Australia's National Science Agency

Australian CDR Roadmap – Modelling Appendix

November 2025

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Scope of analysis

The CDR Roadmap aims to build an evidence base on Australia's potential for novel CDR through transparent, objective and proportionate economic analysis. This quantitative analysis has three objectives:

- Estimate Australia's realisable novel CDR capacity based on conservative assumptions on resource availability.
- Estimate what this CDR may cost in the near term and by 2050.
- Identify regions where CDR may be economically viable, recognising further community engagement is required.

To realise these three objectives, a bottom-up analysis has been carried out that assesses the regional availability of resources necessary for different novel CDR approaches. A series of conservative constraints have been applied to estimate this resource availability, as summarised in Table 1. Regional cost inputs have also been used to understand how the cost of CDR may vary with location.

Capacity is defined as the quantity of CDR that could be carried out in single year, based on the applied resource constraints. This is therefore an annual rate rather than a quantity; however, the term capacity is used for simplicity.

Cost is defined as the levelised (or net present) cost per tonne of this CDR.

While this Roadmap estimates Australia's realisable capacity for novel CDR, it does not suggest that all identified capacity should be realised. In practice, global and national climate ambition will dictate the uptake of CDR. At the same time, site-specific and community factors will determine local viability.

The modelling methodology is designed to provide flexibility to analyse and compared additional CDR approaches in the future, and update assumptions as data becomes available.

This appendix summarises the methodology, parameters and underlying assumptions used to produce the estimates presented in this report. The methodology is presented in two parts: first, the CDR approaches that rely on renewable electricity (DAC+S and OAE) are discussed; this is followed by the approaches that require transport of a feedstock from a source location to a destination (BiCR+S and ERW).

For each CDR approach, the model explores two cost scenarios: a first-of-a-kind (FOAK) case representing projects commencing in 2025, and a long-term nth-of-a-kind (NOAK) case representing projects commencing in 2050. For the NOAK case, a range of annual CDR capacity is estimated by region, spanning a lower bound (referred to as the realisable capacity) and a high ambition scenario.

Table 1: Constraints considered in Cost and Capacity Analysis for CDR approaches.

Constraint/Approach	DAC+S	OAE	BiCR+S	ERW
Land available for variable renewable energy (VRE)	Constraint applied to capacity analysis	Constraint applied to capacity analysis		
Regional VRE generation potential	Constraint applied to the capacity analysis and input to the cost analysis	Constraint applied to the capacity analysis and input to the cost analysis		
Location cost factors	Input to the cost analysis	Input to the cost analysis	Input to the cost analysis	
Geological storage availability	Constraint applied to capacity analysis		Constraint applied to capacity analysis	
Proximity to coastline and existing desalination plants		Constraint applied to capacity analysis		
Biomass feedstock availability			Constraint applied to capacity analysis	
Rock feedstock availability				Constraint applied to capacity analysis
Agricultural land availability				Constraint applied to capacity analysis
Feedstock transport costs			Constraint applied to the capacity analysis and input to the cost analysis	Constraint applied to the capacity analysis and input to the cost analysis

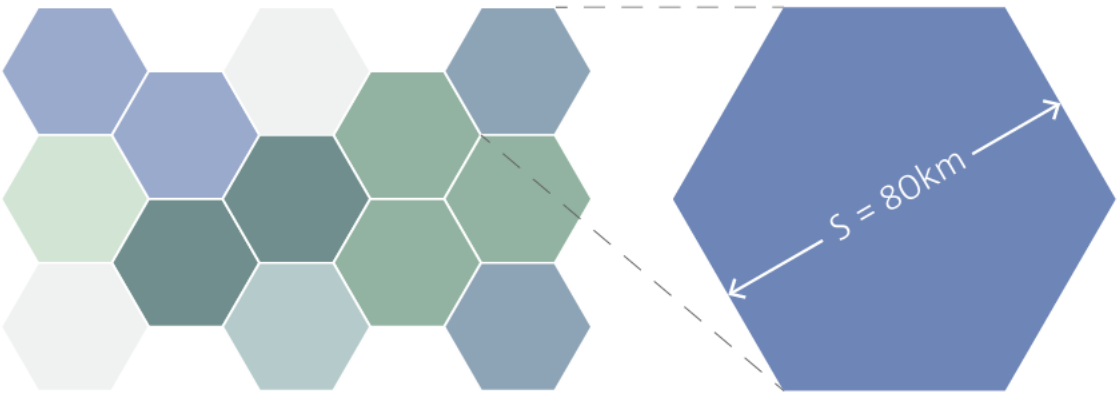
- Constraint applied to the capacity analysis and input to the cost analysis
- Constraint applied to capacity analysis
- Input to the cost analysis

Regional focus

A grid of hexagonal bins (hexbins) has been designed to support the visualisation of CDR capacity and cost across regions. Each hexbin has a short width of 80 km, as shown in Figure 1. This distance is considered an appropriate resolution to capture meaningful regional variation.

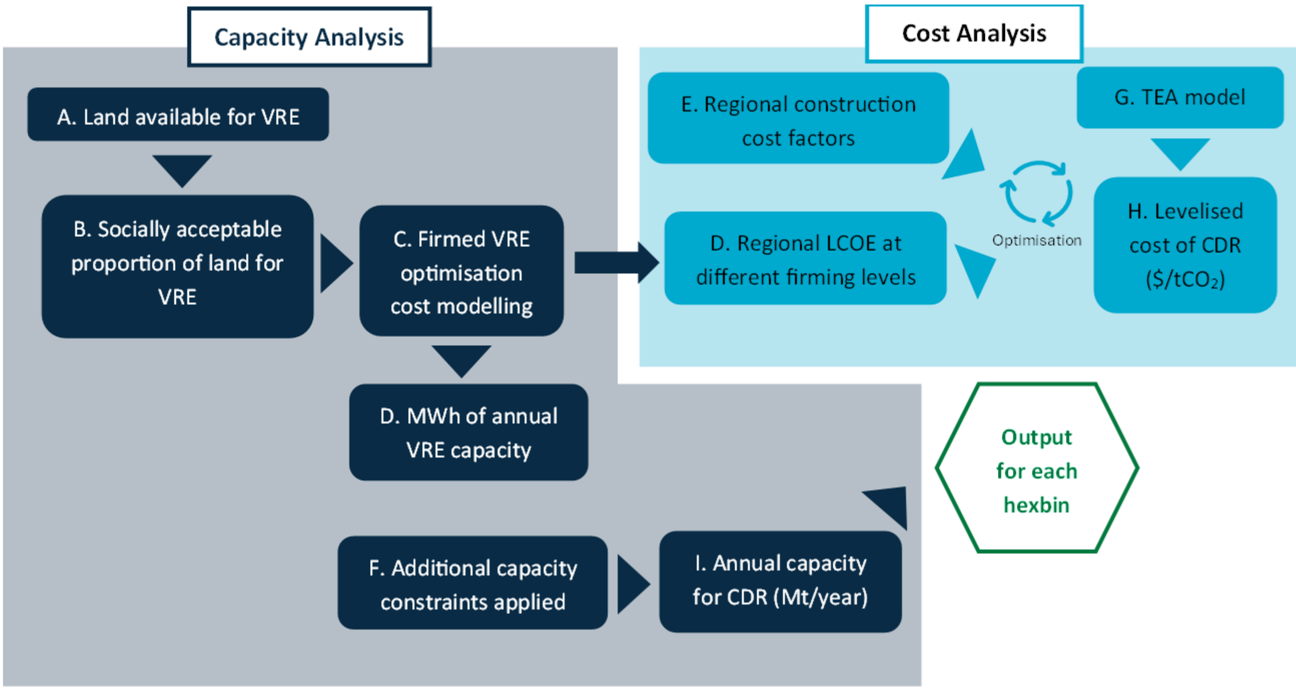
The constraints aligned in Table 1 discussed below are applied at the hexbin level, estimating the realisable capacity for and cost of each CDR approach in each hexbin. National capacity estimates can be calculated by aggregating the capacity of all hexbins.

Figure 1: Hexbin used for spatial resolution in the cost and capacity analysis, with an 80km diagonal distance.



DAC+S and OAE

Figure 2: A series of filters and processing steps have been applied to estimate the capacity and cost of CDR via DAC+S and OAE at a regional level.



The following discussion corresponds to the labelled boxes in Figure 2, and follows the flow of the methodology through this figure.

A. Land available for VRE

Liquid absorbent and solid adsorbent DAC processes require substantial energy for sorbent regeneration, while electrochemical OAE processes demand significant energy to power their electrochemical cells. To ensure net CO_2 removal by these CDR approaches, this energy must be supplied by renewable energy sources. The renewable energy used must be additional to what is currently deployed or planned for decarbonising the electricity grid, to ensure additionality of carbon removal.[1]

Since supplying this energy requires extensive land, the first step to estimate the CDR capacity is to assess the land available for variable renewable energy (VRE) generation in Australia. Constraints are applied to ABARES land use dataset[2], which categorises land use at a 250 m x 250 m pixel resolution. Filters are applied to exclude protected areas, national and state parks, built-up areas, and intensive agricultural land. The process of filtering ABARES Land Use Classification for the VRE capacity analysis is summarised in Table 13 below. Renewable energy zones (REZ), which are areas earmarked for large scale grid-connected renewable energy

[1] It is possible that excess renewable energy from the grid could be used for CDR without violating the principle of additionality, if the only alternative is to spill or curtail this energy. This would require CDR processes with operational flexibility that are economically viable at low plant utilisations.

[2] Land classified as nature conservation, production native forests, plantation forests, irrigated pastures, irrigated cropping, irrigated horticulture, intensive horticulture and animal production, other intensive uses, urban residential, rural residential and farm infrastructure, and mining and waste were excluded, as these areas represent either protected land, national or state parks, built-up areas, or intensive agricultural land. ABARES (Australian Bureau of Agricultural and Resource Economics) (2024) Land use of Australia 2010–11 to 2020–21. Department of Agriculture, Fisheries and Forestry, Canberra. <https://www.agriculture.gov.au/abares/aclump/land-use/land-use-of-australia-2010-11-to-2020-21> (accessed February 2025).

projects, are excluded as they are intended to support grid decarbonisation efforts.[3] Finally, pixels with slopes greater than 5 degrees[4] over more than 50% of their land area are also excluded due to unsuitability for solar installation and contiguous land areas of less than 5 km^2 are excluded to account for the large land requirements of renewable energy technologies as establishing these projects on smaller parcels of land may not be economically viable.[5]

B. Socially acceptable proportion of land for VRE

To reflect the likely socially acceptable extent of renewable energy development, an additional constraint is applied to the remaining land. Up to 1% of the land available for VRE generation is assumed to be used for solar development and up to 5% for wind development.[6] In instances where both solar and wind are selected for use, proportions of the 1% and 5% allocations can be used so that the below expression holds:

$$T \geq \frac{T_s}{0.01} + \frac{T_w}{0.05};$$

where:

T = total land area available

T_S = land area used for solar generation

T_w = land area used for wind generation

Table 2 presents the assumptions used for installation density of solar and wind generation.

Table 2: Assumed installation density of solar and wind generation.

Input	Unit	Value	Source
Solar installation density	kW/km^2	86,487 (0.35 MW/acre)	Reference 7
Wind installation density	kW/km^2	4,300	Reference 8

Figure 27 in the report shows the available land for VRE generation before socially acceptable percentages have been applied. Although DAC and OAE facilities also require land, the area they occupy is negligible compared to the land required for VRE generation to power these systems and is therefore not considered in the analysis.

C. Firmed VRE optimisation cost modelling

The cost of VRE varies across different regions as areas with higher solar and wind capacity factors and greater resource diversity tend to have lower electricity costs. To ensure a reliable and consistent energy supply, the VRE is assumed to be firmed using storage technologies, incurring additional costs. Firmed VRE costs for

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[3] The shapefile representing Renewable Energy Zones (REZ) in Australia was used to exclude REZ areas from the remaining available land. AEMO (Australian Energy Market Operator) (2021) Renewable Energy Zone (REZ) boundaries, 2021. Derived from GIS data available from AEMO. < https://www.arcgis.com/home/item.html?id=b1e8003e917d467c9ff434c556fa8f62> (accessed February 2025).

[4] Geoscience Australia (2011) SRTM-derived 1 Second Digital Elevation Models Version 1.0. Geoscience Australia, Canberra. https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/72759 (accessed February 2025).

[5] Pett-Ridge et al. (2023) Roads to removal: options for carbon dioxide removal in the United States. Lawrence Livermore National Laboratory. <https://www.osti.gov/biblio/2301853>.

[6] The upper land use limits of 5% for wind and 1% for solar within the available land for VRE development were based on AEMO's assumptions regarding maximum land use intensity applied to Renewable Energy Zone (REZ) resources. AEMO (Australian Energy Market Operator) (2023) 2023 Inputs, Assumptions and Scenarios Report. AEMO. <https://www.aemo.com.au/-/media/files/major-publications/isp/2023/2023-inputs-assumptions-and-scenarios-report.pdf>.

[7] Lawrence Berkeley National Laboratory (2022) Land Requirements for Utility-Scale PV: An Empirical Update on Power and Energy Density. <https://eta-publications.lbl.gov/sites/default/files/land_requirements_for_utility-scale_pv.pdf>.

[8] Harrison Atlas D, Lopez A, Lantz E (2022) Dynamic land use implications of rapidly expanding and evolving wind power deployment. Environmental Research Letters 17(4) Article 044064 <https://iopscience.iop.org/article/10.1088/1748-9326/ac5f2c>.

different geographic locations across Australia are modelled by the CSIRO Energy Systems team. Although the data produced is at a finer spatial resolution than that used in this analysis, the results are interpolated to assign a representative firmed VRE cost to each hexbin (see hexbin size above).

The model considers solar and onshore wind generation technologies, with storage provided by battery energy storage systems (BESS). It estimates local capacity factors for both solar and wind at hourly time increments using 30 years of historical weather data.[9] The lowest cost combination of solar, wind and BESS is then determined for a range of firming levels, and the resulting levelised cost of electricity is calculated. Inputs used by the CSIRO Energy Systems team to estimate the generation cost for solar, wind, and the cost of firming from BESS are presented in Table 3 below.

Table 3: Inputs used to estimate firmed VRE costs across Australia.

Input	Unit	2024	2050	Source
Solar PV capital costs	$/kW	1463	647	GenCost 2024-25 Table B.2
Wind turbine capital costs	$/kW	3351	2065	GenCost 2024-25 Table B.2
Battery storage costs (8 hrs)	$/kWh	266	89	AEMO 2025 Table 9-3[10]
Battery inverter costs (8 hrs)[11]	$/kW	471	121	AEMO 2025 Table 9-3[12]
Battery round trip efficiency	%	95.16	95.16	Reference 13
Discount rate	%	5.99	5.99	GenCost 2024-25
Solar PV lifetime	years	30	30	GenCost 2024-25 B.9
Wind turbine lifetime	years	30	30	CSIRO Energy Systems modelling
Battery storage lifetime	years	20	20	GenCost D4.1
Battery inverter lifetime	years	15	15	CSIRO Energy Systems modelling

D. Regional levelised cost of electricity at different levels of firming

Figure 28 in the report presents the variation in electricity costs across each hexbin in Australia following model optimisation across a range of firming levels.

The level of firming determines the proportion of time a DAC+S facility or an OAE facility can operate, referred to as the plant utilisation. The optimal level of firming is subsequently determined through an optimisation process where the technoeconomic model (described later) evaluates the regional cost of electricity at different firming levels and selects the firming level that results in the lowest levelised cost of CDR for each CDR approach.

[9] Historical Data from the Bureau of Meteorology which was hourly and ran from 1990 to 2019 inclusive (30 years) was used. BoM (Bureau of Meteorology) (2022) BARRA2: the Bureau's atmospheric high-resolution regional reanalysis for Australia. <https://www.bom.gov.au/government-and-industry/research-and-development/research-and-development-projects/atmospheric-reanalysis> (accessed January 2025).

[10] Battery storage costs were sourced from AEMO (2025) data on battery systems co-located with large renewable installations, reflecting that an off-grid renewables and battery system would likely be co-located with the CDR facility, thereby reducing grid connection costs. AEMO (Australian Energy Market Operator) (2025) 2024 Energy Technology Cost and Technical Parameter Review, AEMO, Table 9-3, 'co-located with large renewable installation' section <https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2025-iasr-scenarios/final-docs/aurecon-2024-energy-technology-cost-technical-parameter-review-report.pdf>.

[11] For simplicity, the full Balance of Plant (BoP) cost of the battery storage system is assumed to serve as a proxy for the inverter cost. Battery inverter cost, originally expressed in $/kWh, is then converted to $/kW by multiplying it by the storage duration which is 8 hours in this case.

[12] 2050 costs were estimated using the same ratio approach as applied in GenCost 2024–25 (Table B.2) but starting from the 2024 cost estimates for systems co-located with large renewable installations from AEMO (2025), as advised by the GenCost authors. Graham, P., Hayward, J. and Foster J. (2025) GenCost 2024-25: Final report, CSIRO, Australia <https://www.csiro.au/en/research/technology-space/energy/Electricity-transition/GenCost>; AEMO (Australian Energy Market Operator) (2025) 2024 Energy Technology Cost and Technical Parameter Review, AEMO, Table 9-3, 'co-located with large renewable installation' section <https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2025-iasr-scenarios/final-docs/aurecon-2024-energy-technology-cost-technical-parameter-review-report.pdf>.

[13] Battery roundtrip efficiency is calculated as the product of charge and discharge efficiencies. As discharge efficiency is not available, it is assumed to be equal to the charge efficiency. Charge efficiency values are sourced from Table 6 of the source. Safoutin M, Cherry J, McDonald J and Lee S (2015) Effect of Current and SOC on Round-Trip Energy Efficiency of a Lithium-Iron Phosphate (LiFePO4) Battery Pack. AE Technical Paper 2015-01-1186. <https://doi.org/10.4271/2015-01-1186>.

The available land suitable for VRE development is combined with modelled firmed VRE costs to estimate the additional electricity generation potential at various levels of firming. As the analysis assumes no connection to the existing electricity grid, the resulting estimates reflect off-grid VRE deployment, expressed in MWh of energy generated per year.

E. Regional construction cost factors

Project costs can also vary regionally due to a range of factors. To account for these variations, state-based remoteness cost factors are sourced from an AEMO/GHD report and combined with the ABS Remoteness Area classifications to adjust baseline cost estimates into region-specific values (Figure 29 in the report).[14] They capture factors such as transportation costs, labour rates and availability as well as the increased cost of working in remote regions due to the lack of supporting industries and infrastructure. The resulting regional cost multipliers are then applied to the capital cost of each CDR approach and the levelised cost of VRE. These adjusted capital costs are then incorporated into the optimisation model to inform the selection of the optimal firming level discussed above.

F. Additional constraints

Geological Storage

Co-locating DAC+S facilities with geological storage sites significantly reduces CO_2 transportation costs. In the realisable capacity analysis, only hexes that are within 100km[15] of geological storage sites that are either currently operational for CCS projects or have been proven and are developed to a stage nearing commercial viability (subject to geological assessment criteria, see Section 5 in the report) are considered for DAC+S deployment. A high ambition scenario has also been developed, including additional storage locations that have a lower level of classification. As noted in the Roadmap, development of this scenario leveraged Geoscience Australia and CSIRO expertise and should not be directly compared to the realisable capacity estimate, given the geological storage is prospective only.

Proximity to the coast

Proximity to the coast is a key consideration, as OAE systems will naturally be co-located with the required seawater feedstock.[16] Hexbins located along the coastline are therefore filtered to estimate the potential capacity for OAE in Australia. Marine protected areas are currently included in the analysis, with further research needed to understand the impact of OAE facilities on marine ecosystems.

Proximity to desalination plants

For first-of-a-kind (FOAK) OAE facilities, an additional constraint is applied by assuming co-location with existing desalination plants (within 100km). This reflects a near-term deployment strategy that leverages existing infrastructure to reduce capital costs and implementation barriers. This constraint is not applied to NOAK OAE facilities.

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[14] AEMO (Australian Energy Market Operator) (2018) AEMO costs and technical parameter review Report Final Rev 4, AEMO, Table 72 <https://www.aemo.com.au/news/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/9110715-REP-A-Cost-and-Technical-Parameter-Review---Rev-4-Final.pdf>;ABS (Australian Bureau of Statistics) (2023) Australian Statistical Geography Standard (ASGS) Edition 3 <https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/remoteness-structure/remoteness-areas> (accessed February 2025).

[15] Measured from centroid of storage polygon to centroid of hex.

[16] Norton H, Todd D, Crawford C (2024) Storage capacity estimates and site conditions of potential locations for offshore-wind powered carbon dioxide removal and carbon sequestration in ocean basalt. Carbon Capture Science & Technology, 13 Article 100231 <https://doi.org/10.1016/j.ccst.2024.100231>.

G. TEA model

The techno-economic analysis estimates the cost of CO_2 removal in Australia across a range of CDR approaches. The levelised cost of capture and storage (LCOCS) in \$/tonne CO_2 is calculated and key cost drivers are identified. LCOCS measures the present value of all costs incurred over the life of the asset divided by the present value of the CO_2 removed over the life of the asset. These costs include capital expenditure and associated financing costs, electricity to power the CDR system, and fixed and variable operating costs. As outlined above, capital and electricity costs vary by location due to regional differences in firmed VRE prices and construction costs.

Unless stated otherwise, the following general assumptions and calculations are used across technologies in the LCOCS analysis:

Capital costs

- A construction mask is applied to capital costs to reflect a multi-year build period. The duration of the construction period varies by CDR approach and is detailed in the inputs and assumptions tables. Capital expenditure is distributed over this period rather than being incurred as a single upfront investment. The annual capital expenditure in year t, denoted by $CAPEX_t$ for $t = 1, 2, .., Y$ (the construction period in years), is calculated as:

  $$CAPEX_t = m_{cons,t} \, PEC[1 + \%PCC + \%ICC]$$

  where PEC is the purchased equipment cost, $\%PCC$ is the direct capital cost multiplier, $\%ICC$ is the indirect capital cost multiplier, and $m_{cons,t}$ is the construction mask fraction allocated to year t, with $\sum_{t=1}^{Y} m_{cons,t} = 1$.

- The model assumes that capital costs are financed through a loan rather than paid upfront. During the construction period, interest is accrued annually on cumulative capital outlays, and a real deflator is applied each year to express capital costs in real terms (see Figure 3). For example, the total cumulative outlay, denoted by K, over a three-year construction period would be calculated as:

  $$K = d_1 \times CAPEX_1 \times (1 + r)^2 + d_2 \times CAPEX_2 \times (1 + r)^1 + d_3 \times CAPEX_3$$

  where r is the loan interest rate and d_t is the real deflator applied in a given year t, normalised to the base year (2024).

  The total capital outlay is then converted into a loan repayment series based on the specified loan term and interest rate. For FOAK projects, the loan term is 10 years with an interest rate of 10%, while for NOAK projects the loan term is 20 years with an interest rate of 5%. Loan repayments, which comprise both principal and interest components, commence in the first year of operation and continue for the duration of the loan, denoted by N, as detailed in the input and assumptions table for each approach. The annual loan repayment, denoted by A, is calculated as:

  $$A = \frac{r \times K}{1 - (1 + r)^{-N}}$$

  where r is the loan real interest rate.

Operating costs

- Operating costs consist of both fixed and variable components. Variable operating costs scale with utilisation and production ramp-up, whereas fixed operating costs remain constant regardless of plant output.

  For variable operating costs, a production mask is applied to operating costs to reflect a gradual ramp-up period, accounting for commissioning, performance testing, and initial operational constraints typically observed in new plants. A real deflator is applied annually to express operating costs in real terms (see Figure 3). The annual variable operating cost of item i in given year t is denoted by $OPEX_{i,t}$, for $t = 1, 2, .., L$ (the plant lifetime), is calculated as:

  $$OPEX_{i,t} = d_t \times C_i \times Q_{plant} \times u \times m_{prod,t}$$

  where d_t is the real deflator (CPI) in a given year t, normalised to the base year 2024 , C_i is the unit operating cost, Q_{plant} is the annual plant output at full capacity (the nameplate capacity), u is the annual utilisation factor, $m_{prod,t}$ is the production mask reflecting ramp-up and operational constraints in the model. CDR approaches that require dedicated facilities (i.e. DAC+S, BiCR+S and OAE) are assumed to reach full output after two years of operation.

  An example of a variable operating cost component is electricity. Its annual operating cost is calculated as:

  $$OPEX_{elec,t} = d_t \times C_{elec} \times Q_{plant} \times u \times m_{prod,t}$$

  An example of a fixed operating cost is maintenance. It is calculated each year as a fixed percentage (denoted byC_{maint}) of purchased equipment cost (PEC), adjusted by the real deflator d_t. The annual maintenance cost in given year t is denoted by $OPEX_{maint,t}$ for $t = 1, 2, .., L$ (the plant lifetime), is calculated as:

  $$OPEX_{maint,t} = d_t \times C_{maint} \times PEC$$

Utilisation

- The annual production also depends on the utilisation factor, and the production mask is applied to the full-capacity output to reflect a gradual ramp-up period. The projected total quantity of carbon dioxide removed each year, denoted by Q_t, for $t = 1, 2, .., L$ (the plant lifetime) is calculated as:

  $$Q_t = Q_{plant} \times u \times m_{prod}(t)$$

Present value

- All costs are discounted to present value. Loan repayments are discounted over the loan term, operating costs, and the annual quantity of CO_2 removed are discounted over the plant lifetime. The present value of costs is then calculated by adding the present value of repayments and the present value of operating costs as follows:

  $$PV_{cost} = PV_{repayments} + PV_{opex}$$

$$NPV = \sum_{t=1}^{N} \frac{A}{(1+d)^{t+y}} + \sum_{t=1}^{L} \frac{OPEX_t}{(1+d)^{t+y}}$$

where A is the annual repayment, N the loan term, $OPEX_t$ is the total annual operating cost, L is the plant lifetime, y is the construction period and d is the discount rate.

The LCOCS is then calculated by dividing the present value of costs by the present value of production:

$$LCOP = \frac{PV_{cost}}{PV_{prod}}$$

where:

$$PV_{prod} = \sum_{t=1}^{L} \frac{Q_t}{(1+d)^t}$$

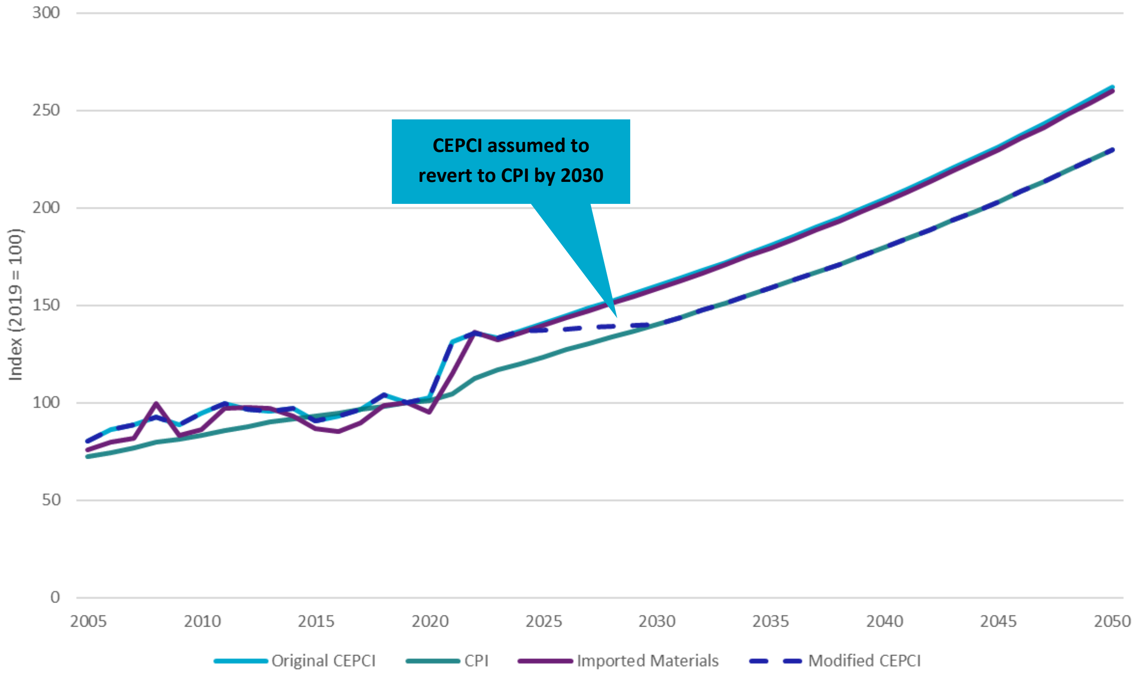
Indexation

- All capital costs and capital-related expenses such as capital maintenance are indexed using the Chemical Engineering Plant Cost Index© (CEPCI), while operational costs are indexed using the Consumer Price Index (CPI).
- Input costs are first indexed to a common price year (2024) using a nominal deflator series illustrated in Figure 3.
- The forecast real price change between this price year and the future year in which the cost will be incurred is then applied using a real price index. CPI is taken to be the real deflator that adjusts nominal indices to real indices.
- Figure 3 illustrates the assumed nominal price indices used in the cost analysis. A significant inflation in the CEPCI can be observed between 2020 and 2023. This rate of inflation is correlated with the ABS Imported Materials Producer Price Index. To avoid overstating future cost escalation, it is assumed that the CEPCI will not continue to escalate from this peak. Instead, the CEPCI is adjusted to revert to the Consumer Price Index (CPI) trend by 2030 as shown by the dashed blue line in Figure 3, consistent with the approach used in the CSIRO GenCost report.[17]
- A long-term nominal inflation rate of 2.5% is assumed for CPI-indexed costs, consistent with the Reserve Bank of Australia's (RBA) target range of 2–3%.[18]

[17] Graham, P., Hayward, J., Foster J. (2023) GenCost 2023-24: Consultation draft, CSIRO, Australia.

[18] RBA (Reserve Bank of Australia) (2025) Australia’s Inflation Target. <https://www.rba.gov.au/education/resources/explainers/australias-inflation-target.html#:~:text=Australia%27s%20inflation%20target%20is%20to%20keep%20annual%20consumer,percentage%20change%20in%20the%20Consumer%20Price%20Index%20%28CPI%29> (accessed July 2025).

Figure 3: Nominal price indices and their pre-covid trends.[19]



- The results, along with the inputs and assumptions listed in the table below, are reported in 2024 AUD.

LCA adjustment

- Each CDR approach will result in some amount of CO_2 emissions over its life cycle either during design, construction, or operation. These emissions must be accounted for when determining the net quantity of carbon removal and the levelised cost of net removal. An LCA adjustment factor is used to account for these emissions at a high level. This factor represents the number of tonnes of gross CO_2 removals required to achieve one tonne of net removals. Approaches that emit a large amount of CO_2 over their lifecycle will have a higher LCA adjustment factor.
  The LCA adjustment factor is applied to the gross levelised cost of CDR to determine the net levelised cost of CDR.

The technoeconomic model described above applies to all approaches considered including DAC+S, OAE, BiCR+S, and ERW, with some modifications specific to ERW discussed later in section F and G of ERW.

The inputs and assumptions underpinning the technoeconomic model described above are summarised in the table below.

Table 4 outlines those for solid adsorbent DAC+S, Table 5 for liquid absorbent DAC+S, and Table 6 for OAE. In the BiCR+S and ERW section, Table 10 outlines the assumptions for BiCR+S and Table 12 outlines those for ERW.

[19] CEPCI data between 2005 and 2024 sourced from: Chemical Engineering (2025) The Chemical Engineering Plant Cost Index©. < https://www.chemengonline.com/pci-home> (accessed June 2025). Other indices sourced from: ABS (Australian Bureau of Statistics) (2025) Price indexes and inflation. <https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation (accessed June 2025).

Table 4: Inputs and assumptions for solid adsorbent DAC+S.

Input	Unit	FOAK	NOAK	Source
Currency	$	AUD	AUD	
Price Year	year	2024	2024	
Plant lifetime	years	10	25	Reference 20
Nameplate capacity	$MtCO_2$/year	1	1	Reference 20
Annual utilisation	%	90*	90*	CSIRO assumption
Total capital costs (TCC)	$m	2280*	1260*	Calculated from 20
Cost of capital	%	10	5	CSIRO assumption
Construction period	years	4	4	Reference 20
LCA adjustment factor	#	1.08	1.04	Calculated from 20
Maintenance	% of CAPEX	3	3	Reference 20
Adsorbent consumption	kg/t CO_2	7.5	3	Reference 20
Electricity Required	MWh/t CO_2	1.82	1.01	Reference 20
Water required	kL/t CO_2	1.6	1.6	Reference 20
Adsorbent price	$/kg	43.2	43.2	Calculated from 20
Electricity Price	$/MWh	128*	97.3*	Reference 21
Water price	$/kL	1.86	1.86	CSIRO assumption
CO_2 Transport	$/t CO_2	16.6	16.6	Reference 20
CO_2 Storage	$/t CO_2	28.7	28.7	Reference 20

***This input is varied in the regional analysis, with the value shown in the table representing the default assumption.**

[20] IEAGHG (2021) Global assessment of direct air capture costs Technical Report 2021-05, December 2021. IEAGHG, UK. <https://publications.ieaghg.org/technicalreports/2021-05%20Global%20Assessment%20of%20Direct%20Air%20Capture%20Costs.pdf>.

[21] STABLE is an 'intermediate horizon' model used to estimate the optimised investment profile and operation to achieve reliability and security in Australia's National Electricity Market (NEM) and other interconnected systems.

Table 5: Inputs and assumptions for liquid absorbent DAC+S.

Input	Unit	FOAK	NOAK	Source
Currency	$	AUD	AUD	
Price Year	Year	2024	2024	
Lifetime	Years	10	25	CSIRO assumption
Nameplate capacity	$MtCO_2$/year	1	1	Reference 20
Annual utilisation	%	90*	90*	CSIRO assumption
Total capital costs (TCC)	$m	2420*	1310*	Calculated from 20
Cost of capital	%	10	5	CSIRO assumption
Construction period	Years	4	4	Reference 20
LCA adjustment factor	#	1.2	1.06	Calculated from 20
Maintenance	% of CAPEX	3	3	Calculated from 20
Natural gas required	GJ/t CO_2	6.8	0	Reference 20
Electricity required	MWh/t CO_2	0.82	2.25	Reference 20
Water required	kL/t CO_2	3	1.5	Reference 20
Natural gas price	$/GJ	14.7	13.2	Reference 22
Electricity Price	$/MWh	128*	97.3*	Reference 23
Water price	$/kL	1.86	1.86	CSIRO assumption
CO_2 Transport	$/t CO_2	16.6	16.6	Reference 20
CO_2 Storage	$/t CO_2	28.7	28.7	Reference 20

***This input is varied in the regional analysis, with the value shown in the table representing the default assumption.**

[22] Natural gas price derived from AEMO's 2024 ISP Inputs and Assumptions Workbook as the average gas price in the Step Change scenario for new CCGT and OCGT generating stations: AEMO (2024) 2024 Integrated System Plan (ISP): Current Inputs, Assumptions and Scenarios. AEMO <https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios>.

[23] STABLE is an 'intermediate horizon' model used to estimate the optimised investment profile and operation to achieve reliability and security in Australia's National Electricity Market (NEM) and other interconnected systems.

Table 6: Inputs and assumptions for OAE and OAE-S.

Input	Unit	OAE FOAK	OAE NOAK	OAE-S NOAK	Source
Currency	$	AUD	AUD	AUD	
Price Year	Year	2024	2024	2024	
Plant lifetime	Years	20	30	30	Consultation[24]
Nameplate capacity	$MtCO_2$/year	0.1	1	1	Consultation
Annual utilisation	%	90*	90*	90*	CSIRO assumption
Electrolyser unit cost	$/kW	4550	758	758	Consultation
Other major equipment	$m	31	50	50	Consultation
Civil costs (intake and outfall)	$\$/m^3$/year	-	-	3.77	Reference 25
Plant contingency[26]	%ICC	30	30	30	CSIRO assumption
Indirect capital costs (ICC)	%ICC	30	30	30	Consultation
Total capital costs (TCC)	$m	194*	323*	1090*	Consultation
Cost of capital	%	10	5	5	CSIRO assumption
Construction period	Years	3	3	3	Consultation
LCA adjustment factor (embedded emissions)	#	1.08	1.04	1.04	Reference 24
Maintenance	% of CAPEX	3	3	3	Consultation
Electricity required	MWh/t CO_2	2.3	1.7	1.7	Reference 27
Alkaline minerals required (for acid neutralisation)	kg/t CO_2	1500	1500	1500	Consultation
Hydrogen produced	kg/t CO_2	29	29	29	Reference 28
Electricity price	$/MWh	128*	97.3*	97.3*	Reference 29
Minerals price	$/kg	0.04	0.04	0.04	Reference 30
Hydrogen price	$/kg	7.69	3.43	3.43	CSIRO assumption

*This input is varied in the regional analysis, with the value shown in the table representing the default assumption.

[24] Stakeholder Consultation – refer to list of stakeholders consulted in CDR Roadmap.

[25] The initial investment costs for various desalination plants in Australia are sourced from the Australian Water Association Desalination Fact Sheet. The modelled civil costs for the OAE NOAK standalone plant were assumed to represent 14% of the average total capital costs of existing Australian desalination plants. This assumption reflects the exclusion of complex diffuser systems, with civil works limited to seawater intake, pretreatment, and outfall infrastructure which aggregates to 14% as per the Capital Cost Elements In the Desalination report. Australian Water Association (n.d.) Desalination Fact Sheet. <https://f.hubspotusercontent30.net/hubfs/14568786/Fact%20Sheets/Desalination_Fact_Sheet.pdf> (accessed July 2024); SWCC (Saline Water Conversion Corporation) (2023) Capital Cost Elements In the Desalination. <https://www.swcc.gov.sa/uploads/Capital-Cost-Elements-Report2023.pdf>.

[26] Plant contingency applies to all equipment but does not apply to civil costs.

[27] La Plante EC, Simonetti DA, Wang J, Al-Tuki A, Chen X, Jassby D, Sant GN (2021) Saline water-based mineralization pathway for gigatonne-scale CO_2 management. ACS Sustainable Chemistry & Engineering 9(3), 1073-[endpage]. <https://pubs.acs.org/doi/10.1021/acssuschemeng.0c08561>.

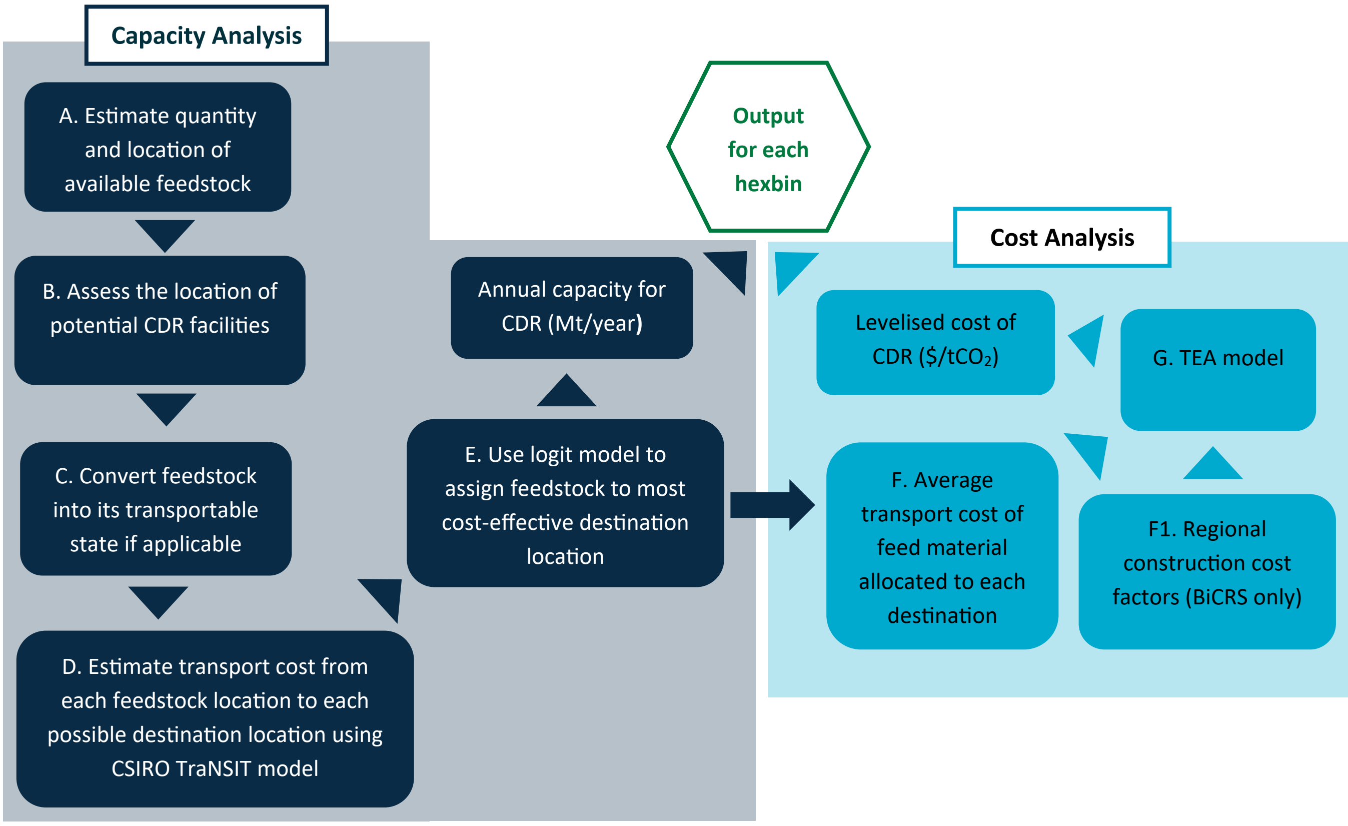
[28] La Plante EC, Simonetti DA, Wang J, Al-Tuki A, Chen X, Jassby D, Sant GN (2021) Saline water-based mineralization pathway for gigatonne-scale CO_2 management. ACS Sustainable Chemistry & Engineering 9(3), 1073-[endpage]. <https://pubs.acs.org/doi/10.1021/acssuschemeng.0c08561>.

[29] STABLE is an 'intermediate horizon' model used to estimate the optimised investment profile and operation to achieve reliability and security in Australia's National Electricity Market (NEM) and other interconnected systems.

[30] Based on ERW modelling.

BiCR+S and ERW

Figure 4: A series of filers and processing steps have been applied to estimate the capacity and cost of CDR via BiCR+S and ERW at a regional level.



The following discussion corresponds to the labelled boxes in Figure 4, and follows the flow of the methodology through this figure. The approach is repeated first for BiCR+S and then for ERW, given the different feedstocks used by these approaches.

BiCR+S

A. Estimate quantity and location of available feedstock

Existing analysis of the annual availability of biomass for bioenergy use forms the basis for estimates of biomass that could be directed toward the BiCR+S approaches in 2050.[31] The types of biomass feedstocks considered are summarised below, along with a brief description of the approach used in the existing analysis:

1. **Agricultural biomass** considered in this analysis includes crop stubbles, grasses, and bagasse.
   a. **Crop stubble** refers to broadacre crop residues that remain after harvest. Given the large interannual variability in crop yields and thus, stubble production, an average over 1996 - 2005 data is assumed to provide a representative estimate of stubble production.
   b. **Grass** biomass refers to native and introduced grasses and forbs from pasture and grazing lands in Australia. The analysis assumes that a portion of the grasses must be retained on the field to maintain soil cover and that harvesting occurs only where economically viable i.e. in areas with low tree density and gentle slopes.

[31] Crawford DF, O'Connor MH, Jovanovic T, Herr A, Raison RJ, O'Connell DA, Baynes T (2016) A spatial assessment of potential biomass for bioenergy in Australia in 2010, and possible expansion by 2030 and 2050. GCB Bioenergy 8, 707-722. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcbb.12295>.

c. **Bagasse** refers to the residue remaining after the crushing of wet cane and extraction of sugar. To estimate the amount available, wet cane yields are adjusted for sugar extraction and moisture content, with dry bagasse assumed to be approximately 15% of the wet cane weight. It is assumed that 100% of this dry bagasse would be potentially available for bioenergy.

2. **Forest residues** refer to pulp logs, in-field woody harvest residues (including woody stems and large branches) and wood processing residues (mainly sawmill residues) from plantation forests. As wood flow estimates can vary over time, a five-year average was used for each reporting period (e.g. the 2010–2014 average represents the 2010 period). A portion of woody residues is assumed to be retained on-site for environmental purposes.
3. **Waste** refers to organic components of municipal solid waste (MSW) including food waste, garden waste, paper and cardboard primarily collected from households and councils through kerbside collection and recycling. National-level data are currently available for Australia, and to account for variation in MSW generation over time, waste volumes are assumed to correlate with population size.
4. **Biomass from short rotation trees (SRTs)** refer to purpose-grown new woody plantings integrated with traditional agriculture, typically harvested on a five-year rotation for use in bioenergy production. As such plantings do not currently exist at scale, scenario modelling was used to estimate potential SRT availability in 2030 and 2050. The scenario assumes that 5% of land currently used for dryland cropping or planted pastures would be used for these trees by 2030, increasing to 10% by 2050.

Several filters are applied by the prior work to account for constraints when harvesting the biomass or diverting it from known uses including:

- **Biomass available for harvest**: Constraints are applied to account for the economic and logistical challenges associated with harvesting and transporting certain biomass types due to their low spatial density, such as stubble or grasses. Environmental constraints included the need to retain a portion of crop residues on the field to protect soil health.
- **Potentially available for diversion:** For biomass already harvested and consumed in existing markets, a portion is assumed to be available for diversion based on their current use, type and potential reallocation.[32]

Baseline estimates of available biomass are made for 2010. For most biomass sources, availability is assumed to remain constant through to 2050, except for biomass from waste and SRT. For waste biomass, future availability is scaled using projected population estimates at the SLA level. For SRT, it is assumed that 5% of cleared farmland would consist of new plantings of SRT (~2.4 Mha) by 2030, with the area extended to 10% (~4.8 Mha) by 2050.[33]

The available biomass estimates are considered to be wet mass, prior to drying. This is a conservative approach that results in a lower mass of dry biomass for use in a BiCR+S process. It is noted that some, but not all, biomass estimates in the source material are provided as dry mass.

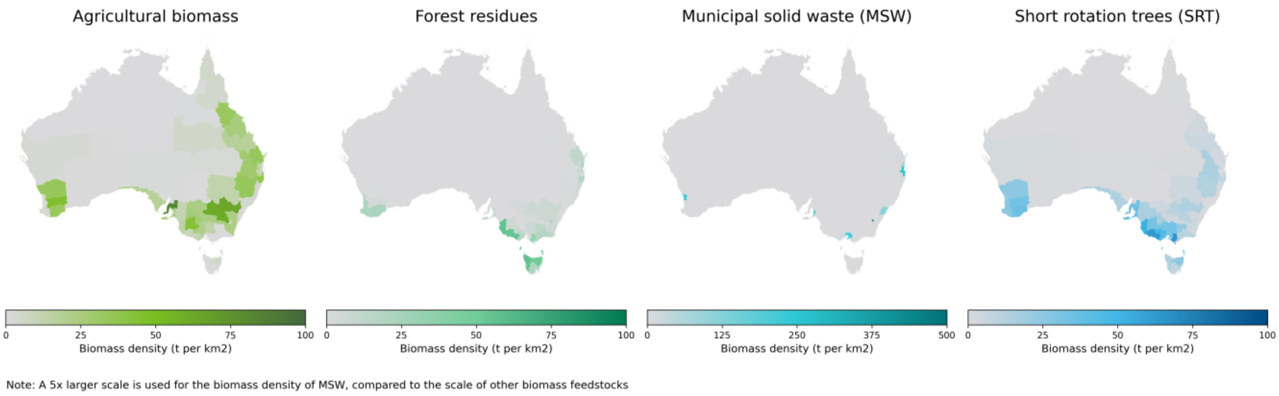
It has been assumed that all available biomass can be allocated to BiCR+S processes, rather than alternative. This results in capacity estimates that reflect the full potential for CDR via BiCR+S, however it is noted that

[32] Crawford DF, O'Connor MH, Jovanovic T, Herr A, Raison RJ, O'Connell DA, Baynes T (2016) A spatial assessment of potential biomass for bioenergy in Australia in 2010, and possible expansion by 2030 and 2050. GCB Bioenergy 8, 707-722. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcbb.12295>.

[33] Crawford DF, O'Connor MH, Jovanovic T, Herr A, Raison RJ, O'Connell DA, Baynes T (2016) A spatial assessment of potential biomass for bioenergy in Australia in 2010, and possible expansion by 2030 and 2050. GCB Bioenergy 8, 707-722. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcbb.12295>.

other competing uses for this biomass may mean that not all of this capacity is realised. The capacity and cost estimates produced in this roadmap can be used to compare the cost effectiveness of biomass used as a BiCR+S feedstock against other potential uses.

Figure 5: Projected density of four types of biomass considered for BiCR+S approaches by 2050, based on the Australian Bureau of Statistics's (ABS) Statistical Areas Level 2.[34]



Note: The source for biomass availability presents results by ABS Statistical Division (SD). This aggregation reduces the accuracy of regional feedstock estimates, particularly for large SDs. Improving the resolution of regional biomass availability through further research should be prioritised.

B. Assess the location of potential BiCR+S facility sites

To simplify the analysis, it is assumed that only the biomass feedstock is transported to the BiCR+S facility over long distances, while transport distances for captured CO_2 are minimised. The BiCR+S facilities are thus assumed to be located within 100 km of near commercial geological storage sites, in a similar approach to the DAC+S cost and capacity analysis.[35] Under this assumption, most of the transport costs are attributed to biomass logistics, while the CO_2 transport costs are minimised. In reality, a combination of biomass and CO_2 transport may occur.

As not all biomass feedstocks are suitable for use by the BiCR processes considered, the biomass feedstock are assessed for compatibility with each BiCR process based on a defined set of eligibility criteria. The two BiCR+S approaches considered in this report are fast pyrolysis to H_2 and combustion to energy. The results of the feedstock compatibility assessment are summarised in Table 7 below.[36]

Table 7: Constraints on feedstock suitability for each BiCR+S approach.

Feedstock/Approach	Fast Pyrolysis	Combustion
Crop Stubble	✓	✓
Grasses	✓	✓
Plantation forests	✓	✓
Native forests	✓	✓
Bagasse	✓	✓
Waste	–	✓
SRT	✓	✓

[34] Crawford DF, O'Connor MH, Jovanovic T, Herr A, Raison RJ, O'Connell DA, Baynes T (2016) A spatial assessment of potential biomass for bioenergy in Australia in 2010, and possible expansion by 2030 and 2050. GCB Bioenergy 8, 707-722. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcbb.12295>.
[35] Refer to DAC+S and OAE section of this methodology for more details on geological sites data used.
[36] Eligibility criteria were determined based on the Roads to removal study, which assessed similar biomass feedstocks. Pett-Ridge et al. (2023) Roads to removal: options for carbon dioxide removal in the United States, Chapter 6. Lawrence Livermore National Laboratory. <https://www.osti.gov/biblio/2301853>.

C. Convert feedstocks into a transportable state

Biomass is modelled to be transported in its wet form, with drying and preprocessing occurring at the BiCR+S facility.

The carbon removal potential of this wet biomass is calculated using proximate and ultimate analysis data for the different biomass types.[37] The proximate analysis quantifies the amount of moisture (M), volatile matter (VM), ash, and fixed carbon (FC) is present in the biomass on a mass percentage basis, while the ultimate analysis determines the elemental composition of the biomass including carbon (C), hydrogen (H), nitrogen (N), sulfur (S) and oxygen (O). This data is summarised in Table 8 below.

The carbon removal potential of dry biomass is first estimated by converting the carbon content of the biomass into an equivalent mass of CO_2, based on the molecular relationship between carbon and CO_2, using the following formula:

$$CDR\ potential\ = \frac{C\ (\%)}{M_C} \times M_{CO_2}$$

For example, assuming a molar mass of CO_2 of 44.01 g/mol and a molar mass of carbon of 12.01 g/mol, the CDR potential of biomass derived from crop stubble is estimated to be 1.48 tonnes of CO_2 per tonne of dry biomass.

The CDR potential per tonne of dry biomass is then converted into the amount of wet biomass required to capture one tonne of CO_2 using the following formula:

$$Wet\ biomass\ required\ to\ capture\ one\ tonne\ of\ CO2 = \frac{1}{\%\ of\ CO_2\ captured\ \times CDR\ potential\ \times (1 - Moisture\ content)}$$

For example, assuming a carbon capture efficiency of 90%, the amount of wet biomass required to capture one tonne of CO_2 for crop stubble biomass is estimated to be 0.79 tonnes.[38] This calculation is applied to all biomass feedstocks and BiCR+S processes.

Table 8: Proximate and ultimate analyses of typical biomass feedstocks.

		Proximate analysis (%)				Ultimate analysis (%)					
Bio feed-stock	**Bulk Density**	**M**	**VM**	**ASH**	**FC**	**C**	**H**	**N**	**S**	**O**	**CDR Potential (dry feedstock)**
Crop stubble	250	4.38	68.52	12.91	14.2	40.36	5.95	0.55	0.27	52.87	1.48
Grasses	250	4.38	68.52	12.91	14.2	40.36	5.95	0.55	0.27	52.87	1.48
Plantation forest	225	22.2	59.75	1.01	17.04	49.7	5.9	0.15	0.03	42.9	1.82
Bagasse[39]	250	46	41.77	6.69	5.54	45.45	5.26	0.23	0.05	36.65	1.67
Waste	290	26	17.21	1.02	0.28	49.7	5.9	1.86	0	39.3	1.82
SRT	250	27.59	47.81	2.61	21.98	48.4	6.3	0.1	0	45.2	1.77

[37] Proximate and ultimate analysis data for all biomass types were sourced from the *Future Fuels CRC* report, except for the short-rotation tree (SRT), for which data were obtained from the second source listed below. Smart S, Ashman P, Scholes C, Tabatabaei M, Hosseini T, Yee R, McConnachie M, Sheil A, Jackson T, Beiraghi J (2023) Technoeconomic Modelling of Future Fuel Production Pathways: Summary Report, Table 8.10. Future Fuels CRC, RP1.2-02, The University of Queensland, The University of Adelaide, The University of Melbourne, Australia. <https://www.futurefuelscrc.com/wp-content/uploads/FFCRC_RP1.2-02_SummaryReport_Open-access.pdf>; Garcia-Perez M, Wang XS, Shen J, Rhodes MJ, Tian F, Lee WJ, Wu H, Li C-Z (2008) Fast pyrolysis of oil mallee woody biomass: Effect of temperature on the yield and quality of pyrolysis products. Industrial & Engineering Chemistry Research 47(6), 1846-1854. <https://doi.org/10.1021/ie071497p>.

[38] The amount of dry biomass required to remove one tonne of CO_2 would be less than this, as it would contain a lower % of moisture.

[39] Note: Ultimate analysis does not add to 100% in source. Carbon content is assumed to be correct.

D. Estimate transport costs via the TraNSIT model

Data from CSIRO's TraNSIT model is used to estimate transport costs between sources of feedstock materials to locations where CDR (via either BiCR+S or ERW approaches) could take place. TraNSIT is a modelling tool that performs mass optimal routing of vehicle movements between thousands of enterprises. For each origin/destination enterprise pair, the model selects the least-cost travel path as well as the optimal vehicle configuration, allowing for road access and conditions, driver fatigue regulations and vehicle decoupling costs.[40]

A cost matrix extracted from the TraNSIT model is used to estimate transport costs for feedstock materials. The matrix contains modelled transport cost data between each grid point to all other locations in the same grid. The cost matrix is based on A-Double (shown in Figure 6 movements along Australia's road network and account for vehicle maintenance costs, fixed costs (including registration fees, insurance, permits), fuel cost, driver cost as well as capital costs and depreciation.[41]

Figure 6: Representative A-Double vehicle.[42]

The TraNSIT cost matrix is first interpolated to match the hex structure used in the capacity analysis. An example of the resulting dataset is shown in Figure 7, in this case showing A-Double travel distance.

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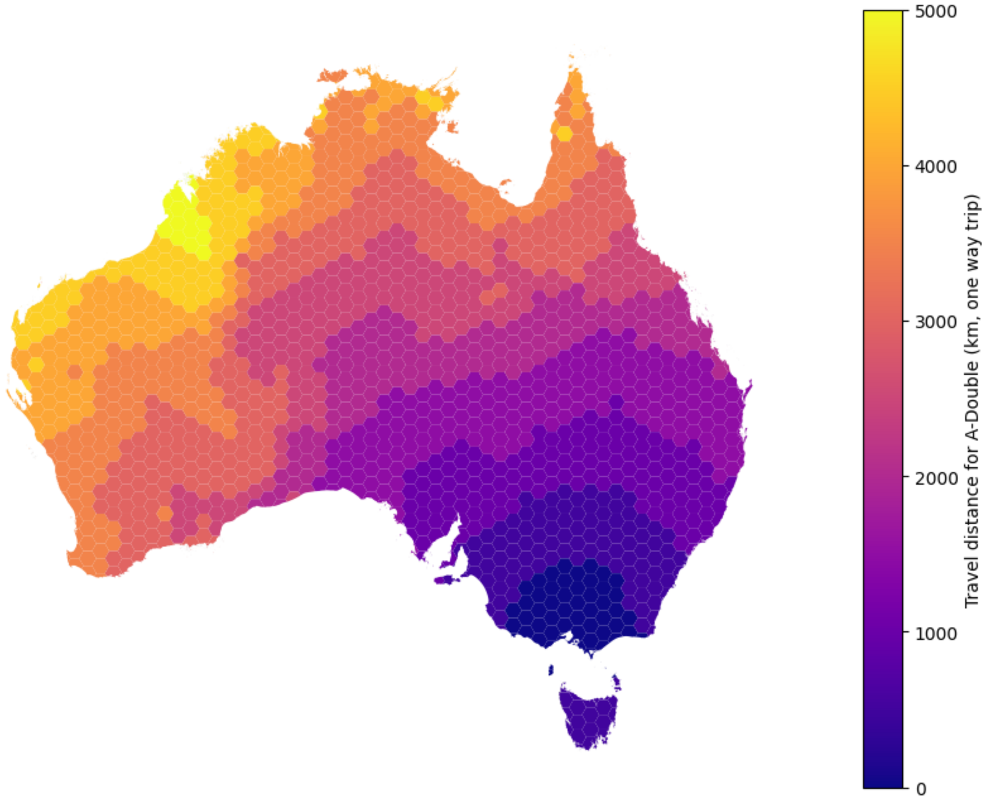
[40] CSIRO (n.d.) Transport logistics-TraNSIT. <https://www.csiro.au/en/research/technology-space/it/Transport-logistics-TRANSIT> (accessed July 2025).

[41] CSIRO (2021) User Guide – Supply Chain Benchmarking Dashboard, page 19. CSIRO. <https://transit.csiro.au/docs/user_guide_dashboard.pdf> (accessed July 2025).

[42] Figure is sourced from NVHR (National Heavy Vehicle Regulator) (2017) Common Heavy Freight Vehicle Combinations. NHVR, Australia. <https://www.nhvr.gov.au/files/201707-0577-common-heavy-freight-vehicles-combinations.pdf> (accessed July 2025).

Figure 7: Example distance matrix output for origin = Melbourne.



E. Assign feedstock to destination locations

A logit model with an agent-based formulation is used to model the allocation of feedstock to different CDR destination hexes. A logit model is a choice model that uses probabilistic approaches to evaluate preferences for different alternatives. They are often used in transport modelling to predict mode selection, route choice or destination choice.[43]

First, the total amount of feedstock available annually in each hex is converted into an annual number of truckloads, using the feedstock bulk density, and truck capacity. Each truckload is then represented as an agent with a set of choices corresponding to the destination hexes suitable for carbon dioxide removal (CDR). In the case of BiCR+S this corresponds to biomass feedstock being transported to a hex co-located with geological storage. In the case of ERW this represents crushed rock material.

Each possible destination is assigned a utility value, calculated using a utility function. The utility function has two components: a deterministic component and a random component. In this application, the deterministic component is represented by TraNSIT's modelled transport cost between an origin hex and a corresponding destination hex, while the random component is represented by an error term to capture unobserved factors that affect individual preferences. The logit model is used to estimate the probability that an agent selects a specific destination, with the probability increasing as the destination's utility rises relative to alternatives. Figure 8 illustrates how the probability of two choices varies with changes in their relative cost (or negative utility). The random component means that the choice with the lowest deterministic cost is not always selected.

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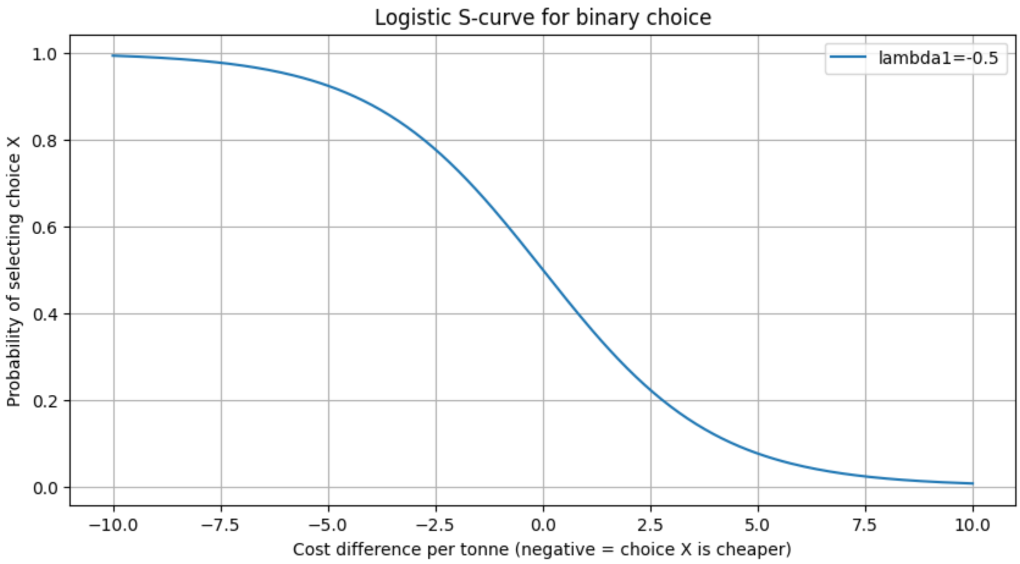
[43] Altaweel A, Mine K, Lee B-Y, Yoon J-S, Wagatsuma H (2025) A Mathematical Framework for Logit Model in Transportation Mode Choice Analysis. In Proceedings of the 2025 International Conference on Artificial Life and Robotics (ICAROB2025). 13-16 February, Oita, Japan. <https://alife-robotics.co.jp/members2025/icarob/data/html/data/GS/GS5/GS5-3.pdf>.

Figure 8: Representative Logit s-curve.



Hexes may be subject to capacity constraints. To account for this, the logit model is modified by imposing a limit on the amount of feed that can be transported to each destination. Once a destination's capacity is reached, the destination is removed from the choice set of all remaining agents. The model thus dynamically adjusts the choice set, leading to selections being both utility-driven and capacity-constrained.

A maximum transport cost threshold of $100 per tonne of feedstock is applied in addition to the destination capacity constraints. This prevents feedstock from being transported over excessive distances, which could significantly increase average transport costs.

The probabilistic nature of agent-based modelling means that repeated model runs may not produce identical results. While aggregate capacity totals and cost profiles have been validated over repeated model runs, the random component of agent decision making may lead to minor variations in hex level capacity and cost totals. There are opportunities to extend this work through further model development and analysis, either through inclusion of additional deterministic components beyond travel cost in the logit model, or by quantifying the variation in hex level results.

Table 9 summarises the assumptions used in transport cost modelling. Tailpipe CO_2 emissions are calculated for each trip, reducing the net quantity of CO_2 removed per tonne of feedstock. The resulting impact on levelised cost is captured in the LCA cost component.

Table 9: Assumptions used in transport cost modelling.

Input	Unit	Value	Source
A-Double volumetric capacity	m^3	134	TraNSIT
A-Double weight capacity	tonnes	46	TraNSIT
One way to return trip cost multiplier	#	1.9	TraNSIT
A-Double fuel efficiency	L/km	0.931	TraNSIT
Diesel emissions	t CO_2/L	0.00268	Engineering Toolbox
Typical transport cost range for 200km one-way trip by A-Double	$(2024)/t km	$0.08 -$0.10	TraNSIT

F & G: Average transport cost and TEA model.

The same technoeconomic model described in the DAC+S and OAE sections is applied to BiCR+S, with slight variations to account for its specific characteristics.

The outputs of the modelling process in section E are the quantities of feed material allocated to each destination and the corresponding average transport cost. These outputs are used as inputs into technoeconomic models of each BiCR+S process to develop hexbin level estimates of CDR capacity and cost.

Similar to DAC+S and OAE, regional construction cost factors are also applied to reflect the likely variation in construction costs for large-scale BiCR+S facilities.[44]

[44] Refer to DAC+S and OAE section for more information.

Table 10: Input and assumption table for BiCR+S NOAK (2050).

Input	Unit	Fast Pyrolysis	Combustion	Source
Currency	$	AUD	AUD	
Price Year	year	2024	2024	
Plant lifetime	years	30	20	
Nameplate capacity	$MtCO_2$/year	1.11	1.18	
Annual utilisation	%	90	90	CSIRO assumption
Total capital costs (TCC)	$m	633*	690*	Reference 45
Direct capital costs (DCC)	%PCC	40	incl above	Reference 45
Indirect capital costs (ICC)	%ICC	76	incl above	Reference 45
Cost of capital	%	5	5	CSIRO assumption
Construction period	years	3	3	Reference 45 and 47
LCA adjustment factor (embedded emissions)	#	1.09	1.09	Reference 46
Maintenance	%PCC	3	3.5	Reference 45 and 47
Biomass required	kg/t CO_2	919	873	Reference 45 and 48
Electricity required	MWh/t CO_2	0.171	-	Reference 45
Electricity produced	MWh/t CO_2	-	0.554	Reference 47
Hydrogen produced	kg/t CO_2	22.6	-	Reference 45
Biomass price	$/kg	0.07	0.07	CSIRO assumption
Electricity price	$/MWh	97.3	97.3	Reference 49
Hydrogen price	$/kg	3.43	-	CSIRO assumption
Biomass transport	$/kg	0.04*	0.04*	CSIRO assumption[50]
CO_2 Transport	$/ t CO_2	16.6	16.6	Reference 46
CO_2 Storage	$/ t CO_2	28.7	28.7	Reference 46

*This input is varied in the regional analysis, with the value shown in the table representing the default assumption.

ERW

A. Estimate quantity and location of available feedstock

To estimate the relative abundance and location of suitable mafic rock of potential use for ERW, a national compilation of mapped mafic and ultramafic units produced by Geoscience Australia is used.[51] The dataset

[45] Smart S, Ashman P, Scholes C, Tabatabaei M, Hosseini T, Yee R, McConnachie M, Sheil A, Jackson T, Beiraghi J (2023) Technoeconomic Modelling of Future Fuel Production Pathways: Summary Report, Table 8.10. Future Fuels CRC, RP1.2-02, The University of Queensland, The University of Adelaide, The University of Melbourne, Australia. <https://www.futurefuelscrc.com/wp-content/uploads/FFCRC_RP1.2-02_SummaryReport_Open-access.pdf>.

[46] The LCA adjustment factor for Solid adsorbent DAC+S was used as proxy for the LCA adjustment factor of BiCR+S. IEAGHG (2021) Global assessment of direct air capture costs Technical Report 2021-05, December 2021. IEAGHG, UK. <https://publications.ieaghg.org/technicalreports/2021-05%20Global%20Assessment%20of%20Direct%20Air%20Capture%20Costs.pdf>.

[47] Davis R, Tao L, Scarlata C, Tan ECD (2015) Process Design and Economics for the Conversion of Lignocellulosic Biomass to Hydrocarbons: Dilute-Acid and Enzymatic Deconstruction of Biomass to Sugars and Catalytic Conversion of Sugars to Hydrocarbon Technical Report National Renewable Energy Laboratory, Golden, CO, US <https://docs.nrel.gov/docs/fy15osti/62498.pdf> (accessed May 2025).

[48] University of Wyoming (n.d.) Integrated Environmental Control Model (IECM): A tool for calculating the performance, emissions, and cost of a fossil-fuelled power plant. <https://www.uwyo.edu/iecm/> (accessed May 2025).

[49] STABLE is an 'intermediate horizon' model used to estimate the optimised investment profile and operation to achieve reliability and security in Australia's National Electricity Market (NEM) and other interconnected systems.

[50] Corresponds to a one-way trip of 200km based on TraNSIT cost data.

[51] Thorne JP, Cooper M, Claoue-Long JC, Highet L, Hoatson DM, Jaireth S, Huston DL., Gallagher R (2014) The Australian Mafic-Ultramafic Magmatic Events GIS Dataset: Archean, Proterozoic and Phanerozoic Magmatic Events. Record 2014/039. Geoscience Australia. <http://dx.doi.org/10.11636/Record.2014.039>; Geoscience Australia (2014) New dataset provides clues to potential mineralisation. Geoscience Australia, 10 July. <https://www.ga.gov.au/news/news-archive/new-dataset-provides-clues-to-potential-mineralisation>.

includes mapped extents along with metadata enabling high-level filtering based on the physical properties of the rock (lithology), general composition, and emplacement history.

The total mapped area is extensive, representing approximately 6% of Australia's total land area. Even under near-term deployment scenarios, the potential supply is expected to greatly exceed demand.

The dataset is cleaned, reprojected and filtered to generate a subset of mafic rock extent polygons suitable as a baseline potential feedstock source for ERW.[52] This involves:

- Geometric cleaning to deal with instances of self-intersection, gaps in polygons and related issues,
- Reprojection from GDA94 (ESPG: 4283) to an equal area projection to ensure consistent area calculations,
- Merging of unit polygons based on their unique identifier (ID); and
- Filtering of units to retain only those dominated by mafic rocks, excluding those where mafic rocks are subordinated or intercalated with other lithologies including sediments.

Further filtering is applied based on land use, using the ABARES national compilation of catchment scale land use data for Australia (CLUM).[53] The mafic rock areal extent dataset is rasterised onto the ABARES grid, and pixels that coincides with land uses described by the following simple land use classification (SIMP) labels are excluded as potential material extraction sites: Nature conservation, Managed resource protection, Other minimal use, Production native forests, Plantation forests, Irrigated pastures, Irrigated cropping, Irrigated horticulture, Intensive Horticulture and animal production, Other intensive uses, Urban residential, Rural residential and farm infrastructure, Mining and waste. Figure 33 in the report illustrates the mafic rock distribution across Australia after filtering those specific land uses.

B. Assess locations of potential ERW project sites

Potential ERW application sites are identified based on an agricultural subset of the ABARES CLUM dataset, selecting pixels classified under the AGIND scheme as having primary land uses of Cropping, Grazing Modified Pasture, or Horticulture. Areas associated with non-agricultural uses, Grazing Native Vegetation, or Intensive Plant and Animal Industries were excluded from consideration. This filtering process results in an area of suitable land for ERW per hexbin. An assumed application rate of 40 tonnes of mafic rock per hectare per year is used when determining the quantity of rock that can be applied to each area. An additional constraint is applied in the realisable capacity scenario, assuming that up to 5% of suitable land is made available for ERW (see Table 11). Figure 34 in the report presents the map of suitable agricultural land for ERW approaches, highlighting the different agricultural land types considered in the analysis.

C. Convert feedstock into its transportable state

The next step converts the available area of mafic rock to an annual quantity of mined and crushed rock that could be used for ERW. This requires several assumptions, documented in Table 11.

To convert an area of mafic rock into a quantity of annual mineable rock, an assumption of average mining depth is required. Further constraints are applied to reflect the likelihood that local (hexbin level) and national quantities of mining for the purposes of ERW are likely to be constrained below this high-level assumption of

[52](as described in Austin et al. <pending release>)

[53] ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences) Catchment Scale Land Use of Australia – Update December 2023 version 2. Department of Agriculture, Fisheries and Forestry, Canberra. <https://www.agriculture.gov.au/sites/default/files/documents/CLUM_DescriptiveMetadata_December2023_v2.pdf>; (CLUM dataset classified as per the Australian Land Use and Management Classification version 8 at 50m resolution, as provided in GeoTIFF format by Digital Earth Australia. <https://explorer.dea.ga.gov.au/products/abares_clum_2023/datasets/21489af0-abbe-54ac-9eb5-89bbcba53a57> (accessed June 2025).

mining depth. The realisable capacity scenario assumes a maximum of 10 Mt of rock mined per hexbin, or 100 Mt of rock mined in total across all hexbins. This is approximately half of Australia's current annual demand for quarried rock for construction. The high ambition scenario assumes the same hexbin maximum but allows up to 1 Gt of rock to be mined annually.

Finally, the carbon removal potential of mined rock is assumed based on feedback from consultation with ERW proponents. It is converted to a present value of removal to reflect the multi-year time period over which this removal occurs for a given application of rock.

Table 11: Assumptions for Converting Mafic Rock to Annual ERW Supply.

Input	Unit	Realisable capacity	High ambition capacity	Source
Maximum annual mining depth	Metres/year	1	1	CSIRO
Maximum annual quantity mined per hex	Mt rock/year	10	10	CSIRO
Maximum total quantity mined	Mt rock/year	100	100	CSIRO
Density of mafic rock	kg/m^3	3000	3000	Ref 54
Bulk density of mined mafic rock	kg/m^3	1480	1480	Ref 55
Percentage of agricultural land available for ERW	%	5%	100%	CSIRO
Carbon removal potential	t CO_2/rock	0.25	0.25	Consultation
Carbon removal potential (present value)	t CO_2/rock	0.22	0.22	Consultation[56]

D. Estimate transport costs

Refer to BiCR+S section above for a description of this step.

E. Assign feedstock to destination locations

Refer to BiCR+S section above for a description of this step.

F & G: Average transport cost and TEA model

The same technoeconomic model described in the DAC+S and OAE sections is applied ERW. ERW differs from the three other modelled CDR approaches in that it does not require significant capital investment to construct an industrial scale facility that captures and stores CO_2 over a period of decades. Instead, ERW requires an initial outlay to procure crushed rock, transport it to a project site and spread it across the site, with sequestration occurring gradually over subsequent years.

For ERW, several key adjustments are made to the standard technoeconomic model: capital costs are assumed to be paid upfront rather than financed through a loan; the construction period is set to zero due to the absence of a centralised facility; and the LCA adjustment factor is set to 1, as transport emissions are accounted for in the TraNSIT model. It is assumed that renewable energy is used for rock extraction and processing.

The outputs of the modelling process in section E (explained in more detail in the BiCR+S section) are the quantities of feed material allocated to each destination and the corresponding average transport cost. These outputs are used as inputs into the technoeconomic model of the ERW process to develop hexbin

[54] Matmake (2025) Density of Common Rocks. <https://matmake.com/properties/density-of-rocks.html> (accessed June 2025).
[55] Bulk density of mined mafic rock corresponds to bulk density of basalt. Bulk Solids Flow (2025) Bulk Handling Global. <https://bulksolidsflow.com.au/free_programs/bulk_density/bulk_density_chart.html> (accessed June 2025).
[56] based on 0.036 tCO_2/t_{rock} /year, 0.25 tCO_2/t_{rock} carbon removal potential and a 5% discount rate.

level estimates of CDR capacity and cost. Refer to Section 9.3.1 for further discussion on the approach used to model ERW costs.

Table 12: Inputs and assumptions for ERW FOAK and NOAK.

Input	Unit	FOAK	NOAK	Source
Currency	$	AUD	AUD	
Price Year	year	2024	2024	
Sequestration duration	years	7	7	Consultation[57]
Sequestration rate	tCO_2/t_{rock}/year	0.036	0.036	Consultation[58]
Spreading rate	t_{rock}/ha	40	40	Reference 59
Carbon removal potential	tCO_2/t_{rock}	0.25	0.25	Consultation
Mineral extraction and processing costs[60]	$/$t_{rock}$	23.8	23.8	Reference 59
Processing energy demand	MWh/t_{rock}	0.02	0.02	Reference 59
Discount rate	%	10	5	CSIRO assumption
LCA adjustment factor	#	1.06	1.06	CSIRO assumption[61]
MRV	$/$t_{rock}$	250	25[62]	Consultation
Electricity price	$/MWh	128	97.3	Reference 63
Freight cost	$/$t_{rock}$	18*	18*	CSIRO assumption[64]
Spreading cost	$/$t_{rock}$	11.6	11.6	Reference 65

*This input is varied in the regional analysis, with the value shown in the table representing the default assumption.

[57] Based on a weathering rate of 0.036 tCO_2 per tonne of rock, as informed by stakeholder consultation, plant lifetime was estimated by dividing the total sequestration potential by the annual weathering rate.
[58] Sequestration rate selected based on subject matter expert advice from within CSIRO and external consultation. While actual sequestration rate is expected to vary significantly based on local climate and soil conditions, the rate selected falls within the sequestration rate range for basalt identified within the following source. Power IM, Hatten VJN, Guo M, Schaffer ZR, Rausis K, Klyn-Hesselink H (2024) Are enhanced rock weathering rates overestimated? A few geochemical and mineralogical pitfalls. Frontiers in Climate 6. <https://doi.org/10.3389/fclim.2024.1510747>.
[59] Beerling DJ, Kantzas EP, Lomas MR, Taylor LL, Zhang S, Kanzaki Y, Eufrasio RM, Renforth P, Mecure J-F, Pollitt H, Holden PB, Edwards NR, Koh L, Epihov DZ., Wolf A, Hansen JE, Banwart SA, Pidgeon NF, Reinhard CT, Planavsky NJ, Val Martin M (2025) Transforming US agriculture for carbon removal with enhanced weathering. Nature 638, 425-434. <https://www.nature.com/articles/s41586-024-08429-2>.
[60] Assuming the rock is ground to a particle size of 100 microns.
[61] The LCA adjustment factor is assumed to be 1, as transport emissions are accounted for in Freight costs, and it is assumed that renewable energy would be used for rock extraction and processing.
[62] NOAK MRV cost is presented as a cost target, this value does not represent a bottom up estimate of future MRV costs.
[63] STABLE is an 'intermediate horizon' model used to estimate the optimised investment profile and operation to achieve reliability and security in Australia's National Electricity Market (NEM) and other interconnected systems.
[64] Corresponds to a one-way trip of 100km based on TraNSIT cost data.
[65] The spreading cost of lime sourced from GRDC was used as a proxy for the spreading cost of crushed rock.

Table 13: Filtering of ABARES Land Use Classification for VRE capacity analysis.

ID	Value	Count	Filter	Simplified Classification	Tertiary Classification	Area (km2)
1	111	2471378	Excluded	Nature conservation	1.1.1 Strict nature reserves	154,461
2	112	616492	Excluded	Nature conservation	1.1.2 Wilderness area	38,531
3	113	6165243	Excluded	Nature conservation	1.1.3 National park	385,328
4	114	293205	Excluded	Nature conservation	1.1.4 Natural feature protection	18,325
5	115	417820	Excluded	Nature conservation	1.1.5 Habitat/species management area	26,114
6	116	1216024	Excluded	Nature conservation	1.1.6 Protected landscape	76,002
7	117	366085	Excluded	Nature conservation	1.1.7 Other conserved area	22,880
8	120	6648114	Excluded	Managed resource protection	1.2.0 Managed resource protection	415,507
9	125	17539682	Included	Managed resource protection	1.2.5 Traditional indigenous uses	1,096,230
10	130	11334404	Included	Other minimal use	1.3.0 Other minimal use	708,400
11	131	437804	Excluded	Other minimal use	1.3.1 Defence land - natural areas	27,363
12	132	96435	Included	Other minimal use	1.3.2 Stock route	6,027
13	133	1409471	Included	Other minimal use	1.3.3 Residual native cover	88,092
14	134	46	Included	Other minimal use	1.3.4 Rehabilitation	3
15	210	53341743	Included	Grazing native vegetation	2.1.0 Grazing native vegetation	3,333,859
16	220	1377210	Excluded	Production native forests	2.2.0 Production native forests	86,076
17	310	6288	Excluded	Plantation forests	3.1.0 Plantation forests	393
18	311	156765	Excluded	Plantation forests	3.1.1 Hardwood plantation forestry	9,798
19	312	202459	Excluded	Plantation forests	3.1.2 Softwood plantation forestry	12,654
20	313	3882	Excluded	Plantation forests	3.1.3 Other forest plantation	243
21	314	2863	Excluded	Plantation forests	3.1.4 Environmental forest plantation	179
22	320	7632713	Included	Grazing modified pastures	3.2.0 Grazing modified pastures	477,045
23	330	21271	Included	Dryland cropping	3.3.0 Cropping	1,329
24	331	4234089	Included	Dryland cropping	3.3.1 Cereals	264,631
25	333	320904	Included	Dryland cropping	3.3.3 Hay and silage	20,057
26	334	558178	Included	Dryland cropping	3.3.4 Oilseeds	34,886
27	335	47634	Included	Dryland cropping	3.3.5 Sugar	2,977
28	336	30384	Included	Dryland cropping	3.3.6 Cotton	1,899
29	338	528679	Included	Dryland cropping	3.3.8 Pulses	33,042
30	340	609	Included	Dryland horticulture	3.4.0 Perennial horticulture	38
31	341	4633	Included	Dryland horticulture	3.4.1 Tree fruits	290
32	343	2534	Included	Dryland horticulture	3.4.3 Tree nuts	158
33	345	248	Included	Dryland horticulture	3.4.5 Shrub berries and fruits	16
34	348	808	Included	Dryland horticulture	3.4.8 Citrus	51
35	349	5516	Included	Dryland horticulture	3.4.9 Grapes	345
36	353	4850	Included	Dryland horticulture	3.5.4 Seasonal vegetables and herbs	303
37	410	191	Excluded	Plantation forests	4.1.0 Irrigated plantation forests	12
38	411	1114	Excluded	Plantation forests	4.1.1 Irrigated hardwood plantation forestry	70
39	412	3	Excluded	Plantation forests	4.1.2 Irrigated softwood plantation forestry	0
40	413	1199	Excluded	Plantation forests	4.1.3 Irrigated other forest production	75
41	414	24	Excluded	Plantation forests	4.1.4 Irrigated environmental forest plantation	2
42	420	104123	Excluded	Irrigated pastures	4.2.0 Grazing irrigated modified pastures	6,508
43	430	19200	Excluded	Irrigated cropping	4.3.0 Irrigated cropping	1,200
44	431	72050	Excluded	Irrigated cropping	4.3.1 Irrigated cereals	4,503
45	433	44152	Excluded	Irrigated cropping	4.3.3 Irrigated hay and silage	2,760
46	434	10631	Excluded	Irrigated cropping	4.3.4 Irrigated oilseeds	664
47	435	23813	Excluded	Irrigated cropping	4.3.5 Irrigated sugar	1,488
48	436	45034	Excluded	Irrigated cropping	4.3.6 Irrigated cotton	2,815
49	438	5850	Excluded	Irrigated cropping	4.3.8 Irrigated pulses	366
50	439	10874	Excluded	Irrigated cropping	4.3.9 Irrigated rice	680
51	440	1216	Excluded	Irrigated horticulture	4.4.0 Irrigated perennial horticulture	76
52	441	21940	Excluded	Irrigated horticulture	4.4.1 Irrigated tree fruits	1,371
53	442	4093	Excluded	Irrigated horticulture	4.4.2 Irrigated olives	256
54	443	18974	Excluded	Irrigated horticulture	4.4.3 Irrigated tree nuts	1,186
55	445	807	Excluded	Irrigated horticulture	4.4.5 Irrigated shrub berries and fruits	50
56	448	9321	Excluded	Irrigated horticulture	4.4.8 Irrigated citrus	583
57	449	34172	Excluded	Irrigated horticulture	4.4.9 Irrigated grapes	2,136
58	453	24897	Excluded	Irrigated horticulture	4.5.3 Irrigated seasonal vegetables and herbs	1,556
59	510	302	Excluded	Intensive horticulture and animal productio	5.1.0 Intensive horticulture	19
60	511	456	Excluded	Intensive horticulture and animal productio	5.1.1 Production nurseries	29
61	512	121	Excluded	Intensive horticulture and animal productio	5.1.2 Shadehouses	8
62	513	812	Excluded	Intensive horticulture and animal productio	5.1.3 Glasshouses	51
63	514	6	Excluded	Intensive horticulture and animal productio	5.1.4 Glasshouses (hydroponic)	0
64	515	28	Excluded	Intensive horticulture and animal productio	5.1.5 Abandoned intensive horticulture	2
65	520	1392	Excluded	Intensive horticulture and animal productio	5.2.0 Intensive animal production	87

ID	Value	Count	Filter	Simplified Classification	Tertiary Classification	Area (km2)
66	521	385	Excluded	Intensive horticulture and animal productioi	5.2.1 Dairy sheds and yards	24
67	522	1850	Excluded	Intensive horticulture and animal productioi	5.2.2 Feedlots	116
68	523	3494	Excluded	Intensive horticulture and animal productioi	5.2.3 Poultry farms	218
69	524	2827	Excluded	Intensive horticulture and animal productioi	5.2.4 Piggeries	177
70	525	1742	Excluded	Intensive horticulture and animal productioi	5.2.5 Aquaculture	109
71	526	7606	Excluded	Intensive horticulture and animal productioi	5.2.6 Horse studs	475
72	527	322	Excluded	Intensive horticulture and animal productioi	5.2.7 Saleyards/stockyards	20
73	528	196	Excluded	Intensive horticulture and animal productioi	5.2.8 Abandoned intensive animal production	12
74	530	18464	Excluded	Other intensive uses	5.3.0 Manufacturing and industrial	1,154
75	531	2341	Excluded	Other intensive uses	5.3.1 General purpose factory	146
76	532	467	Excluded	Other intensive uses	5.3.2 Food processing factory	29
77	533	1351	Excluded	Other intensive uses	5.3.3 Major industrial complex	84
78	534	913	Excluded	Other intensive uses	5.3.4 Bulk grain storage	57
79	535	424	Excluded	Other intensive uses	5.3.5 Abattoirs	27
80	536	180	Excluded	Other intensive uses	5.3.6 Oil refinery	11
81	537	272	Excluded	Other intensive uses	5.3.7 Sawmill	17
82	538	1697	Excluded	Other intensive uses	5.3.8 Abandoned manufacturing and industrial	106
83	540	13097	Excluded	Urban residential	5.4.0 Residential and farm infrastructure	819
84	541	236289	Excluded	Urban residential	5.4.1 Urban residential	14,768
85	542	136177	Excluded	Rural residential and farm infrastructure	5.4.2 Rural residential with agriculture	8,511
86	543	207525	Excluded	Rural residential and farm infrastructure	5.4.3 Rural residential without agriculture	12,970
87	544	1461	Excluded	Rural residential and farm infrastructure	5.4.4 Remote communities	91
88	545	14805	Excluded	Rural residential and farm infrastructure	5.4.5 Farm buildings/infrastructure	925
89	550	2653	Excluded	Other intensive uses	5.5.0 Services	166
90	551	18555	Excluded	Other intensive uses	5.5.1 Commercial services	1,160
91	552	18976	Excluded	Other intensive uses	5.5.2 Public services	1,186
92	553	65544	Excluded	Other intensive uses	5.5.3 Recreation and culture	4,097
93	554	8242	Excluded	Other intensive uses	5.5.4 Defence facilities - urban	515
94	555	1260	Excluded	Other intensive uses	5.5.5 Research facilities	79
95	560	667	Excluded	Other intensive uses	5.6.0 Utilities	42
96	561	512	Excluded	Other intensive uses	5.6.1 Fuel powered electricity generation	32
97	562	22	Excluded	Other intensive uses	5.6.2 Hydro electricity generation	1
98	563	968	Excluded	Other intensive uses	5.6.3 Wind electricity generation	61
99	564	1308	Excluded	Other intensive uses	5.6.4 Solar electricity generation	82
100	565	976	Excluded	Other intensive uses	5.6.5 Electricity substations and transmission	61
101	566	1033	Excluded	Other intensive uses	5.6.6 Gas treatment, storage and transmission	65
102	567	1111	Excluded	Other intensive uses	5.6.7 Water extraction and transmission	69
103	570	2264	Excluded	Other intensive uses	5.7.0 Transport and communication	142
104	571	13855	Excluded	Other intensive uses	5.7.1 Airports/aerodromes	866
105	572	7254	Excluded	Other intensive uses	5.7.2 Roads	453
106	573	737	Excluded	Other intensive uses	5.7.3 Railways	46
107	574	383	Excluded	Other intensive uses	5.7.4 Ports and water transport	24
108	575	2833	Excluded	Other intensive uses	5.7.5 Navigation and communication	177
109	580	35379	Excluded	Mining and waste	5.8.0 Mining	2,211
110	581	37355	Excluded	Mining and waste	5.8.1 Mines	2,335
111	582	13257	Excluded	Mining and waste	5.8.2 Quarries	829
112	583	3442	Excluded	Mining and waste	5.8.3 Tailings	215
113	584	12193	Excluded	Mining and waste	5.8.4 Extractive industry not in use	762
114	590	1713	Excluded	Mining and waste	5.9.0 Waste treatment and disposal	107
115	591	3876	Excluded	Mining and waste	5.9.1 Effluent pond	242
116	592	1299	Excluded	Mining and waste	5.9.2 Landfill	81
117	593	484	Excluded	Mining and waste	5.9.3 Solid garbage	30
118	595	2519	Excluded	Mining and waste	5.9.5 Sewage/sewerage	157
119	600	9454	Excluded	Water	6.0.0 Water	591
120	610	828994	Excluded	Water	6.1.0 Lake	51,812
121	611	810218	Excluded	Water	6.1.1 Lake - conservation	50,639
122	612	59968	Excluded	Water	6.1.2 Lake - production	3,748
123	613	374	Excluded	Water	6.1.3 Lake - intensive use	23
124	614	410	Excluded	Water	6.1.4 Lake - saline	26
125	620	17601	Excluded	Water	6.2.0 Reservoir/dam	1,100
126	621	110637	Excluded	Water	6.2.1 Reservoir	6,915
127	622	22754	Excluded	Water	6.2.2 Water storage - intensive use/farm dams	1,422
128	623	5839	Excluded	Water	6.2.3 Evaporation basin	365
129	630	361559	Excluded	Water	6.3.0 River	22,597
130	631	46713	Excluded	Water	6.3.1 River - conservation	2,920

ID	Value	Count	Filter	Simplified Classification	Tertiary Classification	Area (km2)
131	632	14	Excluded	Water	6.3.2 River - production	1
132	633	1860	Excluded	Water	6.3.3 River - intensive use	116
133	640	1283	Excluded	Water	6.4.0 Channel/aqueduct	80
134	641	126	Excluded	Water	6.4.1 Supply channel/aqueduct	8
135	642	381	Excluded	Water	6.4.2 Drainage channel/aqueduct	24
136	643	17	Excluded	Water	6.4.3 Stormwater	1
137	650	399854	Excluded	Water	6.5.0 Marsh/wetland	24,991
138	651	366675	Excluded	Water	6.5.1 Marsh/wetland - conservation	22,917
139	652	761819	Excluded	Water	6.5.2 Marsh/wetland - production	47,614
140	653	605	Excluded	Water	6.5.3 Marsh/wetland - intensive use	38
141	654	14109	Excluded	Water	6.5.4 Marsh/wetland - saline	882
142	660	168075	Excluded	Water	6.6.0 Estuary/coastal waters	10,505
143	661	280340	Excluded	Water	6.6.1 Estuary/coastal waters - conservation	17,521
144	662	329	Excluded	Water	6.6.2 Estuary/coastal waters - production	21
145	663	389	Excluded	Water	6.6.3 Estuary/coastal waters - intensive use	24

Note: The traditional indigenous uses land use category includes a number of Indigenous Protected Areas. These areas are excluded from the final land availability analysis, in line with exclusion of state and national parks using DCCEEW/NIAA dataset: Indigenous Protected Areas (IPA) - Dedicated - Overview). Land classified as traditional indigenous uses that is not an Indigenous Protected Area is included in the analysis. This approach was informed by consultation and ensures data on regional opportunities is available, to support decision making by local stakeholders.

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