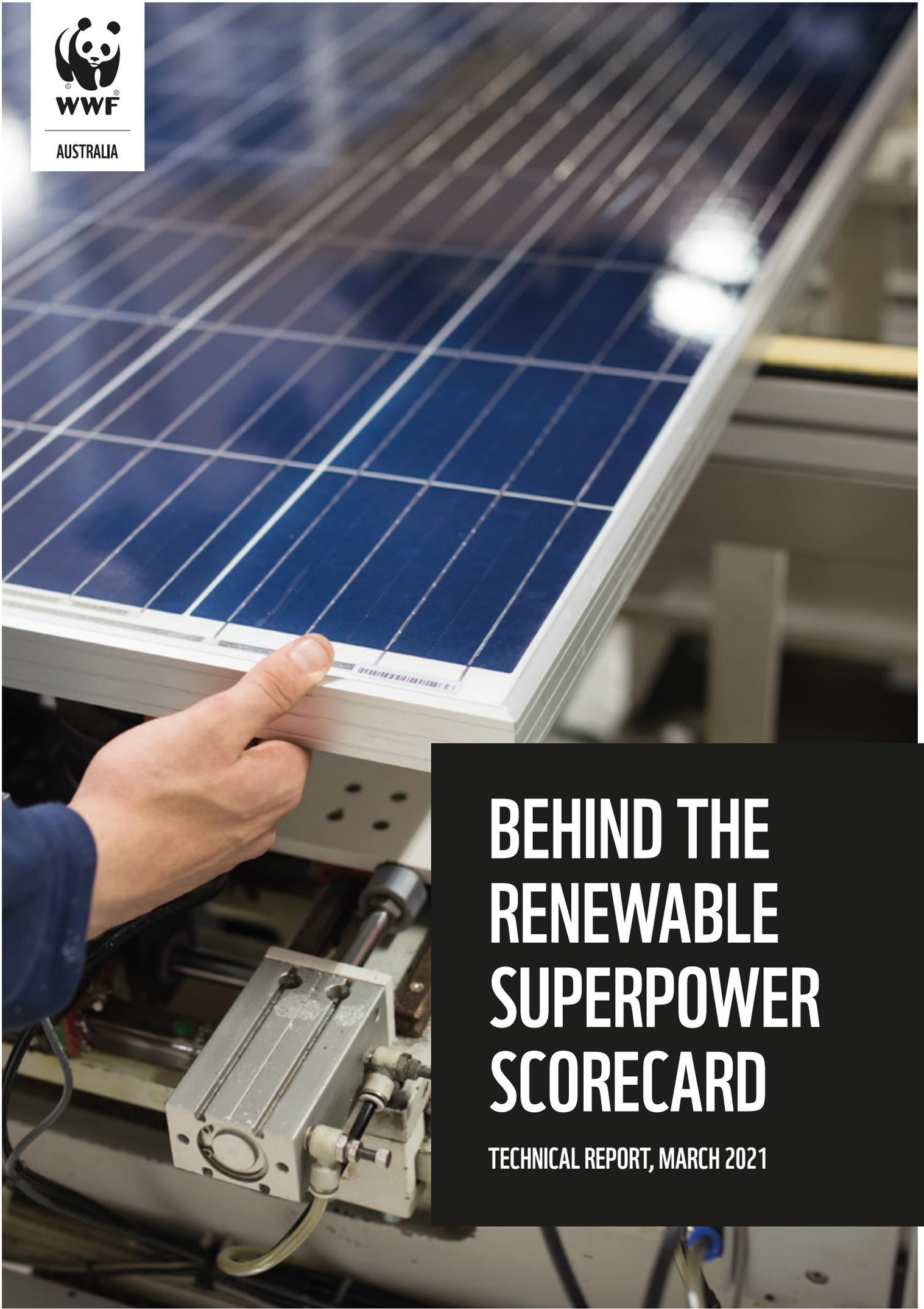




WWF

AUSTRALIA



# BEHIND THE RENEWABLE SUPERPOWER SCORECARD

TECHNICAL REPORT, MARCH 2021

## Acknowledgements

WWF-Australia acknowledges the Traditional Custodians of Country throughout Australia and their continuing connection to land, water and culture. We pay our respects to their Elders - past, present and emerging.

WWF is one of the world's largest and most experienced independent conservation organisations, with over five million supporters and a global network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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# INTRODUCTION

This technical report has been produced to support the [WWF Renewable Superpower Scorecard](#), published in March 2021. Part 1 describes the methodology used to produce the scorecard and provides more detail on the results. Part 2 presents a model of one scenario for achieving an ambitious renewable energy target of 700% for Australia by 2050. The trajectory described in this scenario was used to determine the scoring scale for several of the quantitative indicators in the scorecard.

## Part 1: Methodology & Results

### Overarching approach

Governments were assessed across 10 categories which covered 20 indicators (See Table 1).

Scores for each indicator were applied and aggregated to provide an overall category score. Each indicator carries a maximum score of 5 where the total maximum score achievable would be 100. The total score is presented as a percentage of the total maximum score.

No government was scored against indicator 9c. “*What percentage of the jurisdiction's exports are renewable energy goods and services?*” for this first version of the Renewable Superpower Scorecard as there is limited data or action from the governments to score effectively.

**Table 1: Scoring system**

#	Categories & Indicators	Points
1	Strong Renewable Energy Targets	15
1a	What is the government's 2030 renewable energy target?	5
1b	What is the government's renewable energy target beyond 2030?	5
1c	Is there an effective policy mechanism to deliver the government's renewable energy targets?	5
2	Rolling out renewable energy	10
2a	How much new renewable energy was deployed in the last 2 years?	5
2b	What percentage of the jurisdiction's electricity generation was from renewables?	5
3	Renewable Energy Zones and transmission	10
3a	Is the government developing Renewable Energy Zones?	5
3b	Is the government working to expedite other electricity transmission projects?	5
4	Energy storage and balancing the grid	10
4a	How much energy storage has been deployed in the last 2 years?	5

4b	Is the government supporting energy storage, demand management or other tools to balance the grid?	5
5	Developing a renewable hydrogen industry	10
5a	Is the government investing in the renewable hydrogen industry?	5
5b	Is the government supporting hydrogen from fossil fuels?	5
6	Sharing the benefits of the energy transition	15
6a	Is the government working to ensure First Nations communities benefit from the energy transition and their land and water rights are respected and protected?	5
6b	Is the government working to ensure workers and regional communities are not disadvantaged, and share in the benefits of the energy transition (for example social license, benefit sharing and just transition policies)?	5
6c	Is the government working to ensure consumers, particularly low-income households are not disadvantaged, and share in the benefits of the energy transition?	5
7	Renewable Export Industry Strategy	10
7a	Does the government have a comprehensive Renewable Export Industry Strategy?	5
7b	Is the government supporting production of potential new renewable export industries or products (beyond hydrogen)?	5
8	Renewable Energy Industrial Precincts	5
8a	Is the government developing Renewable Energy Industrial Precincts?	5
9	Growing demand for renewable energy & exports	10
9a	Is the government working to develop local and international markets for renewable export products?	5
9b	Is there an effective policy mechanism to encourage fuel-switching from oil and gas to clean electricity?	5
9c	What percentage of the jurisdiction's exports are renewable energy goods and services?	5
10	2021 Special Category - Renewable Recovery	5
10a	Does the government's COVID economic-recovery program include investment in renewable energy initiatives?	5
<b>MAXIMUM SCORE</b>		<b>100</b>

## Focus on Government Policy

Governments at the state and federal level have a crucial role to play in enabling new renewable export industries. Government responsibilities include ensuring Australia does its fair share of addressing climate change in the speed science indicates is required, delivering essential infrastructure, coordinated planning, providing financial incentives or direct investment, supporting research and development, and ensuring the energy transition is managed in a way that's fair for all parts of society, particularly as energy is an essential service.

That is why this scorecard focuses on assessing policies, commitments and actions taken by governments across Australia, rather than commercial decisions made by business and industry. Of course, private companies and commercial markets will play an enormous role, however, they are not the focus of this scorecard.

## Developing the categories and indicators

The research team developed the initial set of categories and indicators based on WWF's policy agenda and a deep understanding of the different aspects of public policy required to accelerate Australia to be the world's leading renewable export nation. These included aspects of the transition to clean energy that have been on the policy agenda for many years and those that have been newly developed in the last year by WWF's Renewables Nation campaign.

A mix of policy assessment indicators (qualitative) and indicators that assess the real world impact of these policy measures (quantitative) were chosen.

In establishing the categories and indicators, WWF aims to set a transparent 5-year policy agenda, ensuring the goal posts are not changed on governments over time. However, we would expect some degree of iteration as feedback is received and the methodology is refined to more fairly assess governments' actions to support Australia to become a renewable superpower. The noted exception is the #10 Special 2021 Category: Renewable Recovery, which will only be deployed for as long as stimulus is required to support the Australian economy out of the COVID19 induced recession.

The categories and indicators were then shared with state governments and policy and energy experts to provide feedback. Based on this feedback a number of indicators and the balance of indicators under each category were revised and finalised.

## Research and scoring process - qualitative indicators

Of the 20 indicators, 14 are qualitative indicators associated with policies implemented by each jurisdiction, where policy is defined as - law, regulation, plan, program, policy, etc.

### Research process

Initial desktop research was undertaken by WWF using publicly available information. Information was gathered from federal, state/territory government websites, legislation, budget papers, company websites, reports and news websites. This process provided an evidence baseline for the scorecard assessment before conducting stakeholder engagement and a peer review to obtain additional data and methodology validation.

Each government and experts in each jurisdiction were provided an opportunity to submit additional information using a feedback form provided by WWF. WWF did not pre-fill the form or provide any evidence of the research findings.

The initial desktop research, combined with the additional information gathered throughout the stakeholder engagement was used to undertake the scoring and finalise the report findings.

### Setting scoring levels

The qualitative indicators were scored against either a five-point:

- Policy effectiveness scale,
- Support/action scale, or
- A bespoke scale designed for that indicator.

To determine the level of effectiveness or support/action, the mix of policies and actions taken by a government were assessed across a range of criteria including Impact, Economic, Feasibility/Delivery, Timely & Continuing, Certainty or other (see Table 2 for considerations).

**Table 2: Qualitative Indicators Rating Scales – Areas of effectiveness**

<b>Impact</b>	Is there a clear and demonstrable impact as a result of the policy? Aka is it working? And where the policy is new has that type of policy proven effective in other contexts, and as such there is a high degree of confidence it will deliver the desired impact?
<b>Economic</b>	What level of financial support is involved? Note this does not have to be through investment or funding, but could be through something like a trading mechanism like a certificate scheme.
<b>Delivery</b>	Is there a delivery mechanism and a body to deliver it? Is there more than one delivery mechanism?
<b>Timely &amp; Continuing?</b>	Is it timely and ongoing, to the end of the target period?
<b>Certainty</b>	Does it provide certainty? Eg. is it legislated?

**Table 3: Qualitative Indicators Rating Scales – Effectiveness & Support/Action**

Score	RATING SCALE - Effectiveness	RATING SCALE - Support/Action
0	No policy mechanisms	No support/action
1	Not effective	Very low level of support/action
2	Slightly effective	Low level of support/action
3	Somewhat effective	Moderate level of support/action
4	Very effective	High level of support/action
5	Extremely effective	Very high level of support/action

### Scoring process

The research team and peer reviewers were invited to participate in the scoring process. Detailed instructions of how to score each qualitative indicator plus the policy evidence compiled for each indicator and each jurisdiction were sent to the scorers.

They then scored each jurisdiction across these 13 of the 14 indicators independently using the instructions provided. The scores from each scorer were then collated and averaged to find a final score. In assessing policy action and effectiveness a level of expert judgement is required. This independent scoring process was undertaken as a way to minimise individual bias and ensure the scoring process is robust and defensible. One of the policy indicators (1c) had a sufficiently objective enough rating scale that scoring was undertaken centrally by the research team.

### Research and scoring process - quantitative indicators

The remaining six indicators are quantitative and were similarly scored against a five-point scale (See Table 4). To achieve the maximum score of 5, a government was required to demonstrate significant success when compared against a trajectory to 700% renewables (see Part 2) domestic governments or international benchmarks.

The current research to underpin quantitative indicators is based on publicly available information and data sets. Where there are data gaps assumptions have been made based on the best available information. The spreadsheet was automated to assess the data for each state and provide an associated score.

**Table 4: Quantitative Indicators Rating Scales**

Quantitative Indicators	Sources	Unit	Score 1	Score 2	Score 3	Score 4	Score 5
1a. What is the government's 2030 renewable energy target?	State and territory websites and information	% Renewables	50%	75%	100%	125%	150%
1b. What is the government's renewable energy target beyond 2030?	State and territory websites and information	% Renewables	100%	150%	200%	500%	700%
2a. How much new renewable energy was deployed in the last 2 years?	Clean Energy Regulator, ABS	kW/per capita	0.1	0.21	0.24	0.64	0.93
2b. What percentage of the jurisdiction's electricity generation was from renewables?	OpenNEM; Australian Energy Statistics	% Renewables	20%	40%	60%	80%	100%
4a. How much energy storage has been deployed in the last 2 years?	AEMO, Clean Energy Regulator, SunWiz	kWh/per capita	0.02	0.04	0.05	0.13	0.19
5a. Is the government investing in the renewable hydrogen industry?	State and territory websites and information	\$/GDP(GSP)	0.001%	0.026%	0.051%	0.075%	0.100%
10a. Does the government's COVID economic-recovery program include investment in renewable energy initiatives?	State and territory websites and information, ABS	\$/GDP(GSP)	0.10%	0.25%	0.50%	0.75%	1.00%

## Detailed methodology & results for each indicator

### Indicator 1a: What is the government's 2030 renewable energy target?

*Purpose:* A mid-term indicator of the scale of renewables ambition governments are aiming for.

*Data:* 2030 percentage or gigawatt renewable and storage targets made in governments statements, documents or legislation. Note a mechanism underpinning the target is not required to score well in this indicator, policy or mechanisms underpinning targets are assessed in Indicator 1c.

For NSW the 12GW renewable and 2GW storage target legislated in 2020 was converted into a percentage target based on current electricity usage.

For the Federal Government, their 2030 26-28% emissions reduction target was used as the basis for their renewable target, with each sector achieving this reduction.

*Scoring methodology:* Australia is currently on track to exceed 50% renewables by 2030, as such this was set as the minimum target to achieve 1 point. The maximum target (150%) to score 5 points was set based on the 700% renewables by 2050 trajectory, detailed in Part 2 of this paper. A linear extrapolation was used to set interim scores (2-4).

*Results:*

	Federal	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Percentage target	28%	67%	50%	50%	100%	0%	150%	50%	100%
Score	0	1	1	1	3	0	5	1	3

In the discussion for indicator 4a below, Figure 2 compares each jurisdiction's renewable energy target for 2030 with the actual percentage of renewable generation for that state in 2020.

### Indicator 1b: What is the government's renewable energy target beyond 2030?

*Purpose:* A long-term indicator of the scale of renewables ambition governments are aiming for and whether it is commensurate with becoming a renewable superpower.

*Data:* Post-2030 (typically 2040 or 2050) percentage or gigawatt renewable and storage targets made in governments statements, documents or legislation. Note a mechanism underpinning the target is not required to score well in this indicator, policy or mechanisms underpinning targets are assessed in Indicator 1c.

*Scoring methodology:* The scoring levels for the renewable and energy storage deployment indicators were set in line with the 700% trajectory (see Part 2), with 700% renewables receiving the maximum score. While 100% renewables as the minimum level of ambition for Australia WWF would expect is set at a score of 1. An approximate S-curve extrapolation is used to set interim scores (150% = 2, 200% = 3, 500% = 4).

*Results:*

	Federal	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Percentage target	No Target	No Target	No Target	No Target	500%	No Target	200%	No Target	100%
Score	0	0	0	0	4	0	3	0	1

### Indicator 1c: Is there an effective policy mechanism to deliver the jurisdiction's renewable energy targets?

*Purpose:* A policy indicator to identify the level of government support and commitment to delivering the targets set out in 1a and 1b.

*Data:* See Section 4 above for broad description

*Scoring methodology:* The bespoke scale used to assess this indicator is set out below.

Score	Rating scale
0	No Target
1	Aspirational Target/no target but some policy and/or funding
2	Aspirational target with some supporting policy and/or funding
3	Legislated target
4	Legislated target with some supporting policy and/or funding
5	Legislated with substantial supporting policy and/or funding

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Legislated target with some supporting policy and/or funding	Legislated with substantial supporting policy and/or funding	Legislated with substantial supporting policy and/or funding	Aspirational target with some supporting policy and/or funding	Aspirational target with some supporting policy and/or funding
<b>Score</b>	4	5	5	2	2

	WA	TAS	NT	ACT
<b>Level of policy</b>	Aspirational Target/no target but some policy	Legislated target	Aspirational Target/no target but some policy	Legislated with substantial supporting policy and/or funding
<b>Score</b>	1	3	2	5

**Indicator 2a: How much new renewable energy was deployed in the last 2 years?**

*Purpose:* A quantitative indicator to assess how policy is translating into real-world deployment of renewables. This is a momentum indicator.

*Data:* Clean Energy Regulator data on large and small-scale renewables both commissioned and committed and for 2020 and 2019. ABS data for population figures for each jurisdiction.

*Note:* For the ACT, renewable capacity contracted by the ACT Government in the last two years but located in other states was allocated to the ACT.

*Scoring methodology:* The scoring levels were set in line with renewable capacity deployment trajectories to achieve the corresponding post 2030 target. These trajectories (see Part 2 for a detailed methodology for establishing the 700% renewables trajectory) set out annual GW targets for renewables between 2020 and 2050. That is, this indicator assesses which target level each jurisdiction is on track to achieve, based on the renewable deployment over the past two years.

These trajectories and associated targets are national, to fairly apportion them to each jurisdiction, the annual renewable capacity deployment has been turned into a per capita indicator. To get a two year figure, the kW per capita figures were doubled.

Score	1	2	3	4	5
<b>Renewable target trajectory</b>	100%	150%	200%	500%	700%
<b>Renewables deployed per person over two years (kW per capita)</b>	0.1	0.21	0.24	0.64	0.93

It should be noted that between 2020 and 2030 the annual gigawatt targets associated with each trajectory increases every year. As such the amount of renewables deployed over a two year period in jurisdictions will have to increase to achieve the same score.

*Results:*

	Federal	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
<b>Renewables deployed (MW)</b>	16,356	5,146	4,299	3,417	1,321	1,703	308	81	80
<b>Renewables deployed (kW per capita)</b>	0.64	0.63	0.64	0.66	0.75	0.64	0.57	0.33	0.19
<b>Score</b>	3	3	4	4	4	3	3	3	1

## Indicator 2b: What percentage of the jurisdiction's electricity generation was from renewables in 2020\*?

*Purpose:* A quantitative indicator to assess how policy is translating into real-world generation of renewables as a percentage of overall electricity generation in 2020. Note NT data is for 2019. This is an absolute indicator.

*Data:* Data was taken from OpenNEM for NEM states and Department of Industry, Science, Energy and Resources, Australian Energy Statistics, Table O, September 2020

*Note:* OpenNEM data for 2020 was used for NEM connected states and WA and therefore only includes grid connected generation. Data for the NT was taken from the Australian Energy Statistics for 2019. Total renewable energy consumption was forecast for the ACT based on the renewable share of electricity supplied which was reported in the ACT Greenhouse Gas Inventory.

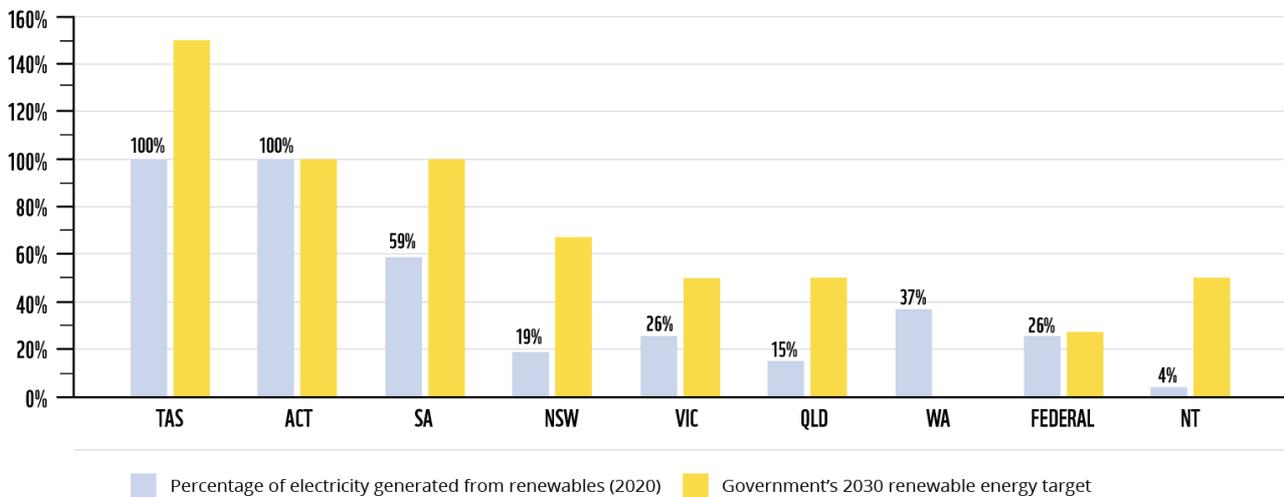
*Scoring methodology:* For approximately a decade Australia's renewable energy target nationally has been 20% renewables by 2020, as such this was taken as the minimum level a jurisdiction should be expected to achieve and thus scores a 1. While 100% renewable electricity was set at the maximum level one should expect for a jurisdiction in 2020 and thus receives a score of 5. A linear extrapolation was used to set interim scores (2-4).

Note governments should expect that in future iterations of this scorecard the percentage targets for this indicator will increase consistent with the 700% trajectory.

Results:

	Federal	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Percentage renewables achieved	26%	19%	26%	15%	59%	37%	100%	4%	100%
Score	1	0	1	0	2	1	5	0	5

### Percentage of electricity generation from renewables in 2020 vs government targets for 2030



**Figure 1.** This graph compares the percentage of generation from renewables in 2020 with the jurisdiction’s target for 2030, and shows that most governments still have a significant way to go to reach the goals they have already committed to, let alone what’s really required to get us on the pathway to 700% by 2050.

### Indicator 3a: Is the government developing Renewable Energy Zones?

*Purpose:* This policy indicator assesses to what extent governments are planning to ensure new renewable capacity can be brought online into the future and consistent with the scale required to become a renewable export powerhouse. This includes energy system planning (from a security and reliability perspective), transmission, land-use, social license, skills, infrastructure and other planning requirements. A Renewable Energy Zone has been identified as the most efficient way to achieve this – by focusing future renewable deployment in geographical clusters.

It should be noted that while REZs are a NEM construct, WWF believes they will be needed across Australia and not just in major grids like the SWIS. For example, the focus on solar deployment around Alice Springs could and should be considered a REZ.

*Data:* See section 4 above for broad description.

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Moderate level of support/action	Very high level of support/action	High level of support/action	High level of support/action	Moderate level of support/action
<b>Score</b>	3	5	4	4	3

	WA	TAS	NT	ACT
<b>Level of policy</b>	Low level of support/action	Low level of support/action	Low level of support/action	N/A
<b>Score</b>	2	3	2	N/A

### Indicator 3b: Is the government working to expedite other electricity transmission projects?

*Purpose:* This policy indicator assesses the level of action being undertaken by governments to support greater transmission capacity, particularly interconnection.

Interconnection has been shown in a series of high-penetration renewables research studies<sup>1</sup> to reduce the overall cost of the renewables transition, as it involves greater geographical diversity of renewables, tapping into different weather patterns, and also allows for greater sharing of capacity.

While this predominantly relates to the NEM, it is very fair to say that Australia does not yet have the transmission capacity required to become a renewable superpower and thus policy support is required in all jurisdictions, even where existing transmission capacity exists.

*Data:* See section 4 above for broad description

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Moderate level of support/action	High level of support/action	High level of support/action	Moderate level of support/action	High level of support/action
<b>Score</b>	3	4	4	3	4

	WA	TAS	NT	ACT
<b>Level of policy</b>	Low level of support/action	Very high level of support/action	Moderate level of support/action	N/A
<b>Score</b>	2	5	3	N/A

<sup>1</sup> Lu, B., Blakers, A., Stocks, M., Cheng, C., and Nadolny, A. (2021). A zero-carbon, reliable and affordable energy future in Australia. Australian National University

## Indicator 4a: How much energy storage has been deployed in the last 2 years?

*Purpose:* A quantitative indicator to assess how policy is translating into real-world deployment of storage. This is a momentum indicator.

Storage is a critical type of technology for moving to high penetrations of renewable energy and momentum is required to ensure Australia is building its storage industry at a fast enough pace to match the renewables momentum. Storage in this indicator covers batteries at all scales (household, community and large-scale) and pumped hydro, and in future iterations will include battery storage in electric vehicle capacity.

### *Data:*

Utility-scale storage - AEMO's NEM Generation information 2020 was used to find the nameplate storage capacity in MWh for utility scale storage projects as well as desktop research for other regions.

Small-scale storage - Postcode data for small scale installations from the Clean Energy Regulator was used to determine the number of PV systems with concurrent battery storage capacity (This data is based on voluntarily disclosed data for batteries that were installed at the same time as the solar PV system and is likely to significantly understate the number of battery installations). The number of battery systems were then multiplied by the average battery size reported by SunWiz.

Pumped hydro - AER data<sup>2</sup> is used to assess current hydro and pumped hydro capacity.

Note the scorecard does not make any assessment on the mix of different duration storage required.

*Scoring methodology:* As with indicator 2a, the storage scoring levels were set in line with storage capacity deployment trajectories to achieve the corresponding post 2030 target. These trajectories (see Part 2 for a detailed methodology for establishing the 700% renewables trajectory) set out annual GW targets for storage between 2020 and 2050. It is assumed that 20% of the combined renewables and storage capacity deployed should be storage or dispatchable renewables.

These trajectories and associated targets are national, to fairly apportion them to each jurisdiction, the annual renewable capacity deployment has been turned into a per capita indicator. To get a two-year figure, the kWh per capita figures were doubled.

Score	1	2	3	4	5
Renewable target trajectory	100%	150%	200%	500%	700%
Storage deployed per person over two years (kWh per capita)	0.02	0.04	0.05	0.13	0.19

The studies and modelling that the 700% trajectory is based on show that approximately 20% of total capacity needs to be storage or dispatchable generation for Australia to achieve 100% or 200% renewable status. As such, for this indicator, if any region has demonstrated that over 40% of their generation comes from dispatchable renewable generation such as hydro or storage they automatically score 5.

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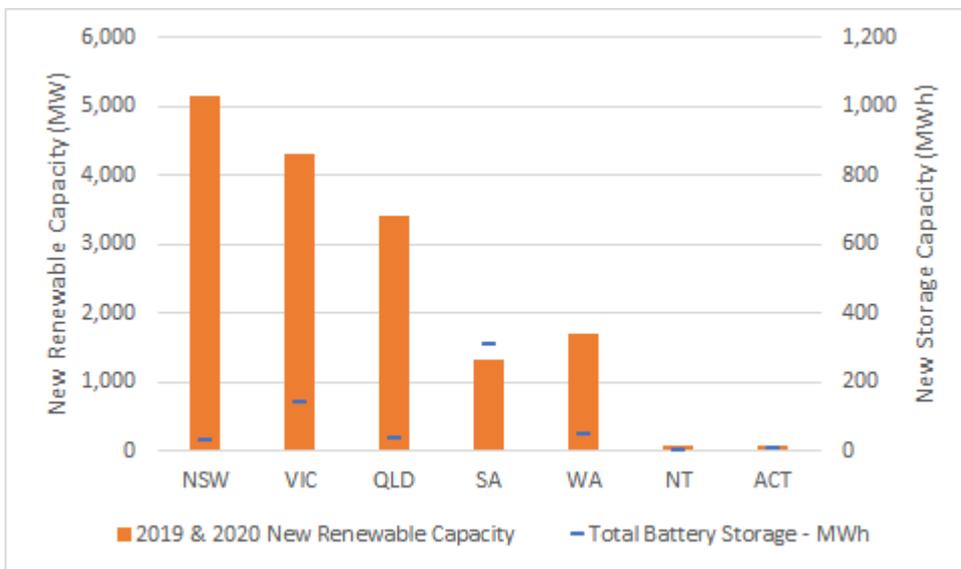
<sup>2</sup> [Australian Energy Regulator data](#)

Results:

	Federal	NSW	VIC	QLD	SA	WA	TAS*	NT	ACT
<b>Storage deployed (MWh)</b>	534.3	31.7	139.4	36.6	306.0	10.1	2.0	1.5	7.1
<b>Storage deployed (kWh per capita)</b>	0.022	0.004	0.021	0.007	0.173	0.018	N/A	0.006	0.016
<b>Score</b>	1	0	1	0	4	0	5	0	0

\* Tasmania's generation is 87% from hydro and as such more than meets the requirements to score a 5.

Figure 2 New renewable energy generation compared to new battery storage 2019 & 2020.



**Notes:** Figure 2 compares the deployment of new renewable energy generation (MW) to new battery storage (MWh) in 2019 & 2020, using data from indicators 4a and 2a. Only battery storage is included, since no new projects using other renewable storage technology have been commissioned recently. The Hornsdale Power Reserve has been included in the SA total, although the first stage began operating in Dec 2017; Tasmania is not included since no additional energy storage is required in the state.

As shown in Figure 2, in the last few years the deployment of new renewable energy storage has been well behind the rollout of variable renewables. As a “rule of thumb” experts advise that a well-balanced renewable electricity system should be made up of around 20% dispatchable renewable energy and storage and 80% variable renewables. As the graph illustrates, Australia is a long way from meeting that benchmark.

In recent years South Australia has led the way by balancing the deployment of new wind and solar farms with new battery storage. Most states now have plans to build big batteries, and a few like NSW and Queensland have given grants to support pumped hydro projects. The Snowy 2.0 project put forward by the federal government and the Battery of the Nation project supported by Tasmania and Canberra both aim to address this gap.

## Indicator 4b: Is the government supporting energy storage, demand management or other tools to balance the grid?

*Purpose:* A policy indicator to identify the level of government support and commitment to delivering storage, demand response programs and other tools to balance the electricity grid.

*Data:* See section 4 above for broad description

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	High level of support/action	High level of support/action	High level of support/action	Moderate level of support/action	Very high level of support/action
<b>Score</b>	4	4	4	3	5

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Moderate level of support/action	Moderate level of support/action	High level of support/action
<b>Score</b>	3	3	3	4

## Indicator 5a: Is the government investing in the renewable hydrogen industry?

*Purpose:* A quantitative indicator to assess the level of government support for renewable hydrogen both to date and committed.

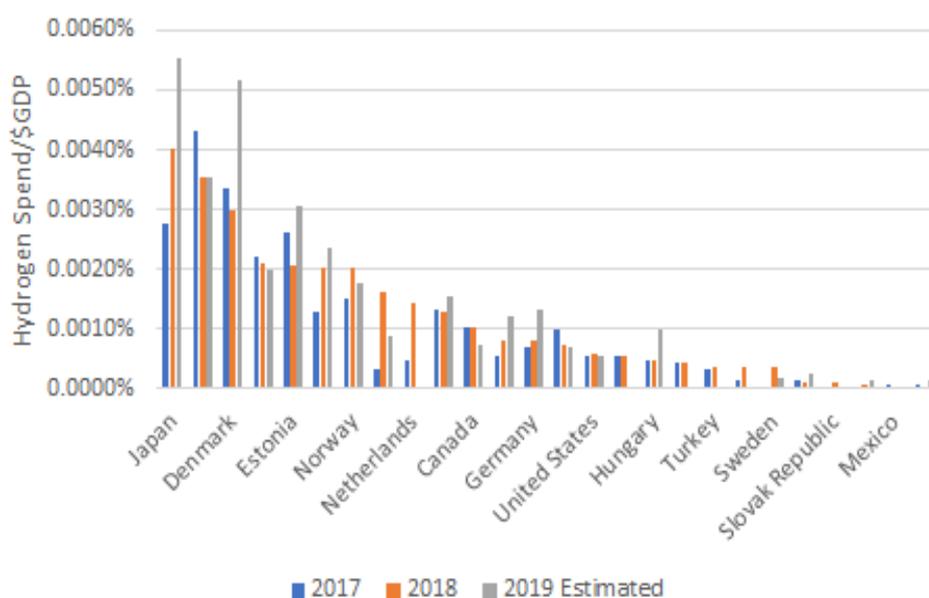
Note: between them, the categories assess policies related to all six types of renewable export products identified by WWF as holding great potential for Australia (see Renewable Superpower Scorecard Report). However, Government support for the renewable hydrogen industry has been given a category of its own because hydrogen is a major part of the current Australian energy policy conversation and this versatile renewable fuel will have a huge role to play in decarbonising hard-to-decarbonise nations and sectors such as steel globally. For more information see [WWF Australia's Hydrogen Position Paper](#).

*Data:* Sources included budget statements and government websites and information and the governments had the opportunity to provide feedback on their level of spending. For international benchmarking, data was sourced through desktop research of publicly available data including hydrogen spending from the International Energy Agency (IEA) and Energy Policy Tracker.

*Scoring methodology:* To assist in creating the scoring levels 1 to 5, an international analysis of renewable hydrogen spending was undertaken. To compare the findings between regions, the data was converted into \$ per GDP.

Below are the findings from the IEA research which revealed very low government spending historically and was used to determine the level 1 scores. On the higher end of the scale, recent renewable recovery initiatives by government around the world for renewable hydrogen were greater than 0.1% of GDP. For example, Germany has committed [\\$10 billion for hydrogen industry development](#) which represents over 0.2% of GDP.

Figure 3: Hydrogen Spend/\$GDP - Adapted from IEA with GDP figures from the World Bank



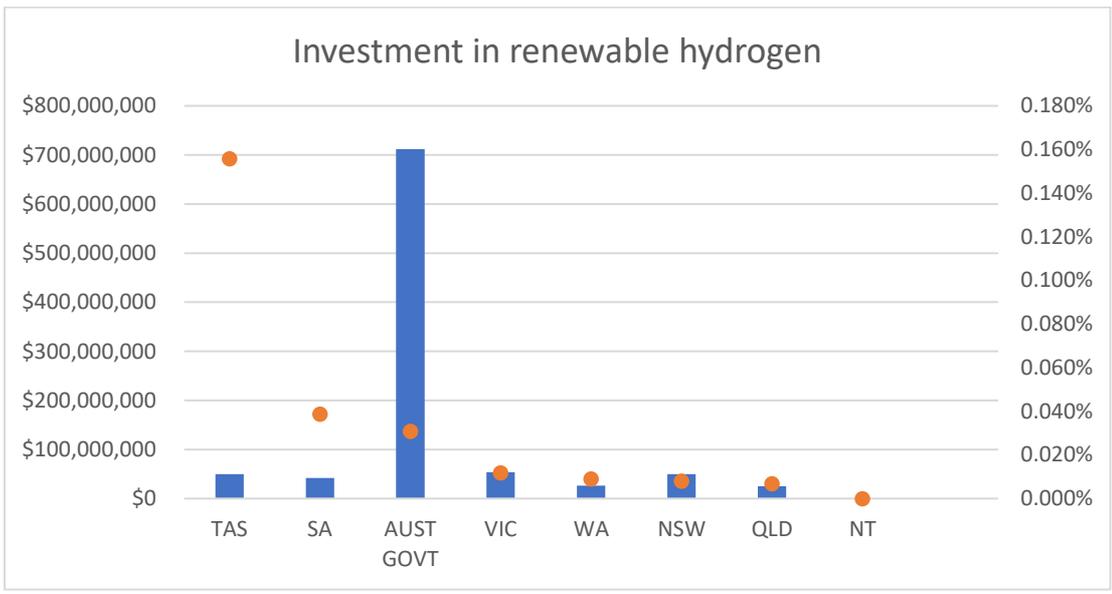
Based on this analysis the following scoring levels were set:

Score	1	2	3	4	5
<b>Government hydrogen spending total (\$/GDP(GSP))</b>	0.001%	0.026%	0.051%	0.075%	0.10%

Results:

	Federal	NSW	VIC	QLD	SA	WA	TAS*	NT	ACT
<b>Total gov investment in renewable hydrogen (\$m)</b>	\$712	\$50	\$54	\$57	\$42	\$26	\$50.1	\$0	N/A
<b>Gov investment in renewable hydrogen as a percentage of GDP/GSP</b>	0.046%	0.008%	0.012%	0.016%	0.039%	0.009%	0.156%	0.000%	N/A
<b>Score</b>	2	1	1	1	2	1	5	0	N/A

Figure 4. Government investment in the renewable hydrogen industry



**Notes:** Figure 4 shows the total amount invested in renewable hydrogen by each government, and the total as a proportion of Gross State or Domestic Product (GSP or GDP). Note some government funded programs may also allow financial support for non-renewable hydrogen (eg. Aust Govt Low emissions technology roadmap).

**Indicator 5b: Is the government supporting hydrogen from fossil fuels?**

*Purpose:* As outlined in the organisation’s Hydrogen Position Paper, WWF supports renewable hydrogen since it is the only guaranteed hydrogen production method that is zero carbon. Hydrogen from coal and gas contributes to climate change and distracts from renewable hydrogen-based industries that are essential to the decarbonisation of the global economy. This qualitative indicator assesses the extent to which government policy and programs are consistent with WWF’s position on this issue.

*Data:* See Section 4 above for broad description

*Scoring methodology:* The bespoke scale was used to assess this indicator is set out below.

Score	Rating scale
0	Yes the government is supporting hydrogen from fossil fuels
3	No the government is not currently supporting hydrogen from fossil fuels
4	The government is not currently supporting hydrogen from fossil fuels and is publicly advocating for renewable hydrogen
5	The government has legislated that it will not support hydrogen from fossil fuels

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Support for fossil hydrogen?</b>	Yes	No	Yes	Publicly advocating for renewable hydrogen	No
<b>Score</b>	0	3	0	4	3

	WA	TAS	NT	ACT
<b>Support for fossil hydrogen?</b>	Publicly advocating for renewable hydrogen	Publicly advocating for renewable hydrogen	Publicly advocating for renewable hydrogen	N/A
<b>Score</b>	4	4	4	N/A

**Indicator 6a: Is the government working to ensure First Nations communities benefit from the energy transition and their land and water rights are respected and protected?**

*Purpose:* [WWF Australia is committed](#) to respecting First Nations Peoples' human and development rights and recognising the importance of conserving their cultures. This qualitative indicator assesses whether governments are addressing issues of social justice for indigenous peoples in relation to the transition to renewable energy.

*Data:* See section 4 above for broad description

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Very low level of support/action	Very low level of support/action	Low level of support/action	Low level of support/action	Very low level of support/action
<b>Score</b>	1	1	2	2	1

	WA	TAS	NT	ACT
<b>Level of policy</b>	Low level of support/action	No support/action	Low level of support/action	No support/action
<b>Score</b>	2	0	2	0

**Indicator 6b: Is the government working to ensure workers and regional communities are not disadvantaged, and share in the benefits of the energy transition (for example social license, benefit sharing and just transition policies)?**

*Purpose:* WWF Australia is committed to a just and fair energy transition, particularly for workers and communities in carbon intensive industries such as coal, as well as the communities that host renewable energy projects and associated infrastructure. This qualitative metric assesses the extent to which government policy and programs are proactively enabling a just transition and regional communities and workers to share in the benefits of new renewable energy projects.

*Data:* See section 4 above for broad description

*Scoring methodology:* The action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Very low level of support/action	Low level of support/action	Moderate level of support/action	Low level of support/action	Very low level of support/action
<b>Score</b>	1	2	3	2	1

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Low level of support/action	No support/action	Low level of support/action
<b>Score</b>	2	2	0	2

### Indicator 6c: Is the government working to ensure consumers, particularly low-income households are not disadvantaged, and share in the benefits of the energy transition?

*Purpose:* WWF-Australia supports the principle that all Australians should have access to affordable electricity. This qualitative metric assesses the extent to which government policy and programs are consistent with [policy priorities identified by the Australian Council of Social Services](#).

Governments should ensure that policies to accelerate the transition to renewable energy also improve access and affordability for disadvantaged Australians.

*Data:* See section 4 above for broad description

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Very low level of support/action	Low level of support/action	Moderate level of support/action	Low level of support/action	Low level of support/action
<b>Score</b>	1	2	3	2	2

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Very low level of support/action	No support/action	High level of support/action
<b>Score</b>	3	1	0	4

## Indicator 7a: Does the government have a comprehensive Renewable Export Industry Strategy?

*Purpose:* WWF has identified the development of a Renewable Energy Industry Strategy as a key step in the critical path to Australia becoming a renewable superpower and thus a policy priority for our Renewables Nation Program.

South Australia was the first jurisdiction to develop a hydrogen strategy, this in turn became a national process and now every jurisdiction not only has a hydrogen strategy but is actively supporting the development of a renewable hydrogen industry. This process needs to be applied to the full range of Australia's renewable export opportunities.

As such, this policy indicator assesses the level of policy activity undertaken by each jurisdiction towards all of the six renewable export opportunities WWF has identified, that are relevant to that jurisdiction.

*Data:* See section 4 above for broad description.

*Scoring methodology:* The bespoke scale used to assess this indicator is set out below.

Score	Rating scale
0	No renewable export industry strategy
1	A hydrogen strategy
2	A hydrogen strategy + a strategy for one other export opportunity/initial scoping of broader export opportunities
3	A hydrogen strategy + a strategy for multiple other export opportunity/more scoping of broader export opportunities
4	A renewable export industry strategy
5	A comprehensive and well resourced Renewable Export Industry development strategy

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	A hydrogen strategy + a strategy for one other export opportunity/initial scoping of broader export opportunities	A hydrogen strategy + a strategy for one other export opportunity/initial scoping of broader export opportunities	A hydrogen strategy + a strategy for one other export opportunity/initial scoping of broader export opportunities	A hydrogen strategy	A hydrogen strategy
<b>Score</b>	2	2	2	1	1

	WA	TAS	NT	ACT
<b>Level of policy</b>	A hydrogen strategy + a strategy for multiple other export opportunity/more scoping of broader export opportunities	A hydrogen strategy + a strategy for one other export opportunity/initial scoping of broader export opportunities	A hydrogen strategy + a strategy for one other export opportunity/initial scoping of broader export opportunities	N/A
<b>Score</b>	3	2	2	N/A

### Indicator 8a: Is the government developing Renewable Energy Industrial Precincts?

*Purpose:* WWF has identified the development of a [Renewable Energy Industrial Precincts](#) as a key step in the critical path to Australia becoming a renewable superpower and thus a policy priority for our Renewables Nation Program.

A Renewable Energy Industrial Precinct supports a cluster of manufacturers powered by 100% renewable energy. These precincts could be existing industrial centers or greenfield sites. They are either located within Renewable Energy Zones or connected to renewable energy generation through high-voltage transmission lines. They also have access to clean heat and renewable hydrogen production, skills development and export infrastructure, including good transport links.

This policy indicator assesses the level of policy activity undertaken by each jurisdiction towards establishing at least one Renewable Energy Industrial Precinct in their jurisdiction.

*Data:* See section 4 above for broad description.

Note, while the term Renewable Energy Industrial Precinct is not currently in common usage, there are a number of developments and policy activities that are supporting clusters of manufacturers to move to renewable energy and as such have been taken as evidence of a government supporting Renewable Energy Industrial Precincts.

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Low level of support/action	Low level of support/action	No support/action	Low level of support/action	Moderate level of support/action
<b>Score</b>	2	2	0	2	3

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Moderate level of support/action	Very low level support/action	N/A
<b>Score</b>	3	3	1	N/A

## Indicator 7b: Is the government supporting production of potential new renewable export industries or products (beyond hydrogen)?

*Purpose:* This policy indicator assesses whether a government is supporting the establishment of the production supply chains required for new renewable export industries beyond hydrogen. This could include battery manufacture, green steel, export cables to other countries etc.

*Data:* See section 4 above for broad description

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Low level of support/action	Low level of support/action	Very low level of support/action	Low level of support/action	Low level of support/action
<b>Score</b>	2	2	1	2	2

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Very low level of support/action	Moderate level support/action	N/A
<b>Score</b>	2	1	3	N/A

## Indicator 8a: Is the government developing Renewable Energy Industrial Precincts?

*Purpose:* WWF has identified the development of a [Renewable Energy Industrial Precincts](#) as a key step in the critical path to Australia becoming a renewable superpower and thus a policy priority for our Renewables Nation Program.

A Renewable Energy Industrial Precinct supports a cluster of manufacturers powered by 100% renewable energy. These precincts could be existing industrial centers or greenfield sites. They are either located within Renewable Energy Zones or connected to renewable energy generation through high-voltage transmission lines. They also have access to clean heat and renewable hydrogen production, skills development and export infrastructure, including good transport links.

This policy indicator assesses the level of policy activity undertaken by each jurisdiction towards establishing at least one Renewable Energy Industrial Precinct in their jurisdiction.

*Data:* See section 4 above for broad description.

Note, while the term Renewable Energy Industrial Precinct is not currently in common usage, there are a number of developments and policy activities that are supporting clusters of manufacturers to move to renewable energy and as such have been taken as evidence of a government supporting Renewable Energy Industrial Precincts.

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Low level of support/action	Low level of support/action	No support/action	Low level of support/action	Moderate level of support/action
<b>Score</b>	2	2	0	2	3

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Moderate level of support/action	Very low level support/action	N/A
<b>Score</b>	3	3	1	N/A

### Indicator 9a: Is the government working to develop local and international markets for renewable export products?

*Purpose:* A policy indicator to assess the scale of government activity to support the growth in demand for renewable export product, commodities and services both in Australian and international markets.

Too often policy focuses on supply side solutions. However, stimulating and ensuring there are markets and market demand for renewable exports is critical to the success of these export opportunities. In addition, this indicator considers both domestic and international markets, because typically (though not exclusively) the growth of a domestic market is the best way to build capacity to establish an export industry, that is by scaling up a domestic industry.

*Data:* See section 4 above for broad description

*Scoring methodology:* The support/action scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy</b>	Low level of support/action	Low level of support/action	Low level of support/action	Moderate level of support/action	Moderate level of support/action
<b>Score</b>	2	2	2	3	3

	WA	TAS	NT	ACT
<b>Level of policy</b>	Moderate level of support/action	Moderate level of support/action	Moderate level of support/action	Low level of support/action
<b>Score</b>	3	3	3	2

## Indicator 9b: Is there an effective policy mechanism to encourage fuel-switching from oil and gas to clean electricity?

*Purpose:* A policy indicator to identify the effectiveness of government policy in supporting fuel switching away from fossil fuels to renewable electric or other renewable fuelled alternatives in the transport, building and industry sectors.

This fuel switching or electrification indicator grows demand for Australia's renewable electricity and is critical to achieving the decarbonisation of Australia's total energy system or 200% renewables – a key element of becoming a renewable superpower.

*Data:* See section 4 above for broad description.

This indicator includes support for:

- Electric cars and zero emission buses,
- Houses and commercial buildings to move away from gas through technologies such as heat pumps and electric stoves, and
- Industry to move to more energy efficient and renewable forms of heat and renewable or zero carbon feedstocks.

*Scoring methodology:* The policy effectiveness scale set out in Section 4 was used to assess this indicator.

*Results:*

	Federal	NSW	VIC	QLD	SA
<b>Level of policy effectiveness</b>	Not effective	Slightly effective	Slightly effective	Not effective	Not effective
<b>Score</b>	1	2	2	1	1

	WA	TAS	NT	ACT
<b>Level of policy effectiveness</b>	Not effective	Not effective	No policy mechanisms	Moderately effective
<b>Score</b>	1	1	0	3

## Indicator 9c: What percentage of the jurisdiction's exports are renewable energy goods and services?

Methodology not developed for this indicator in this iteration of the scorecard.

## Indicator 10a: Does the government's COVID economic-recovery program include investment in renewable energy initiatives?

*Purpose:* A quantitative indicator to assess the level of government support for a renewable recovery or clean stimulus over the forward estimates as the country emerges from the COVID19 pandemic induced economic downturn.

A renewable recovery is a policy priority for the WWF Renewables Nation program in 2021.

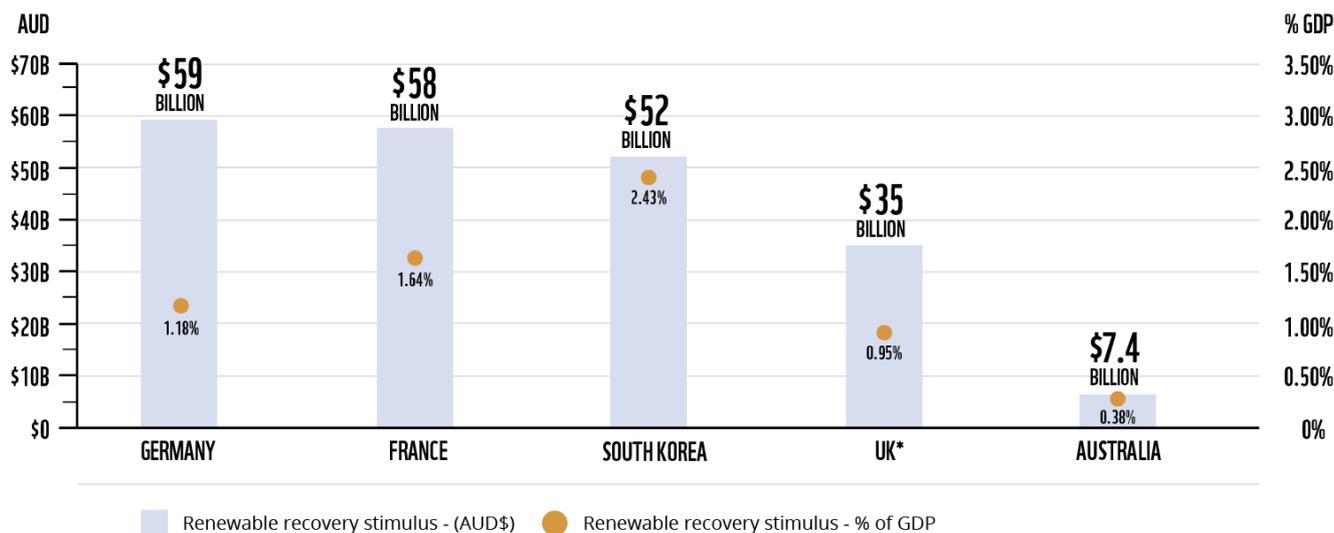
*Data:* Renewable recovery initiatives were only considered if reported in the 2020-21 budgets for each jurisdiction and are only calculated over the forward estimates period (four years).

Renewable Recovery measures are those related to energy or clean manufacturing and industry, including energy efficiency measures that were newly announced or significantly upscaled in 2020 budgets, as compared to previous years. Note ACT's 2020 budget was released in January 2021.

*Scoring methodology:* To assist in creating the scoring levels 1 to 5, an international analysis of renewable recovery initiatives was undertaken. To compare the findings between regions, the data was converted into \$ per GDP. Data was sourced through desktop research of publicly available data including hydrogen spending from the Centre for Policy Development and Energy Policy Tracker. Below are some of the findings used to determine the scores.

Figure 5: Clean Recovery stimulus - % of GDP

## Renewable recovery spending - international comparison (\$AUD)



**Notes:** This graph shows both the total amount invested in renewable recovery projects by each government, and the total as a proportion of Gross State or Domestic Product (GSP or GDP)

Based on this analysis the following scoring levels were set:

Score	1	2	3	4	5
Government renewable recovery spending total (\$/GDP(GSP))	0.01%	0.25%	0.5%	0.75%	1.0%

Results:

	Federal	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Total gov investment in a renewable recovery (\$m)	\$1,566	\$2,492	\$2,860	\$510	\$76	\$137	\$24	\$8	\$306
Gov investment in a renewable recovery as a percentage of GDP/GSP	0.06%	0.38%	0.62%	0.14%	0.07%	0.04%	0.08%	0.03%	0.75%
Score	1	2	3	1	1	1	1	1	3

# Part 2: 700% Renewables Trajectory

Authors: Michael Lord, Daniel Zelcer, Nicky Ison

## Introduction

With abundant renewable resources and proximity to key export markets, including Asia, Australia has a significant potential to ramp up the deployment of renewable generation capacity and become a renewable superpower. In this research paper, we model a scenario to achieve an ambitious renewable energy target of 700% for Australia by 2050 to highlight a pathway beyond the complete electrification of the country with renewable energy.

Previous research was analysed to:

- Set a baseline for a 100% renewable *electricity* target, and
- Set a renewable *energy* target for the complete electrification and decarbonisation of Australia's energy usage.

A scenario that covers a range of different renewable export opportunities - renewable hydrogen and ammonia, embodied renewable energy in products like steel and aluminium and undersea HVDC cable exports - was developed. These baseline targets and the renewables deployment required to achieve this renewable export scenario were then extrapolated to set a renewable deployment trajectory to achieve 700% renewables by 2050.

To achieve this ambitious target, Australia would need to significantly ramp up the deployment of renewable generation technology and energy storage over the next two decades.

## Why 700%?

In 2019, Darren Miller, CEO of the Australian Renewable Energy Agency (ARENA), was the first person to [publicly raise the concept of 700%](#) renewables for Australia, saying this achievable goal would deliver a similar amount of energy to what we currently export through Australia's LNG industry.

WWF-Australia believes that Australia should be aiming for a renewable industry at least as big as our LNG industry, if not bigger. Indeed, the analysis in this paper shows that if we move to 700% renewables and storage (or seven times the amount of electricity we currently generate across Australia) and invest in associated upstream and downstream manufacturing, we can more than replace all the jobs in and revenue from Australia's current fossil fuel export industries.

## Setting a baseline: Calculating 100% renewables

### How much renewable & storage capacity is required to reach 100% renewables in Australia?

There have been at least 16 studies into 100% renewables, near 100% and 200% renewables in Australia. This paper draws on evidence from the studies published in the last three years, as they represent the most up to date technology costs and thus the most likely technology mix and thus capacity.

The most recent studies have focussed on the National Electricity Market (NEM), rather than the whole country. Table 5 summarises six of these studies.

**Table 5: Recent analyses of 100% (or close to 100%) renewable National Electricity Markets**

Organisation	Study/Scenario	PV	Wind	Hydro + bio	Other	Storage	Total RE	Total wind/PV
AEMO <sup>3</sup>	ISP Step-change 94%RE	66	35	7	8	16	131	101
ITP (OpenCEM) <sup>4</sup>	100%RE	51	45	7	1	30	133	96
ANU <sup>5</sup>	200%RE	108	63	8		55	234	171
ANU	200%RE+transmission	80	65	8		46	199	145
ANU	200%RE+transmission+ demand management	93	60	8		38	199	153
Windlab <sup>6</sup>	94%RE (2020 version)	51	38	7	6	26	128	89

*Notes on Table 5*

Table 5 shows there is reasonable consistency in the overall capacity required for 100% renewable grid. But there are large differences in the *balance* of components (solar, wind and storage).

Differences between models partly reflect different, but equally valid, assumptions about the future. For example, additional inter-state transmission and demand management is likely to lead to lower capacity requirements. On the other hand, if a model assumes lower costs for wind, solar and storage, it may prioritise higher capacity above transmission. Energy mixes with higher wind generation are also likely to have lower capacity and storage requirements. There is no single best method of projecting the capacity requirements of a 100%RE grid.

Three ANU models have been included as they usefully distinguish scenarios with extra transmission and demand management. The ANU modelling is for a 200% renewable NEM (actually 198%) as it includes electrification of buildings, land transport, and industry. To calculate the averages in Table 5, the ANU's capacity figures have been halved.

All scenarios in Table 5 include 7GW hydro and 1GW biomass which already exist on NEM. In reality, non-NEM generation may need to contain a higher proportion of solar and storage because it would include many microgrids such as isolated towns and mines. OpenCEM now calculates higher storage than most other models as it relies predominantly on batteries since AEMO increased its estimate of the cost of pumped hydro by 40%.

**Approach to calculating the baseline**

To calculate a baseline for the 700% target capacity for the NEM, an average of the 100% renewables capacities from the studies in Table 5 was taken, as such for the purpose of this paper it is assumed that:

<sup>3</sup> <https://www.aemo.com.au/-/media/files/major-publications/isp/2020/final-2020-integrated-system-plan.pdf>

<sup>4</sup> <https://itpau.com.au/open-source-grid-integration-modelling-project/>

<sup>5</sup> <https://arxiv.org/ftp/arxiv/papers/2007/2007.09586.pdf>

<sup>6</sup> [https://www.dropbox.com/sh/qajm9vynno0dydp/AADzO1LzEu7sn-g\\_KCN54liua?dl=0&preview=3a+David+Osmond.pptx](https://www.dropbox.com/sh/qajm9vynno0dydp/AADzO1LzEu7sn-g_KCN54liua?dl=0&preview=3a+David+Osmond.pptx)

- **100% renewable NEM = 119 GW capacity (96 GW renewable generation plus 24 GW storage)**

To calculate an Australia-wide figure, the current electricity generation output of the south-western system in WA (WEM) and all other smaller grids and off-grid generation was added to the NEM and the 100% renewables figures were scaled up proportionally:

- **100% renewable Australia = 156 GW capacity (125 GW renewable generation and 31 GW storage).**

How much renewable and storage capacity is already installed across Australia?

Table 6 shows registered capacities of renewables generation and storage in the NEM as reported by the Australian Energy Regulator on 1 October 2020.<sup>7</sup>

**Table 6: Current generation and storage installation across the NEM**

	Capacity (GW)
Total Capacity	50.5
Wind	7.5
Utility-scale solar	4.2
Behind-the-meter solar <sup>8</sup>	12
Hydropower	8
<b>Total renewable generation</b>	<b>31.7</b>
Behind-the-meter battery	0.5*
Utility-scale batteries <sup>9</sup>	0.3
Pumped hydro	2.2
<b>Total storage</b>	<b>2.9</b>

\*estimate based on 1 GWh

*Note on storage*

Hydropower is not included in the above figures on storage as it is sometimes used for bulk energy generation, particularly in Tasmania. However, as more variable renewable energy enters the system, the main use of all hydropower is likely to be for dispatchable energy, and it will make sense to categorise it as energy storage.

Capacity for Pumped hydro is included in the 8 GW for Hydro - it is not additional. Existing pumped hydro consists of three sites in NSW and QLD, all of which are all under-used as explained [here](#). Demand for the pumping capacity of these sites is likely to increase as more variable renewables enter the system.

<sup>7</sup> [www.aer.gov.au/wholesale-markets/wholesale-statistics/registered-capacity-by-fuel-source-regions](http://www.aer.gov.au/wholesale-markets/wholesale-statistics/registered-capacity-by-fuel-source-regions)

<sup>8</sup> <http://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/QCMR%20June%20Quarter%202020.pdf>

<sup>9</sup> NEM Generation information 2020

## Establishing stronger targets

### How much renewable & storage capacity is required to decarbonise total energy use in Australia?

Total energy use includes, in addition to electricity generation and use, the energy used for transport, to heat buildings and in industrial processes, particularly heating and cooling. Typically, these applications use gas, petrol or diesel and in some cases coal to generate energy. The most likely and cost-efficient pathways to decarbonise these existing non-electricity end-use applications will be through electrification and some hydrogen, where both the additional electricity and hydrogen production are powered by renewable generation.

ANU in its 2020 study, is one of the first organisations to calculate the additional electricity needed in the NEM to electrify land transport, buildings and manufacturing. **The study concludes that electrifying these sectors would roughly double electricity demand requiring a renewable target of 200%:**

- Land transport +48% more electricity generation required,
- Building heating +10% more electricity generation required, and
- Industrial heat +40% more electricity generation required.<sup>10</sup>

As such it is assumed to achieve total decarbonisation of energy use in Australia 200% renewables will be required (excluding aviation and shipping). This has been calculated by doubling the national 100% figures.

How much renewable energy and downstream industry capacity would be required to replace Australia's jobs and revenue from fossil fuel exports?

Table 7 shows there are 115,000 direct jobs in high-carbon products. Of these around **41,000 jobs** are in fossil exports, assuming 75% of Australian coal and gas production is exported.<sup>11</sup> On average across the last three financial years, the export revenue from these products was A\$193 billion, nearly half of which was from iron ore. The revenue from fossil fuel exports was \$107 billion.

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<sup>10</sup> Lu, B., Blakers, A., Stocks, M., Cheng, C. and Nadolny, A., 2020. A zero-carbon, reliable and affordable energy future in Australia. *arXiv preprint arXiv:2007.09586*.

<sup>11</sup> Australian Energy Update 2020. <https://www.energy.gov.au/publications/australian-energy-update-2020>.

NB: the 16.6% of off-grid generation explains most of the discrepancy between the CER baseline & AEMO baseline - CER state GW capacity summaries include off-grid generation in each state.

**Table 7. Australia's current high-carbon exports (including government projected revenues for 2020-21)**

Export	Direct jobs	Revenue <sup>12</sup> (A\$ Bn)	Quantity exported FY20	Energy content PJ/TWh
<b>Thermal coal</b>	37,000 <sup>13</sup>	26.0 (FY19) 20.0 (FY20) <sup>[4]</sup> 17.0 (FY21) Avg: 21	210 MT	5270 / 1460 <sup>14</sup>
<b>Metallurgical coal</b>		43.6 (FY19) 35.0 (FY20) 23.0 (FY21) Avg: 33.6	184 MT	5420 / 1500 <sup>15</sup>
<b>LNG</b>	18,000*	50.5 (FY19) 49.7 (FY20) 31.0 (FY 21) Avg: 43.7	79 MT	4080 / 1130 <sup>16</sup>
<b>Oil **</b>		9.3 (FY19) 9.1 (FY20) 6.8 (FY21) Avg: 8.4	14 MT	640 / 170 <sup>17</sup>
<b>Iron ore</b>	60,000 <sup>18</sup>	77.8 (FY 19) 102 (FY 20) 80 (FY21) Avg: 86.6	860 MT	n/a
<b>Total FFs</b>	55,000	\$106.7		
<b>Total</b>	115,000	\$193.3		

\*Includes all oil & gas extraction jobs \*\*All figures ignore oil imports - Australia is a net importer of oil.

Table 8 presents a scenario for replacing Australia's fossil fuel exports with renewable exports. This scenario replaces 41,000 jobs related to exports of coal, gas and oil, as well as A\$77 billion in export revenue. The scenario requires an additional 950 TWh of renewable electricity requiring around 450 GW of renewable and storage capacity. In addition to total domestic energy decarbonisation this would result in an estimated 760 GW of renewables and storage or approximately a 500% renewables target (on a capacity basis).

The scenario includes a mix of renewable export opportunities, specifically - hydrogen and ammonia, export of electricity via undersea HVDC cables and onshoring the refinement of iron-ore, aluminium and manganese. In this

12 <https://www.dfat.gov.au/sites/default/files/cot-2018-19.pdf>

13 [publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2020/documents/Resources-and-Energy-Quarterly-June-2020-Thermal-Coal.pdf](https://publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2020/documents/Resources-and-Energy-Quarterly-June-2020-Thermal-Coal.pdf)

14 [publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2020/documents/Resources-and-Energy-Quarterly-June-2020-Thermal-Coal.pdf](https://publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2020/documents/Resources-and-Energy-Quarterly-June-2020-Thermal-Coal.pdf)

15 Assuming 1 tonne metallurgical coal = 29.5 GJ [www.ga.gov.au/webtemp/image\\_cache/GA17060.pdf](http://www.ga.gov.au/webtemp/image_cache/GA17060.pdf)

16 Assuming 1 tonne LNG = 52 GJ: [www.unitjuggler.com/convert-energy-from-MtLNG-to-GJ.html](http://www.unitjuggler.com/convert-energy-from-MtLNG-to-GJ.html)

17 Assuming 1 barrel oil = 6GJ: [www.eia.gov/energyexplained/units-and-calculators/](http://www.eia.gov/energyexplained/units-and-calculators/)

18 <https://miningresume.com.au/western-australia-mining/mining-companies-in-western-australia/>

scenario, Australia exports both direct-reduced iron and steel. The scenario assumes the production of nearly 10 million tonnes of hydrogen which is split:

- 2 Mt for hydrogen exports;
- 2 Mt for ammonia projection; and
- 5.5 Mt for iron production.

**Table 8: A scenario for replacing Australia's fossil fuel exports with renewable exports**

Export	Quantity (MT) <sup>19</sup>	Percentage current global output	Energy input (TWh)	New ongoing jobs**	New revenue* (\$AU bn)
Direct-reduced iron	50	3	180	6,000	13
Steel	50	3	212	20,000	26
Aluminium	10	15	140	12,000	15
Manganese	1	4	5	1,000	2
Hydrogen	2	n/a	100	1,700	8 <sup>20</sup>
Ammonia	11.4	6	107	2,300	3
HVDC			200	500	10
<b>TOTAL</b>			<b>944</b>	<b>43,500</b>	<b>77</b>

\* These figures subtract revenues from existing exports of iron ore, alumina and aluminium.

\*\* Note that this does not include the additional operation and maintenance jobs in renewable energy, which would be in the tens of thousands. ([Briggs et al](#) p. 8), nor the jobs in the manufacture of renewable energy and storage components that could be unlocked with this scale of renewables industry.

## Developing a trajectory for 700% renewables by 2050

### Calculating 700% renewables for Australia

The 700% renewable energy target was calculated simply by multiplying the 100% baseline by seven – see Table 9.

For the first 200% generation and storage is split using the average percentage split from the six studies aka ~20% storage. The additional 500% assumes that some industries will manage with semi-firmed renewables, because stored hydrogen will allow them to continue producing during times of lower generation. This assumption means this overbuild should enable the level of storage reduces to ~15% storage at 700% capacity.

19 These quantities equate to 18% of Australia's current iron ore production and about 50% of Australia's bauxite and manganese ore production.

20 Hydrogen revenue assumes a delivered price of \$4/kg which includes the costs of transportation. See for example, ACIL Allen. 2018. Opportunities for Australia from Hydrogen Exports; Table 4.7..

**Table 9: 700% Estimate<sup>21</sup>**

	Total Capacity (GW)	Generation (GW)	Storage (GW)	% Renewables (net)
100% Renewable NEM	120	95	25	100%
100% Renewable Australia	155	125	30	100%
100% Renewable Australia - Electrification	310	250	60	200%
Estimated 500% renewable target for Australia	760	640	125	500%
Estimated 700% renewable target for Australia	1095	930	165	700%

### Developing a 700% renewables trajectory

To achieve 700% renewables by 2050, two interim targets were set for 2030 and 2040:

- 150% renewables by 2030. This would see the demand for electricity grow by 50% over the next decade on and off Australia’s main grids, as both electrification and renewable export demand starts to increase. The scale of this target from a generation perspective is consistent with deploying the current large-scale renewable energy and storage pipeline in Australia get built, the continuing the rooftop solar boom and the building the mega projects such as the Asian Renewable Energy Hub and Suncable and others that we know through industry conversations are early development, but are not yet publicly announced.
- 500% renewables by 2040. This would see sufficient renewable energy and storage capacity and associated upstream and downstream manufacturing to replace the jobs in and much of the revenue from Australia’s current fossil fuel export industries (see 500% scenario above).

It should be noted that in this analysis 100% renewables (or net 100%), which would be achieved before 2030, equates to sufficient renewables generation to equal Australia’s current electricity needs, and does not necessarily mean that there will be no fossil fuel generation in Australia’s electricity mix. It is assumed that there will be significant growth in electricity demand through electrification and the establishment of renewable export projects. For example, 26GWs of the trajectory between 2020 and 2040 is associated with [the Asian Renewable Energy Hub](#) alone.

Based on these interim targets a trajectory has then been developed (see Figure 6). Below is the seven step methodology that was followed to produce the 700% trajectory, and subsequently apply the growth rate to achieve the other targets (100%, 150%, 200% and 500%).

**Step 1** - Set RET in target years to achieve 700% RET by 2050

**Step 2** - Set a plausible replacement level of renewable generation and storage capacity for 2050 of 25GWs per year or ~2% of total capacity. That is the amount of renewable and storage capacity that will need to be built every year to replace aging solar, wind and storage system. This would ensure the creation of a sustainable long-term market, and not see huge contraction and loss of jobs in just 1-2 years in 2050 as a 700% renewables target is achieved.

**Step 3** - Linear Interpolation to reach generation capacity by target year

**Step 4** - Smooth curve using polynomial trendline

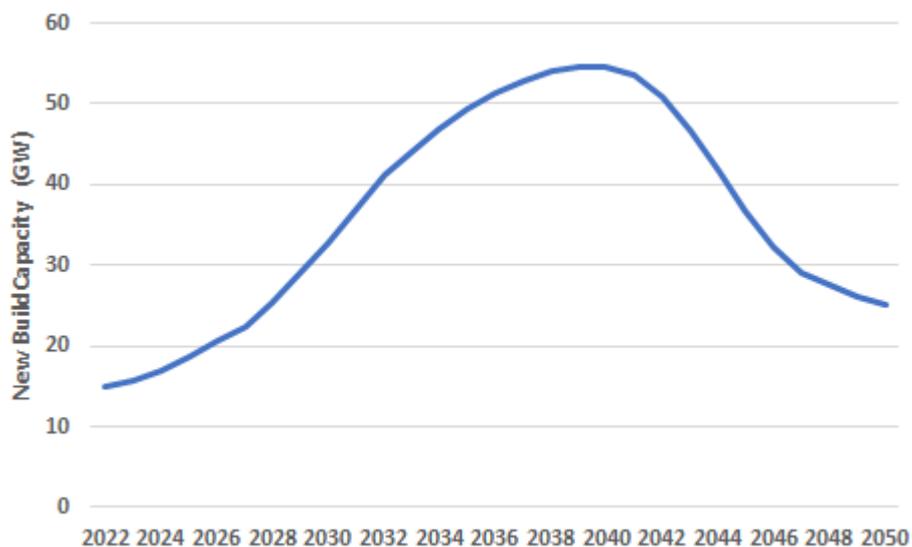
<sup>21</sup> These figures are based on those in Appendix 1 and have been rounded to the nearest five.

**Step 5** - Adjust results to reach generation capacity by target year

**Step 6** - Determine growth rates

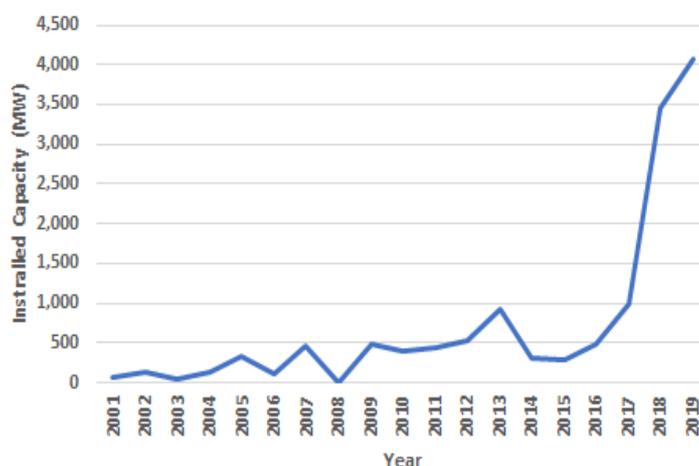
**Step 7** - Adjust annual generation capacity to reach set RET by 2050

Figure 6: Estimated New Build Capacity per Year to meet 700% Target (GW)



This trajectory reflects the fact that Australia's renewable energy deployment has seen significant step changes in deployment rate in the past, and there is no reason these step changes or an exponential increase in renewable and storage deployment isn't possible.

Chart 2: Accredited Large-scale Wind and Solar PV Installed Capacity (MW)<sup>22</sup>



The slow growth rate in the next five years reflects the fact that new transmission is urgently required and will take time to build. While the export scale projects such as Suncable also have many more years in development before construction begins.

<sup>22</sup> <http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/Large-scale-Renewable-Energy-Target-market-data/large-scale-renewable-energy-target-supply-data/historical-large-scale-renewable-energy-target-supply-data>

The very large annual deployment of renewables between 2030 and 2040 is reflective of the likely timeframe to establish a renewable export industry and for technologies and processes such as those to produce green steel and ammonia based shipping to be proven, piloted, commercialised and upscaled. That is, we are likely to see mass market scale-up of renewable hydrogen, ammonia, steel and other metal refining in the 2030s globally, creating significant additional demand for renewable electricity that Australia can contribute to.

The 700% trajectory and associated targets are meant to be indicative of the scale and rate of renewables deployment required to become a renewable export powerhouse. More detailed analysis will be required in order to ensure sufficient transmission and distribution and finance is available to achieve 700% by 2050.

# Appendix 1 - 700% Trajectory Summary Data

Table 10: Summary of Results for each Step

Workings	1	2	3	4	5	6					
Year	RET	Linear Interpolation	Smooth curve using polynomial trendlines	Annual Deployment - 700%	Growth Rate	100%	150%	200%	500%	700%	
2021		41			41		41	41	41	41	41
2022		57			14.9		2	3	4	10	15
2023		74			15.6	28%	2	3	4	11	16
2024		90			16.9	24%	2	3	4	12	17
2025		107			18.7	21%	2	3	5	13	19
2026		123			20.6	19%	2	4	5	14	21
2027		140			22.5	18%	2	4	6	15	22
2028	100%	156			25.3	17%	3	5	7	17	25
2029		195			29.0	17%	3	5	7	20	29
2030	150%	234			32.6	16%	4	6	8	23	33
2031		273			37.0	16%	4	7	10	26	37
2032	200%	312			41.1	15%	4	8	11	28	41
2033		369			44.1	14%	5	8	11	30	44
2034		426			46.9	13%	5	9	12	32	47
2035		482			49.3	12%	5	9	13	34	49
2036		539			51.3	11%	6	9	13	35	51
2037		596			52.9	10%	6	10	14	36	53
2038		653			54.0	10%	6	10	14	37	54
2039		709			54.6	9%	6	10	14	38	55
2040	500%	766			54.6	8%	6	10	14	38	55
2041		799			53.5	7%	6	10	14	37	54
2042		831			50.9	7%	6	9	13	35	51
2043		864			46.6	6%	5	9	12	32	47
2044		896			41.6	5%	5	8	11	29	42
2045		929			36.7	4%	4	7	9	25	37
2046		962			32.4	3%	4	6	8	22	32
2047		994		29.2	3%	3	5	8	20	29	
2048		1,027		27.5	3%	3	5	7	19	27	
2049		1,059		26.1	3%	3	5	7	18	26	
2050	700%	1092		25.0	2%	3	5	6	17	25	
						<b>156</b>	<b>234</b>	<b>312</b>	<b>766</b>	<b>1,092</b>	

## Appendix 2 - Superpower Scorecard - detailed results

Scorecard categories	Federal	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Max
<b>1. Strong Renewable Energy Targets</b>	4	6	6	3	9	1	11	3	9	15
1a. What is the government's 2030 renewable energy target?	0	1	1	1	3	0	5	1	3	5
1b. What is the government's renewable energy target beyond 2030?	0	0	0	0	4	0	3	0	1	5
1c. Is there an effective policy mechanism to deliver the jurisdiction's renewable energy targets?	4	5	5	2	2	1	3	2	5	5
<b>2. Rolling out renewable energy</b>	4	3	5	4	6	4	8	3	6	10
2a. How much new renewable energy was deployed in the last 2 years?	3	3	4	4	4	3	3	3	1	5
2b. What percentage of the jurisdiction's electricity generation was from renewables?	1	0	1	0	2	1	5	0	5	5
<b>3. Renewable Energy Zones and transmission</b>	6	9	8	7	7	4	8	5	N/A	10
3a. Is the government developing Renewable Energy Zones?	3	5	4	4	3	2	3	2	N/A	5
3b. Is the government working to expedite other electricity transmission projects?	3	4	4	3	4	2	5	3	N/A	5
<b>4. Energy storage and balancing the grid</b>	5	4	5	3	9	4	8	3	5	10
4a. How much energy storage has been deployed in the last 2 years?	1	0	1	0	4	1	5	0	1	5
4b. Is the government supporting energy storage, demand management or other tools to balance the grid?	4	4	4	3	5	3	3	3	4	5
<b>5. Developing a renewable hydrogen industry</b>	2	4	1	5	5	5	9	4	N/A	10
5a. Is the government investing in the renewable hydrogen industry?	2	1	1	1	2	1	5	0	N/A	5
5b. Is the government supporting hydrogen from fossil fuels?	0	3	0	4	3	4	4	4	N/A	5
<b>6. Sharing the benefits of the energy transition</b>	3	5	8	6	4	7	3	2	6	15
6a. Are there effective policy mechanisms to ensure First Nations communities are not disadvantaged, and share in the benefits of the energy transition?	1	1	2	2	1	2	0	2	0	5

6b. Are there effective policy mechanisms to ensure workers and communities are not disadvantaged, and share in the benefits of the energy transition (for example social license, benefit sharing and just transition policies)?	1	2	3	2	1	2	2	0	2	5
6c. Are there effective policy mechanisms to ensure consumers, particularly low-income households are not disadvantaged, and share in the benefits of the energy transition?	1	2	3	2	2	3	1	0	4	5
<b>7. Renewable Export Industry Strategy</b>	4	4	3	3	3	5	3	5	N/A	10
7a. Does the government have a comprehensive Renewable Export Industry Strategy?	2	2	2	1	1	3	2	2	N/A	5
7b. Is the government supporting production of potential new renewable export industries or products (beyond hydrogen)?	2	2	1	2	2	2	1	3	N/A	5
<b>8. Renewable Energy Industrial Precincts</b>	2	2	0	2	3	3	3	1	N/A	5
8a. Is the government developing Renewable Energy Industrial Precincts?	2	2	0	2	3	3	3	1	N/A	5
<b>9. Growing demand for renewable energy &amp; exports</b>	3	4	4	4	4	4	4	3	5	10
9a. Is the government working to develop local and international markets for renewable export products?	2	2	2	3	3	3	3	3	2	5
9b. Is there an effective policy mechanism to encourage fuel-switching from oil and gas to clean electricity?	1	2	2	1	1	1	1	0	3	5
9c. What percentage of the jurisdiction's exports are renewable energy goods and services?	1	2	3	1	1	1	1	1	3	5
<b>10. Renewable Recovery - 2021 Special Category</b>	1	2	3	1	1	1	1	1	3	5
10a. Does the government's COVID economic-recovery program include investment in renewable energy initiatives?	1	2	3	1	1	1	1	1	3	5
<b>TOTAL SCORE</b>	<b>34%</b>	<b>43%</b>	<b>43%</b>	<b>38%</b>	<b>51%</b>	<b>38%</b>	<b>58%</b>	<b>30%</b>	<b>N/A</b>	<b>100</b>
<b>RANKING</b>	<b>7</b>	<b>3</b>	<b>3</b>	<b>5</b>	<b>2</b>	<b>5</b>	<b>1</b>	<b>8</b>	<b>N/A</b>	
	<b>Federal</b>	<b>NSW</b>	<b>VIC</b>	<b>QLD</b>	<b>SA</b>	<b>WA</b>	<b>TAS</b>	<b>NT</b>	<b>ACT</b>	



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