An Australian Government Initiative

Renewable energy on the Mid North Coast, Lord Howe Island and Norfolk Island

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An Australian Government Initiative

Regional Development Australia

MID NORTH COAST

Renewable energy on the Mid North Coast

Executive summary

The principal opportunities for the Mid North Coast (MNC) of NSW to participate in the renewable energy industry are rooftop solar, solar farms, off shore wind farms, transmission, pumped hydro energy storage, conversion of the vehicle fleet to electric, and electrification of gas-powered appliances. The MNC region has far larger opportunities for future participation in the Australian energy industry than hitherto.

Opportunities for the MNC for onshore wind farms and hydrogen production are unfavourable.

Benefits from active participation in the renewable energy industry include very large-scale local investment in construction, operations, maintenance, hosting and refurbishment of solar and wind farms, together with the associated employment. Environmental and social impacts are far smaller than equivalent fossil fuel investments.

The MNC region has a broader and deeper portfolio of opportunities than most other regions in Australia.

Many Australian regions could participate in the renewable energy industry – there are far more solar and wind resources than required. Investment is likely to flow preferentially to those regions that welcome renewable energy investment.

The principal strategy for decarbonisation is to stop buying new fossil fuel machines, including coal and gas fired power stations, vehicles, water heaters, space heaters, industrial furnaces and cookers. Over one or two decades, most of these existing machines will reach the end of their productive lives and can be replaced with solar/wind driven electric versions. The MNC region is well-placed to adopt this strategy, and to rapidly reduce its greenhouse emissions because of its low participation in the fossil fuel industry and its mild climate.

Summary and recommendations

1. Financial impact of renewable energy in the regions
   a. All the solar farms, windfarms, transmission, and pumped hydro energy storage will be constructed in regional areas, such as the mid north coast. Billions of dollars per year will flow to regional areas.
   b. The mid north coast has vast opportunities for solar farms. About 1000 Gigawats (GW) of solar power could be accommodated, generating twice as much solar energy per year as required to fully decarbonise the whole Australian economy.
   c. Many other regions also have large solar and wind potential, which creates competition for hosting solar & wind farms. Regions that are welcoming to the construction of solar and wind farms, trans mission, and storage will benefit more than other areas.
2. Solar farms
   a. Facilitate planning approvals, including for power lines connecting solar farms to high power trans mission lines.
   b. Encourage landholders to group together to negotiate collectively with solar farm developers to host solar farms (in return for lease fees) in suitable areas (as shown in solar heat maps described below).
3. Wind energy
   a. The mid north coast has few opportunities for onshore wind farms.
   b. There is extensive offshore wind energy potential. Identify suitable skills, ports and facilities to sup port offshore wind farms, with a view to being an early mover.
   c. Encourage community consultation in respect of offshore wind zones, similar to those approved in South and Central New South Wales and in Bass Strait.
4. Rooftop solar
   a. Strongly encourage installation of rooftop solar on dwellings and commercial buildings.
   b. Commission large rooftop solar relations on public buildings such as council chambers, schools, public car parks.
5. Transmission
   a. Undertake detailed analysis of potential high-voltage (high power) transmission routes connecting Southern Queensland with Sydney that traverse the MNC region. This can be greenfield or upgrading existing transmission.
   b. Engage in preliminary community consultation in relation to these projects.
   c. Discover which landholders in the path of potential transmission are in favour of hosting transmission (in return for lease fees) and which are against, to facilitate route choice.
6. Pumped hydro
   a. The mid north coast has excellent opportunities for several high-value (billion-dollar), low impact pumped hydro energy storage facilities close to high power transmission between New South Wales and Queensland.
   b. Councils can facilitate the selection of half a dozen class A and class B sites for detailed analysis and community consultation.
7. Social licence:
   a. Strongly emphasise the large financial benefit of hosting transmission ($200,000 per km).
   b. Councils should strongly encourage developers of renewable energy facilities to share financial rewards with neighbours and local communities.
8. Hydrogen: there are negligible opportunities to participate in the clean hydrogen industry in the MNC region, at least for the next decade.

9. Lord Howe and Norfolk Islands: strongly encourage deployment of additional solar and wind generation, and replacement of retiring vehicles with electric versions.
10. Electric vehicles
    a. Strongly encourage private purchase of electric vehicles through facilitation of charging stations, preferred parking and transit lanes, facilitation of overnight charging in rental and high-rise properties, and similar measures.
    b. Local government should exclusively purchase electric vehicles.
11. Elimination of fossil gas from buildings
    a. Strongly encourage complete electrification of dwellings and commercial businesses and discourage use of fossil gas.
    b. Strongly discourage (or prohibit) new connections to the gas network.
    c. Remove gas use in council-controlled buildings, schools and other public institutions and replace with electric water heaters, space heaters and cooking facilities.

Scope of the report

This report was commissioned by Dr. Madeleine Lawler (CEO and Director of the RDA Mid North Coast). The purpose of the report is to facilitate development of a renewable energy strategy to reduce carbon emissions, identify opportunities in local government areas (LGA), facilitate community consultation, and attract investment.

The scope of this report is a high-level overview rather than a detailed feasibility study. The aims are to provide a global, national and regional overview of renewable energy, and point to opportunities relevant to the mid north coast. The regions are covered in this report are:

- Coffs Harbour
- Bellingen Shire
- Nambucca Valley Shire
- Kempsey Shire
- Port Macquarie Hastings
- Midcoast Council
- Lord Howe Island
- Norfolk Island

Specific recommendations pertaining to each of these jurisdictions are included at the end of this report.

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The mid north coast region of NSW

The mid north coast region (figure 1) has an area of 2.13m hectares and a population of 326,488 people. It is characterised by a narrow coastal plain in the east, tablelands in the west, and deeply incised river valleys in between. There are extensive forests, national parks and remnant native vegetation (figure 2), particularly in steep areas, which are unsuitable for use in solar farms and wind farms.

The MNC region has enormous potential for solar farms and rooftop solar. There is negligible potential for onshore wind farms, but large offshore wind potential. Existing high-power transmission connecting New South Wales to Queensland runs through the MNC region. There are extensive opportunities for pumped hydro energy storage.

Figure 1: The mid north coast region of NSW

Figure 2: Mid north coast region illustrating extensive forests and national parks and a 30km wide continental shelf (potentially suitable for offshore wind farms). (Google Earth)

Renewable energy

Global renewable energy

By far the fastest energy change in history is underway (figure 3). Around 400 Gigawat s (GW) of new solar and wind capacity will be added in 2023, which comprises 80% of the total (and 99% in Australia). The large and growing disparity between the deployment rates of solar and wind on the one hand, and coal/gas/nuclear on the other, means that nearly all the global growth in electricity demand is being met by solar and wind.

Figure 3 illustrates that the only serious low emission technologies are solar and wind. Hydroelectricity is limited by lack of rivers to dam and encounters strong social pushback. Nuclear, bio, solar thermal, carbon capture and storage, and geothermal, have tiny construction industries in comparison with solar and wind. Extravagant and unlikely growth rates are required for these technologies to become significant compared with solar and wind (which are themselves growing rapidly) before the task of decarbonising the world is completed before mid-century.

The fundamental reason for the dominance of solar and wind is their compelling economic advantage over alternatives.

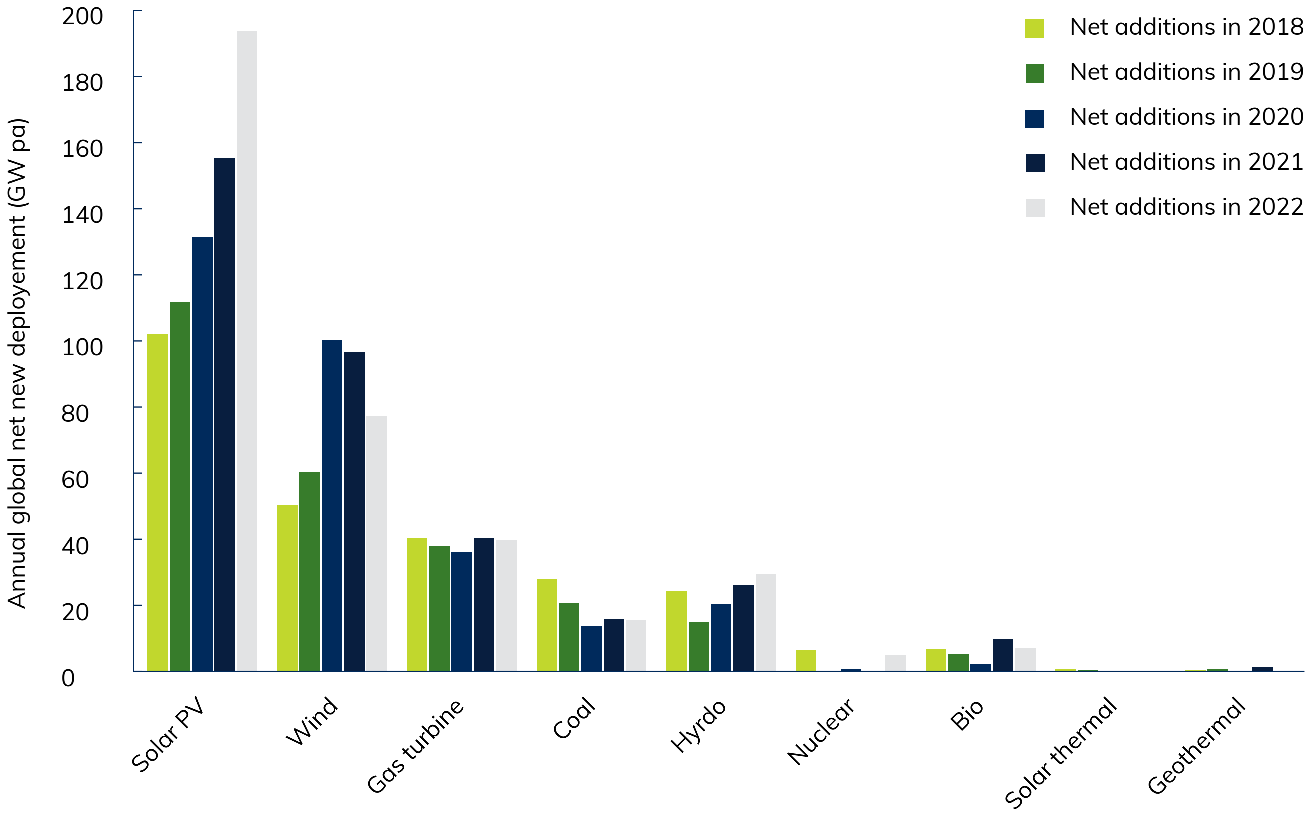

Figure 3: The fastest energy change in history. IRENA, GWEC, WNA, GEM, CC BY.

Current global electricity demand is about 30,000 Terawat-hours (TWh) per year. This could rise to around 200,000 TWh per year towards the end of the century to accommodate rising population, rising affluence and electrification of nearly all energy services. Nearly all of this electricity will be produced from solar and wind because of their compelling economic advantage. They are producing the cheapest energy in history.

As well as eliminating most greenhouse emissions, getting rid of fossil fuels also eliminates car exhausts, smokestacks, urban smog, coal mines, ash dumps, oil spills, oil-related warfare and gas fracking.

All the leading countries for per capita solar and wind generation are in Europe – except Australia (figure 4). In Australia, 99% of new generation capacity is now solar and wind because it is cheap. But unlike European countries, Australia cannot share electricity across national boundaries. Instead, Australia must cope with rapidly increasing levels of solar and wind by sharing it across state boundaries. This is proving to be relatively straightforward. Solar and wind have reached a share of 31% of the national electricity market, while the grid remains stable. The Government target is 75% solar and wind by 2030, plus 7% from existing hydro. Like 80% of the world's population, Australians reside at low to moderate latitudes where there is plentiful sunshine, even in winter. That means that the methods that Australia pioneers can be readily adopted by most of the global population.

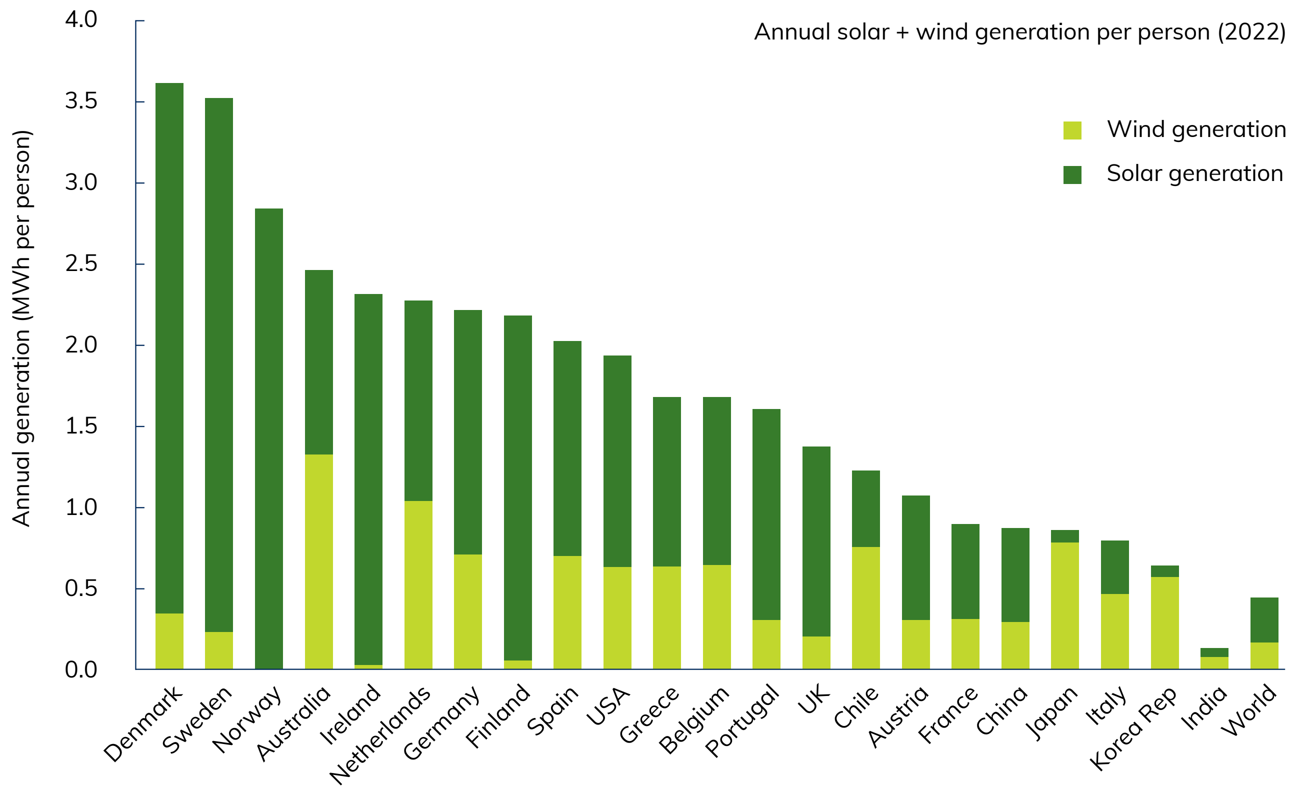

Figure 4: Australia is a global pathfinder for per capita solar and wind generation. Ember, CC BY.

Renewable energy in Australia

In a developed country like Australia, electricity demand (currently 250 TWh per year) must double to 500 TWh per year to accommodate electrification of land transport (via electric vehicles) and heating (via electric heat pumps and electric furnaces). Elimination of fossil fuels from the chemical industry (ammonia, metals, plastics, ceramic, synthetic jet fuel) requires tripling current electricity demand to 750 TWh per year. Elimination of fossil fuel use throughout the Australian economy via the use of solar and wind leads to elimination of about 85% of Australia's greenhouse emissions.

Australia will need 400 to 500 GW of new solar (figure 5) and wind to completely eliminate fossil fuel use well before 2050. Current deployment of solar and wind is only 10-15% of what will eventually be needed. Thus, there is very large scope for additional solar and wind, and the associated supporting technologies of storage, transmission, demand management, and electrification of fossil fuel functions.

Many solar farms will operate in conjunction with agriculture (agrisolar) - typically sheep graze between the rows of panels to suppress grass and obtain additional income.

Figure 5: Royalla solar farm near Canberra

Heatmaps for solar and wind farms

Only some areas of land are suitable for solar and wind farms. National parks, urban areas and other protected areas are unavailable. Additionally, removal of existing remnant native vegetation is undesirable.

The best solar farms are located in relatively flat land, tilted to face the equator, in regions with high levels of solar availability, and close to transmission. Access to existing transmission is important because construction of new transmission (although relatively inexpensive) is slow. A solar farm company only needs to negotiate with a few landholders to obtain enough land. However, a transmission company must negotiate with dozens to hundreds of landholders to create an easement.

Heat maps illustrate where solar and farms can be optimally placed. In a heat map, the best regions are coloured red, grading down to blue for undesirable regions, and green represents unavailable land.

Heat maps for the whole of Australia are available online from ANU's website.

Each pixel in a heat map represents the quality of that small region in terms of solar or wind resource, distance to existing transmission, whether or not the land is protected, and several other factors. Figures 6 and 7 illustrates heat maps for a region west of Coffs Harbour. As can be seen, there is a great deal of protected land (green), and the best sites cluster relatively closely to the existing transmission.

Public heat maps allow landholders and councils to assess the best regions for solar and wind farms in their LGA. Landholders can determine whether they are in highly favourable or less favourable regions. Groups of landholders can caucus together and present a united front in negotiations over lease fees and conditions with a solar or wind farm developer, or a transmission company. This evens up the negotiating power of landholders with companies, since solar and wind farm companies have private heat maps. Councils can determine the best regions to put their effort in facilitating construction of new solar farms, wind farms and transmission.

Figure 6: Detailed wind heat map (250m resolution) west of Coffs Harbour. The black line is existing high power transmission. Redder is better. Green is unsuitable land.

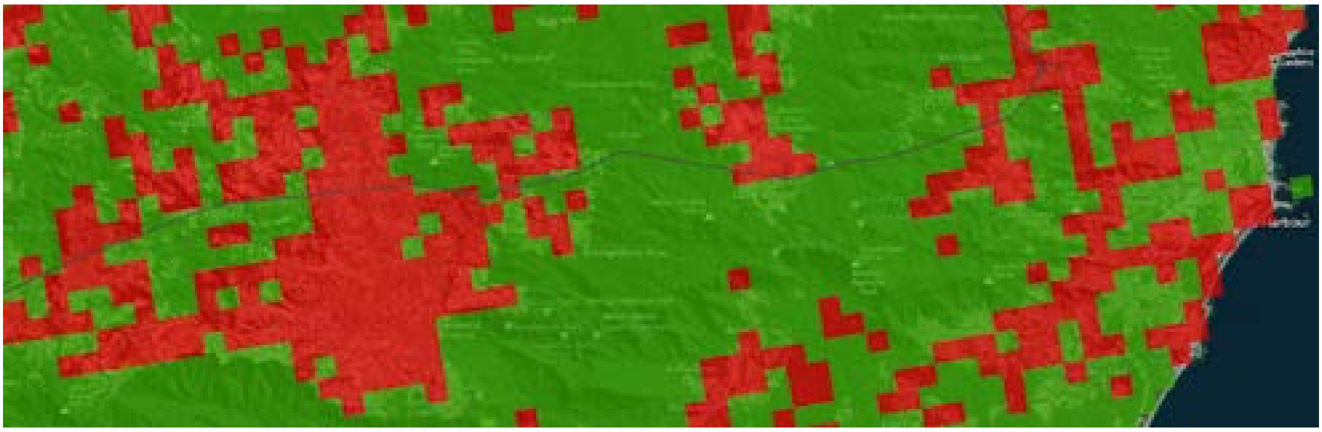

Figure 7: Detailed solar heat map (1km resolution) west of Coffs Harbour. The black line is existing high power transmission. Redder is better. Green is unsuitable land.

Solar energy in the MNC

Solar energy in the MNC is high by world standards (figure 8) and is also high compared with where most Australians live (along the south-east and southern coast). The solar resource improves slowly but steadily as one moves inland. Because of the moderate latitude (31 degrees), the seasonality of available solar energy is relatively low. In other words, there is good sunshine in both summer and winter.

Solar panels can be placed on building rooftops, in solar farms, and floating on water. For the MNC region, most panels will be placed on rooftops and in solar farms. Figure 9 shows the solar heat map for the MNC region. Readers can go to the online solar heat map, and pan and zoom down to a resolution of 1 km.

It is evident that most of the MNC region is unsuitable for solar farms. The best and most extensive regions for solar farms in the wider MNC region are on the tablelands. There are also substantial opportunities close to the coast near existing transmission. While Gigawat-rated solar farms could be built in the West, there are many opportunities for small (1-50 Megawat) solar farms to be built in the lowlands. Small solar farms can connect directly to low-voltage electricity distribution networks.

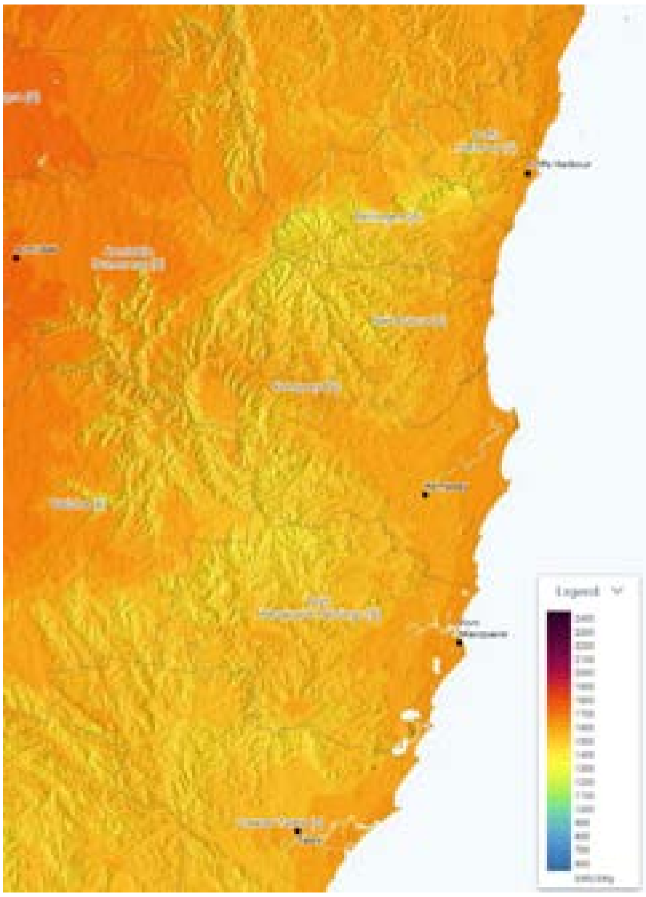

Figure 8: Global Solar Atlas. Redder is better.

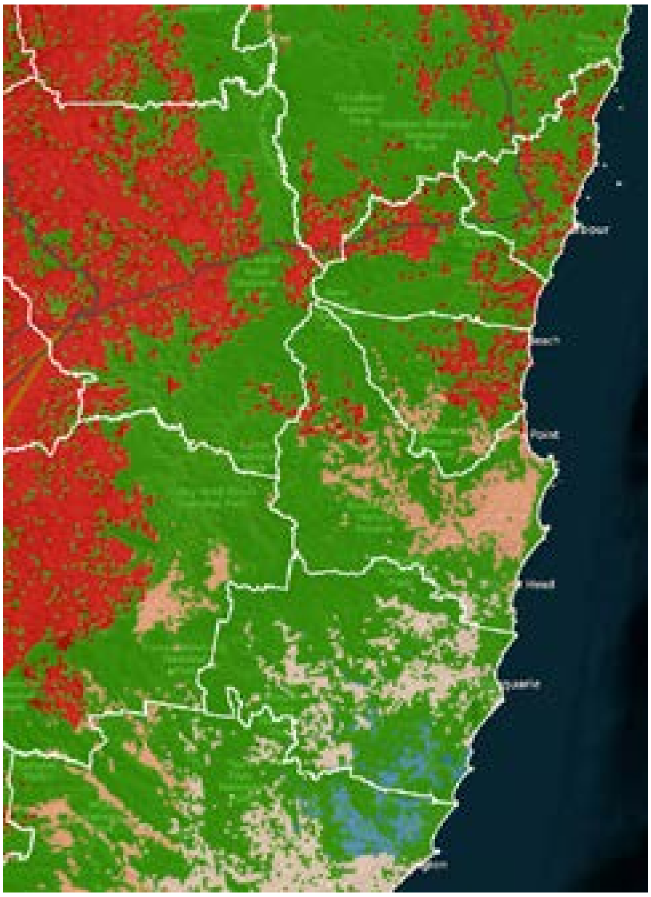

Figure 9: Solar heat maps. Redder is better. Green is unsuitable land. Resolution is 1km.

The energy density of solar is so high that the MNC region could supply vast quantities of solar energy. As shown in Table 1, the MNC region could host solar farms with a total capacity of about 1,000 GW that are capable of generating 1,500 TWh per year. For context, this is twice as much energy as required to completely decarbonize the Australian economy. Plainly, there is no real constraint on very large-scale participation of the MNC region in the solar energy industry.

Table 1: Solar farm availability (GW) in cost classes A (best) to D (more expensive) for overhead transmission and low-cost scenario. Further information is available here.

LGA	Class A (GW)	Class B (GW)	Class C (GW)	Class D (GW)
Coffs Harbour (C)	53	0	0	0
Bellingen (A)	62	0	0	0
Nambucca Valley (A)	47	20	0	0
Kempsey (A)	16	119	11	0
Port Macquarie-Hastings (A)	0	0	112	26
Mid-Coast (A)	17	204	249	38
Total (GW)	195	343	372	64
Approximate annual generation (TWh)	290	510	560	100

Wind energy in the MNC

There is a large opportunity for offshore wind in the MNC region (figure 10). The continental shelf is about 30 km wide, and this is the preferred location of offshore wind turbines because of relatively shallow water to allow anchoring. A 10 km wide band of wind turbines stretching north-south for 150 km along the MNC could accommodate about 6 GW of wind turbines with the potential to generate about 25 TWh per year. For context, current electricity generation in Australia is 250 TWh per year.

Although the offshore wind resource is better in Bass Strait, proximity to large populations in northern New South Wales and southern Queensland could make offshore wind in the MNC attractive.

Currently, offshore wind energy is more expensive than onshore wind energy, despite higher average wind speeds. Development of offshore wind farms is lagging well behind onshore wind farms and may continue to do so for another decade. However, global energy developments strongly favour offshore wind. The reason for this is that Europe, Japan and Northeast USA have relatively poor solar resources (particularly in winter) and limited onshore wind resources. However, they have enormous high-quality offshore wind resources in the Baltic Sea, the North Sea, the Sea of Japan, and the north-west Atlantic Ocean. These northern countries will get much of their future energy needs from offshore wind, which will strongly drive technology improvement, commercial deployment and falling prices.

Onshore wind energy in the MNC is small by Australian standards (figure 11), and closely follows existing transmission. A total of about 50 GW of class E (high cost) onshore wind sites are available, and almost none in the better cost classes A through D. It is unlikely that significant onshore wind will be constructed in the MNC region.

However, there is immense wind energy potential immediately to the west on the tablelands. The main role of the MNC region in the onshore wind industry could be provision of transmission northwards towards Queensland, by way of participation in construction, operation and maintenance of upgraded transmission, and in hosting fees paid to landholders by transmission companies ($200k/km).

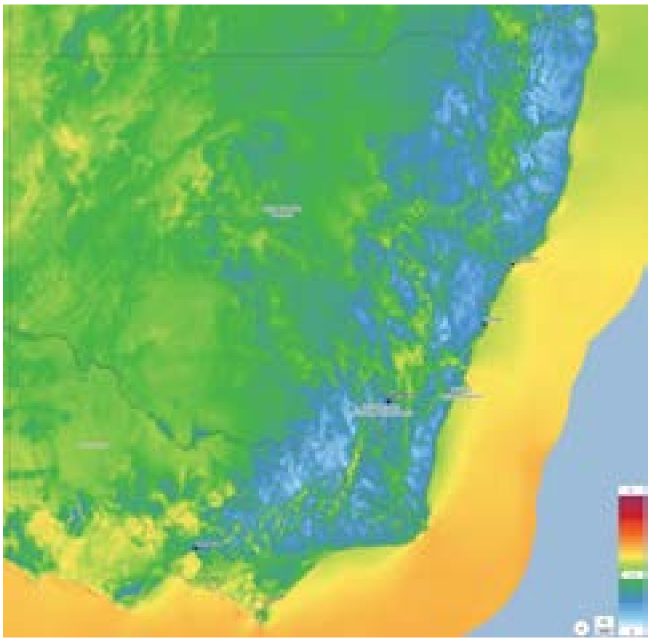

Figure 10: Global Wind Atlas. Redder is better.

Figure 10: Wind heat maps. Redder is better. Green is unsuitable land.

Balancing renewable energy

Solar and wind energy are variable and require balancing to ensure that energy is available for every hour of the year. Balancing is straightforward using off-the-shelf technology comprising transmission (to smooth out local weather), storage (to cover for periods with low sun and wind) and demand management (to moderate demand during periods that are stressful for the grid).

Transmission

Transmission is a key supporting technology for solar and wind. High voltage transmission currently focuses on connecting coal and gas power stations to cities. However, most solar and wind farms are not near coal-fired power stations. Large amounts of new transmission are required to bring new solar and wind energy into the cities. The fact that electricity demand must triple before mid-century to fully decarbonize the Australian economy adds greatly to the requirement for new transmission.

In addition, strong interstate transmission is required to smooth out local weather and demand. Thus, when Victoria experiences a wet and windless week, New South Wales might be able to supply solar and wind electricity. Next month, the roles may be reversed. Detailed analysis shows that about five times more storage is required for an Australian electricity system in which each state “goes it alone” in reaching 100% renewable electricity compared with a scenario where the eastern states are strongly interconnected.

A very important recent development has been a large increase in payments to landholders whose properties are traversed by high power transmission. The payments are a set rate of $200,000 (in real 2022 dollars) per km of transmission hosted, paid out in annual installments over 20 years. This payment may engender competition among landholders for hosting transmission, considering that (in most cases) it far exceeds the cost of inconvenience (as measured by “just terms” acquisition). Hosting payments for transmission brings large amounts of reliable income into the region on top of construction and maintenance of the transmission.

The key roles for the MNC region in respect of transmission are:

- Facilitate connection of local solar farms and offshore wind farms into the state grid
- Facilitate stronger interconnection of New South Wales and Queensland through duplication or upgrade of existing transmission that traverses the region (figure 12).

Pumped hydro energy storage

Pumped hydro energy storage (PHES) comprises about 98% of global storage for the electricity industry. In Australia, there are three existing pumped hydro systems (Tumut 3, Kangaroo Valley and Wivenhoe), two more under construction (Snowy 2.0 and Genex/Kidston) and about a dozen under serious consideration. These systems have more energy storage than all the utility batteries in the world combined.

PHES involves pumping water uphill from one reservoir to another at a higher elevation for storage on sunny and windy days. When power is needed, water is released to flow downhill through turbines, generating electricity on its way to the lower reservoir. For example, a pair of 100-hectare reservoirs with an average depth of 20 meters, spaced a few kilometers apart, and connected with a tunnel, and with an altitude difference of 600 meters, can store 24 Gigawat-hours (GWh) of energy. This means the system could supply 1 Gigawat (GW) of power for 24 hours, which is enough for a million people.

There are about a million "off-river" pumped hydro energy storage sites around the world. These sites are located away from rivers, and do not require new dams and rivers. The MNC region has many high-quality off-river pumped hydro energy storage sites running from the tablelands down into the valleys. These can be visualised on ANU's Global Pumped Hydro Atlas at a resolution of 30 m. Figures 13 and 14 illustrate the location of small (15 GWh) and large (150 GW) pumped hydro systems in the MNC region.

Figure 12: Existing and planned high voltage power transmission.

Figure 13: Small (15 GWh) pumped hydro prospects. Redder is better..

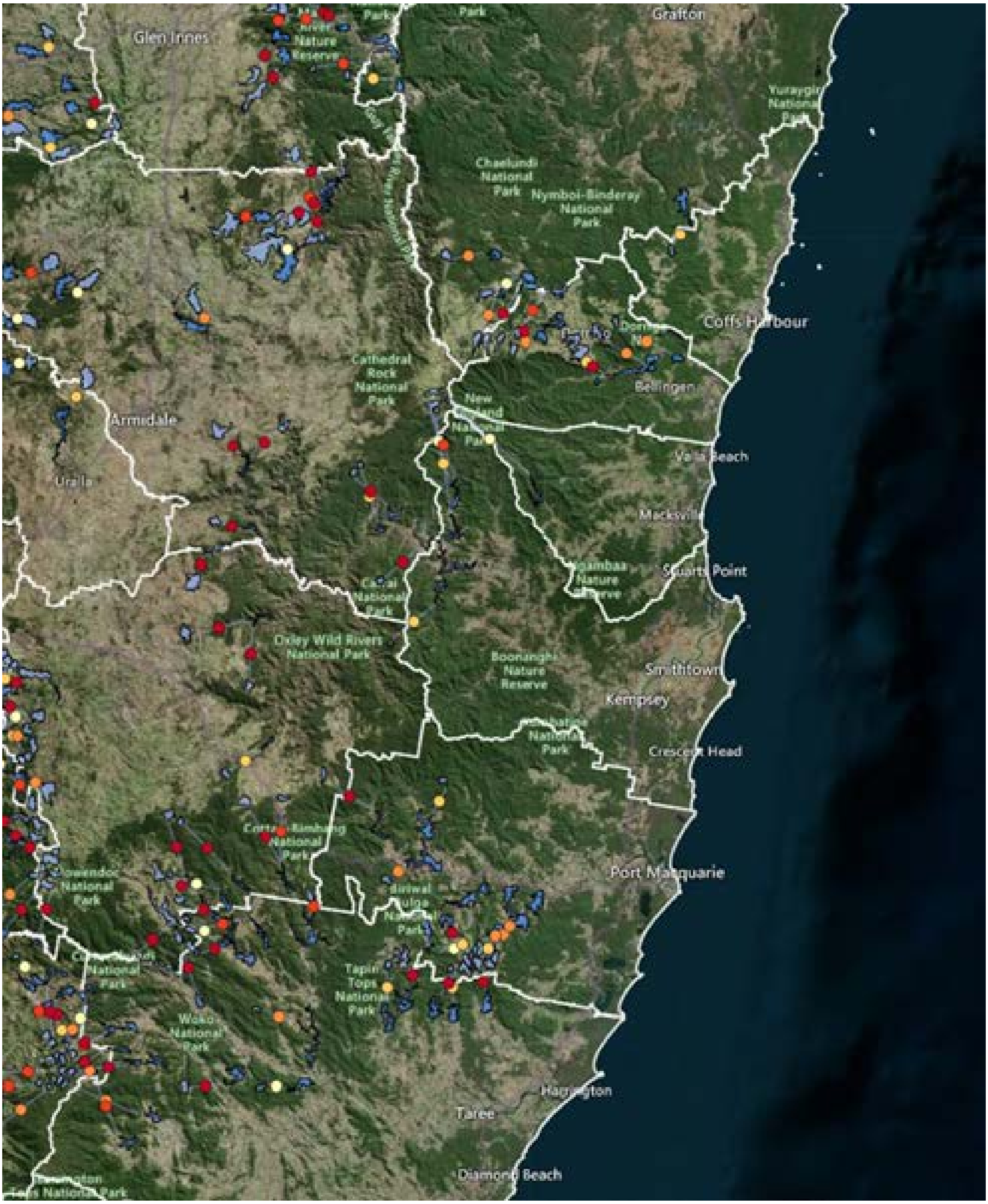

Figure 14: Large [(150 GWh) pumped hydro prospects](). Redder is better.

Figure 15 shows a synthetic view of hypothetical large (150 GWh) PHES systems 20km west of Coffs Harbour. This region bears striking geographical resemblance to the [Pioneer Burdekin]() pumped hydro system (5 GW of power and 120 GWh of energy storage) that is under development west of Mackay in Queensland.

The land use is very low per unit of storage: about 5-10 hectares per GWh, which is much lower than the area intensity of the solar farms that the storage supports. Since Australia has about 4,000 good off-river PHES sites, and will only need 10-20 of them, only the very best sites with the lowest environmental and social impact are required.

Water use is also very small, comprising an initial fill (that will last 100 years) and a small amount of annual water to replace evaporation losses – which may be zero in this well-watered region. Water consumption is below 1 Gigalitre (GL) per Gigawat-hour of storage (about 100 GL for the Pioneer-Burdekin project). This water is recycled for 100 years, and represents a very small fraction of agricultural water use.

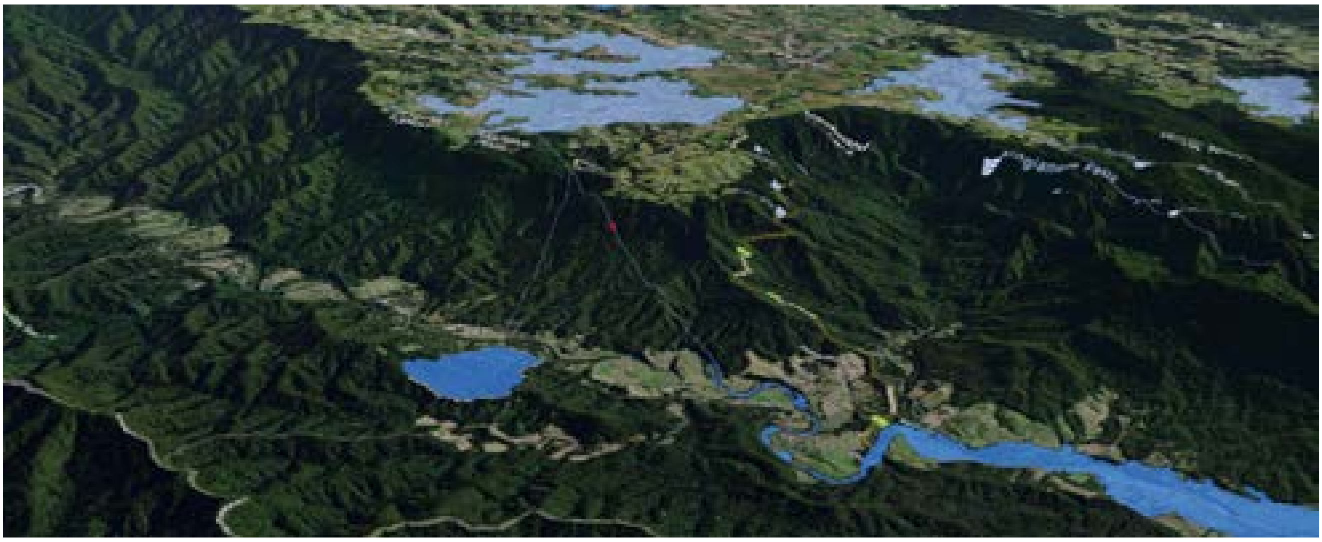

Figure 15: 150 GWh PHES systems near Coffs Harbour.

Battery storage

Battery storage is rapidly rising in importance. Utility batteries can be located almost anywhere, including near solar and wind farms and in cities. Typical "big battery" sizes are 0.2 GW of power for 2 hours (0.4 GWh of energy). For comparison, Snowy 2.0 has about 10 times larger power capacity and 1,000 times larger energy storage: power of 2 GW for 175 hours (350 GWh of energy).

Battery storage is preferred for high-power, short-term applications (seconds to hours), whereas hydro is preferred for moderate power, large energy applications (hours to days). Battery storage and pumped hydro are complimentary.

Demand management

Demand management operates like storage. Refraining from using electricity during periods of stress in the grid reduces peak loads and increases use of the grid during off-peak periods. Examples include temporarily shutting down aluminium smelters, charging solar hot water systems during daytime, and charging electric vehicles outside of peak periods. Demand management in thousands of small applications can be packaged by a company and presented to the grid operator as a large flexibility option.

Pumped hydro, batteries and demand management are complementary. All are required, rather than one or other.

Potential financial benefits from renewable energy and social pushback

All the solar farms, windfarms, transmission, and pumped hydro energy storage will be constructed in regional areas, such as the mid north coast. Very large amounts (billions of dollars per year) of stable, long-term money will flow to these regions for hosting, construction, operation, maintenance and periodic replacement of these facilities. In most LGAs, potential financial flows are far larger than ever flowed in relation to the existing coal and gas-based electricity system.

Australia has far more opportunities for placement of these facilities than it will ever need. Some LGA's have the opportunity to garner a much larger share than others. This is a very large financial opportunity for first-mover LGA's that present themselves as attractive destinations to developers of these facilities.

In some regions, strong opposition to solar farms, windfarms, transmission, and pumped hydro energy storage develops. One possible reason for this is that, while individual landowners benefit substantially from hosting fees for these facilities, neighbours enjoy much lower levels of benefit. Jealousy is a powerful motivator. Councils can strongly encourage developers of these facilities to share financial rewards with neighbours and local communities.

Hydrogen

A regrettable quantity of hype has been generated in respect of clean hydrogen.

Clean hydrogen can be produced via electrolysis of water driven by solar and wind. Hydrogen could do a lot of things in the energy sector, but it is rarely the best tool. Direct use of electricity derived from solar and wind is usually much better. There is currently negligible clean hydrogen production anywhere.

In any event, the route to clean hydrogen is through solar and wind.

Electric machines have a far larger market share than hydrogen-powered equivalents because they are cheaper. Electric vehicles outsell hydrogen-powered vehicles in a ratio of 400 to 1. Electrification of heating is well underway, whereas the implementation of clean hydrogen for heating is negligible.

There are large energy losses in a hydrogen cycle. Solar and wind can be used to produce hydrogen, which then needs to be compressed, shipped, stored and then converted back to electricity or motive power. About three-quarters of the energy is lost during this process. This approximately triples the cost of producing clean energy using hydrogen. Prospects for large-scale hydrogen energy use are largely illusory.

Though hydrogen will not be widely used in the energy industry, hydrogen atoms are required in very large quantity in the chemical industry for the clean production of ammonia, plastics, synthetic jet fuel and metals. Currently, most hydrogen atoms for chemicals are derived from fossil gas (methane) with associated carbon dioxide emissions. The chemical industry will be the main market for clean hydrogen, probably from the mid-2030s onwards.

Claims have been made that massive new industries will be built around the export of hydrogen compounds from Australia and other countries. However, solar and wind resources are far more widely available than fossil fuels. Most countries can generate far more wind and solar energy than they need, even densely populated countries like Japan and Indonesia, including from floating offshore solar panels.

Solar and wind energy are the main components of the future decarbonised global energy economy, in conjunction with electrification of most energy functions. Most countries can produce all the energy they need from solar and wind and make their own clean hydrogen for their chemical industry. Large scale international trade in hydrogen, on a comparable scale to current fossil fuel trade, is quite unlikely.

It is difficult to see how the MNC region could participate significantly in clean hydrogen trading for the chemical industry. Other regions in Australia have better solar and wind resources, better ports and more heavy industry.

Emissions

Figure 16 is a pie chart of Australian emissions by sector. It is straightforward to mitigate most of Australia's greenhouse emissions at low cost using off-the-shelf technology:

- Electricity (33%) is being decarbonized through the use of solar and wind. The government target of 82% renewable electricity by 2030 will largely decarbonize this sector. The MNC region can assist by welcoming rooftop solar, solar farms, offshore wind farms, pumped hydro energy storage, and transmission.
- Stationary energy (22%) is mostly heating in buildings and factories using fossil gas. This can be readily decarbonized by substituting electric heat pumps for space and water heating, and electric furnaces for industrial gas heating. The MNC region can assist by strongly discouraging extensions of the gas network to new buildings, and by strongly encouraging the uptake of electric machines to replace gas burning machines when they reach the end of their operational life. Because the life of gas burning machines is typically 15 years, most will be gone by 2040.
- Transport (21%) is mostly land transport, which can be readily decarbonized using electric vehicles. The MNC region can assist by strongly encouraging the uptake of electric vehicles. Because vehicle life is typically 15 years, most fossil fuel cars will be gone by 2040.

- Fugitive emissions (10%) mostly relate to methane emissions from coal and gas mining. This will tend to zero as coal and gas mining are phased out. The MNC region has low participation in fossil fuel mining.
- The remaining sectors sum to 14% and require substantial research and commercialisation to mitigate. This is a job for the 2030s.

Electrification of everything in the MNC region

Electrification of most energy functions allows low-cost solar and wind electricity to decarbonize transport, heating and industry.

For the MNC region, decarbonization through electrification can proceed as follows:

- Land transport: strongly encourage uptake of electric vehicles. This can include conversion of Council car fleets to electric; direct encouragement for the electrification of the vehicle fleets of companies that do business with councils (garbage trucks, school buses, delivery vehicles); provision of rapid EV chargers; and preferred transit lanes and car parking for EVs. EV sales in Canberra are tracking towards 50% of all sales by 2025. This implies that the majority of vehicles will be electric about 10 years later, as the vehicle fleet turns over. Rapid change is possible. • Displace gas use in buildings: strongly discourage or prohibit extension of the gas network to new dwellings and suburbs; strongly discourage like-for-like replacement of retiring gas burners, and instead, encourage substitution of equivalent electric machines (hot water heaters, space heaters, cookers). Most gas use in buildings will end about 15 years after cessation of like-for-like replacement of gas burning machines.
- Victoria and the ACT are placing strong restrictions on further extension of the gas network, and the City of Sydney is doing likewise. It's probable that all states will follow the lead of Victoria and the ACT over the next few years. The MNC region could be an early mover.

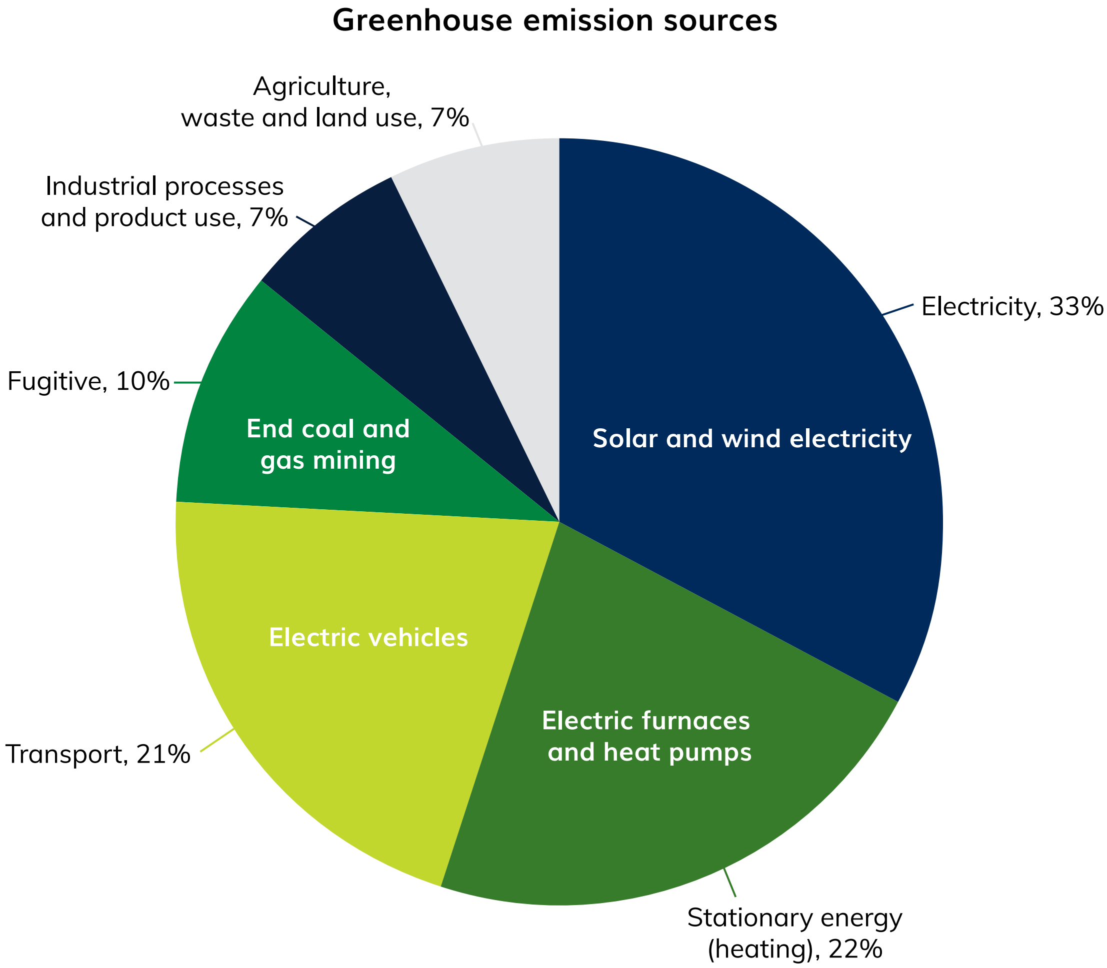

Figure 16: Australian emissions by sector. DCCEEW

Local Government Areas

In this section, specific recommendations are made for each of the MNC Councils. These are in addition to the general recommendations made on pages 2 and 3 that apply to all the MNC Councils.

Coffs Harbour

1. Pursue large-scale solar farm opportunities in favourable locations (redder is better) shown on the ANU heatmaps and summarized in figure 9.
2. Explore opportunities to strengthen or duplicate the Armidale-Grafton high voltage transmission link that passes near Coffs Harbour as summarized in figure 12.
3. Explore the opportunity for a large pumped hydro system (redder is bet er) to be located as shown in the ANU pumped hydro atlas as summarized in figures 13 and 14.
4. Encourage rooftop solar, electric vehicles, electric heat pumps, electric water heaters, electric cookers and electrification of all energy services. Discourage purchase of new fossil fuel machines (vehicles, heaters, water heaters, furnaces, cookers).
5. Encourage discussion of an offshore wind industry
6. Discuss the large potential investments and associated employment that will flow to the regions in respect of solar, wind, transmission and storage projects.
7. Recognise that many Australian regions could participate in the renewable energy industry –there are far more solar and wind resources than required – and that investment will flow preferentially to those regions that welcome renewable energy investment.

Bellingen Shire

1. Pursue large-scale solar farm opportunities in favourable locations (redder is better) shown on the ANU heatmaps and summarized in figure 9.
2. Explore the opportunity for a large pumped hydro system (redder is bet er) to be located as shown in the ANU pumped hydro atlas as summarized in figures 13 and 14.
3. Encourage rooftop solar, electric vehicles, electric heat pumps, electric water heaters, electric cookers and electrification of all energy services. Discourage purchase of new fossil fuel machines (vehicles, heaters, water heaters, furnaces, cookers).
4. Encourage discussion of an offshore wind industry
5. Discuss the large potential investments and associated employment that will flow to the regions in respect of solar, wind, transmission and storage projects.
6. Recognise that many Australian regions could participate in the renewable energy industry –there are far more solar and wind resources than required – and that investment will flow preferentially to those regions that welcome renewable energy investment.

Nambucca Valley Shire

1. Pursue large-scale solar farm opportunities in favourable locations (redder is better) shown on the ANU heatmaps and summarized in figure 9.
2. Encourage rooftop solar, electric vehicles, electric heat pumps, electric water heaters, electric cookers and electrification of all energy services. Discourage purchase of new fossil fuel machines (vehicles, heaters, water heaters, furnaces, cookers).
3. Encourage discussion of an offshore wind industry

4. Discuss the large potential investments and associated employment that will flow to the regions in respect of solar, wind, transmission and storage projects.
5. Recognise that many Australian regions could participate in the renewable energy industry –there are far more solar and wind resources than required – and that investment will flow preferentially to those regions that welcome renewable energy investment.

Kempsey Shire

1. Pursue small solar farm opportunities in favourable locations (redder is better) shown on the ANU heatmaps and summarized in figure 9.
2. Encourage rooftop solar, electric vehicles, electric heat pumps, electric water heaters, electric cookers and electrification of all energy services. Discourage purchase of new fossil fuel machines (vehicles, heaters, water heaters, furnaces, cookers).
3. Encourage discussion of an offshore wind industry
4. Discuss the large potential investments and associated employment that will flow to the regions in respect of solar, wind, transmission and storage projects.
5. Recognise that many Australian regions could participate in the renewable energy industry –there are far more solar and wind resources than required – and that investment will flow preferentially to those regions that welcome renewable energy investment.

Port Macquarie Hastings

1. Pursue small solar farm opportunities in favourable locations (redder is better) shown on the ANU heatmaps and summarized in figure 9.
2. Explore construction of a strong transmission link from Port Macquarie to Eraring. This will open many opportunities for solar farms and pumped hydro storage.
3. Explore the opportunity for a large pumped hydro system (redder is bet er) to be located as shown in the ANU pumped hydro atlas as summarized in figures 13 and 14.
4. Encourage rooftop solar, electric vehicles, electric heat pumps, electric water heaters, electric cookers and electrification of all energy services. Discourage purchase of new fossil fuel machines (vehicles, heaters, water heaters, furnaces, cookers).
5. Encourage discussion of an offshore wind industry
6. Discuss the large potential investments and associated employment that will flow to the regions in respect of solar, wind, transmission and storage projects.
7. Recognise that many Australian regions could participate in the renewable energy industry –there are far more solar and wind resources than required – and that investment will flow preferentially to those regions that welcome renewable energy investment.

MidCoast Council

1. Pursue large-scale solar farm opportunities in favourable locations (redder is better) shown on the ANU heatmaps and summarized in figure 9.
2. Explore construction of a strong transmission link from Port Macquarie to Eraring. This will open many opportunities for solar farms and pumped hydro storage.
3. Encourage rooftop solar, electric vehicles, electric heat pumps, electric water heaters, electric cookers and electrification of all energy services. Discourage purchase of new fossil fuel machines (vehicles, heaters, water heaters, furnaces, cookers).
4. Encourage discussion of an offshore wind industry

5. Discuss the large potential investments and associated employment that will flow to the regions in respect of solar, wind, transmission and storage projects.
6. Recognise that many Australian regions could participate in the renewable energy industry –there are far more solar and wind resources than required – and that investment will flow preferentially to those regions that welcome renewable energy investment.

Islands

Lord Howe Island

Lord Howe Island is located 600 km east of Port Macquarie. Currently, electricity is supplied from solar panels and diesel generators, with support from a battery system. The car fleet is predominantly fossil fueled, and there is significant use of fossil gas. There is substantial wind availability. Funding was procured for small wind turbines but was blocked by a previous Federal Minister on the grounds of visual intrusion.

Available biomass is insignificant. Pumped hydro storage is effectively unavailable because of small available head. Because of its remote location, Lord Howe Island is unsuitable for experimental technologies.

The decarbonisation pathway for Lord Howe Island is straight forward using off-the-shelf technologies to suppress the need for fossil fuels:

- Explore whether several small wind turbines could be installed on Transit Hill. Solar and wind are often counter correlated, and the combination is better than either alone for reducing storage requirements.
- Install another 500-1000 kW of privately-owned solar scattered across the entire island in small lots, including on rooftops. Private funding avoids the need for the LHI Board to find funding and locations, and also avoids the need for the LHIB to maintain the systems. Private owners carry the risk rather than LHIB. Additional solar should not be placed near the existing solar farm on Transit Hill since local cloud on Transit Hill already causes very rapid changes in solar-electric energy output. There is ample space for additional solar, as documented here.
- Adopt a strategy strongly to encourage storage: the right to purchase and install private solar should be contingent upon co-purchase of comparable batteries, either in the form of a home battery or an electric vehicle. Specifically, 2.5 hours of storage should be required for every kW of solar panel (similar to the ratio of the Transit Hill project). Thus, an electric vehicle with a 50 kWh battery would allow the owner to install a 20 kW solar system. Installation of a Tesla 13 kW Powerwall could be matched with a 5 kW solar system.
- Strongly encourage electric vehicles in preference to internal combustion vehicles. EVs have large batteries and can substantially improve matching of grid demand with solar and wind availability. Require that recharging of EVs happen during daytime hours (to match solar availability), either by regulation or tariff structure. In the future, more sophisticated charging regimes could be introduced that match solar and wind availability in real time, and discourage charging during stress periods for the grid.
- All water heaters should be electric heat pumps or solar thermal equipped with electric heat pump boosters. The heating cycle should only operate during daylight hours. Heat pumps reduce electricity consumption by 80% per unit of delivered heat. Hot water tanks represent a large amount of very low-cost energy storage.

- All space heaters should be electric heat pumps. Much of the heating in winter occurs during daylight hours when solar is available. In the evening, run off battery. Overall, there is a substantial reduction in fossil fuel consumption and increase in solar required.
- Progressively ban import of new fossil fuel appliances and let the existing appliances and vehicles die of old age over the next 15 years.

Norfolk Island

Norfolk Island is located 1500 km east of Port Macquarie. Currently, electricity is supplied from solar panels and diesel generators. The car fleet is predominantly fossil fueled, and there is significant use of fossil gas. There is substantial wind availability.

Available biomass is insignificant. Pumped hydro storage is effectively unavailable because of small available head. Because of its remote location, Norfolk is unsuitable for experimental technologies.

The decarbonisation pathway for Norfolk Island is straight forward using off-the-shelf technology to suppress the need for fossil fuels:

- Explore whether several small wind turbines could be installed. Solar and wind are often counter correlated, and the combination is beter than either alone for reducing storage requirements.
- Install additional privately-owned solar scatered across the entire island in small lots, including on rooftops. Private funding avoids the need for Government to find funding and locations, and also avoids the need for Government to maintain the systems. Private owners carry the risk. Additional solar should not be clumped together to avoid rapid changes in solar-electric energy output.
- Adopt a strategy strongly to encourage storage: the right to purchase and install private solar should be contingent upon co-purchase of comparable bateries, either in the form of a home batery or an electric vehicle. Specifically, 2.5 hours of storage should be required for every kW of solar panel. Thus, an electric vehicle with a 50 kWh batery would allow the owner to install a 20 kW solar system. Installation of a Tesla 13 kW Powerwall could be matched with a 5 kW solar system.
- Strongly encourage electric vehicles in preference to internal combustion vehicles. EVs have large bateries and can substantially improve matching of grid demand with solar and wind availability. Require that recharging of EVs happen during daytime hours (to match solar availability), either by regulation or tariff structure. In the future, more sophisticated charging regimes could be introduced that match solar and wind availability in real time, and discourage charging during stress periods for the grid.
- All water heaters should be electric heat pumps or solar thermal equipped with electric heat pump boosters. The heating cycle should only operate during daylight hours. Heat pumps reduce electricity consumption by 80% per unit of delivered heat. Hot water tanks represent a large amount of very low-cost energy storage..
- All space heaters should be electric heat pumps. Much of the heating in winter occurs during daylight hours when solar is available. In the evening, run off batery and diesel. Overall, there is a substantial reduction in fossil fuel consumption and increase in solar required.
- Progressively ban import of new fossil fuel appliances and let the existing appliances and vehicles die of old age over the next 15 years.

Appendix

Glossary

ANU: Australian National University

EV: electric vehicle

GW: Gigawat

GWh: Gigawat hour

LGA: local government area

MNC: mid north coast

PHES: pumped hydro energy storage

TWh: Terawat hour

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About the authors

Andrew Blakers is Professor of Engineering at the Australian National University. In the 1980s and 1990s he helped produce silicon solar cells with world record efficiencies. He was a lead developer of the PERC silicon solar cell, for which he was joint winner of the 2023 Queen Elizabeth Prize for Engineering. PERC has 80% of the global solar market, cumulative module sales of US$150 billion and is mitigating 2% of global greenhouse gas emissions through displacement of coal. Prof Blakers engages in analysis of energy systems with 80-100% penetration by wind and photovoltaics supported by storage for which he was joint winner of the 2018 Eureka Prize for Environmental Research. His team developed a comprehensive global atlas of a million off-river pumped hydro energy storage sites.

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