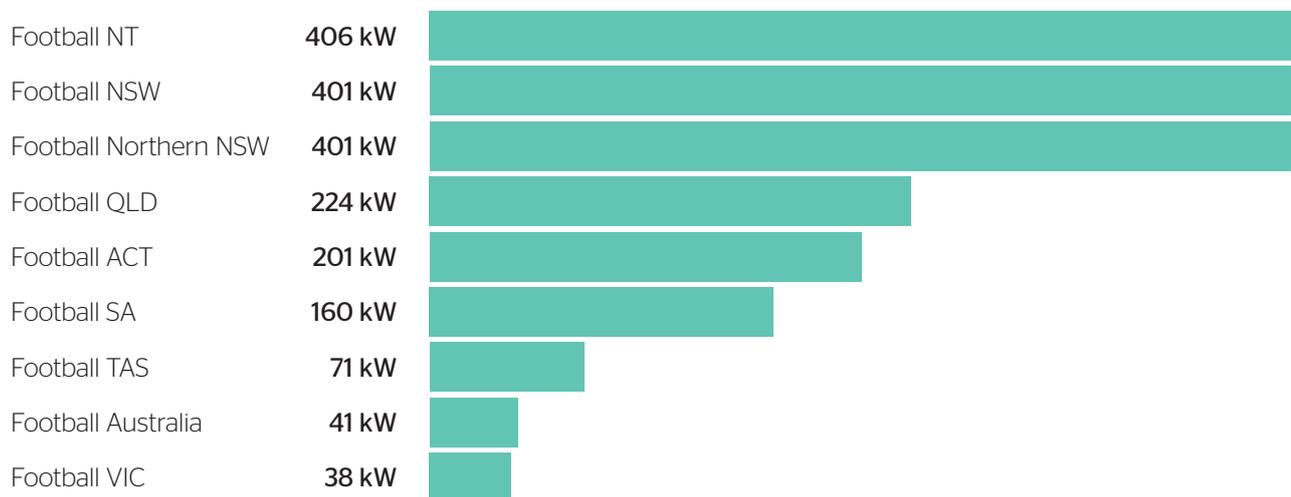


Figure 2: Potential rooftop solar capacity on football federation headquarters and associated stadia

Prices paid by commercial customers for electricity from the grid are negotiated with their retailer and vary between states, networks and customers, depending on the generation costs of the electricity, charges for transmission and distribution, and retail margins. According to the ACCC, the median price paid by small and medium enterprises in 2019 was 32.3 c/kWh.¹¹ It is likely that some of the estimated 2,700 MWh that could be generated annually by solar systems on the football federation headquarters described in this report

would be exported to the grid, and while some commercial customers negotiate to receive a feed-in tariff, others receive nothing for the export. Using a conservative assumption that half the generated energy is consumed within the facilities and that half of the exported energy attracts a typical FiT of 9.5 c/kWh, the annual solar generation could save the organisations up to \$0.5 million annually.

¹¹ [ACCC (2020). Inquiry into the National Electricity Market – September 2020 report]

Table 1 shows the area and power capacity of these potential solar systems, along with the annual energy produced and estimates of their potential impacts, in terms of avoided CO₂ emissions over the typical 20-year life of the system and

the equivalent number of trees planted, as well as the number of typical households that could be powered by each array and the employment generated through their deployment.

Stadium	Seating capacity	Array area (m ²)	PV capacity (kW peak)	Estimated energy production (MWh/year)	Estimated avoided emissions (kilo tonnes-CO ₂ -e / 20 years)	Equivalent # household energy supplied	Equivalent 1000's trees (over 20 yrs)	Estimated job-hours created	Estimated system cost (\$1,000's)
Football Australia office, NSW	-	205	41	57	1	7	15	400	\$42
Valentine Sport Park, NSW	500	2,005	401	524	8	71	141	3,908	\$409
Lake Macquarie Regional Football Facility, NSW	1,000	2,007	401	554	9	75	150	3,911	\$409
Football Victoria office, VIC	-	189	38	49	1	8	17	368	\$40
Coopers Stadium, SA	16,500	378	76	102	1	14	15	737	\$78
West Beach Parks, SA	200	423	85	121	1	17	18	824	\$87
KGV Park, TAS	4,000	355	71	90	0	8	5	691	\$79
Meakin Park, QLD	-	1,121	224	331	5	43	85	2,185	\$238
Football NT-Office, NT	-	1,051	210	320	4	31	67	2,049	\$307
Larrakia Park Stadium, NT	6,000	979	196	304	4	30	64	1,908	\$286
Capital Football-Office, ACT	-	755	151	222	4	23	60	1,471	\$145
Hawker Centre, ACT	-	248	50	67	1	7	18	484	\$48
TOTALS	28,200	9,717	1,943	2,741	39	334	654	18,937	\$2,168

Table 1: Potential solar generation and equivalent metrics for case studies completed on football federation headquarters and associated stadia rooftops

Football NSW

Football New South Wales is based at Valentine Sports Park in Glenwood, which has indoor and outdoor sports facilities, a 20 m pool, teaching, medical, office and catering facilities¹². There is a small rooftop solar installation, but our analysis

shows sufficient unused roof area across the complex for an additional 401 kW of solar (Figure 3), excluding the 2 central buildings which are heavily shaded by surrounding trees and therefore unsuitable for solar.

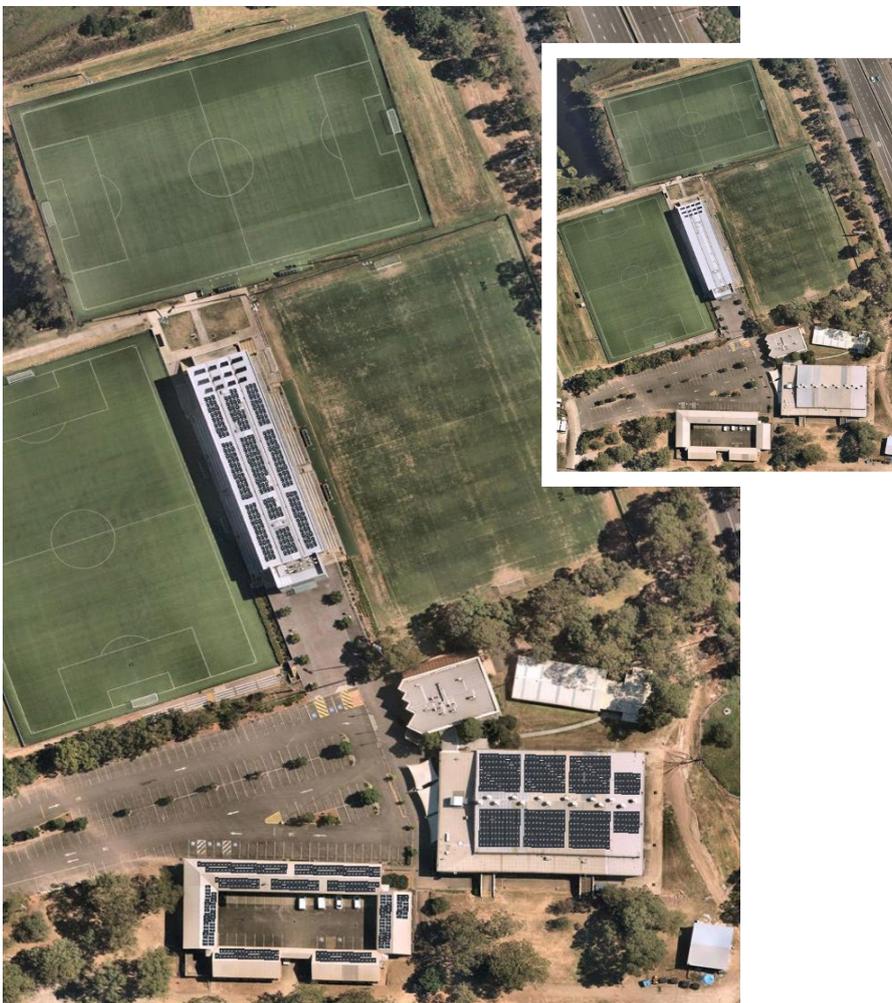


Figure 3: Valentine Sports Park, now (inset) and with potential 401 kW solar array

¹² <http://valentinesportspark.com.au/facilities/>

Northern NSW Football

Northern New South Wales Football (NNSWF) has its administrative headquarters, along with extensive training facilities, turf and synthetic pitches, meeting rooms and function facilities, at Lake Macquarie Regional Football Facility.¹³

There is good solar potential on the rooftops of the facilities. Figure 4 shows the potential for solar systems with a combined capacity of 401 kW, capable of producing 554 MWh of electricity per year.



Figure 4: Lake Macquarie Regional Football Facility, now (inset) and with potential 401 kW of solar arrays

¹³ <https://northernnswfootball.com.au/about-us/lake-macquarie-regional-football-facility/>

Football Victoria

Football Victoria (FV) has its administrative headquarters on St Kilda Rd in Melbourne, in a high-rise multi-occupancy building owned by the Shakespeare Property Group. Our analysis shows capacity on the roof for a 38 kW solar system (Figure 5), although the 49 MWh of energy generated annually would only make a small contribution to the total electricity consumption of the building.

In the longer term, FV's planned development of a new facility to provide a home for the Matildas as well as the state federation provides a superb opportunity to demonstrate the value of putting energy efficiency, renewable energy and sustainable building practices at the heart of a new sports facility.

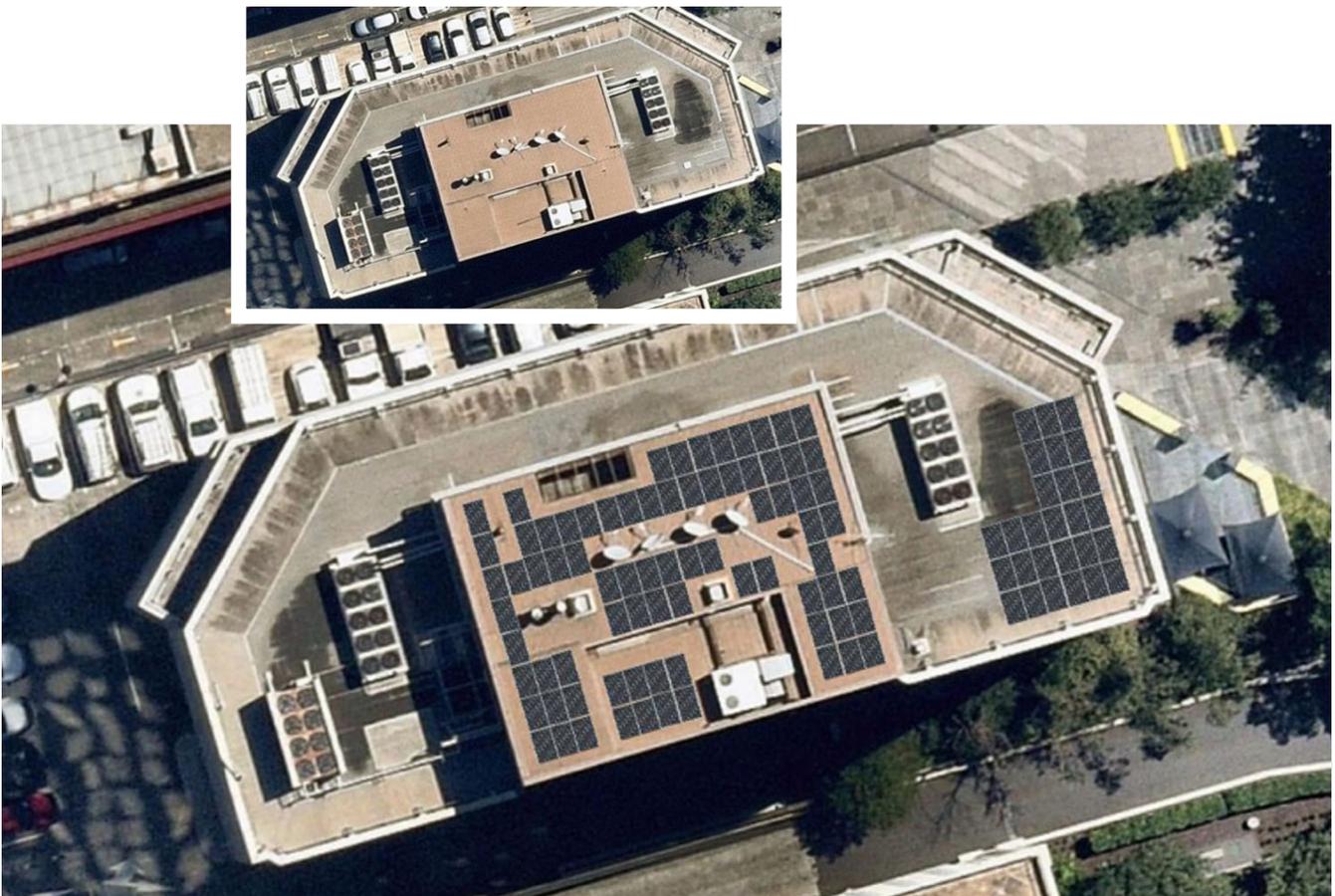


Figure 5: Football Victoria administrative headquarters, now (inset) and with potential 38 kW solar array

Football Queensland

Football Queensland is based at Meakin Park, a multisport facility which they share with rugby league, rugby union and baseball. Our analysis shows that this complex has rooftop potential for solar arrays with combined capacity of 224 kW, generating 331 MWh annually.

FQ's key infrastructure priorities – a Centre of Excellence for women's football, regional high-performance centres and a boutique multi-sport stadium¹⁴ – could all provide opportunities to showcase the benefits of investing in substantial energy efficiency and solar generation.



Figure 6: Meakin Park, now (inset) and with potential 224 kW of solar arrays

¹⁴ <https://footballqueensland.com.au/future-of-football/>

Football South Australia

The governing body of South Australian Football (FSA) is based at Coopers Stadium, which is also the home ground to the A-League team, Adelaide United FC. As shown in Figure 7, the rooftop of the stands have supporting metal structures and cable that obstruct parts of the roof area which will have some shading effect on a rooftop solar system.

However, the available space allows for an estimated 76 kW solar array, producing 102 MWh of electricity per year. While there are some smaller surrounding buildings, these are associated with either the Adelaide United FC team or the “Fire and Folk” Museum and have not been included in this analysis.



Figure 7: Coopers Stadium, now (inset) and with a potential 76 kW solar array

Football South Australia *continued*

Some of FSA's additional facilities, including the Valo Football Centre and Barrett Reserve boast modest rooftop solar on their pavilions, while further deployment opportunities exist at West Beach Parks Football Centre, approximately 10 km away from Coopers Stadium, which is home to the Adelaide Lady Reds W-League team. The 200-seat

grandstand and centre's rooftops (Figure 8) have the potential for an 85 kW solar system, capable of generating 121 MWh of electricity per year. Because of the low slope of the centre's rooftop, panels would be mounted on tilt frames, shown here with 10° tilt and appropriate spacing between the rows of the solar array.



Figure 8: West Beach Parks Football Centre, now (inset) and with a potential 85 kW PV array

Football West

Football West is planning a new State Football Centre at Queens Park, Cannington¹⁵ and has raised half the estimated \$32.5 million required for the development. While the concept images for the development include a small rooftop solar array (Figure 9), no details are yet available but it is to be hoped that the final designs incorporate a solar system that fully utilises the available roof area.



Figure 9: WA Proposed State Park Football Centre

¹⁵ <https://www.dlgsc.wa.gov.au/sport-and-recreation/the-state-football-centre#The-State-Football-Centre-design>

Football Northern Territory

The headquarters of Football Northern Territory (FNT) is located in the “Italian Club” on the eastern side of the Marrara Sporting Precinct. The FNT office building rooftop has an existing solar system (Figure 10), but the available roof space could support an additional 210 kW solar system, capable of generating 320 MWh of electricity per year.

Larrakia Park Stadium is also located within the precinct, at the north-western side, with 2 football pitches and a 1,120-seater grandstand.¹⁶ As shown in Figure 11, the rooftop of the grandstand has the potential for a 196 kW solar system, capable of generating 304 MWh of electricity per year.



Figure 10: The FNT headquarters, with existing solar (inset) and with a potential 210 kW PV array



Figure 11: Larrakia Park Stadium, now (inset) and with a potential 196 kW PV array

¹⁶ <https://www.austadiums.com/stadiums/darwin-football-stadium>

Football Tasmania

Football Tasmania (FT) is based at King George V (KGV) Park. The synthetic turf field is home to the Glenorchy Knights and Hobart Zebras whose teams participate in club level to national premier league.¹⁷

The rooftops of the headquarters building and grandstand combined have capacity for a modest 71 kW solar system, capable of producing 90 MWh of electricity per year.



Figure 12: KGV Park, now (inset) and with a potential 71 kW PV array

¹⁷ <https://www.austadiums.com/stadiums/kgv-park>

Capital Football

Capital Football is the governing body for football in the Australian Capital Territory, where football has the highest participation among organised sports and has its headquarters at Football House in Deakin, which has a large and uncluttered roof, with potential for a 151 kW solar system. Because of the very low roof slope, the panels in Figure 13 are shown mounted on tilt arrays at 10° to allow self-cleaning, with appropriate spacing to avoid shading.

Capital Football also manages the Hawker Football Centre. Which has a flat rooftop on the western side of the field covering the entrance and exit, bathrooms and canteen, with potential for a modest 50 kW solar array (Figure 14), capable of supplying 67 MWh of electricity per year.



Figure 13: Capital Football Headquarters, now (inset) and with a potential 151 kW PV array



Figure 14: Hawker Football Centre, now (inset) and with a potential 50 kW PV array

Regional and community football

Over 450 football clubs participate in the higher level Australian soccer league system, including the national A-and W-leagues and state-based leagues.¹⁸

However, if the numerous community clubs across the country are included, the numbers are significantly higher, with 1000 clubs across NSW alone¹⁹ and more than 600 more in Victoria²⁰ and Queensland²¹, so in excess of 1200 non-league clubs across the country.

The range of playing fields and facilities available to these clubs is wide. While some have covered grandstands, function facilities or indoor training areas, others have more basic amenities. Moreover, much of this infrastructure is multiuse, shared with other sports clubs, schools, markets, country shows and diverse community activities. Ownership, and responsibility for electricity supply may rest with the club, the state football federation, local council, state government, or be shared between multiple parties.

Nevertheless, at a minimum, each of these community clubs has access to toilet and changing facilities, while league clubs will have some seating. Using only half the roof area of a minimal 100 m² building, each of these community clubs could install a 10 kW solar system, while 20 kW would represent a reasonable lower limit for the majority of league clubs. Combining these gives a conservative estimate of a minimum of 21 MW solar capacity on Australia's league and community football clubs at an approximate investment cost of \$25 million.

As well as reducing electricity costs for community clubs (with bill savings likely to repay installation costs within a few years, particularly if a feed-in-tariff is available), these systems contribute to the decarbonization of the energy system and help reduce emissions. For clubs in bushfire-affected areas, the addition of a battery and hybrid, anti-islanding inverter could also provide a reliable electricity supply during grid outages caused by fires or other extreme weather events, increasing community resilience.

In 2020, Football NSW and Northern NSW Football launched an infrastructure strategy²² which identifies the need to update aging community playing fields, lighting, changing rooms and other facilities across the state, but makes no mention of managing energy use, installing efficient lighting and appliances, reducing electricity or carbon emissions, or deploying rooftop solar. Similarly, Football Victoria has a vision for 420 new pitches and 58 new pavilions by 2026, as well as upgrades to existing facilities.²³ However, this facilities strategy, which has received \$240 million in government support, currently overlooks the need for energy efficiency upgrades, solar deployment and other sustainability improvements.

In common with the other state federations, FT's strategic plan makes no mention of sustainability, climate change or renewable energy²⁴, while Football Queensland's 2020+ "Future of Football" paper²⁴ identifies a number of challenges facing the sport including challenges of governance and administration. However, the paper fails to note the threat posed to the sport by climate change or the need for action to mitigate the threat, although their \$60 million infrastructure plan for 2020-2024 does include 5 regional solar power projects.²⁶

The potential to develop sustainability facilities for Australia's community football clubs presents a leadership opportunity that the state federations have so far failed to grasp.

¹⁸ https://en.wikipedia.org/wiki/List_of_soccer_clubs_in_Australia

¹⁹ <https://footballfacilities.com.au/2020/10/02/state-member-federations-join-forces-to-release-nsw-football-infrastructure-strategy/>

²⁰ <https://www.footballvictoria.com.au/sites/ffv/files/2020-05/FFV0023%20ANNUAL%20REPORT%202019.pdf>

²¹ <https://footballqueensland.com.au/wp-content/uploads/2020/09/Future-of-Football-2020-Opportunities-Paper.pdf>

²² <https://footballfacilities.com.au/wp-content/uploads/sites/11/2020/10/NSW-Football-Infrastructure-Strategy-2020-web.pdf>

²³ https://www.footballvictoria.com.au/sites/ffv/files/2018-12/FFV_Facilities_Strategy.pdf

²⁴ <https://footballfedtas.com.au/about/important-documents-and-policies/>

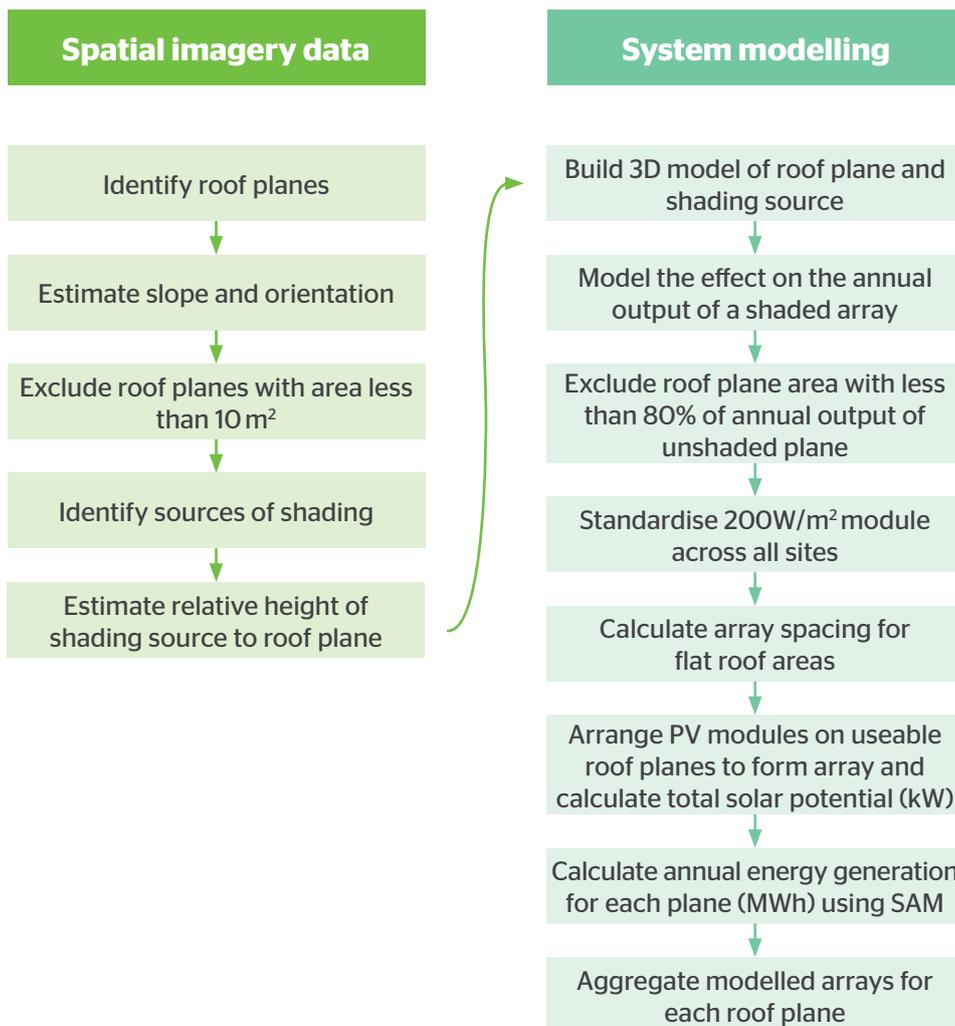
²⁵ <https://footballqueensland.com.au/future-of-football/>

²⁶ <https://footballqueensland.com.au/football-qld-facilities/strategic-infrastructure-plan/>

Methodology

This section describes the method used to estimate the rooftop solar potential of the buildings and grandstands in the report. The steps in the methodology are illustrated in Figure 15.

Figure 15: Major steps in the estimation of rooftop solar potential using visual analysis



Analysis of solar potential and energy generation

The potential solar capacity of the case study buildings were assessed visually, using multiple viewpoint aerial imagery from Nearmap [2]. Unsuitable surfaces and obstructions were identified and excluded from the usable roof area. Roof slope was estimated using the measuring tools in Nearmap's Oblique View imagery, and small rooftop obstructions and perimeter walls were also identified and their height estimated. The shading on a PV module at a range of distances from obstructions of different heights was modelled using the 3D shading calculator in NREL's System Advisor Model (SAM) and the impact on annual output for a horizontal PV panel was calculated. Using this data, additional roof area proximate to rooftop obstructions was excluded if estimated annual output was less than 80% of an unshaded horizontal panel.

Nearmap's Solar Tool was then used to arrange 1.7 m x 1.06 m PV panels on the usable roof space. On all usable roof areas with greater than 10° slope, PV arrays were assumed to be installed flush to the roof, while 'flat' roofs were assumed to have rack-mounted arrays installed at a tilt of 10°. The rack-mounted arrays were spaced to avoid self-shading. The PV capacity was calculated assuming modules of 360 W (and a consequent DC size factor of 200 W/m²), and the annual energy output was calculated using NREL's System Advisor Model [3] and an 'ERMY' weather file [4] for the nearest Bureau of Meteorology (BOM) weather station.

As the assessment was carried out remotely, there may be additional physical constraints on the available roof area as well as structural restrictions on the potential array size that have not been considered here. The systems described represent the available rooftop solar potential, not a design proposal.

Carbon and equivalency metrics

The annual energy produced by potential rooftop solar PV has been compared to the average annual household energy consumption in each state (Table 2 derived from [5-7]), using data for a 4-person household in the climate zone of each stadium.

Potential CO₂-e emissions reductions from rooftop solar were calculated by multiplying the indirect (Scope 2) emissions factor for consumption of electricity purchased from the grid in each state (see Table 3) by the expected annual energy generation from the system over the 20 year module lifetime, and subtracting the estimated embodied carbon emissions from the manufacture, installation, operation and decommissioning of the PV system (0.045 kg CO₂-e/kW[8]).

Since solar is very low-maintenance, jobs created in Australia through solar deployment are predominantly in sales and installation, at an estimated 5.8 job-years (assumed equivalent to 9,744 job-hours) per MW of commercial solar installed [10].

The carbon uptake of trees is highly variable, depending on species and growing conditions. For our estimate of the number of planted trees that would avoid an equivalent amount of carbon emissions as the potential solar installations, we used a figure of 0.06 tonnes CO₂-e per urban tree planted and allowed to grow for ten years [11]. This was divided into the estimated 20-year lifetime generation of the potential solar PV.

Table 2: Annual household energy consumption by state and climate zone

State	Zone	kWh/ year
NSW	5	7,311
QLD	2	7,682
SA	5	7,121
TAS	7	10,820
VIC	6	5,805
WA	5	5,198
NT	1	10,074
ACT	7	9,542

Table 3: Scope 2 emissions factors by state [9]

State	Emissions factor (kg-CO ₂ / kWh)
NSW	0.81
QLD	0.77
SA	0.44
TAS	0.15
VIC	1.02
WA	0.69
NT	0.63
ACT	0.81

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The School of Photovoltaic and Renewable Energy Engineering (SPREE) at the University of New South Wales (UNSW) has an international reputation for solar energy research. The SunSPoT Solar Potential Tool, which is the technical basis for the solar potential estimates in this report and a series of Solar Potential assessments published by the Australian PV Institute (APVI) for major Australian Cities, was developed and validated at SPREE for APVI to help inform and facilitate ongoing investment in solar photovoltaic (PV) systems in Australia. This work is part of a broader renewable energy systems research program at SPREE, including renewable energy resource assessment, performance analysis, modelling and mapping, renewable and distributed energy integration, and building energy modelling.

The Australian PV Institute (APVI) is a not-for-profit, member-based organisation providing data analysis, reliable and objective information, and collaborative research to support the uptake of solar photovoltaics and related technologies. APVI promotes PV through its live solar mapping platform (<http://pv-map.apvi.org.au>), organises Australia's national solar research conference, and coordinates Australia's participation in two International Energy Agency programs: Photovoltaic Power Systems and Solar Heating and Cooling.

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Satellite imagery is sourced from nearmap.com.au



Australian Soccer has an
**opportunity to play a
role in slowing global
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the existential threats that
it faces 

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