Strategic Land Use MCA: Distributed Energy Resources Land Limit

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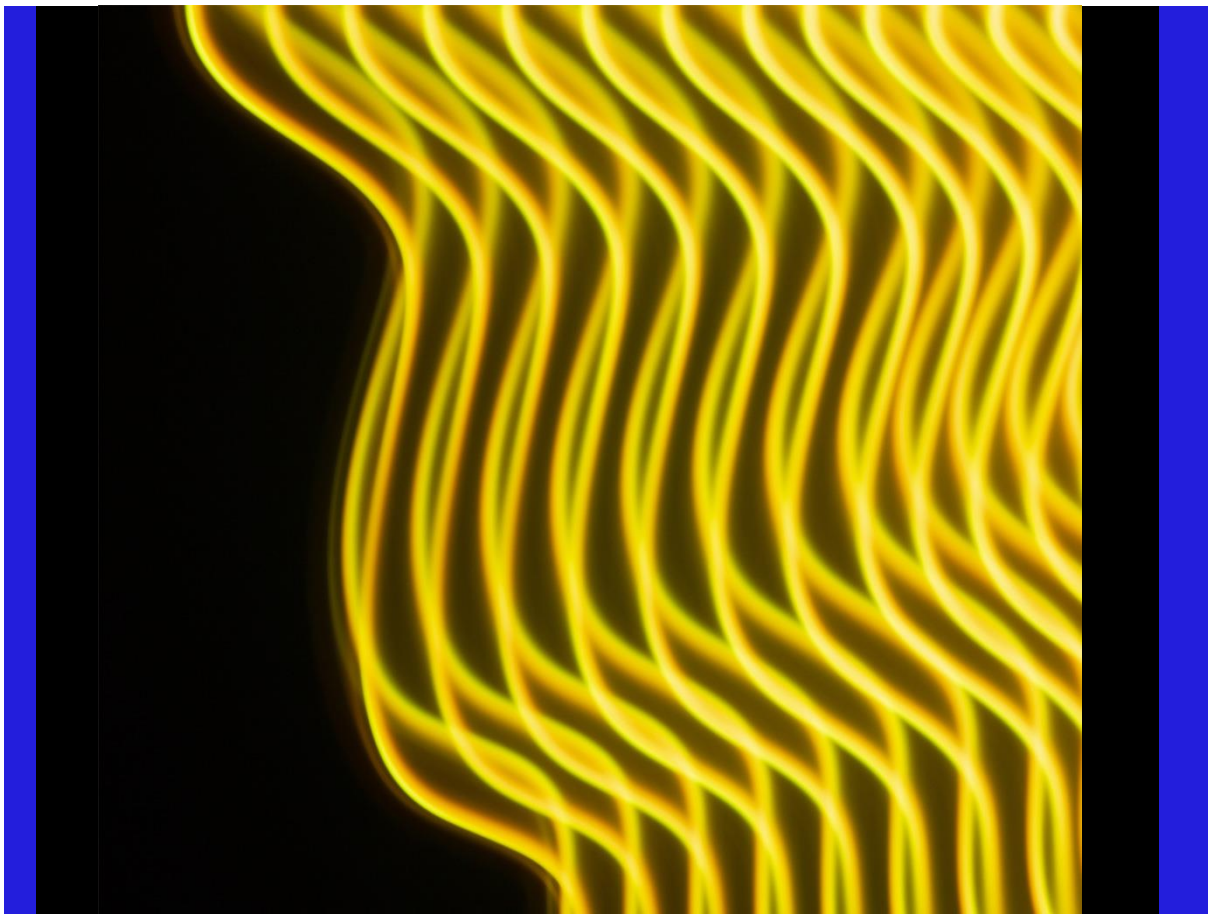
Australian Energy Market Operator

Strategic Land Use MCA



Strategic Land Use MCA:
Distributed Energy Resources Land Limit

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Executive summary

AEMO is currently developing the 2026 Integrated System Plan (ISP) and are incorporating distributed energy resources (DER) into their modelling to understand their impact on the National Electricity Market (NEM).

To support this, a strategic land use multi-criteria analysis (MCA) to determine distributed energy resources (DER) land limits across the NEM was conducted. It focused on establishing land limits for commercial and utility-scale solar PV (5-20MW) and battery energy storage systems (BESS) (~500kWh) based on land use, planning and approval constraints.

The assessment incorporated criteria related to land use, planning, environment, cultural heritage, geotechnical factors, and community impacts. Additionally, it excluded unsuitable areas such as national parks, world heritage sites, and residential zones. To account for the importance of proximity to connection points, an approximation of substation locations was developed using transformer data and, where unavailable, population density.

It further focused on identifying suitable land within defined proximities to these assumed substations in proximity to urban and industrial areas, reflecting likely local demand on the distribution network. The MCA results were used to calculate available land area across three tiers of suitability (1: 10%, 2: 25%, and 3: 50% least constrained) for each NEM sub-region.

Key findings from the assessment include:

- Coastal and mountainous regions are generally excluded or highly constrained due to environmental sensitivities and terrain limitations.
- Rural and agricultural areas offer less constrained land for DER development, particularly in inland areas.
- Queensland and South Australia results appear less constrained, partly due to data limitations in planning zone information.
- Significant variation exists between sub-regions in available land area, reflecting diverse geographical and regulatory landscapes across the NEM.

The results provide estimates of total and 5% conversion limited land area available for solar PV and BESS development in each sub-region. A summary of tiers 1 and 2 results is presented in Table ES-1.

Table ES-1. Summary of Tiers 1 and 2 total and 5% limited MW DER land limits

SubRegion	BESS (5% conversion)		Solar PV (5% conversion)	
	Tier 2 MW	Tier 1 MW	Tier 2 MW	Tier 1 MW
CNSW	10839	6664	1510	533
CQ	12439	8440	1237	789
CSA	6272	467	4967	2008
GG	1101	349	116	47
MEL	1228	656	91	59
NNSW	5702	2711	824	105
NQ	17615	10888	1480	919
NSA	1549	263	939	507
SESA	7358	1961	2017	1434

SubRegion	BESS (5% conversion)		Solar PV (5% conversion)	
	Tier 2 MW	Tier 1 MW	Tier 2 MW	Tier 1 MW
SEV	610	373	118	62
SNSW	20800	11341	2542	615
SNW	2199	997	361	81
SQ	34158	18664	2821	1358
TAS	4866	2261	560	263
WNV	3125	1547	475	274

Recommendations include using a more constrained DER land limits for modelling purposes to account for cumulative impacts and local factors not captured at this scale of analysis. This approach acknowledges that while the areas may be theoretically suitable, practical limitations and cumulative effects may restrict development in an area identified by the assessment.

Several limitations and potential improvements are noted, particularly around:

- Acquiring accurate substation location data from Distribution Network Service Providers
- Obtaining consistent planning zone information for Queensland
- Refining setback assumptions for solar farms and BESS across jurisdictions
- Incorporating more detailed local-scale considerations for commercial-scale DER

Despite these limitations, this strategic assessment provides a robust foundation for incorporating land use constraints into AEMO's planning processes. It offers a consistent, NEM-wide approach to estimating DER land limits, while acknowledging the need for more detailed analysis at the project level. The methodology developed is flexible and can be refined as more accurate data becomes available, ensuring its continued relevance in future planning cycles.

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In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by Australian Energy Market Operator and from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

The Strategic Land Use MCA DER Land Limit was prepared to provide an overview and summary of information and data relating provides land use, planning and approval constraints across the NEM to facilitate the assessment of distributed energy resources for the purposes of supporting strategic modelling.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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Additional work has been carried out for the Australian Energy Market Operator as part of this project delivery which does not form part of this report.

1. Introduction

1.1 Project Description

AEMO has started to consider the capacity of the distribution network to support distributed energy resources (DER) and the cumulative impact of these connections on the bulk power system for the continued safe and reliable operation of the National Electricity Market (NEM). One key element in this is to understand the limit on capacity determined by the amount of physical space available for future solar and battery storage infrastructure due to land use constraints.

The DER Land Limit assessment has been developed as a state-based model of the National Electricity Market (NEM), seeking to identify areas suitable for utility scale solar PV (5MW-20MW) and battery energy storage system (BESS) (~500kWh).

Through a strategic multi-criteria analysis, this assessment has been developed to establish assumed land limits per sub-region based on land use, planning and approval constraints. This is intended to support subsequent modelling and decision making to inform the 2026 Integrated System Plan (ISP).

1.2 Overview of approach

The DER Land Limit assessment has been implemented through spatial Multi-Criteria Analysis (MCA), which identifies and gathers data that represents the key issues spatially and aggregates their relative significance, providing an overarching view of the complexity at each location across the NEM. This has been further refined with filters around assumed substation locations and proximity to typical demand centres. Figure 1-1 provides an overview of the assessment and Section 2 provides an overview of the model and implementation.

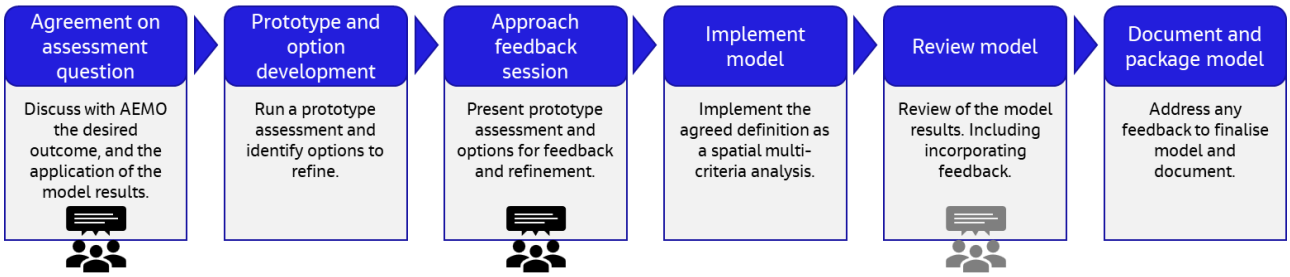

Figure 1-1. Overview of project approach

Vital to delivering a model that supports the decision making, engagement with key stakeholders ( ) who will inform or use the outcomes of the assessment. As such, engagement with AEMO stakeholders throughout the development of the model was critical. Approaches were presented to Distribution Network Service Providers (DNSPs) to receive feedback and calibrate assumptions.

1.3 Purpose

This document outlines the assessment, presented in Figure 1-2. The purpose of which is:

To outline the robust, repeatable and defensible process for incorporating land use, planning and approval constraints into determining a land based limit for the development of distributed energy resources as part of the Integrated System Plan.

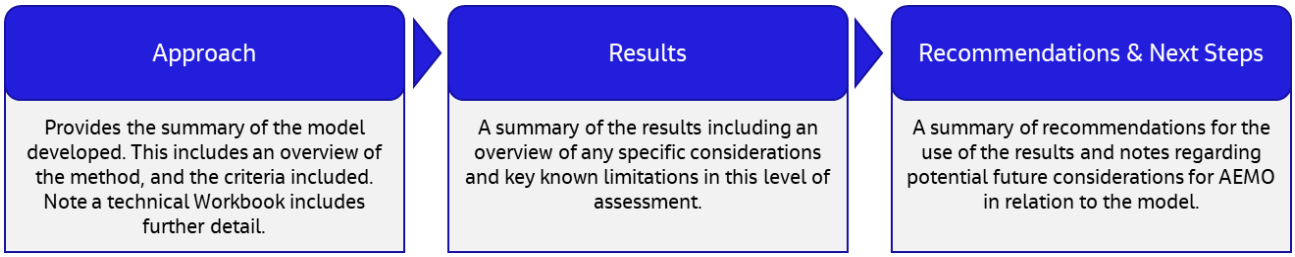

Figure 1-2. Document outline

2. Approach

The approach used to undertake the DER Land Limit assessment is outlined below, further details are provided in the MCA Workbook.

2.1 Area of assessment

The DER Land Limit assessment has been developed to support planning across the NEM, covering all states within. State-based assessments have been conducted separately, reflecting the process, data, and more importantly its usability, refer Figure 2-1.

Figure 2-1. Area of assessment

2.2 Overview of assessment

As outlined in Figure 1-1, the approach involves multiple stages. Figure 2-2 focuses in on the implementation of the assessment, highlighting the key steps undertaken. Noting that this process presents the broader approach and does reflect the draft and revision iterations conducted.

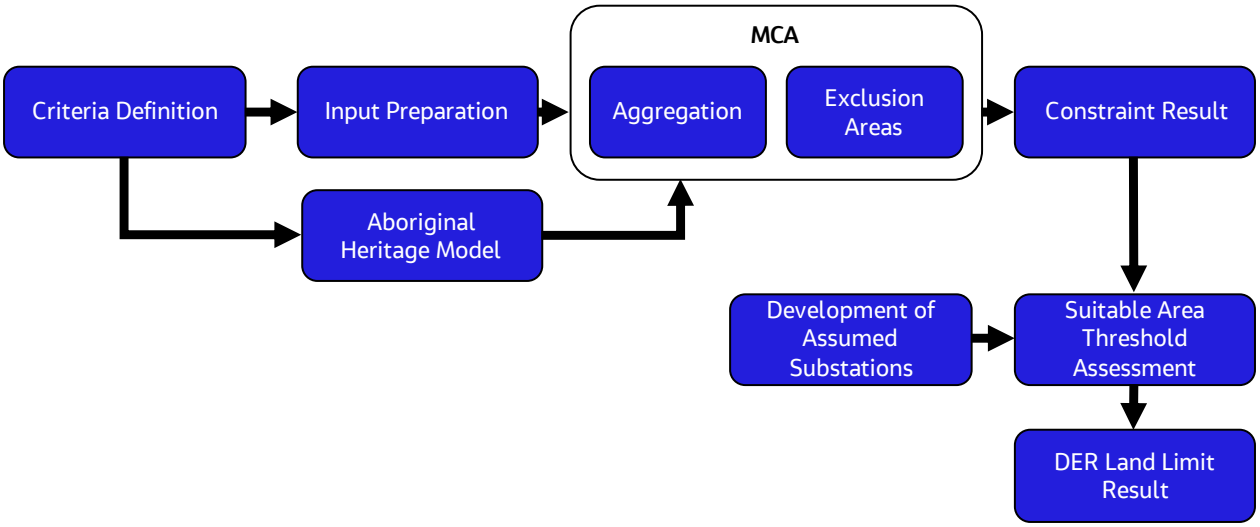

Figure 2-2. Assessment overview

2.3 DER land limit MCA

The DER Land Limit MCA seeks to create a constraint result of the accumulation of the geospatial features based on publicly available sourced data, representing sensitivity or significant areas in the assessment. This is also known as a "heat map".

The heat map was generated through the implementation of a spatial Multi-Criteria Analysis (MCA) which sought to map the accumulated sensitivity or significance of geospatial features when considering potential impacts by DER infrastructure. This included constraints that represent areas sensitive to transmission projects or the feasibility of a DER infrastructure project.

This assessment used the concept of complexity with respect to the presence of DER infrastructure to assess the criteria. In this context, higher scores reflect areas that are more likely to contain either multiple criteria or criteria of greater significance, shown as an accumulation. Complexity can be considered by the time required to obtain planning approval or associated with constructability factors.

Identify areas of low constraint based on strategic land use complexity for DER infrastructure in relation to the planning approval requirements or the complexity of construction.

The criteria themes considered in this assessment are highlighted in Figure 2-3. Additional detail with respect to the method are provided in the Workbook.

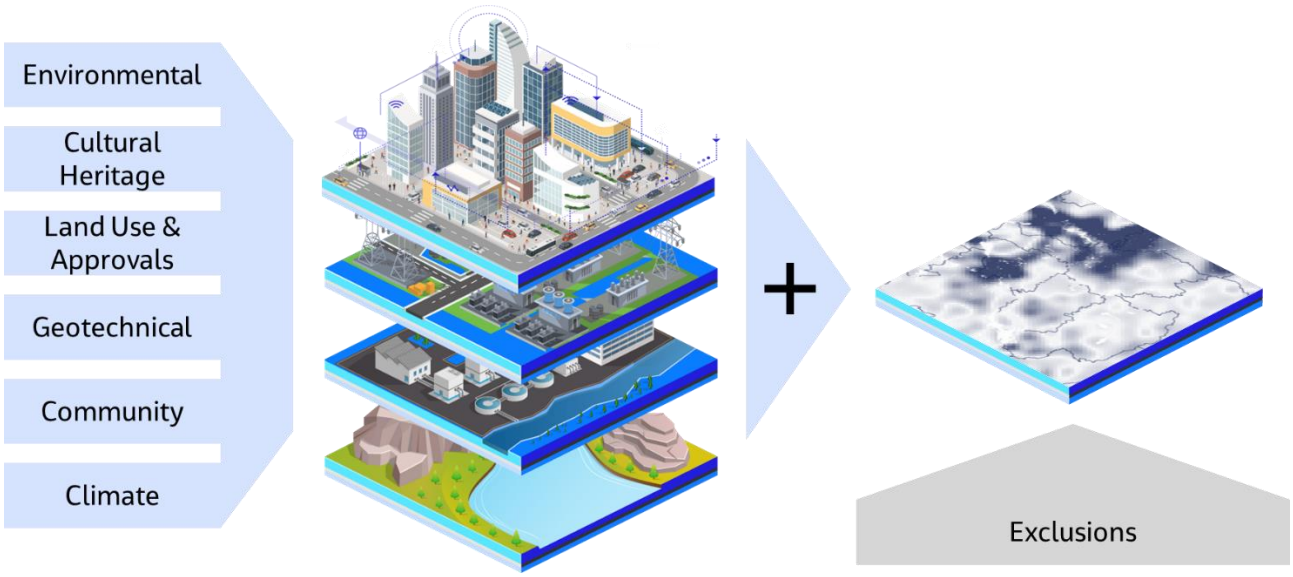

Figure 2-3. Overview of MCA

2.3.1 Criteria

Criteria have been identified to support the assessment, each prepared and scored in relation to its complexity for DER infrastructure projects, refer Table 2-1. A summary of these criteria themes are provided in the following Sections (2.3.1.1 to 2.3.1.7), noting criteria are grouped by theme for ease of understanding and presentation purposes only and that the model was run with criteria ungrouped.

Table 2-1. Criteria score scale

Score	Label	Environmental	Heritage	Land use and Planning	Geotechnical & Climate	Community
1	Very Low Complexity	Local Government Authority (LGA) regulatory involvement required	Local / LGA: Average within 12 months approval process	Local / LGA: up to 6 months approval process	The constraints are not significant and small capital investment can make necessary adjustment to the line to mitigate the risks associated with this constraint	Impact to the constraints may have a very low response from the community
2	Low Complexity	Local and regional regulatory involvement required	In between local and state	Local / LGA: Average within 6 - 8 months approval process	The cost and schedule contingency allowance to mitigate the resulting risk is low.	Impact to the constraints may have a low response from the community
3	Medium Complexity	State regulatory involvement required	State: Average 6-12 months approval process, can be 1+ years. Commonwealth: 3 months to 3+ years approval process.	Local / LGA: Average within 8 - 12 months approval process	The cost contingency is high but schedule contingency is low to mitigate the resulting risk.	Impact to the constraints may have a moderate response from the community

4	High Complexity	National and State regulatory involvement required	National: 2-3 years, possibly 3+ years approval process	State: can be 1+ years. Commonwealth: 3 months to 1+ years approval process.	The cost and schedule contingency allowance to mitigate the resulting risk is high.	Impact to the constraints may have a high response from the community
5	Very High Complexity	Both International (world) and National regulatory involvement required	World: 5+ years approval process	State: can be 2+ years. Commonwealth: 3 months to 2+ years approval process.	The cost and schedule contingency allowance to mitigate the resulting risk could be too high to make the project commercially feasible.	Impact to the constraints may have a very high response from the community

2.3.1.1 Land use and approvals

The criteria for Land Use and Approvals categorises land based on land uses and zones in each of the jurisdictions planning schemes, with associated scores according to the criteria outlined in section 2.3.1. Across the jurisdictions, planning zones have been aligned with the land use categories, derived from the land uses that are permitted within those zones. Land uses are categorised according to broader land use categories (residential, mixed use, rural, urban, industrial, infrastructure, transport, environment, flooding and other), which are broken down into primary and secondary land uses. These categories are the same for both BESS and solar. Refer Table 2-3 (BESS) and Table 2-4 (Solar).

Table 2-2 reflects the criteria applied, rationale and scoring for more generalised scoring to certain land uses. For example, public land such as national and state parks are automatically excluded.

The scoring reflects the impacts from BESS or solar farms on the land use. The major impact from BESS (utility scale) is noise, with some visual impacts depending on the location, while the major impact from solar (utility scale) is primarily visual, with noise during construction (not operational noise).

Any land uses/zones which include residential (e.g., mixed uses, tourism and hotels) received a high score due to the noise impacts from BESS on people residing in their homes, and visual impacts from solar farms. For BESS's, mixed uses can be difficult to score and are based on the receiving environment, which is reflected in the scoring. If located in a dense area where there is already significant noise, the noise from a BESS would be less disruptive. While, if located in a quieter area, the noise impacts from a BESS could be significant.

Urban, commercial (including employment areas, shopping centres, business parks and big box retail), and industrial land uses are scored of lower complexity. These land uses typically don't contain sensitive land uses and experience higher background noise from the surrounding environment, so the impacts from both BESS and solar farms are of a generally low complexity.

Commonwealth/Crown land includes areas of strategic or national importance, such as military bases, and conservation land. Crown land scores high as any activity on or affecting Commonwealth land must be assessed for its environmental impact and may require approval from the Federal Minister. These lands are managed with heightened sensitivity to ensure national security, public safety, and environmental protection.

Where public land is a national or a state park, it received a high score due to its national/state significance. This significance is reflected in the reservation of the land in legislation, which is underpinned by land use planning policies that seek to protect and enhance the land for its natural environment, natural processes and contribution to place.

Land that is valued for its significant contribution to landscapes, or is environmentally sensitive, such as environmental, conservation and recreation land uses also has a high score due to its environmental significance. This land is not of national or state significance but is recognised by the state's land use planning system to be of contributing value to the natural environment, natural processes and contribution to

place. The scoring recognises that the land will usually contain large areas of high value biodiversity that is relatively undisturbed, and as a consequence of the potential impact to these environments, the statutory approvals process would be significantly more complex. This is all the more-so when compared to the significantly disturbed environments associated within agricultural areas. These values are usually recognised in a state's land use planning system via a set of planning controls that seek to define the local values to be protected and how development will be regulated to minimise the impact on the environment. These areas are also supplemented by, for example in the Victorian context, overlays such as the Significant Landscape Overlay and Environmental Significance Overlay.

Ultimately, this framework results in a dichotomy. Environmentally significant areas that the land use planning systems seek to protect from further disturbance, where there is broad public interest. With the other common type being the agricultural areas, which are usually highly disturbed areas with patches of fragmented habitat, where individual interests and planning systems that do not always distinguish between the different types of agricultural land uses.

Through the collection of secondary data, of which the quality varies from state to state, the criteria seek to delineate between the types of agriculture. Rural land uses can be more difficult to score due to the combination of land uses that can occur, including industry, agricultural production, mixed uses including farms and homes, and land that is preserved for its rural aesthetic. Scoring in this category reflects the permitted uses within each of the zones across the states. Farming practices, such as irrigated agriculture, that have the potential for a greater conflict, are recognised with a high ranking. By comparison, farming practices like grazing livestock are recognised with a low ranking.

Land uses/zones relating to transport and infrastructure scored very low as these areas are typically zoned for utilities, being locations where Council utilities are often located and where BESS could be co-located with negligible amenity impacts.

Table 2-2. Land uses and scores

Criteria	Rationale	State Data	Score
Public land - National/Marine/State Parks	Areas to protect Australian native landscapes, including native flora and fauna. Community concerns about construction in or adjacent to a national park could adversely impact on the time taken to engage with the community and to secure approvals. A state park is a park managed by the state for a variety of uses including recreation, forestry, environmental protection and others	State specific	Exclude
Other Public Land - Parks	To protect and enhance the natural environment and natural processes for their historic, archaeological and scientific interest, landscape, faunal habitat and cultural values.	State specific	3
Active extractive industry	Consent may be required to impact on the land. Land may not be available in the future for occupation by power line	State specific No data for ACT	4
Plantations	Existing plantations are less desirable, but generally do not prohibit development.	State specific No data for ACT	1

2.3.1.1.1 Planning Zones

Table 2-3. BESS - Planning groups and scores

Broad Land use	Land use category	Score	Score
Residential	Residential Rural Residential	State Data No QLD	Exclude

Mixed Use	Mixed Use Local Town Centre CBD Community Infrastructure Accommodation Tourism Golf course/housing/tourism	State Data No QLD	2-4
Rural	Rural industry Rural production Rural landscape	State Data No QLD	2-4
Urban	Urban Commercial – CBD Commercial – big box	State Data No QLD	1-5
Industrial	Industrial Extractive	State Data No QLD	1-3
Infrastructure	Infrastructure	State Data No QLD	1-3
Transport	Transport	State Data No QLD	1
Environment	Environment / conservation Recreation	State Data No QLD	3,5
Flood Drainage	Flood / Drainage	State Data No QLD	5
Other	Land not yet integrated into the local environmental plan (NSW)	State Data No QLD	3

Table 2-4. Solar - Planning groups and scores

Broad Land use	Land use category	Score	Score
Residential	Residential Rural Residential	State Data No QLD	Exclude
Mixed Use	Mixed Use Local Town Centre CBD Community Infrastructure Accommodation Tourism Golf course/housing/tourism	State Data No QLD	4
Rural	Rural industry Rural production Rural landscape	State Data No QLD	2-4

Urban	Urban Commercial – CBD Commercial – big box	State Data No QLD	1-5
Industrial	Industrial Extractive	State Data No QLD	1-3
Infrastructure	Infrastructure	State Data No QLD	1-3
Transport	Transport	State Data No QLD	1
Environment	Environment / conservation Recreation	State Data No QLD	3,5
Flood Drainage	Flood / Drainage	State Data No QLD	5
Other	Land not yet integrated into the local environmental plan (NSW)	State Data No QLD	3

2.3.1.2 Environmental

The criteria used to determine ecological values primarily focuses on data that identifies large scale areas which likely provide key habitat for native flora and fauna. This includes nationally listed Ramsar and important wetlands, conservation reserves (identified for their high conservation value), areas of native vegetation, waterbodies and waterways.

Although these criteria are useful in identifying key ecological areas and provide an efficient approach for the avoidance of potential impacts, these datasets are limited due to their scale and do not represent all potential values that may occur in any given region. This includes populations of Commonwealth and state-listed threatened species and/or other significant areas of habitat for flora and fauna that may occur at a smaller scale which are usually identified during on-the-ground surveys.

Scoring has been reduced for criteria that covers broad swathes of land such as the Native Vegetation, this criterion indicates added complexity to available land. These would need to be assessed at a more detailed scale for smaller infrastructure projects, with the criteria focussed more on indicating presence of potential complicating factors.

Water based criteria are scored higher and excluded in this assessment due to the assumption that BESS and Solar infrastructure should be on sites not impacted by waterways.

Table 2-5. Environmental criteria

Criteria	Rationale	State Data	Score
Ramsar Wetlands	Ramsar wetlands are rare or unique wetlands or are important for conserving biological diversity. Ramsar wetlands are protected under the Commonwealth EPBC Act and international treaties.	National Data	Exclude
Conservation Reserves	CAPAD, published every 2 years, is used to provide a national perspective of the conservation of biodiversity in protected areas. It also allows Australia to report on the status of protected areas to meet international obligations such as	National Data	2

	those under the Convention on Biological Diversity (CBD). Australian protected area information is also included in the World Database on Protected Areas (WDPA). Under Australia's Strategy for the National Reserve System 2009-2030 all state and territory Governments and the Australian Government agreed to adopt international standards for the definition of a protected area and management categories used by the IUCN.		
Waterways and Waterbodies	Waterways and waterbodies may have differing levels of significance to conservation values. Avoid waterways due to additional complexity from an engineering and geotechnical perspective. Buffered by 100m, defined as "watercourse".	National Data	Exclude
Wetlands	Nationally important wetlands, protected under the EPBC Act Includes any other state based mapped wetlands due to additional complexity from an engineering and geotechnical perspective.	State Data	5
Native Vegetation	Impacts to native vegetation likely to support threatened species or threatened ecological communities to be avoided where possible, minimised, or managed through State and/or Commonwealth approvals with conditions, possibly involving offsetting payments/efforts.	National Data	1

2.3.1.3 Cultural Heritage

Consideration has been given to the avoidance of historic and indigenous heritage values by using several publicly available datasets as the basis for criteria. These include national and state level heritage lists and registers, including the World Heritage List, Commonwealth Heritage List, National Heritage List, and state-specific registers including those listing historical heritage places of outstanding cultural significance.

Due to a gap in consistent and available Aboriginal heritage information across the states, a derived dataset has been generated that can be applied across the NEM, with criteria definitions driven by landform data. This captures landscape features with a perceived increase in archaeological sensitivity (such as elevated landforms and land beside waterways) and thus increased potential to trigger Aboriginal cultural heritage approvals.

Table 2-6. Cultural heritage criteria

Criteria	Rationale	State Data	Score
Indigenous and Historical - World heritage	Sites identified by the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act): World Heritage List, Commonwealth Government Register.	National Data	Exclude

National Heritage List	Sites identified by the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act): National Heritage List, Commonwealth Government Register.	National Data	4
Historical Heritage - State	The heritage layer provides protection for places, objects, relics or shipwrecks assessed as being of outstanding cultural significance within the relevant state.	National Data	4
Commonwealth Heritage List	Sites identified by the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act): Commonwealth Heritage List.	State Data	3
Potential of an area to trigger an additional level of assessment for Cultural Heritage	Attempts to measure the potential of an area to trigger an additional level of assessment for Aboriginal cultural heritage. Derived dataset that does not predict the presence or absence of Aboriginal cultural heritage sites and does not use known or surveyed sites or similar existing data, it focuses on the use of landforms whose presence may typically trigger the need for additional assessment. See Section 2.3.1.3.1	National Data	3-5

2.3.1.3.1 Potential for additional Aboriginal cultural heritage assessment

It was determined that there was a gap in the representation of Aboriginal cultural heritage values across the states to facilitate the Aboriginal cultural heritage aspects of the assessment. In many jurisdictions across the NEM, datasets do not exist, provide sufficient information or publicly accessible.

A derived dataset was developed to cover the NEM, representing the potential of an area to trigger an additional level of assessment with respect to Aboriginal cultural heritage. The derived dataset does not make any assumptions about the presence or absence of cultural heritage sites nor include known or surveyed sites or similar existing data (due to the data availability). It focuses on the use of landforms whose presence may typically trigger the need for additional assessment.

This was conducted as a stand-alone assessment, and the results were normalised to a 3-5 scale to consolidate the importance of the criteria to the DER assessment when compared with the other criteria. This was then included as an input criterion to the overarching DER assessment.

Table 2-7. Potential for additional Aboriginal cultural heritage assessment criteria

Criteria	Rationale	State Data	Score
Waterways	Waterways/waterbodies and proximity are considered sensitive. Uses a 100m buffer for proximity, distance determined by analysis pixel size.	National dataset	5
Elevated feature relative to the surrounding landscape	Elevated features such as lunettes and rocky outcrops may have a high potential for the presence of cultural heritage that may correlate with a requirement for additional assessment. These elevated landforms are extracted, relative to the surrounding landscape, where a "feature" must follow the rule below, relative to the surrounding landscape. This is to prevent all hills from being included in the criterion whilst identifying elevated features:	National dataset	4

	Height >= 5m and height <= 900m, with a hill footprint < 200 square kilometres		
Coastal buffer	300m coastal buffer to capture areas of sensitivity that may be covered or exposed with changes to the coastline.	National dataset	3
Geology: Dunes, Sand sheets, Lunettes, Caves / Rocky Outcrops	Lunettes: all lunettes are considered areas of cultural heritage sensitivity over all geology types and commonly associated with lower elevations. Dunes, including an inland, riverine, lacustrine or coastal dune, are considered areas of cultural heritage sensitivity over all geology types and commonly associated with lower elevations. Sand sheets are considered areas of cultural heritage sensitivity over all geology types and commonly associated with lower elevations and may be aeolian, fluvial or colluvial in origin. Rocky outcrops (elevated features such as lunettes and rocky outcrops may have a high potential for the presence of cultural heritage that may correlate with a requirement for additional assessment.)	National dataset	3

2.3.1.4 Geotechnical

From a national and state or territory level, geotechnical constraints for potential BESS and Solar infrastructure are variable, typically requiring more detailed studies once a preferred site or development zone is identified. Typical geotechnical impacts for surface-based infrastructure comes from poor ground conditions including geological features such lineaments and fault lines, topographical constraints such as steep terrain, landslide potential and soft ground e.g. marshes and swamp deposits.

For the MCA, the geotechnical criteria focussed on geology and soil high level impacts, and does not reflect environmental or human health perspectives e.g. occurrences of serpentinite, radioactivity etc. There are intersections of the various data sets with other disciplines, which has been verified to ensure that scoring is not amplified e.g. extraction and mining activities is excluded from the geotechnical criteria.

For this assessment structural geological features e.g. lineaments and fault lines have been removed as criteria, when compared to the recent transmission assessment. These factors are critical but can't be well represented within the MCA result and therefore should be considered separately when considering sites. Additionally, Depth to Water table is a criterion that should be considered for future assessments of this nature.

Table 2-8. Geotechnical Criteria

Criteria	Rationale	State Data	Score
Australian Soil Classification type	The criteria scores are based on the broad soil behaviours for the 12 major groups described in the Australian Soil Classification (ASC) handbook. Problematic behaviour e.g. shrink swell in vertesols or being waterlogged for a minimum 3 months of the year (hydrosols), score highly.	State specific No data SA and TAS	See workbook
Acid Sulphate Soils (ASS)	The criteria score adopted is based on the existing classification, with no recorded ASS being the lowest score, with recorded ASS being the highest. The scoring	State specific	1-3

	aligns to the national classification criteria, with escalation as probability increases or known soils occur.		
Terrain slope in degrees	The criteria for scoring the existing slope angle is an initial screening tool for constructability constraints, for this assessment slopes greater than 5 degrees have been excluded. Flat terrain preferred as it reduces cut and fill cost. Additionally slopes less than 5 degrees are considered by the CFA to contribute to a low-risk environment for fire risk. Renewable Energy Fire Safety | CFA (Country Fire Authority) In Tasmania this has been supplemented with landslide hazard bands and mapped landslide polygons. Engineering solutions will be more costly in areas of former or current landslide activity.	National Data	Exclude
Surface geology	The criteria score for the surface geology is not straightforward and is bespoke to the project context. The scoring makes informed assumptions as to geotechnical risks associated with the development. In this study it is assumed that in the case of an above ground transmission line, tower foundations are likely to be shallow (within 1m of the existing ground level). Therefore, competent ground has be scored lower than disturbed or soft ground. If the development required deep foundations or mass excavation, then surface geology would be scored differently.	State specific No data ACT	See workbook
Distance from waterbodies/ water courses	Geotechnical constraints and risks increase with proximity to waterbodies and water courses. For water courses, higher scores have been assigned within nominated buffer zones of the mapped features. This criterion is captured in the environmental criteria and has not been used twice.	National Data	See Environmental criteria
Flooding - Urban / River / Coastal	Areas with flooding potential should be avoided	State specific No data ACT, QLD, and SA	3

2.3.1.5 Community

From a community perspective, the main concerns regarding energy projects often relate to impact on lifestyle and amenity, particularly during construction phase. This has the potential to impact on gaining planning approvals. For that reason and for the purpose of the MCA, the planning zones have been assessed to identify residential and rural residential zones which have been flagged as excluded and removed from consideration, more detail regarding the planning and land use criteria can be found in Section 2.3.1.1.

The ABS Urban Centres and Localities was used to supplement the zones with a score rather than additional exclusion areas. This is due to the potential colocation benefits of the infrastructure near to where the community may reside.

Table 2-9. Community criteria

Criteria	Rationale	State Data	Score
5k buffer from Urban Centres and Localities	Community concerns of construction in close proximity to towns could delay planning approvals	National dataset	3

2.3.1.6 Climate

Climate conditions were not identified as a key driver for this assessment. Two key climate related impacts, flooding (addressed under the Geotechnical theme) and land prone to bushfires were included. These represent the primary risks that can be mitigated within a site.

For bushfire prone areas, the consistency of data and how the states represent areas of elevated risk vary greatly. Many states develop detailed fire risk models, but these are typically not made publicly available. For this assessment, the criteria have focused on planning-based controls which highlight elevated risk, but the variability of this data, as well as the often-generalised nature of the coverage has been mitigated by a lower score. Fire risk should be assessed at a site scale.

Table 2-10. Climate criteria

Criteria	Rationale	State Data	Score
Bushfire	Fire risk to life and property	State specific No data ACT and QLD	1

2.3.1.7 Exclusions

These represent areas which have been deemed unsuitable for further consideration and have been *excluded* from the assessment. These have erred on a relatively liberal view when compared to the Transmission Assessment, focused on areas where it would be unlikely for approval to be given in addition to areas where it may not be permitted to build.

The criteria have been listed in the above sections. Exclusions used in the transmission assessment do not carry over, as many of those locations indicate site of possible colocation for Solar and BESS infrastructure.

2.4 Assumed substation locations

As DER projects have a lower threshold for the capital costs of the infrastructure, particularly of the connection asset, the proximity of sites to connection points has a material impact on site suitability.

Unfortunately, locations for distribution substations were not available for the entire NEM as GIS data for analysis. As such, an approximation was required to assume substation locations. This imposes a limitation on the accuracy of the assessment, however, in line with the strategic planning purpose and intended use of the assessment results, the assumption made for the approximation is deemed suitable. While distribution substations were available for some regions, it was determined that the consistency of the analysis across the NEM (where possible, refer Approach 2 – SA specific) would provide consistency in the result for the purpose of the downstream modelling.

Two approaches were developed:

Approach 1 – NEM wide, except SA

The default approach was based on the use of the Transformer location data provided by AEMO and the Zone Substation Areas, see Table 2-11.

For each Zone Substation Area:

- The transformer locations were clustered,
- The three largest clusters were selected,
- The cluster with the highest density was selected, and
- The medoid of the cluster was adopted as the approximate substation location.

Table 2-11. Substation approximation – Approach 1 source data

Data	Source
Transformer Locations	Provided by AEMO
Zone Substation Areas	https://nationalmap.gov.au/#share=s-mcOP6WUTjLTl15T0SS7cLs8XNL9

Approach 2 – SA specific

Transformer location data was not available in South Australia, as an alternative approach population density was used, see Table 2-12. Population density has correlation with transformer density but introduces additional assumptions.

For each Zone Substation Area:

- The ABS Census mesh block with the highest population was selected, and
- The centroid for the mesh block adopted as the approximate substation location.

Table 2-12. Substation approximation – Approach 2 source data

Data	Source
Population Density	https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/main-structure-and-greater-capital-city-statistical-areas/mesh-blocks
Zone Substation Areas	https://nationalmap.gov.au/#share=s-mcOP6WUTjLTl15T0SS7cLs8XNL9

Assumed substation results

This assessment generated an assumed location for a substation for each Zone Substation Area. Figure 2-4 depicts the NEM wide distribution of the locations generated.

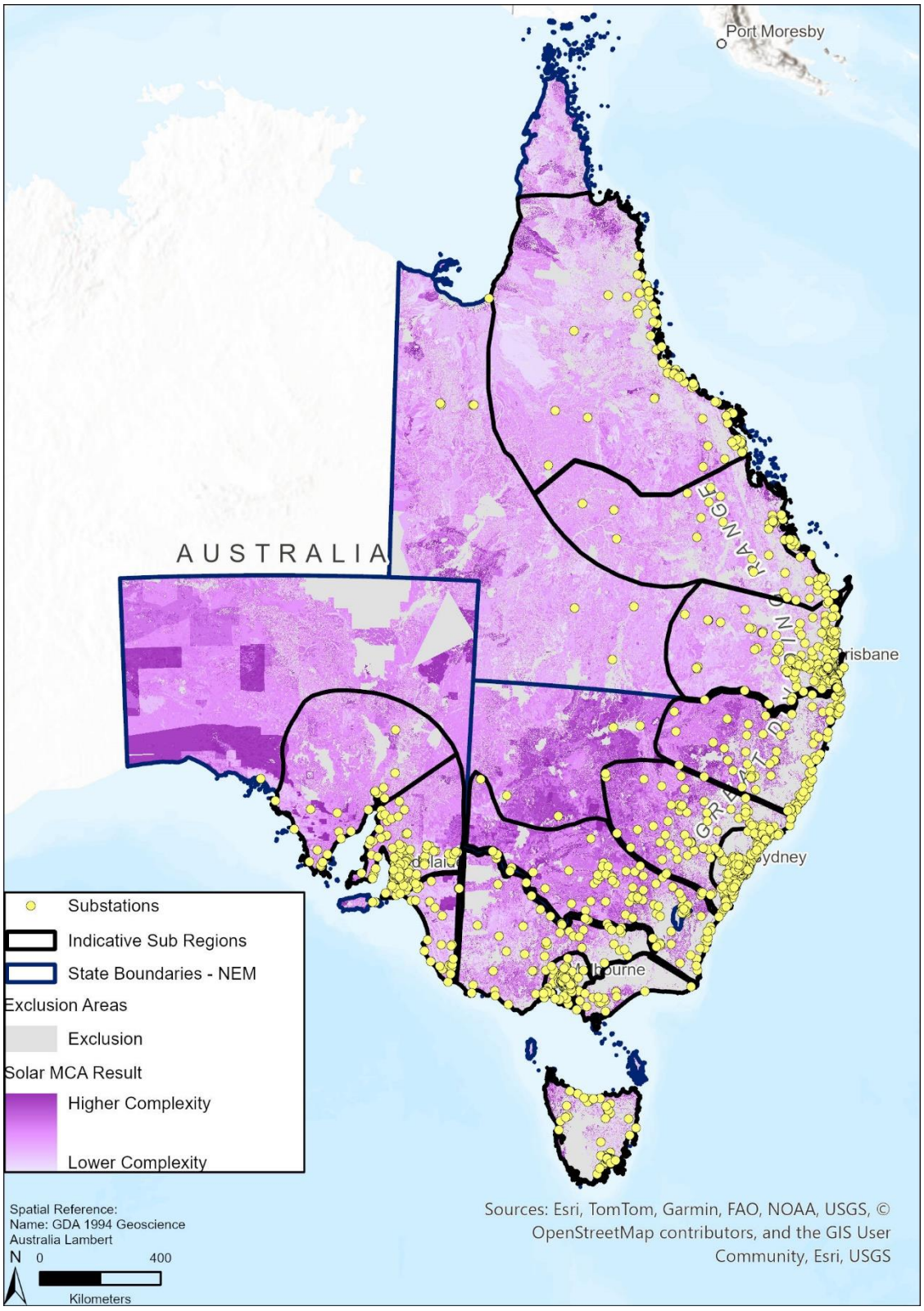

Figure 2-4. Overview of assumed substation locations (overlayed on the Solar MCA result)

These locations are known to not accurately reflect the location of the zone substations. However, the approach ensures that the assumed location occurs in an areas of concentrated network infrastructure. The limitation with this is that it can preference assuming the location within the urban centres. The assumed locations of substations are a key area where improving the data would be beneficial (refer Section 1).

2.5 Suitable area threshold assessment

The suitable area threshold assessment for the DER Land Limit brings together the MCA result and the assumed substation locations to determine an available area for BESS and Solar PV. The approach considered the proximity to urban centres and industrial areas as an indication of likely local demand on the distribution network and applies a distance limit from the location of the assumed substation location to reflect that DER will be built near connection points. Table 2-13 lists the proximity thresholds used for this assessment. This creates Areas of Assessment for potential Solar PV and BESS DER siting.

Table 2-13. Proximity thresholds used for the suitable area threshold assessment

Threshold	Distance
Proximity of Assumed Substation Location to Urban Centres and Localities and industrial land use	10km
Proximity for BESS from Assumed Substation Location	2.5km
Proximity for Solar PV from Assumed Substation Location	5km

In parallel, the results of the Solar PV and BESS MCA that determined land suitability (Section 2.3) analysed to identify the least constrained (most suitable) areas within each state, using three percentile-based thresholds (see Table 2-14). These areas were converted into three levels of Solar PV and BESS Available Area.

Table 2-14. MCA constraint value thresholds used for the suitable area threshold assessment

Threshold	Percentage
Tier 1	Lowest 10%
Tier 2	Lowest 25%
Tier 3	Lowest 50%

Combining the Solar PV and BESS Areas of Assessment with the three levels of Solar PV and BESS Available Area provides three tiers of available land forming the DER land limit area. This approach was taken to allow for refinement of the Assumed Substation Locations independently of the identification of the least constrained areas for Solar PV and BESS.

From these areas, minimum contiguous areas were identified from the Solar PV and BESS land limit areas. This process eliminated any small regions that would not be able to host the infrastructure. The minimum areas used are as per Table 2-15, and align with the lower end of the typical footprint for DER infrastructure.

Table 2-15. Minimum contiguous area thresholds

Technology	Minimum Area
Solar PV	122,000 m^2
BESS	130m^2

Finally, these filtered areas were aggregated to provide a summary of available land for both solar and BESS projects for each subregion across the NEM. These totals were used for each tier and the 5% conversion limit was applied to account of local constraints and cumulative impact.

3. Land limit results

3.1 Overview

The outcome of combining the two-part analysis (a. determining Areas of Assessment around the filtered assumed Substation Locations, and b. land use based Available Areas) has provided a suite of results that can be incorporated into the modelling at different sensitivities. This will allow AEMO to balance the sensitivity of the land limit in relation to the other constraints in the model.

Whilst the land use constraint threshold places a restrictive filter to the area available for DER, excluding larger areas where DER infrastructure could be developed but is less suitable, the results are also presented as 5% of that area. This limit is used by AEMO to reflect other factors not assessed will influence the total area used, this includes the cumulative impact as more of a landscape is used for energy generation. Given the constraint assessment undertaken to support the Available Area assessment, this value is likely conservative in this analysis.

The following provides an overview of the results from the assessment.

3.2 DER land limit observations

The DER land limit results delivered consistent results between Solar and BESS, with the main difference being lower complexity across planning zones defined in the "Mixed Use" categories. A per state summary is provided in the following sections, of both the MCA and suitable area assessment.

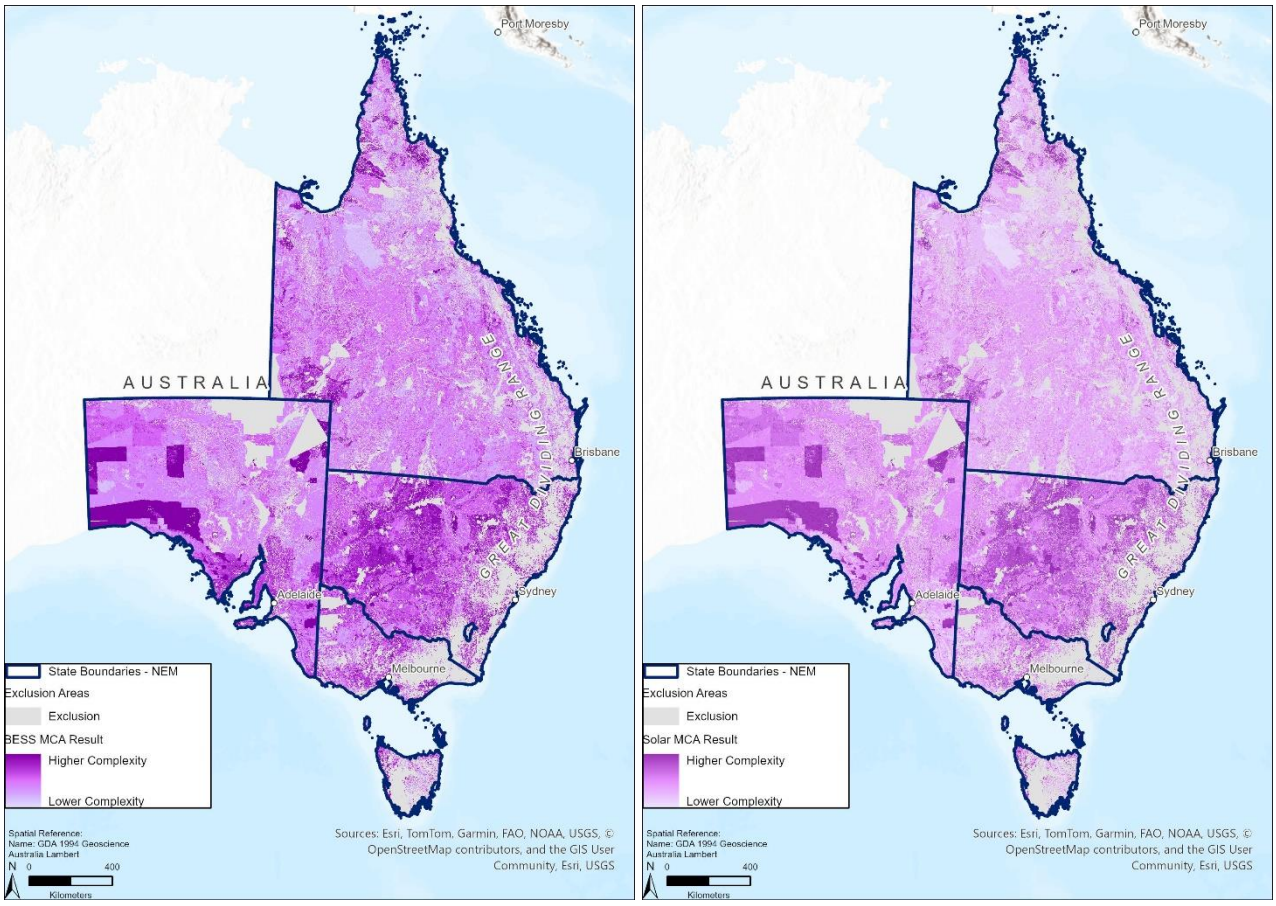

Figure 3-1. BESS and Solar MCA results

3.2.1 Exclusion Areas

Across the NEM the exclusions have eliminated a large portion of area, several factors are collocated, for example World Heritage sites, that sit over National or State Parks, and areas of steep and undulating elevation. These areas also tend to include waterways, native vegetation and other park land, essentially excluding large swathes of areas that would have been highly scored regardless. This shows that the exclusion areas are aligning with areas of stacked criteria and very high complexity.

3.2.2 Australian Capital Territory

The Australian Capital Territory is almost completely excluded with respect to land availability, primarily due to the presence of National Parks and residential areas. This leaves a small portion of land in the centre and edges of the Territory. These areas fall within the rural planning categories and complexity spikes are driven by high scores in geotechnical or cultural heritage criteria.

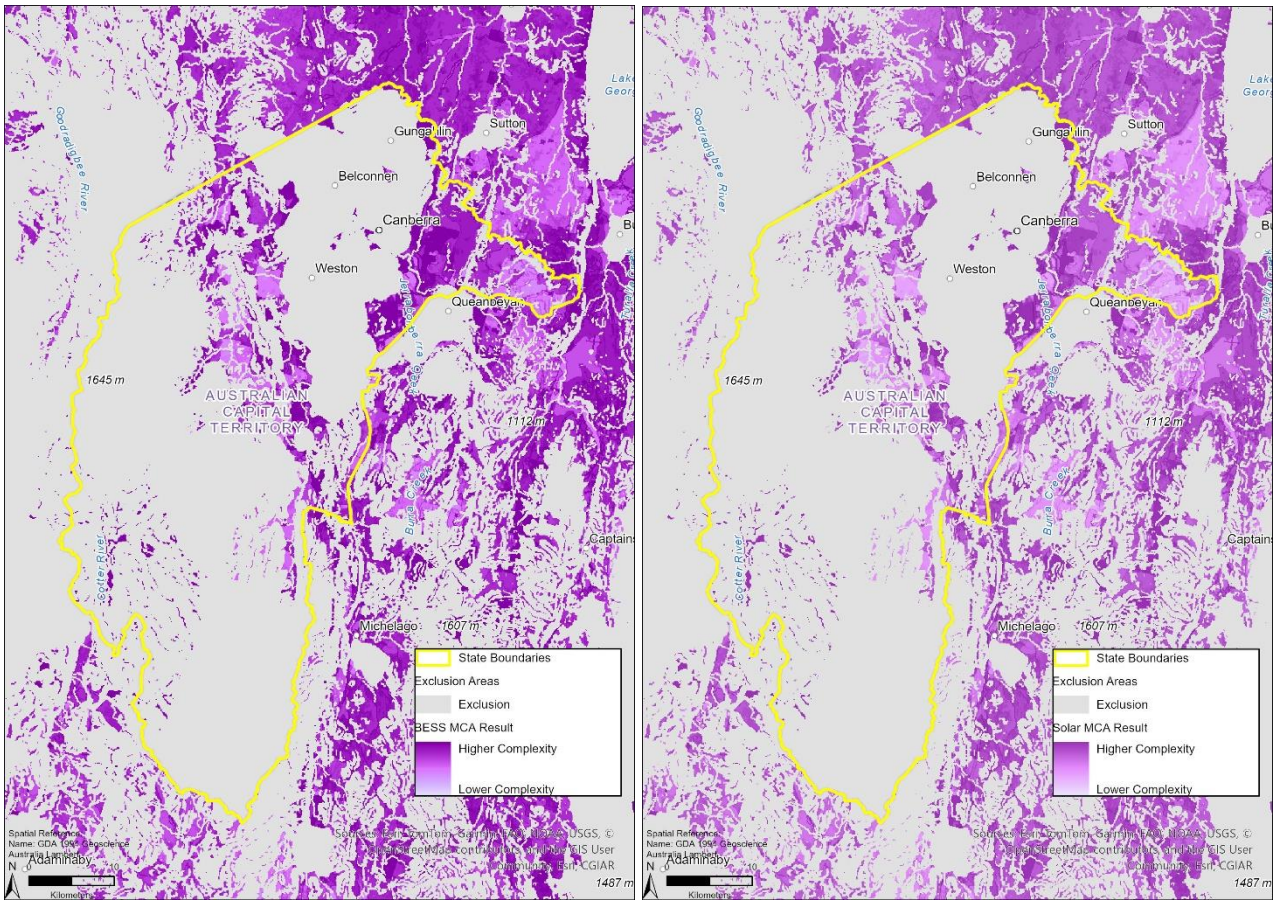

Figure 3-2. Australian Capital Territory BESS and Solar MCA results

3.2.3 New South Wales

Most of the coastal region of New South Wales has been excluded from consideration, this is due to a combination of residential areas, surrounded by parklands with steep terrain. The central and western extents of the state are primarily left as available; this is land predominately agricultural land use with some areas of parkland and native vegetation.

Areas of high complexity can be seen in the areas of other parkland, or through the occurrence of wetlands. While the remainder of the state has score fluctuations resulting from the geotechnical criteria with the mixed-use planning zone categories. There is slight uplift in complexity from the BESS assessment to the Solar assessment, due to an increase in complexity for the mixed-use planning categories, in the case of New

South Wales these are areas classified as “Primary Production” however the change isn’t as obvious as it is with South Australia, leaving a consistent result between the Solar and BESS assessments.

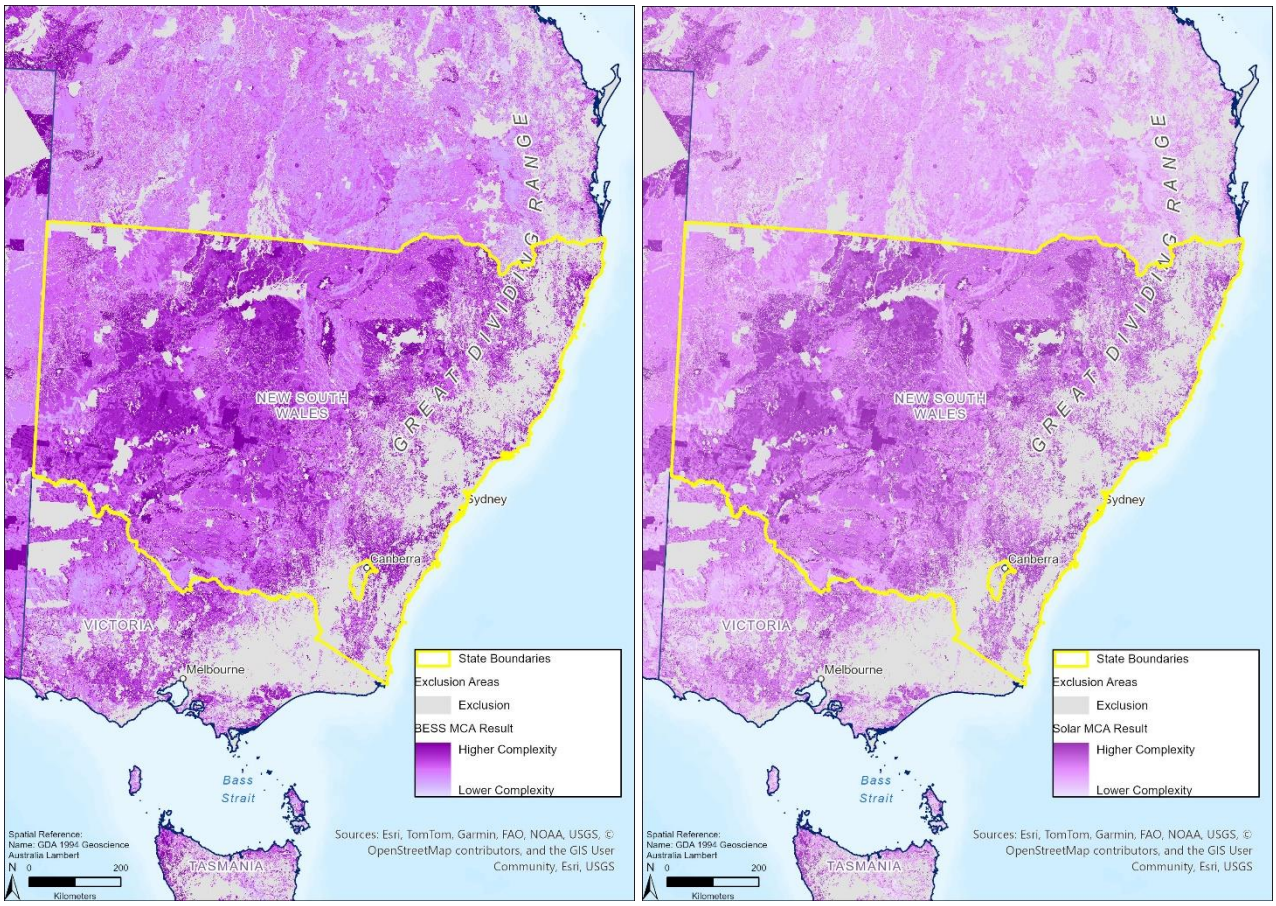

Figure 3-3. New South Wales BESS and Solar MCA results

Figure 3-4 to Figure 3-7 show the BESS and Solar PV Tier 2 available areas identified. These are the top 25% least constrained areas in the state within the area of assessment (the radius around the assumed location of the substations selected). Note that the Tier 1 regions (top 10%) are a subset of the areas shown.

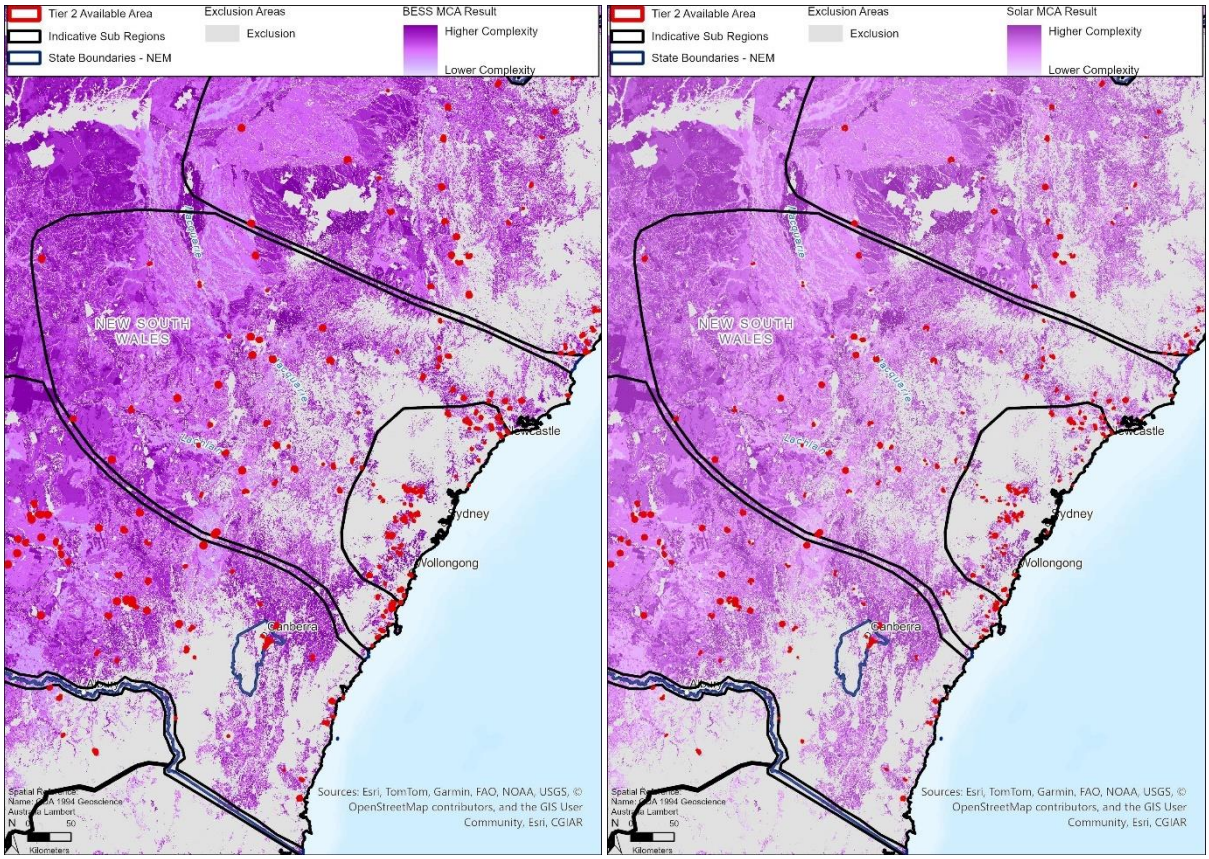

Figure 3-4. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for CNSW

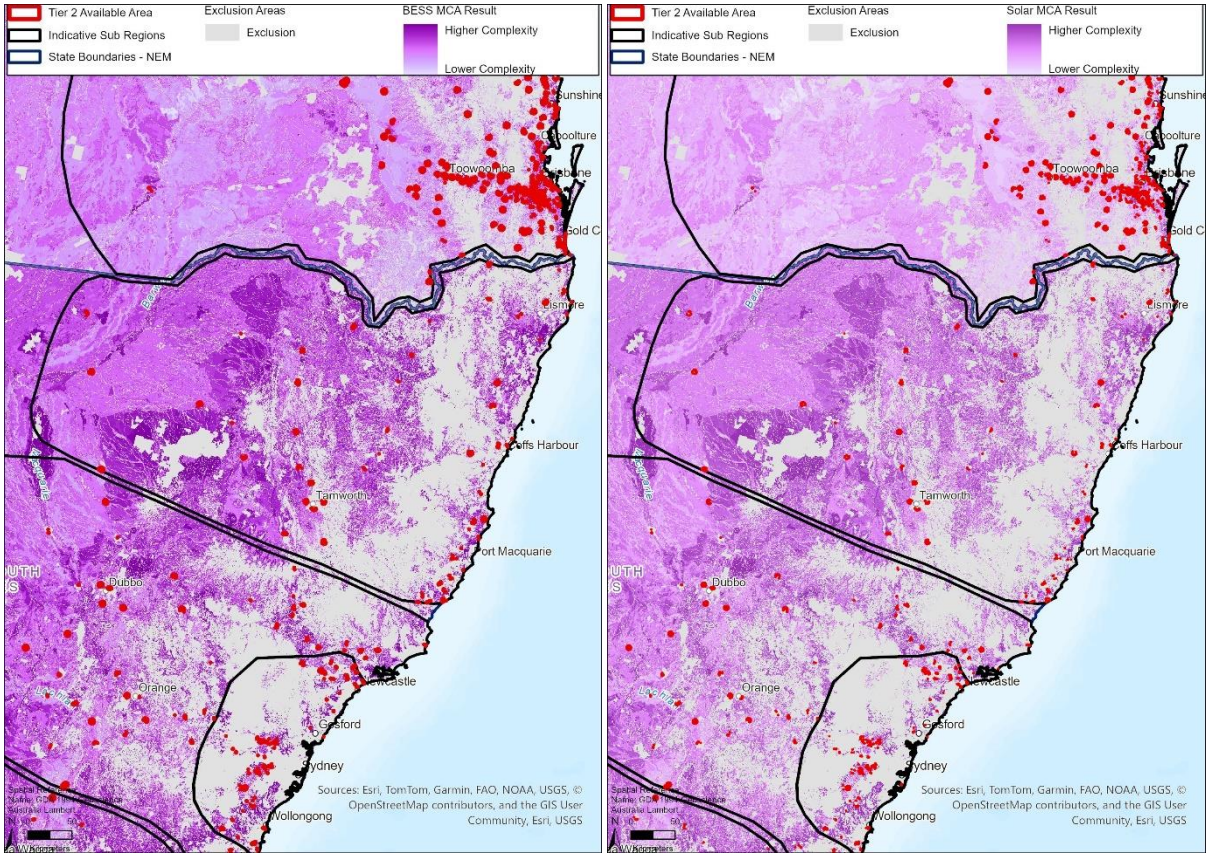

Figure 3-5. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for NNSW

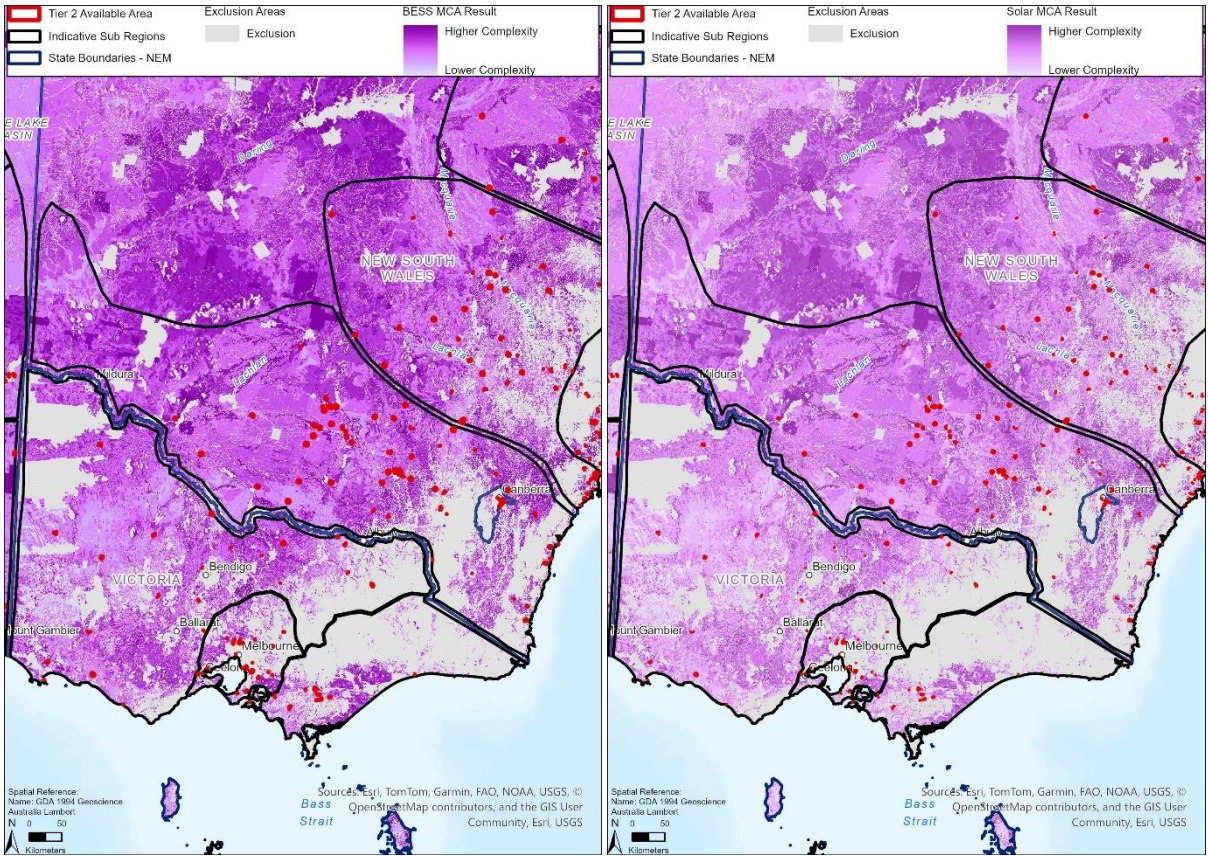

Figure 3-6. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for SNSW

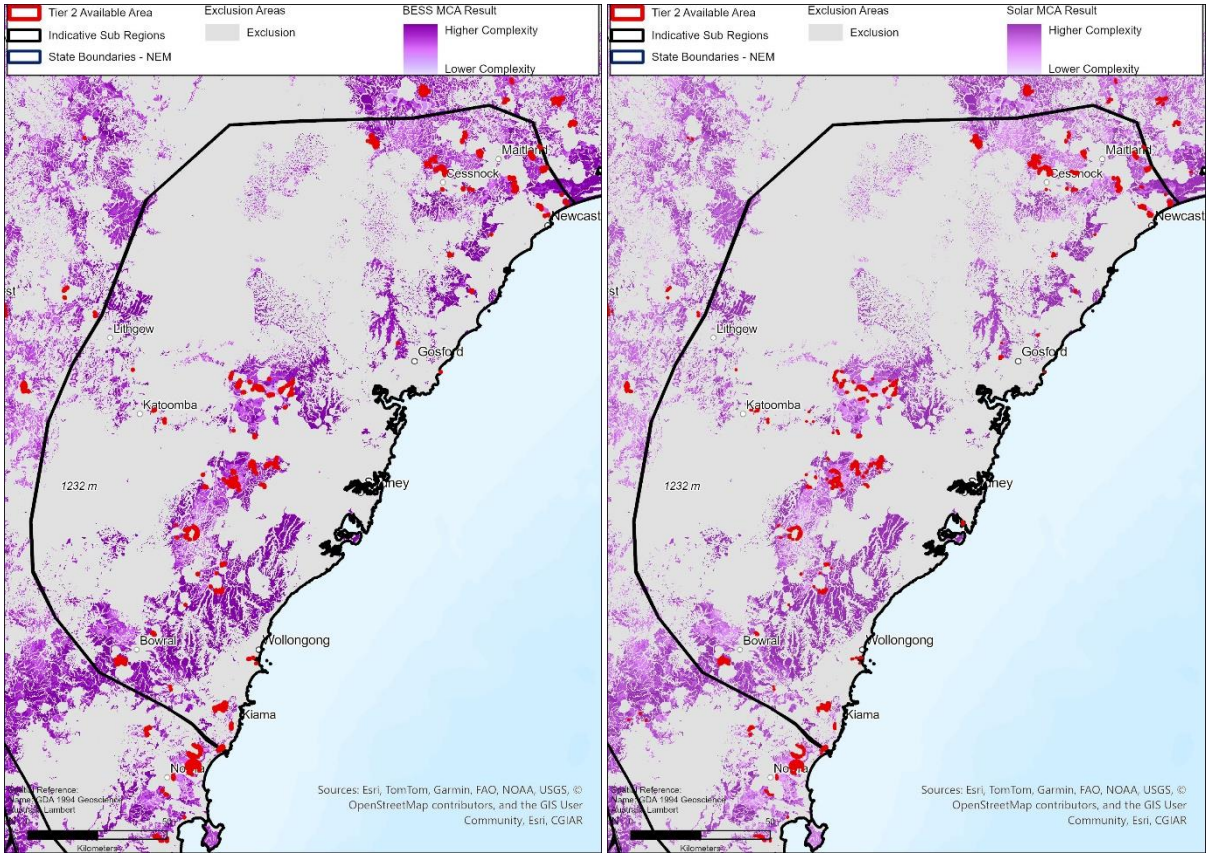

Figure 3-7. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for SNW

3.2.4 Queensland

Queensland planning layers are kept at a local council level and are not accessible for the wider state, this has limited the criteria being used and can be seen in the generally less complicated nature of the state. Land use was considered as a replacement but unfortunately did not have the level of detail required to equate it to the planning criteria categories. As such when considering results in Queensland, it does not present equivalent relative complexity to other jurisdictions.

The land available is consistently within the centre of the state, driven by low occurrence of environmental criteria. Peaks of complexity align with areas of complex soil, geology and acid sulphate soils in additional environmental features such as conservation reserves.

While the urban centre and localities layer was included as a moderate criterion to account for urban sprawl outside of residential planning zones, due to a lack of planning zones in Queensland some land availability may be occurring in residential areas that otherwise would be excluded.

Any preferred sites located in Queensland should be subjected to an additional level of scrutiny due to the lack of high-resolution spatial data this assessment was able to use.

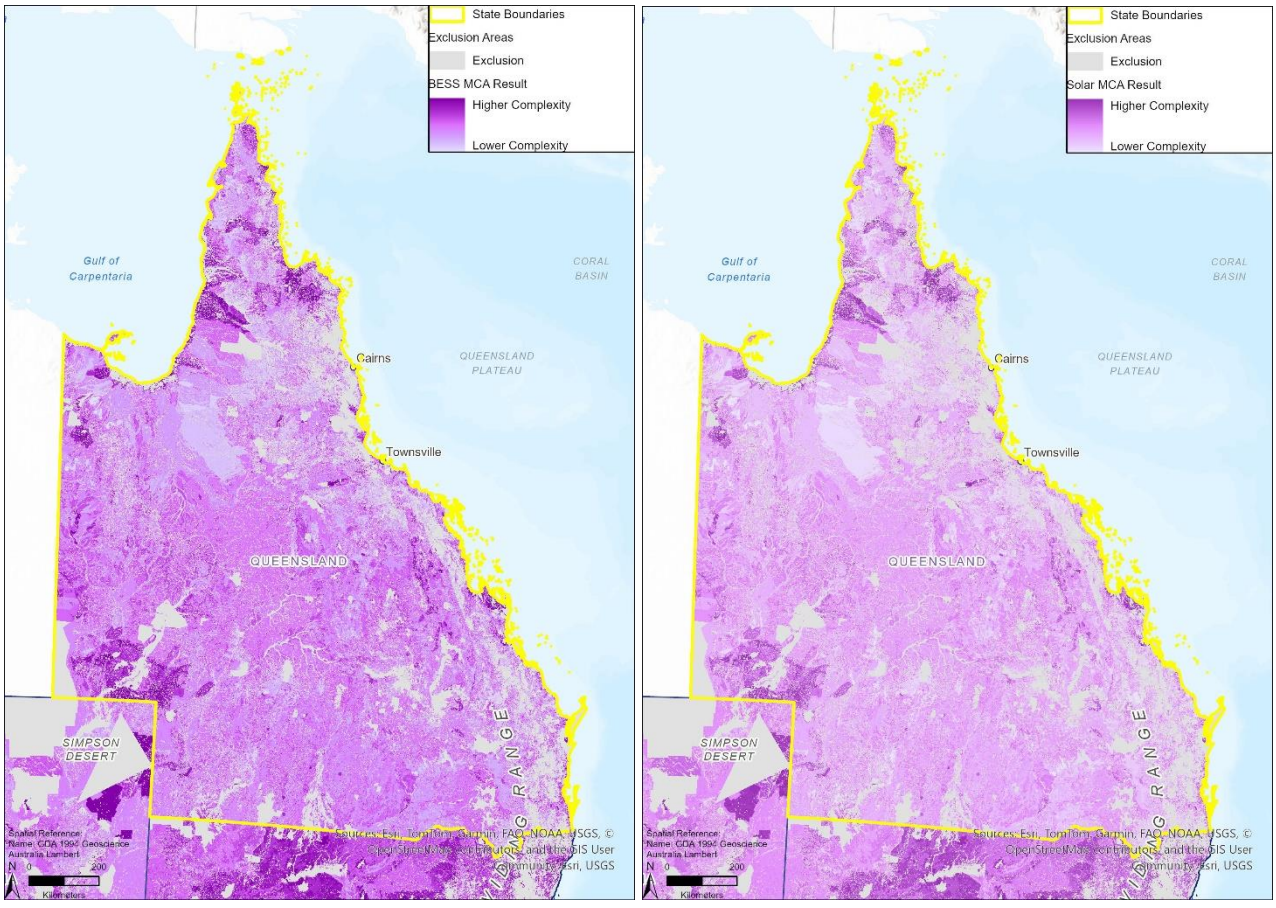

Figure 3-8. Queensland BESS and Solar MCA results

Figure 3-9 to Figure 3-12 show the BESS and Solar PV Tier 2 available areas identified. These are the top 25% least constrained areas in the state within the area of assessment (the radius around the assumed location of the substations selected). Note that the Tier 1 regions (top 10%) are a subset of the areas shown.

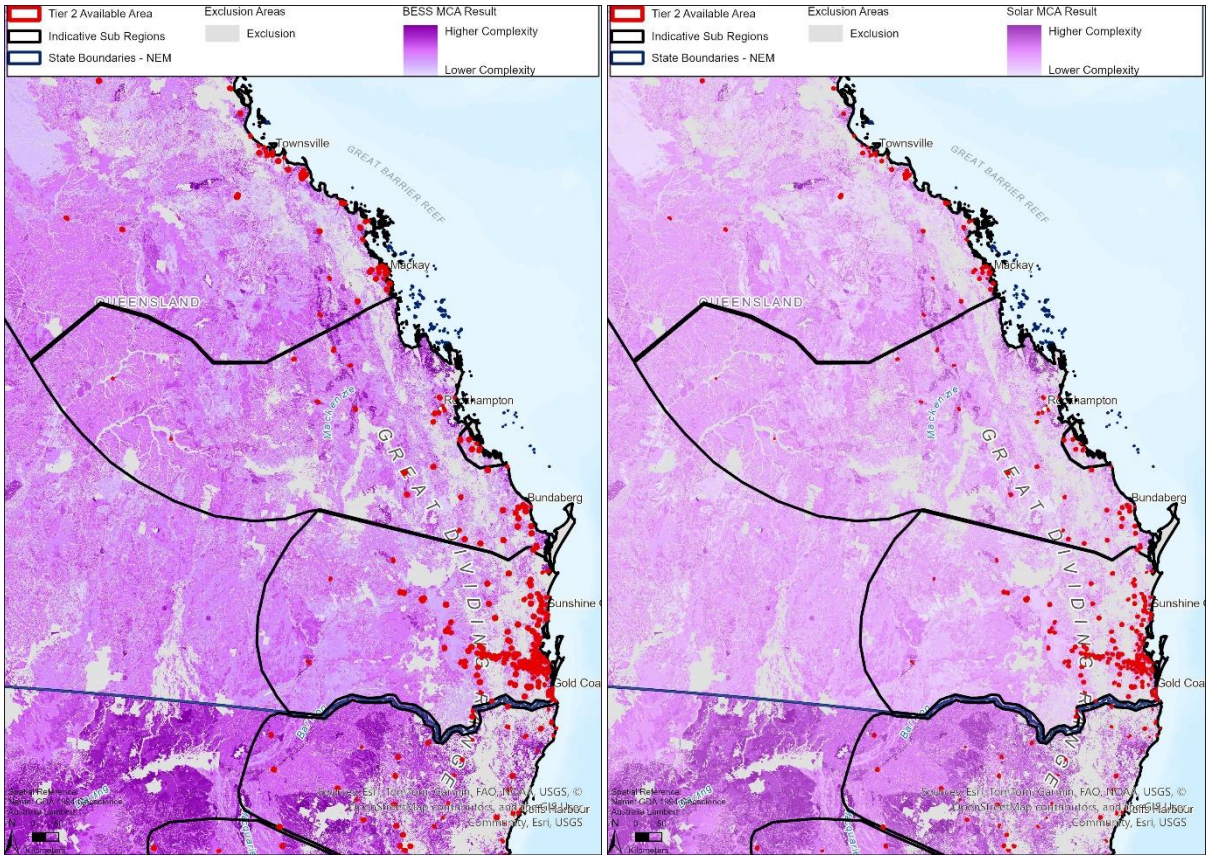

Figure 3-9. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for CQ

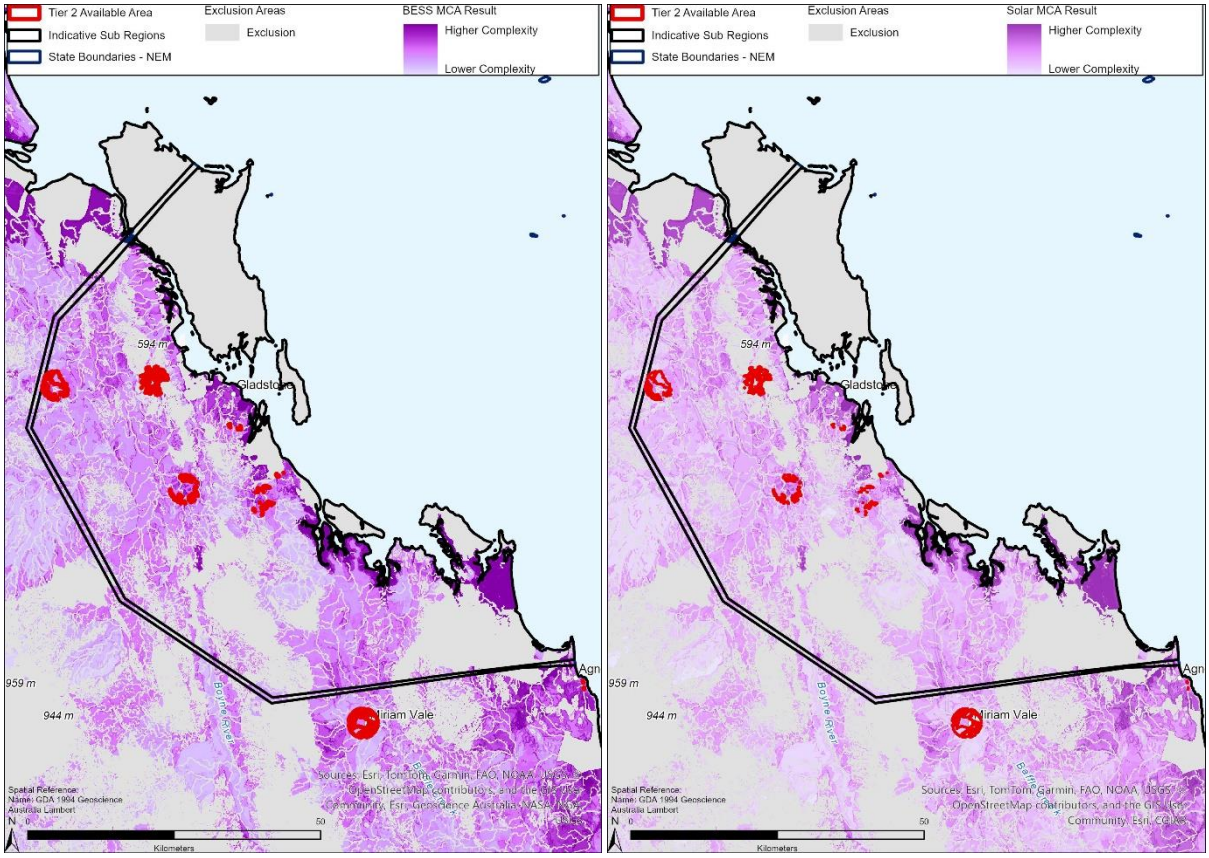

Figure 3-10. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for GG

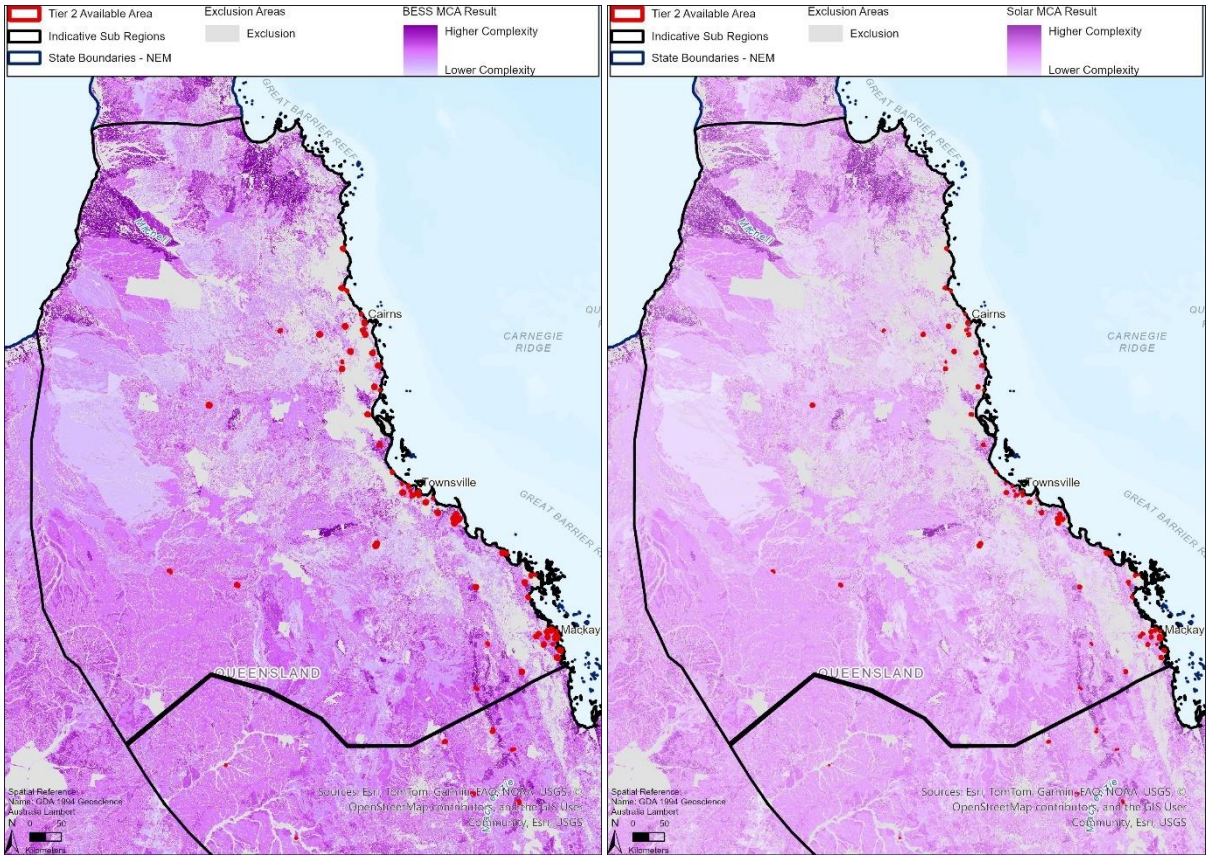

Figure 3-11. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for NQ

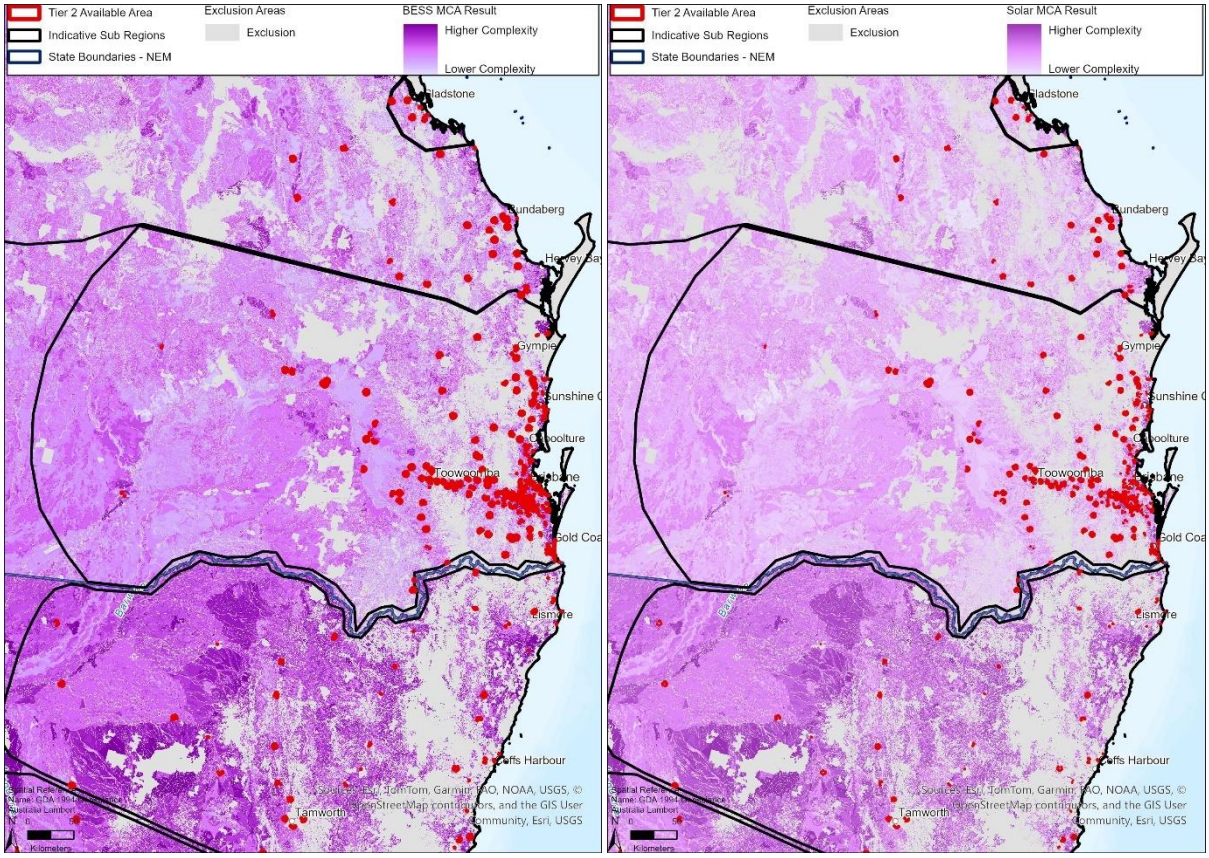

Figure 3-12. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for SQ

3.2.5 South Australia

Observing South Australia from the state extent it's apparent that spatial data is collected at a higher resolution in urban areas when compared to the regional areas of the state, resulting in what appears to be very blocky land features. This has resulted in some clear areas of complexity around areas of stacked criteria in conservation reserves, native vegetation, other parks and planning based environmental conservation. Additionally, areas in the south of the state, close to the major urban areas have a range of moderate to high complexity when compared to the rest of the state.

The areas considered available are primarily centred in what the planning layers consider to be "remote areas". For the BESS assessment these align with the complexity of rural areas, however for the Solar assessment the remote areas, as a part of the mixed-use categories of planning have been given a higher complexity value, resulting in a slightly higher score.

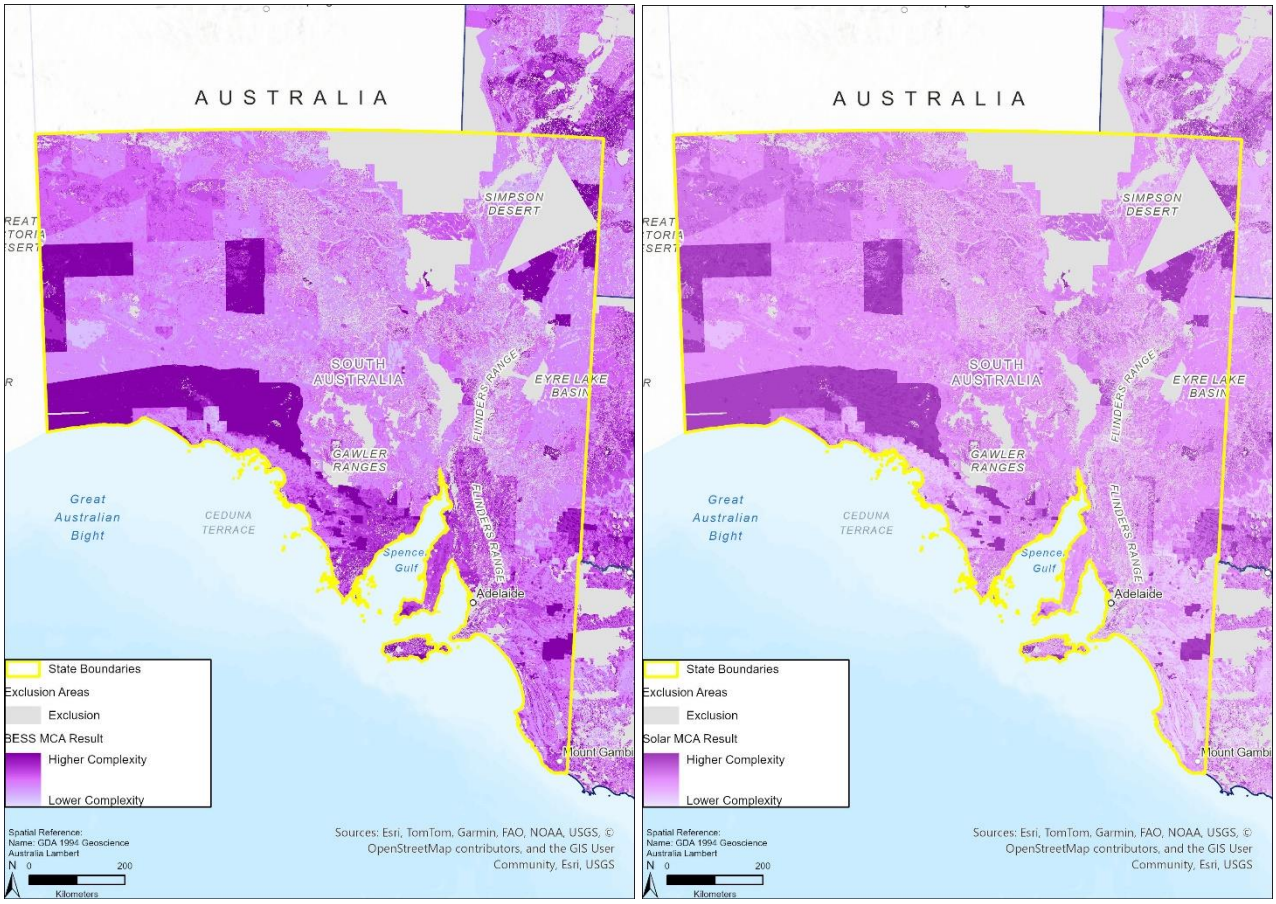

Figure 3-13. South Australian BESS and Solar MCA results

Error! Reference source not found. to Figure 3-16 show the BESS and Solar PV Tier 2 available areas identified. These are the top 25% least constrained areas in the state within the area of assessment (the radius around the assumed location of the substations selected). Note that the Tier 1 regions (top 10%) are a subset of the areas shown.

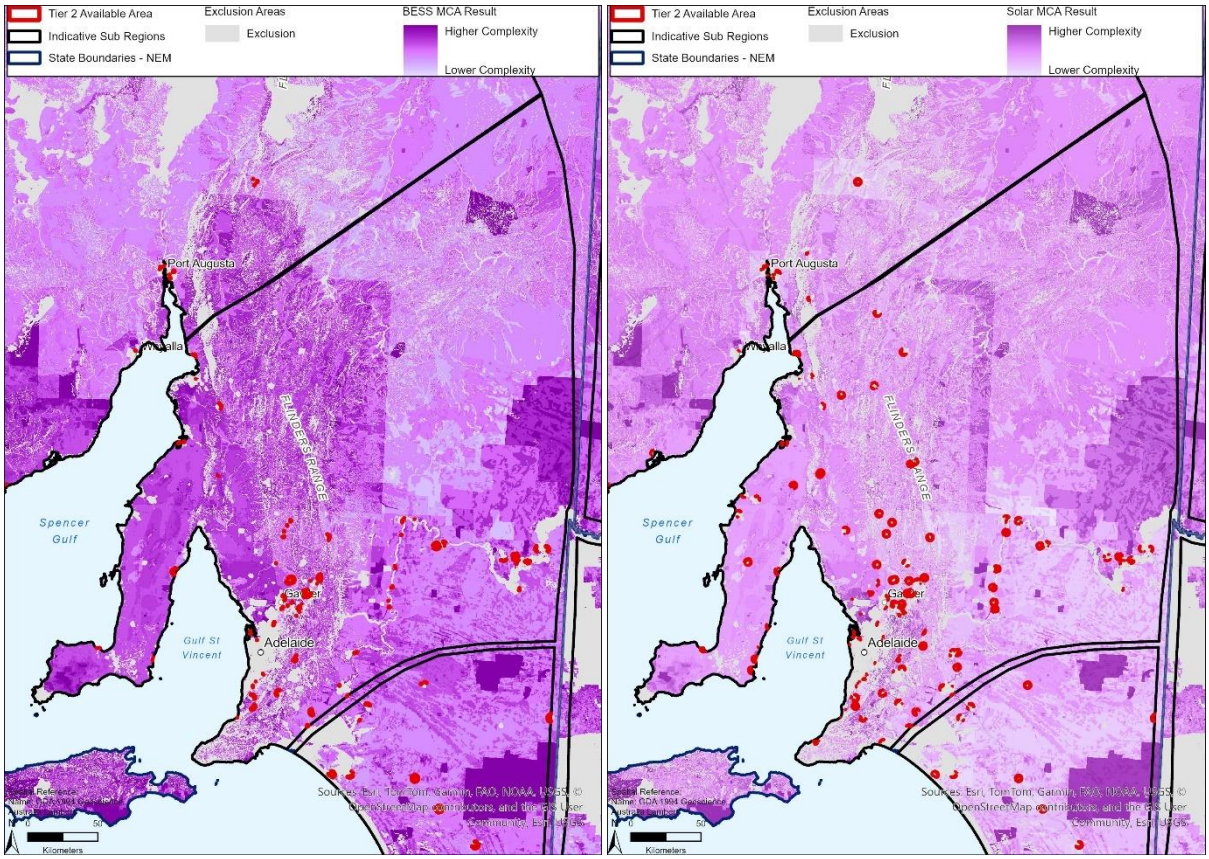

Figure 3-14. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for CSA

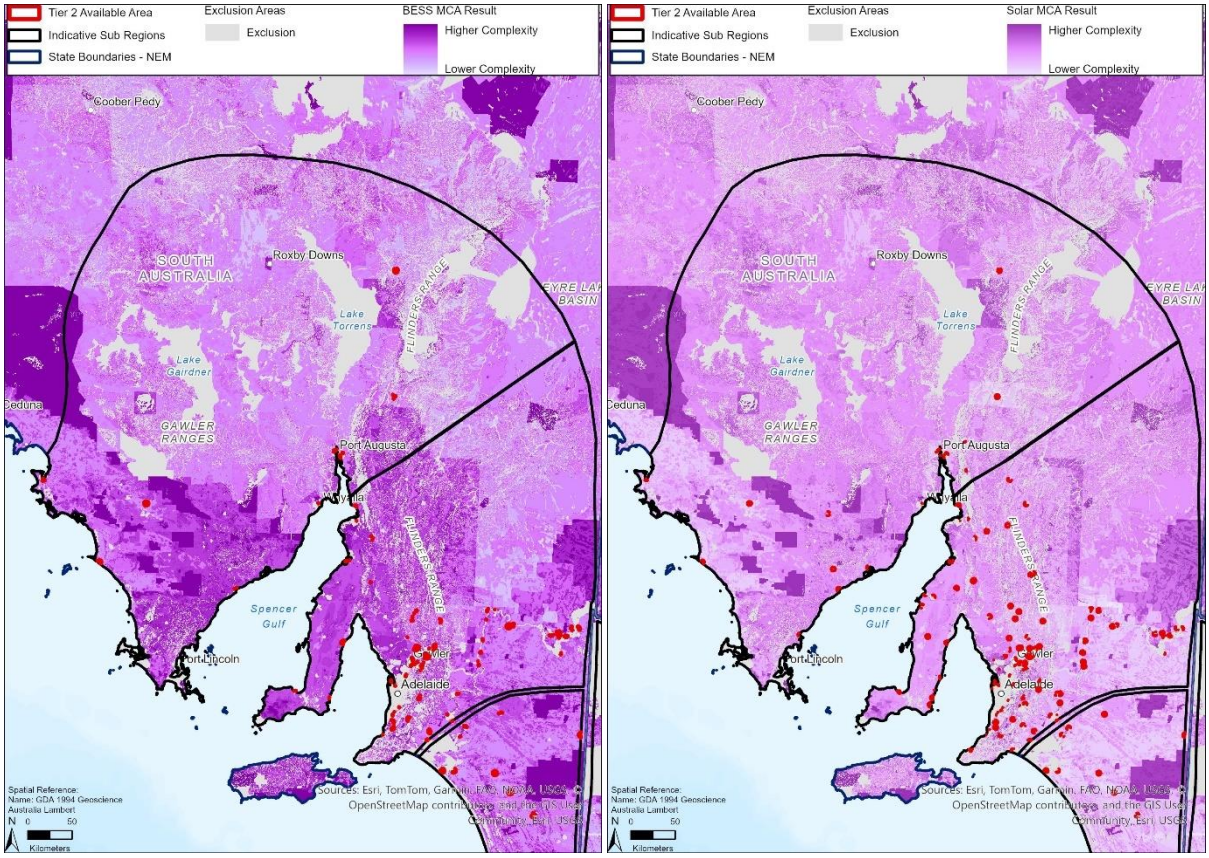

Figure 3-15. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for NSA

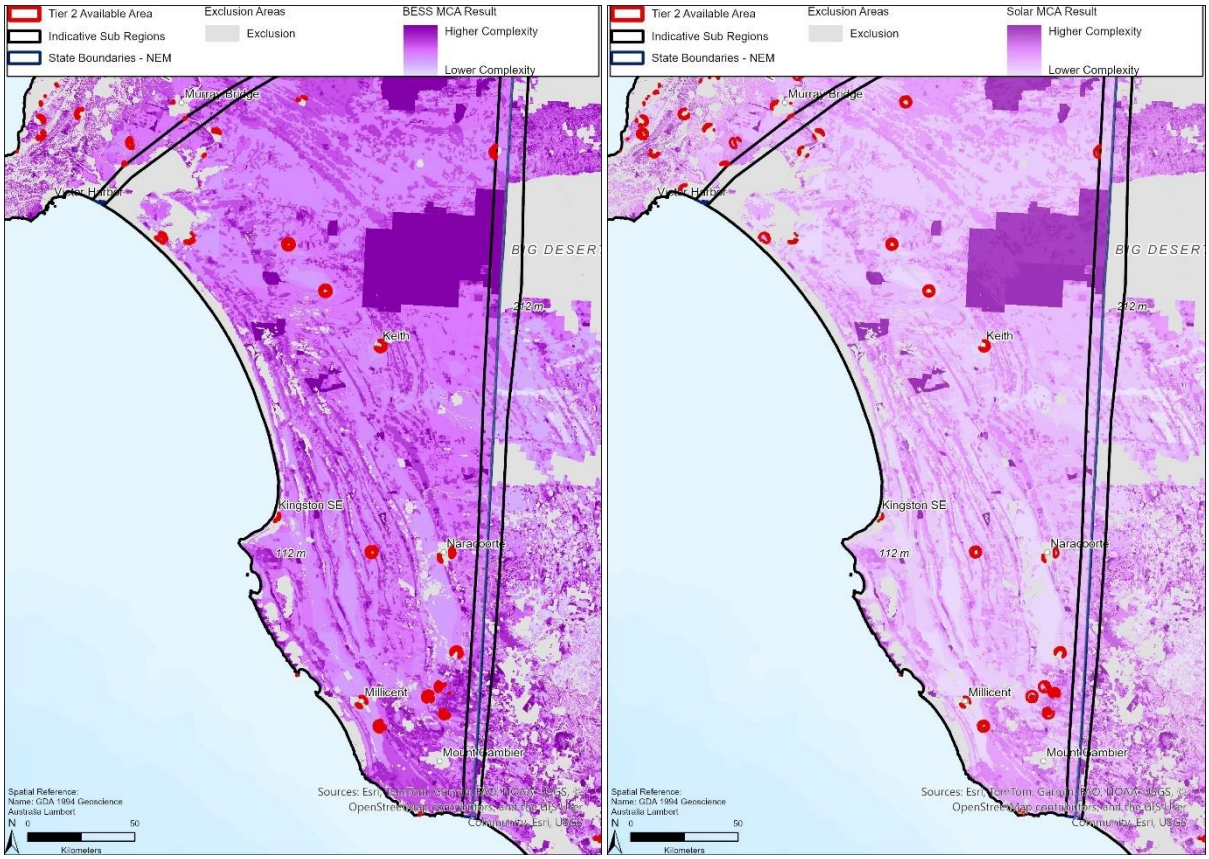

Figure 3-16. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for SESA

3.2.6 Tasmania

The majority of Tasmania has been classified as excluded from being available, this aligns with the inclusion of National and State parks and World Heritage Sites in the exclusion layers, as this covers a large portion of the west of the state.

The areas considered available are along the western coast and northwest, as well as portions through the centre of the state. The western most areas have results that are more complex due to the presence of park land, drawing park and planning based environmental criteria. The remaining areas through the centre of the state align with the results from Victoria with most of this area being farmland and having moderate planning scores from rural, mixed used or urban categories.

The results are consistent from a statewide view between the Solar and BESS assessment, with the difference restricted to a site scale.

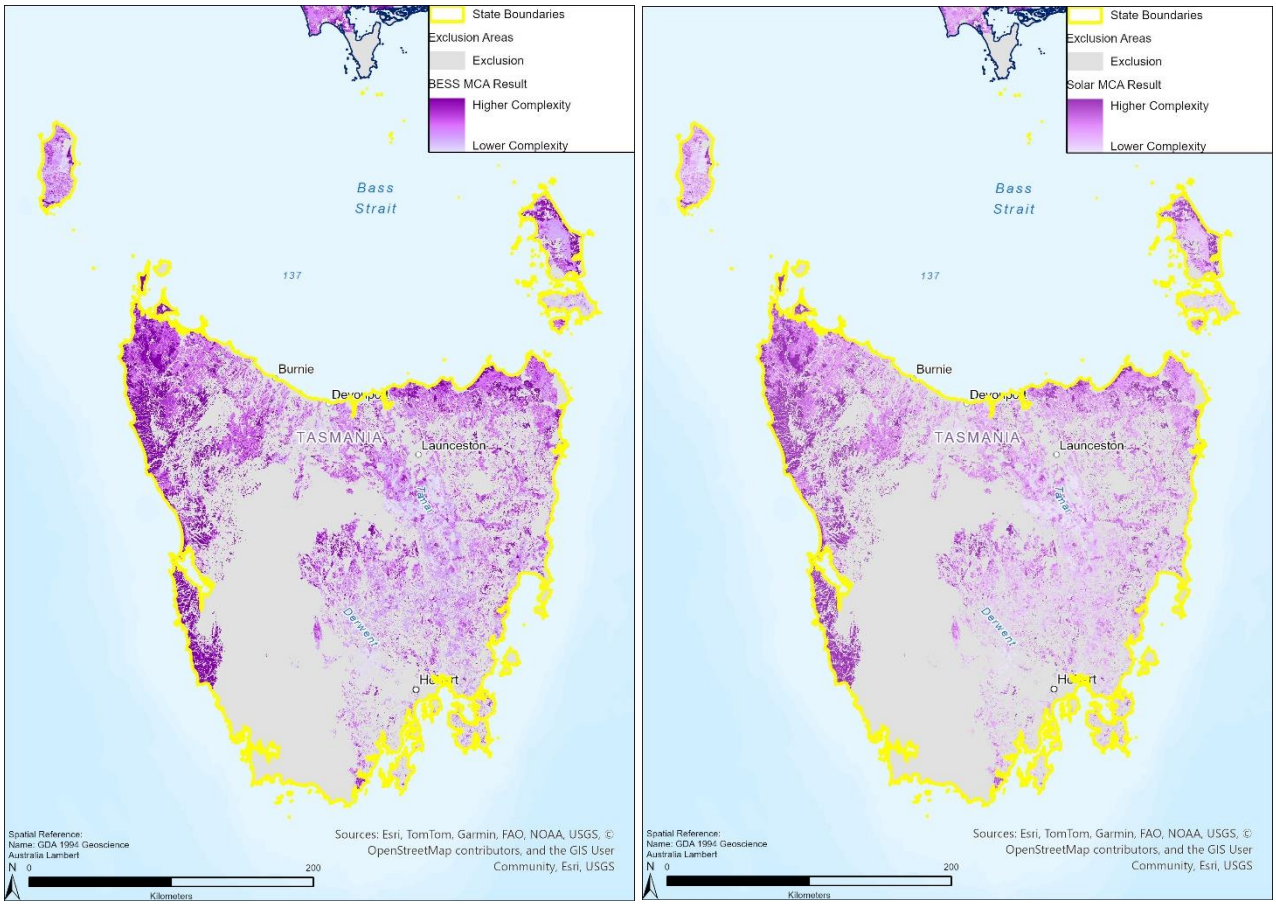

Figure 3-17. Tasmanian BESS and Solar MCA results

Figure 3-18 show the BESS and Solar PV Tier 2 available areas identified. These are the top 25% least constrained areas in the state within the area of assessment (the radius around the assumed location of the substations selected). Note that the Tier 1 regions (top 10%) are a subset of the areas shown.

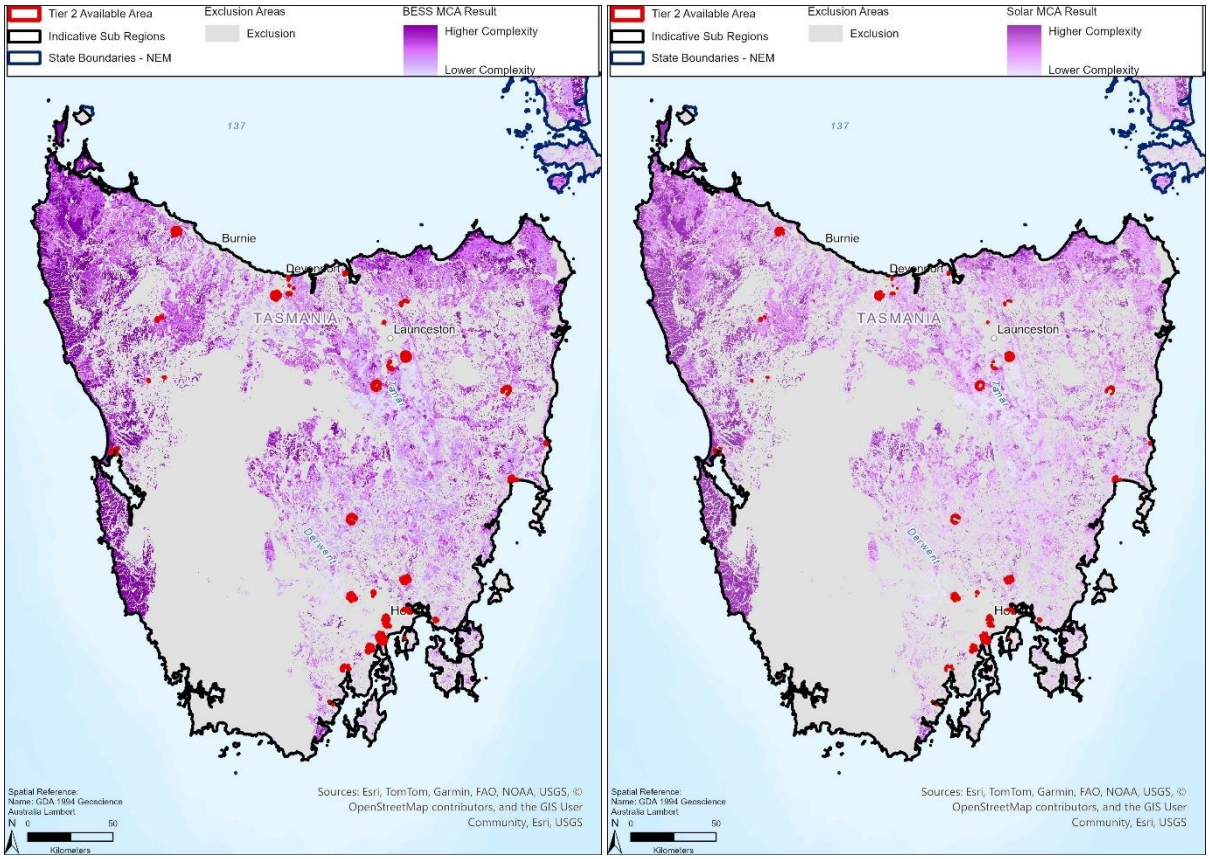

Figure 3-18. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for TAS

3.2.7 Victoria

The makeup of the land that is available is primarily areas that appear to be regional rural farming, in addition to fringe areas around urban or developed areas. This aligns with the presence of moderately scored planning criteria which covers zones grouped in rural production, urban and mixed use.

The northwest areas of Victoria area scoring as the least complex, compared to areas available in the southwest. The land available has a range of soil and geological scores, with the areas in northwest Victoria showing lower complexity having marginally higher geological complexity. The presence of "Areas with potential for cultural assessment" criteria in the southwest appears to be driving the difference in complexity for this state.

Pockets of highly complex land is typically adjacent to exclusions areas which collocate with most of the highest scoring criteria including environmental conservation and residential areas.

The results are consistent from a statewide view between the Solar and BESS assessment, with the difference restricted to a site scale.

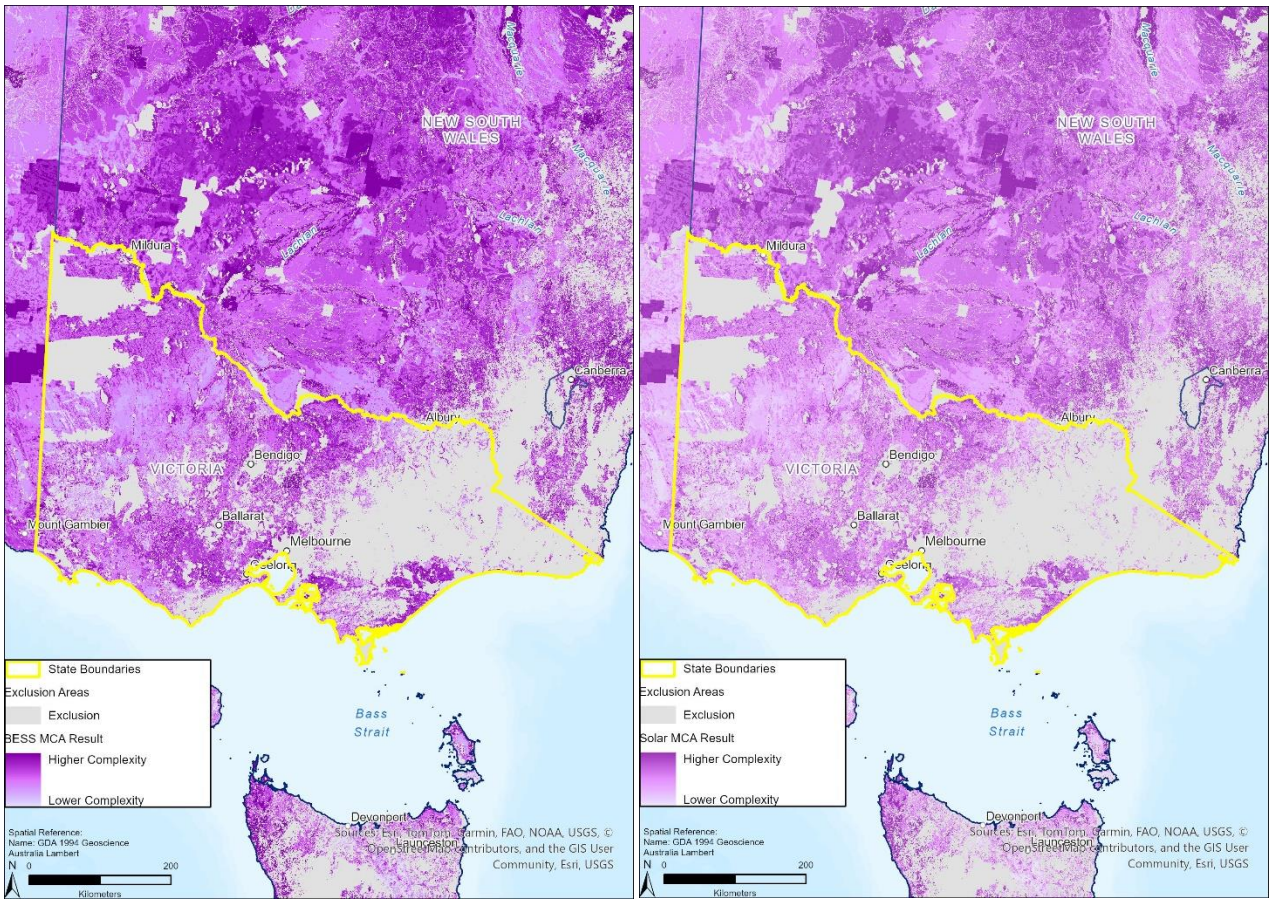

Figure 3-19. Victorian BESS and Solar MCA results

Figure 3-20 to Figure 3-22 show the BESS and Solar PV Tier 2 available areas identified. These are the top 25% least constrained areas in the state within the area of assessment (the radius around the assumed location of the substations selected). Note that the Tier 1 regions (top 10%) are a subset of the areas shown.

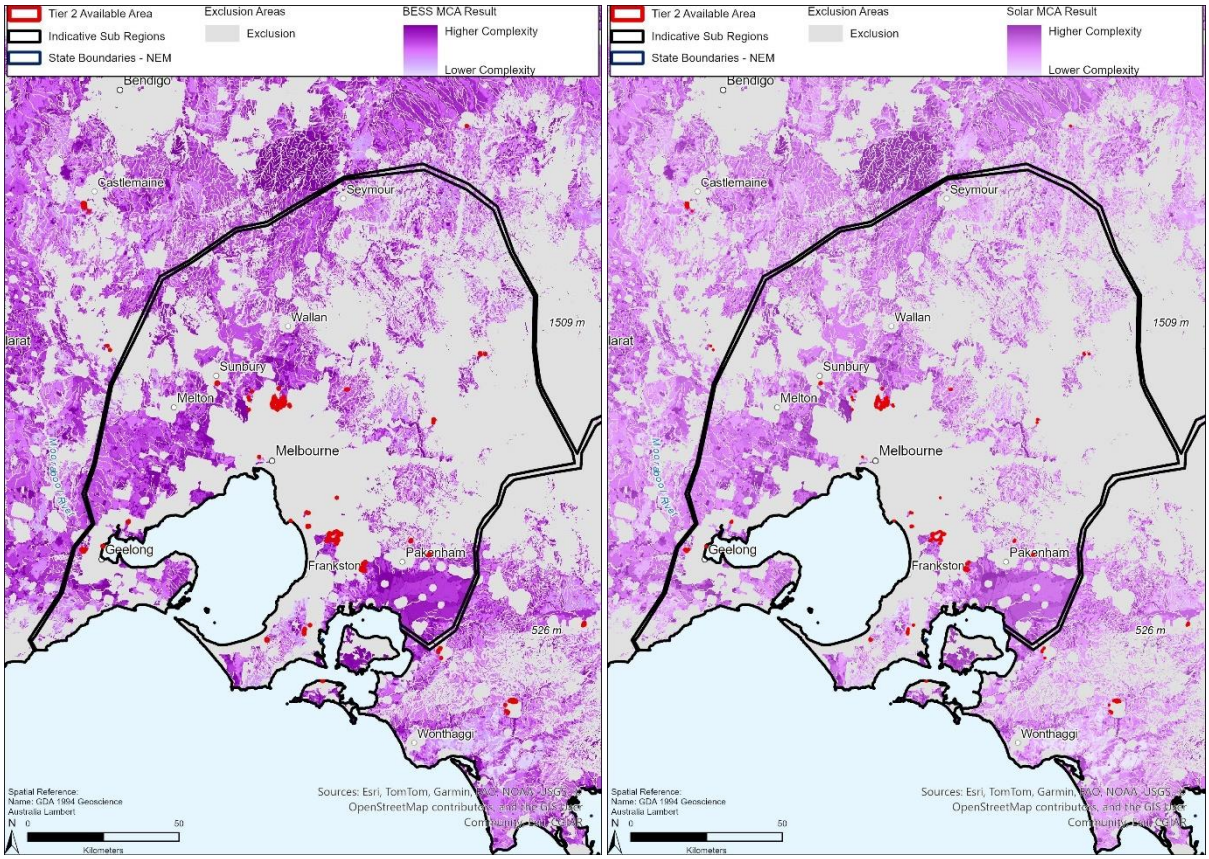

Figure 3-20. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for MEL

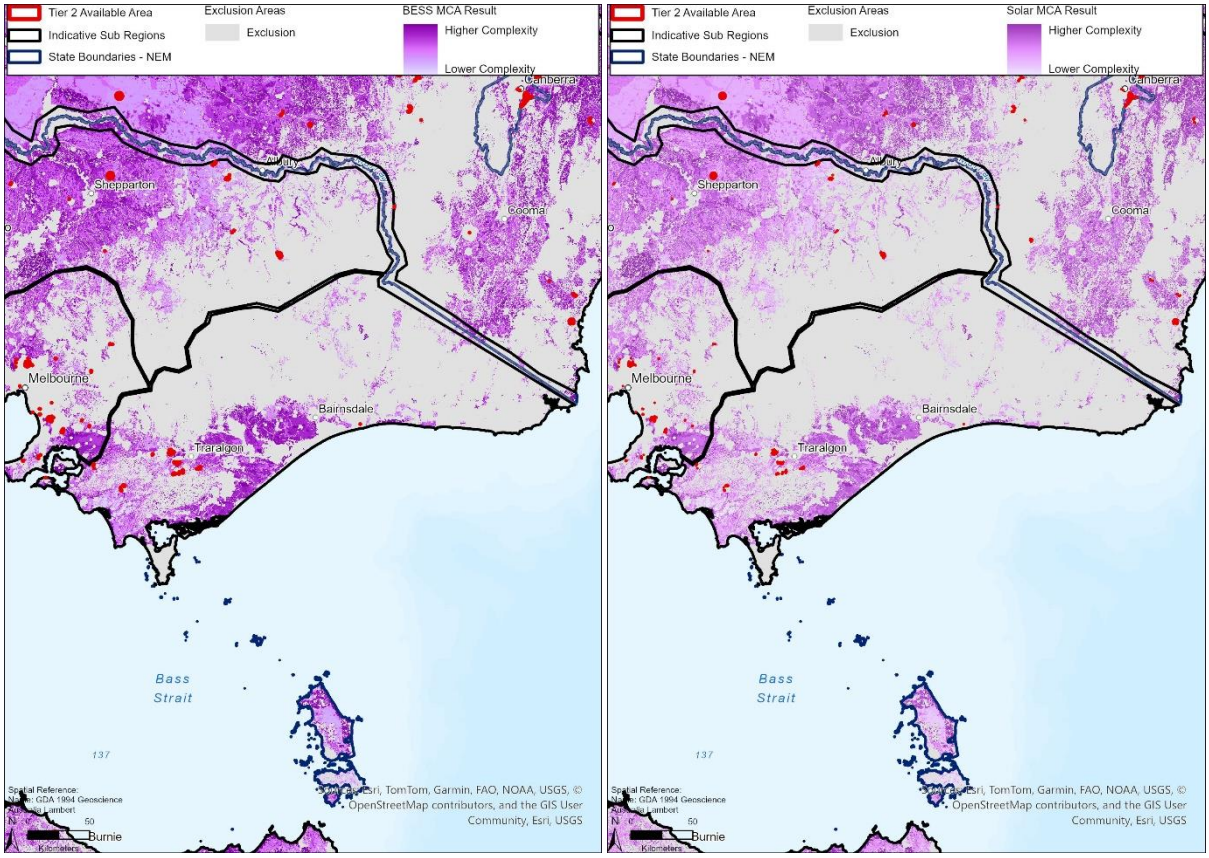

Figure 3-21. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for SEV

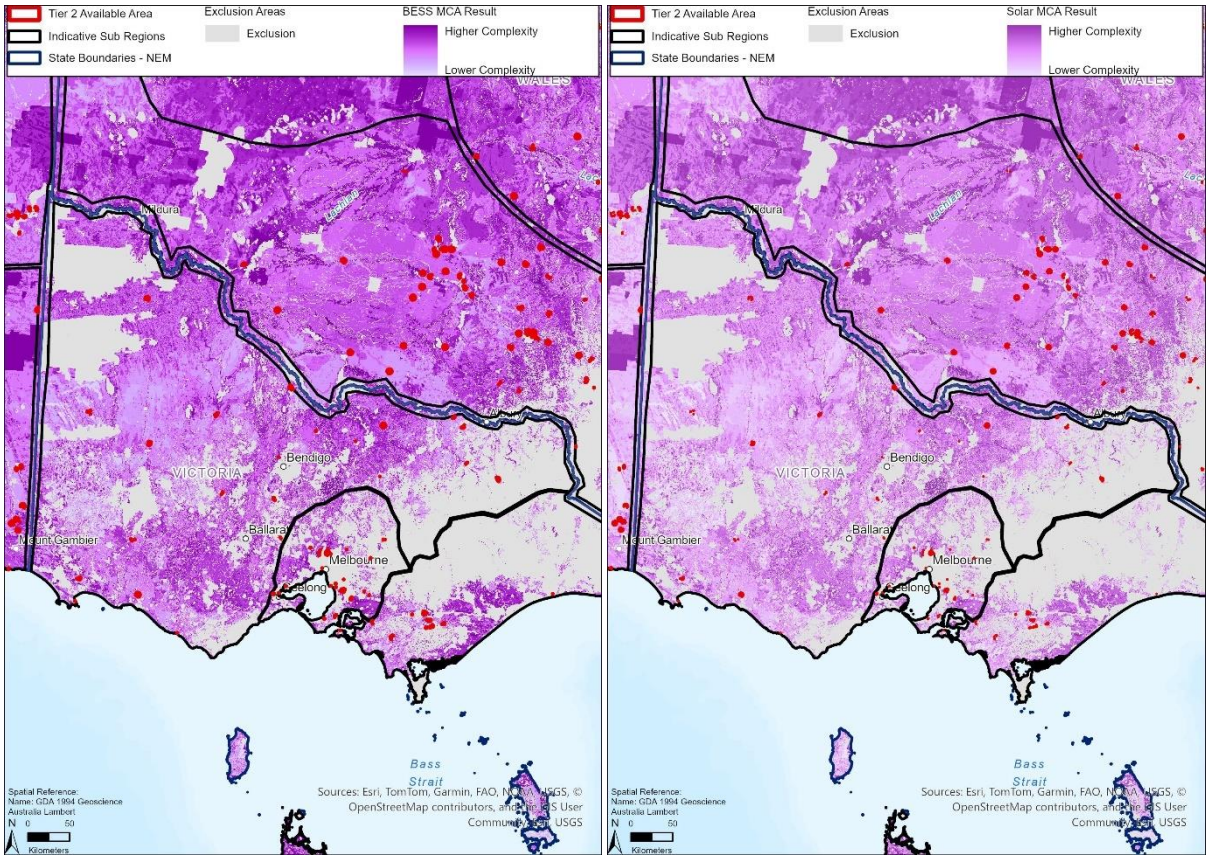

Figure 3-22. Distribution of Tier 2 BESS and Solar Tier 2 Available Areas for WNV

3.3 Table of DER land limit results by sub-region

3.3.1 Solar PV

Table 3-1. DER land limit for Solar PV within 5km of Assumed Substation Locations within 10km of UCL and industrial areas

SubRegion	Tier 3 – Lowest 50%				Tier 2 – Lowest 25%				Tier 1 – Lowest 10%			
	Total		5% Conversion		Total		5% Conversion		Total		5% Conversion	
	km²	MW	km²	MW	km²	MW	km²	MW	km²	MW	km²	MW
CNSW	1089	43576	54	2179	755	30207	38	1510	266	10659	13	533
CQ	1350	53990	67	2699	619	24749	31	1237	394	15774	20	789
CSA	2484	99342	124	4967	2484	99342	124	4967	1004	40162	50	2008
GG	122	4867	6	243	58	2317	3	116	23	932	1	47
MEL	175	7004	9	350	45	1817	2	91	29	1171	1	59
NNSW	689	27567	34	1378	412	16475	21	824	52	2094	3	105
NQ	1585	63406	79	3170	740	29603	37	1480	459	18377	23	919
NSA	470	18784	23	939	470	18784	23	939	253	10140	13	507
SESA	1009	40340	50	2017	1009	40340	50	2017	717	28674	36	1434
SEV	162	6498	8	325	59	2364	3	118	31	1236	2	62
SNSW	1652	66060	83	3303	1271	50836	64	2542	307	12298	15	615
SNW	292	11687	15	584	180	7211	9	361	41	1628	2	81
SQ	3457	138286	173	6914	1410	56415	71	2821	679	27166	34	1358
TAS	423	16918	21	846	280	11197	14	560	131	5250	7	263
WNV	636	25439	32	1272	238	9501	12	475	137	5472	7	274

3.3.2 BESS

Table 3-2. DER land limit for BESS within 2.5km of Assumed Substation Locations within 10km of UCL and industrial areas

SubRegion	Tier 3 – 50% least constrained				Tier 2 –25% least constrained				Tier 1 –10% least constrained			
	Total		5% Conversion		Total		5% Conversion		Total		5% Conversion	
	km²	MW	km²	MW	km²	MW	km²	MW	km²	MW	km²	MW
CNSW	209	314244	10	15712	145	216771	7	10839	89	133270	4	6664
CQ	329	493704	16	24685	166	248781	8	12439	113	168809	6	8440
CSA	137	205434	7	10272	84	125437	4	6272	6	9343	<1	467
GG	32	47400	2	2370	15	22015	1	1101	5	6978	<1	349
MEL	53	79421	3	3971	16	24566	1	1228	9	13121	<1	656
NNSW	117	175384	6	8769	76	114043	4	5702	36	54225	2	2711
NQ	523	784810	26	39240	235	352304	12	17615	145	217755	7	10888
NSA	34	51628	2	2581	21	30973	1	1549	4	5253	<1	263
SESA	111	166733	6	8337	98	147158	5	7358	26	39214	1	1961
SEV	18	26412	1	1321	8	12207	<1	610	5	7467	<1	373
SNSW	364	545668	18	27283	277	415993	14	20800	151	226828	8	11341
SNW	50	75546	3	3777	29	43972	1	2199	13	19942	1	997
SQ	1202	1803459	60	90173	455	683168	23	34158	249	373285	12	18664
TAS	93	139426	5	6971	65	97311	3	4866	30	45228	2	2261
WNV	100	150705	5	7535	42	62498	2	3125	21	30949	1	1547

4. Recommendations and next steps

The assessment relies on assumptions, particularly given the NEM wide scale of the assessment. These assumptions are appropriate for the purpose of setting a land limit to constrain strategic modelling of generation siting.

While multiple thresholds of land suitability have been calculated, using the limit based on the total area does not appropriately account for factors such as cumulative impact, or all local factors.

For use in the modelling, it is suggested that a more constrained value is used.

Limitations and improvements

During the development of the assessment, some limitations and considerations for future improvements were identified. These include:

Substation

- Distribution Network Service Providers (DNSP) are the custodians of the distribution substation data. This data is not available for use across the NEM. While the analysis to identify Assumed Locations produced a reasonable assumption for the scale of analysis, using the actual locations from the DNSPs would produce a more accurate result.
- Transformer data (used to determine the Assumed Location) was not available for South Australia. An alternative approximation, using population density, was used. This correlated with transformer data in other states, however, presents a difference in method and assumptions.

Solar farms and BESS

- The proximity to demand was used to remove substations that were more isolated in the network. However, the approximation of demand is based on general land use indicators and may not accurately reflect demand on the network.
- The development of land use and approvals criteria relied on planning zones in most states, however, in Queensland this data is held by local governments in inconsistent formats. As such, land use was primarily used. Land use is not as specific as planning zones and result in a less constrained DER land limit MCA. The impact of this was mitigated by assessing the suitable area threshold assessment state by state. However, differences will remain, and acquiring planning zone information for Queensland could improve the accuracy of the result.
- While colocation of DER with compatible land uses were considered as part of the land use and approvals component of the DER land limit MCA, the data to differentiate the capacity to host was not available at a NEM wide scale. Further refinement of the, particularly, commercial scale DER may add additional detail but would require local-scale considerations.

Solar farms

- For solar farms, different buffers are applied across the jurisdictions. Additionally, not all jurisdictions have guidelines. NSW has guidance for State significant solar farms e.g., Large-Scale Solar Energy Guideline, Department of Planning, Housing and Infrastructure, NSW, August 2022, which is conservative. Across the jurisdictions, there are differences in how setbacks are applied, so we have applied the most conservative scale of NSW.
- The setbacks in NSW are related to construction noise (not operational) and are primarily related to the magnitude of visual impact. This is based on the application of setbacks to solar farms, where from an 8km distance, solar farms are not dominant on the landscape.

BESS

- For BESS, there are no guidelines. Generally, the approach for solar farms regarding the visual impact and landscape sensitivity / magnitude of change, has been applied.
- Noise is the considered the primary setback for BESS. Generally, dependent on the adjacent land uses, a setback of 500 metres allows for noise issues to be managed. However, it may vary based on technical solutions adopted.