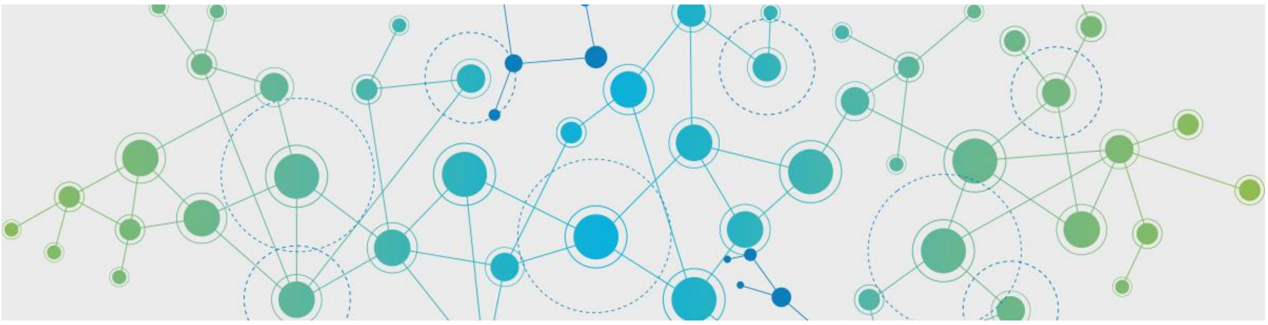
OFFSETTING EMISSIONS FROM LIQUIFIED NATURAL GAS PROJECTS IN WESTERN AUSTRALIA

For the Conservation Council of Western Australia (CCWA)

November 2018



RepuTex ENERGY

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26 November 2018

Piers Verstegen
Executive Director
Conservation Council of Western Australia
City West Lotteries House, 2 Delhi St,
West Perth, Western Australia

Dear Piers,

OFFSETTING EMISSIONS FROM LIQUIFIED NATURAL GAS (LNG) PROJECTS IN WESTERN AUSTRALIA

In accordance with the Agreement for the Provision of Services dated 20 June 2018 ('Agreement'), RepuTex has been engaged by the Conservation Council of Western Australia (CCWA) for the provision of analysis on the offsetting of LNG emissions in Western Australia.

The enclosed report sets out the outcomes of our work. The scope of our work, including the grounds for any opinion, modelling assumptions and exclusions, are detailed within this Report.

The Report has been prepared for the sole use of the customer, for a specific purpose as stated in the document. Parts of this Report may include assumptions on future policy or market conditions that have been reasonably made based on our professional experience. These assumptions are stated within the Report. As with any analysis that considers future circumstances, caution should be taken when relying on outcomes, with future market dynamics potentially different to actual results.

The Report is structured as follows:

- Sections 1 and 2 provide a summary and background to the engagement;
- Section 3 describes the scope of our analysis and modelled scenarios;
- Section 4 contains our modelling results, including outcomes for offset availability in Western Australia; offset supply and price scenarios to meet modelled demand; implied economic value and offset investment; and regional job creation in Western Australia;
- Section 5 provides two case studies for the co-benefits of implementing different offset projects - a rangelands restoration project, and a renewable energy project in Collie;
- Appendices provide further information on our research models and methodologies.

Should you have any questions please contact me on (03) 9600 0990 or hugh.grossman@reputex.com

Yours Sincerely,

Hugh Grossman
Executive Director
Energy and Carbon Markets

ABOUT REPUTEX

RepuTex is a leading provider of independent analysis and pricing insights for the Australian renewable energy, power and emissions markets.

We have worked with over 150 customers across Australia and the Asia-Pacific, including large energy users and emitters, offtakers and project developers, financials and government departments & agencies.

Since 1999, our insights have become a key reference point for the market, providing our customers with an advanced perspective on the impact of new forces – such as renewable penetration, new energy storage technology and emissions contracting – on price formation and market development.

Our focus is on data-driven insights: In doing so, we draw on our proprietary advanced analytics models to provide our customers with a deeper perspective on evolving market risk and pricing patterns.

We have offices in Melbourne and Hong Kong, supported by a team of analysts with backgrounds in econometrics, statistics, commodities & policy. The company is a winner of the China Light and Power-Australia China Business Award for research across Asia-Pacific.

To learn more, please visit www.reputex.com

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1. EXECUTIVE SUMMARY

Project background

- RepuTex has been engaged by the Conservation Council of Western Australia (CCWA) to analyse the economic benefits of reinstating greenhouse gas (GHG) conditions on Liquified Natural Gas (LNG) projects in Western Australia, specifically the requirement for proponents to offset emissions from LNG developments.
- This Report presents the modelling outcomes of a series of illustrative scenarios, which seek to understand the type and price of carbon offsets that could be available within Western Australia should an offset industry be developed, and the economic benefits of local investment.
- Modelling aligns offset supply with illustrative annual offset demand at three reference levels:
  - **Low Scenario** - Demand for offsets equivalent to 15 million tonne of carbon dioxide per annum (Mtpa), reflecting approximately half of domestic emissions from current LNG facilities;
  - **Medium Scenario** - Demand for 30 Mtpa, reflecting approximately all direct domestic emissions from current LNG facilities;
  - **High Scenario** - Demand for 60 Mtpa, a doubling of the medium scenario, reflecting illustrative demand to offset direct emissions from current and proposed LNG developments.
- In determining the potential availability, cost, and co-benefits of abatement needed meet the above demand reference levels, we draw on our Marginal Abatement Cost (MAC) model to identify potential emissions reduction activities in Western Australia and quantify the total volume and cost of undertaking identified activities. Analysis then considers investment and employment opportunities for Western Australia that are likely to develop as a result of a local carbon offset industry.

Availability of Western Australian abatement

- Issuance of Australian Carbon Credit Units (ACCUs) in Western Australia is currently about 700,000 per annum (p.a.) - derived largely from landfill gas and savannah fire management activities – and represents approximately 10 per cent of the Commonwealth's Emissions Reduction Fund (ERF).
- Considering legal barriers to carbon rights on Western Australian rangelands is now being addressed, we anticipate a quick expansion in 'Human Induced Regeneration' (HIR) projects, doubling Western Australia ACCU issuance in less than two years. The total potential supply of offsets from Western Australia's rangelands, however, is much larger still. Though a combination of expanded methodologies, greater certainty, and higher prices, we estimate Western Australia rangelands alone could generate around 4.5 million ACCUs p.a. by 2030.
- There is a similar potential to create tens of millions of additional offsets per annum though a wider diversity of renewable energy, agriculture and vegetation management activities in Western Australia. In total, Western Australia has the potential to supply in excess of 80 Mt of abatement per annum.

Investment necessary to drive new offset supply in Western Australia

- Should LNG production facilities be required to offset their direct emissions, analysis suggests that Western Australia has ample abatement potential to meet offset demand within the state.
- For the Low Scenario for 15 Mtpa of abatement, modelling suggests a carbon offset price could settle at around $15 per tonne – about the same as the current value of ACCUs. Notably, findings indicate that a considerable supply of around 5 to 6 Mtpa of abatement is available at little to no net-cost to farmers. These offsets could be issued for agricultural (crop and livestock) efficiencies that can both increase yields and reduce agricultural emissions. Such activities would therefore be of a higher value than business-as-usual (BAU) and result in little to no net-cost for the farmer.
- While the market price of offsets from these activities will ultimately be determined by the balance of supply and demand (rather than the underlying net-costs of a project), findings indicate that

Western Australia has ample ‘low cost’ offset opportunities, should policy be designed to overcome market inefficiencies and unlock this supply.

- A Medium Scenario for 30 Mtpa of emissions reductions would approximately triple investment in offset projects, with carbon offset prices modelled to grow to more than $50 per tonne as ‘low-hanging’ abatement is contracted, and demand for offsets ‘buys its way up the cost curve’. This demonstrates that as prices rise, a greater supply of offsets could become available. Under this scenario, investment in renewable energy sector could play a complementary role to ACCU methodologies, supplying around one third of all offsets.
- Under the High Scenario for 60 Mtpa, forest and rangeland sectors are modelled to supply a large volume of offsets though large-scale and long-term sequestration activities, that may begin to transform land-use practices in the state. This would see carbon offset prices grow to around $100 per tonne, underpinned by the need to unlock higher cost abatement projects.
- The midpoint of the Marginal Abatement Cost Curve for Western Australian abatement is modelled to be about $40 per tonne. While this is higher than current ACCU prices underpinned by the ERF, this should still be competitive against forecast international carbon price benchmarks. For example, in Europe, carbon prices are projected to grow from about A$30 per tonne today to more than A$60 per tonne by 2023 as policy ambition increases.

Economic and employment benefits for Western Australia

- The development of a carbon offset market in Western Australia has the potential to provide significant benefits beyond GHG emissions abatement. These include large economic opportunities for investment and job creation across the state, particularly in regional communities, as well as co-benefits to biodiversity, landscape protection and water quality.
- Should enough demand be realised to create a carbon offset market in Western Australia, analysis indicates that value of the offset industry may range between $81 million (low scenario) to $2.9 billion (high scenario) per annum.
- On an employment per million dollars of investment basis, Savana Burning projects are found to create the largest number of jobs per dollar invested, with 12 jobs per million dollars ($m), followed by Reforestation Plantings (10 jobs/$m), Rangeland Regeneration (9 jobs/$m) and Renewable Energy (5 jobs/$m)
- In total employment terms, these activities are modelled to create around 4,000 jobs under the Medium Scenario. Five out of six jobs of these jobs are expected to be created in the land sector, with the largest portion of jobs in the South West and Southern Rangelands areas.
- Jobs attributed to Reforestation Plantings are expected to be the largest source of new job creation (1,190), reflecting larger investment in that activity, followed by Renewable Energy (614), Rangeland Regeneration (249) and Savanah Burning (186); with all remaining jobs attributed to other land-sector projects (1,694).
- Abatement from the land sector is expected to generate permanent job creation, such as aboriginal rangers, bee keepers, carbon foresters, land managers, stockmen and tree planting contractors, along with indirect employment, such as the service and tourism industries in regional areas.
- Abatement from the renewable energy projects could assist with substituting the coal mining and coal-fired power facility jobs that are declining in the Collie region as generators age and coal plants are not anticipated to be replaced.
- Comparably, large-scale renewable energy projects are expected to create both a net gain int employment and higher paying jobs, which are needed to build not only the solar and wind facilities, but also the new electricity infrastructure needed to access these resources and carry them to electricity consumers. New jobs are also created to operate and maintain large-scale solar and wind energy facilities.

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2. BACKGROUND

2.1 LNG project development in Western Australia

Western Australia currently has four operating liquefied natural gas (LNG) projects: Woodside's North West Shelf and Pluto facilities; and Chevron's Gorgon and Wheatstone projects. Including Shell's Prelude floating LNG (FLNG) plant, which is expected to commence shipping in late 2018, LNG exports from these projects are expected to grow to a total capacity of around 50 million tonnes of LNG per annum.[1] This places Western Australia second to Qatar (77 million tonnes of LNG per annum) as the world's largest LNG exporting centre, with Australia's total export capacity of 88 million tonnes of LNG per annum projected to surpass Qatar in 2018.[2]

Woodside's North West Shelf Venture began exporting LNG in 1989, growing to current production of up to 16.9 million tonnes of LNG per annum from five trains. In 2005, Woodside began construction on the Pluto gas field, which now produces approximately 4.7 million tonnes of LNG per annum. Chevron's Gorgon project began exporting from its first LNG train in March 2016. With all trains at full production, the project has a total capacity of up to 15.6 million tonnes of LNG per annum. In 2017, Chevron commenced production at its nearby Wheatstone project, with a combined capacity of up to 8.9 million tonnes of LNG per annum. In parallel, Shell's Prelude (FLNG) facility is being commissioned and is expected to produce around 3.6 million tonnes of LNG per annum from the fourth quarter of 2018.

In addition to operating and commissioning facilities, Woodside's proposed Browse LNG project remains in progress, potentially developed to feed an expansion at the North West Shelf plant when its current gas source runs dry in the 2020s.[3] A final investment decision is expected around 2020-21, with gas production of approximately 10–12 million tonnes of LNG per annum.[4] Woodside is also proposing to develop the Scarborough gas resource, estimated to produce around 4-9 million tonnes of LNG per annum,[5] with a final investment decision expected in 2020 ahead of start-up in 2023-24. Between 58 and 70 million tonnes of LNG per annum of capacity is projected to be available through all WA facilities.

Table 1: Current and major proposed LNG projects in Western Australia.

Project	Operating Company	Status	Start	Current Capacity (Mtpa LNG)[6]	Projected Gas Feedstock for LNG exports (Mtpa LNG)[7]
North West Shelf Venture	Woodside	Operating	1989	16.9	16.9
Pluto	Woodside	Operating	2012	4.7	5.3
Gorgon LNG	Chevron	Operating	2016	15.6	15.6 - 20.8
Wheatstone LNG	Chevron	Operating	2017	8.9	13.35
Prelude Floating LNG	Shell	Commissioning	2018	3.6	3.6
Browse^	Woodside	Proposed	2026-30	-	10 - 12
Scarborough*	Woodside	Proposed	2023-30	-	4 - 9

^ Gas production expected to be sent via the NW Shelf facility

* Gas production expected to be sent via the Pluto facility

[1] Government of Western Australia, August 2018. *WA Liquified Natural Gas Industry* Profile, Available here. This does not include gas from wells processed on the Ichthys Explorer offshore platform (processed in Darwin).
[2] Government of Western Australia, Department of Jobs, Tourism, Science and Innovation, WA Liquefied Natural Gas Industry Profile, August 2017
[3] Reuters, Woodside sees new momentum on long-delayed Browse gas project, 18/4/18
[4] Woodside, Browse project webpage: here. Accessed 17 Sep. 2018
[5] Woodside, Scarborough project webpage, here. Accessed 17 Sep. 2018
[6] Office of the Chief Economist, Resources and Energy Quarterly, June 2018.
[7] Nominal production capacity inferred from Table 10 in AEMO, 2017. *Gas Statement of Opportunities for Western Australia*, Available here. Scarborough's proposed downstream development will require an additional train at Pluto LNG with a targeted capacity of 4–5 Mtpa.

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2.2 Greenhouse gas emissions from LNG projects

The conversion of natural gas into LNG by cooling it for transport is a highly energy and emissions intensive process, however GHG emissions from LNG plants are, in practice, no longer limited by any federal regulation. Limited federal regulation has led to increasing pressure for and gas developers operating in Australia to take a proactive approach to reduce their emissions, and for states to strengthen environmental approval and oversight processes.

GHG emissions for LNG developments are considered as part of each project's environmental approval process, with emissions performance and reporting requirements able to be implemented under Ministerial Statements (MS). Conditions vary by project and are subject to review by the Minister.[8] For example, MS 873 (2011) gave approval for Chevron to construct and operate the Wheatstone LNG development subject to appropriate actions to 'minimise emissions to levels as low as practicable', including measures to report performance against an emissions benchmark and offset reservoir GHG emissions.[9] Following the implementation of the *Clean Energy Act 2011* (Carbon Pricing Mechanism or 'CPM') these conditions were lifted,[10] with regulations not reinstated following the repeal of the CPM.

The Western Australian Environmental Protection Authority (EPA) is currently reviewing the adequacy of conditions implemented for Chevron's Wheatstone project[11], along with conditions applied to the Gorgon development to investigate the likelihood of success and adequacy of geo-sequestration or reservoir gas on Barrow island.[12] This has potential to result in stricter operating conditions for these projects, particularly should requirements to offset GHG emissions be reinstated for proponents.

As shown in Figure 1, Western Australian greenhouse gas (GHG) emissions from LNG production at current LNG facilities are projected to grow to around 30 Mtpa of CO_2e13 - an increase of approximately 300 percent on 2005 LNG emission levels when there was only a single operating LNG production facility in Western Australia. These LNG projects will increase Western Australia's total state emissions about 44 per cent above 2005 levels.[14]

Including the potential for limited onshore development in the Canning basin, GHG emissions from LNG production in Western Australia could easily grow to 60 Mt CO_2e per annum or more, with future developments already progressing in the Scarborough and Browse[15] fields. As a signatory to the Paris Agreement on climate change, Australia has committed to reduce its total emissions to 26-28 per cent below 2005 levels by 2030 and reach net zero emissions by 2050.[16]

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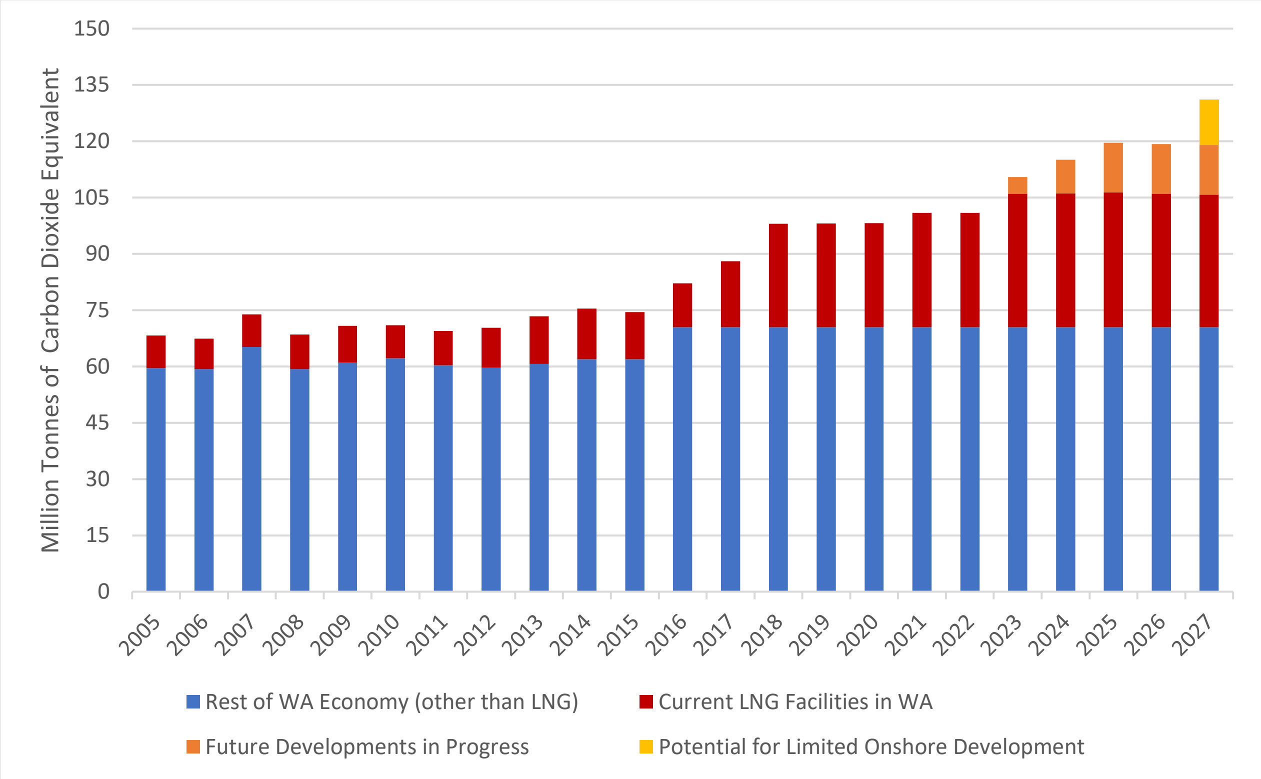
[8] Under Section 46 of the Environmental Protection Act 1986 the Minister may request the EPA to inquire into and report on the matter of changing implementation conditions relating to proposals.
[9] Ministerial Statement 873, Conditions 19-1 to 19-8 (August 2011)
[10] Ministerial Statement 922
[11] http://www.epa.wa.gov.au/proposals/wheatstone-development-%E2%80%93-gas-processing-export-facilities-and-infrastructure-s46-2143
[12] http://www.epa.wa.gov.au/proposals/gorgon-gas-development-revised-and-expanded-proposal-s46-2161
[13] The 30 Mtpa figure is net of floating LNG located in international waters.
[14] Total CO_2 emissions in Western Australia were about 68 Mt in 2005.
[15] Torosa, Brecknock, and Calliance fields.
[16] Australia ratified the Paris Agreement on 10 November 2016. Our Nationally Determined Contribution ('NDC'), dated August 2015, sets an economy-wide target to reduce GHG emissions by 26 to 28 per cent below 2005 levels by 2030. This target has been rated as 'insufficient, and with a level of ambition that, if followed by all other countries, would lead to global warming of over 2°C and up to 3°C'.

Figure 1: Western Australia's past, projected and potential GHG emissions.



Source: LNG emissions projection data from RepuTex. 'Rest of WA Economy' data from State and Territory Greenhouse Gas Inventories 2016, Commonwealth of Australia 2018.

2.2.1 Total 'lifecycle' emissions

While analysis is limited to emissions that occur in Western Australia, there is a much larger volume of 'downstream' GHG emissions from the shipping, distribution, and end use of LNG. Should entire lifecycle emissions be considered, GHG emissions from all operating and proposed LNG projects are projected to be approximately 5 times those from manufacturing LNG,[17] largely attributed to emissions from the distribution and end use of gas. A more complete calculation of 'life cycle GHG emissions' from Western Australia LNG production would therefore extend total emissions from current operating and commissioned facilities to almost 200 Mtpa.

Table 2: Emissions from gas mining and export of LNG from Western Australia (million tonnes of carbon dioxide equivalent every year).

LIFECYCLE TOTAL	197.2
Exploration and drilling	0.1
Gas processing	36
Gas use in WA	24.1
Domestic Subtotal	**60.2**
Shipping overseas	4.4
Distribution	0.6
Usage overseas	132
International Subtotal	**137.0**

Source: Clean State.

[17] Hardisty, P., Clarke, T., Hynes, R. (2012), *Life Cycle Greenhouse Gas Emissions from Electricity Generation: A Comparative Analysis of Australian Energy Sources* – Energies.

2.2.2 Future development of unconventional gas emissions in Western Australia

At present LNG developments in Western Australia focus on 'conventional' natural gas resources, however, some companies are exploring the development of 'unconventional' resources, including exploiting shale gas in the Canning Basin using hydraulic fracturing (fracking). Fracking is the process of injecting liquid at high pressure into subterranean rocks, boreholes, etc. to force open existing fissures and extract oil and gas. This extraction method requires many wells and is an inherently leaky process.

Based on analysis undertaken by Climate Analytics on unconventional gas in Western Australia,[18] unconventional gas resources from even relatively small basins - such as Carnarvon - could extend total emissions by a further 3.4 to 3.9 Gt CO_2-e. Combining this with other larger gas basins - like Canning - could see Western Australia emissions rise by approximately 13.4 to 20.8 Gt CO_2-e.[19] Developing and using these resources would therefore entail a large increase in GHG emissions for Western Australia.

[18] Hare, Roming, Hutfilter, Schaeffer, & Beer (2018), *Western Australia's Gas Gamble: Implications for exploiting Canning Basin and other unconventional gas resources for achieving climate targets* – Climate Analytics; Table 1.
[19] Assuming 6.5% CH_4 leakage. These figures are only for domestic emissions. The lifecycle emissions of unconventional gas development would be much more.

3. ABOUT THIS ENGAGEMENT

3.1 Scope of engagement

RepuTex has been engaged by the Conservation Council of Western Australia (CCWA) to analyse the economic benefits of reinstating greenhouse gas (GHG) conditions on LNG projects in Western Australia, specifically the requirement for proponents to offset emissions from LNG developments.

This Report presents the modelling outcomes of a series of questions, which seek to understand the type and nature of carbon pollution offsets that could potentially be available within Western Australia should offset conditions be reinstated, and the economic benefits of developing a local carbon offset industry.

Key modelling questions include:

- Identify the type and nature of carbon pollution offsets that would potentially be available in Western Australia to offset carbon emissions at various reference levels;
- Quantify the number, type and spread of jobs that could be created in WA, if emissions from LNG projects were required to be 100 per cent offset through the acquisition and retirement of carbon credits generated in Western Australia;
- Understand, on a regional basis, the economic, investment, employment and business development opportunities that would be created in WA through generation of carbon offsets at the reference levels;
- Understand the benefits of developing a carbon sequestration industry in WA's rangelands by focusing on this industry as a delivery vehicle for offsets; and
- Understand opportunities to provide new employment and diversify regional economies in transition (such as the Collie region) through the development of new offset industries;

Sections one and two of this report provide a summary and background to the engagement; section three describes the scope of our analysis and modelled scenarios; section four contains our modelling results, including outcomes for offset availability in Western Australia, the annual value of offset investment in Western Australia, and regional job creation; section five details illustrative case studies for the co-benefits of offset projects in regional Western Australia.

3.2 Scope of analysis

To understand the type and volume of GHG emissions offsets that may be available in Western Australia, and subsequent economic investment and job creation opportunities, we establish three reference levels for emissions offset requirements that could be reinstated on LNG developments.

Modelling aligns offset supply with illustrative annual offset demand at thee reference levels, reflecting 'low', 'medium' and 'high' scenarios for the acquisition and retirement of offsets:

- **Low Scenario** - Demand for offsets equivalent to 15 million tonne of carbon dioxide per annum (Mtpa), reflecting approximately half of domestic emissions from current LNG facilities;
- **Medium Scenario** - Demand for 30 Mtpa, reflecting approximately all direct domestic emissions from current LNG facilities;
- **High Scenario** - Demand for 60 Mtpa, a doubling of the medium scenario, reflecting illustrative demand to offset direct emissions from current and proposed LNG developments.

The scope of this Report does not consider offsetting lifecycle emission scenario, however, using a more complete approach to emissions liability would be more consistent with Ecological Sustainable

Development (ESD) principles[20]. These principles require that LNG developments share responsibility for ensuring there is no net increase in life cycle GHG emissions, even if this results in emissions transported overseas being offset overseas, as recommended by a recent Australian gas development inquiry.[21] A condition for 100 per cent of life cycle GHG emissions to be offset would create significant demand for CO_2-e offsets, which may present a challenge for an economy the size of Western Australia. Although outside the scope of this analysis, international offsets may need to be considered for emissions that occur outside of Australia.

The scope of this report also does not include the full potential for higher GHG emissions associated with unconventional gas resources. Although not expressly modelled, the cost of offsetting these emissions would be higher than our High Scenario. The future development of these resources would also put significant upward pressure on the cost of offsets, which may become prohibitively expensive unless offsets could be accessed from outside of Western Australia.

3.3 Summary of modelling process

In determining the potential availability, cost, and co-benefits of abatement offsets available in Western Australia to meet the above demand reference levels, we draw on our Marginal Abatement Cost (MAC) model to identify potential emissions reduction activities in Western Australia and quantify the total volume and cost of undertaking identified activities.

For the purposes of this report, analysis focuses on GHG abatement activities related to emissions removals from the land-sector, along with a broader set of activities that are likely to deliver large-scale emissions reductions, while creating significant economic and environmental benefits for Western Australia. For example, investment in GHG abatement activities that assists with the task of replacing coal-fired generation with renewable energy may be favourable given the potential for this investment to support the transition of the Western Australian economy, particularly in the Collie region, through the development of new industries that generate GHG offsets.

Abatement activities are classified into the following categories: “Renewable Energy”, “Agriculture” and “Vegetation Management”, described in Table 3:

[20] Chapter 4: Evidence and Risk Assessment Methodology, Principles of ESD - Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.

[21] Chapter 9: Greenhouse Gas Emissions, Recommendation 9.8 – That the Northern Territory and Australian governments seek to ensure that there is not net increase in the life cycle GHG emissions emitted in Australia from any onshore shale gas produced in the Northern Territory (Scientific Inquiry into Hydraulic Fracturing in the Northern Territory).

Table 3 – Summary of GHG abatement activities by category.

Category	Major Activities	Summary
Agriculture	Livestock Management	Abatement is delivered because livestock produce emissions for fewer days, and fewer animals are required for a given level of output. Managers can reduce emissions by establishing higher quality pasture, providing a feed supplement all year round, improving weaning percentage by culling unproductive cows, installing fences to control heard movements and improve joining practices, and expanding watering points to allow cattle to graze more widely and make better use of available pasture.
Renewable Energy	Lage-scale Solar	Abatement is delivered by the annual electricity generation of a >1 MW solar energy project displacing the emissions intensity of fossil fuels in the South West Interconnected System (SWIS).
	Large-scale Wind	Abatement is delivered by the annual electricity generation of a >1 MW wind energy project displacing the emissions intensity of fossil fuels in the SWIS.
Vegetation management	Avoided Deforestation	Abatement is mainly generated by stopping all harvesting in the public native forests, and thereby avoiding the emissions that clearing would have produced.
	Rangeland Regeneration	Projects capture carbon by changing rangeland management practices to facilitate regeneration of native vegetation. Landholders can assist regeneration through activities such as excluding livestock from the project area, managing the timing and extent of grazing, managing feral animals and non-native plants in the project area, and stopping activities such as mechanical destruction of natural regrowth.
	Reforestation Plantings	Projects capture carbon by permanently planting native trees or mallees to establish forest cover. This includes 'integrated carbon farming' that in addition to biodiverse tree plantings could also include other complementary activities like some farm forestry – e.g. sandalwood – sheep grazing and bee keeping.
	Savannah Burning	Participants undertake appropriate fire management in their projects, so carbon dioxide is removed from the atmosphere by sequestering carbon in dead organic matter and to avoiding emissions of methane and nitrous oxide from the late dry season burning of grasslands.

Projected costs and abatement volumes are derived from bottom-up examination of different project types in line with our in-house MAC curve for the Australian economy. Given there is often a wide range of abatement costs associated with different individual projects, we apply average marginal abatement costs, which are calculated to represent the typical cost of undertaking each activity in Western Australia.

Estimated offset supply volumes are aligned with assumed offset demand levels described in Section 3.2. This establishes whether there is likely to be enough abatement within Western Australia to cover the demand scenarios, while enabling the analysis of what types of projects are likely to supply the bulk of emissions offsets, and the price at which offset supply and demand may be balanced.

3.4 Key assumptions

A MAC curve is a dynamic tool which needs to be regularly updated due to changes in emissions baselines, fuel and technology costs, technological developments and process improvements. Subsequently, in developing our MAC model for the Australian economy, we draw on regular consultation with market stakeholders. In undertaking analysis in this Report, we specifically consider feedback from Western Australian carbon farmers, pastoralists, and renewable energy developers, including Emissions Reduction Fund (ERF) project proponents, aggregators, financial institutions, academic researchers and policymakers. Input on investment, job creation, project costs, abatement volumes, timing and transaction cost assumptions are incorporated into our modelling assumptions and our proprietary cost databases, which we present within this study.

Modelled projects are scaled to a state-wide activity level based on available land area, appropriate vegetation, timing and location, to provide a cumulative estimate of abatement in Western Australia. To compare abatement costs across such a wide range of activities, a marginal abatement cost is estimated by dividing the net present value of a project by its total abatement.

Modelling assumes the below settings:

- GHG abatement activities are assumed to be undertaken in Western Australia;
- Proponents are required to offset their emissions in line with the emissions reference scenarios above (e.g. 50-100 per cent of emissions);
- Prices are reported in 2018 Australian dollars unless otherwise noted. No pricing interaction with any future changes in federal policy is considered;
- Modelled MAC outcomes depict the technological potential of abatement measures, based on the maximum estimated abatement potential of each activity, exclusive of behavioural aspects and policy implementation barriers;
- While some abatement measures may result in cost savings relative to business as usual (BAU), in practice, savings are only realised once market inefficiencies are overcome (for example by policy). These inefficiencies may be in the form of split incentives, information gaps, policy uncertainty and/or significant upfront payment barriers;
- Transaction costs may be included when estimating potential abatement prices, referred to as ‘offset prices’, or the price that an offset may receive in the market. Transaction costs are an overlay on abatement costs, varying by project type, size, and location. These reflect administrative costs of development, such as project sourcing, measurement of abatement and legal costs;
- Where relevant, abatement activities are consistent with Australian Carbon Credit Unit (ACCU) methodologies and may therefore be considered fungible with any future compliance scheme. Total abatement estimates included forecast changes and expansions of Emissions Reduction Fund methodologies.
- Direct and indirect employment is included in job multipliers;

For further information on our research process and methodology refer to Appendix A.

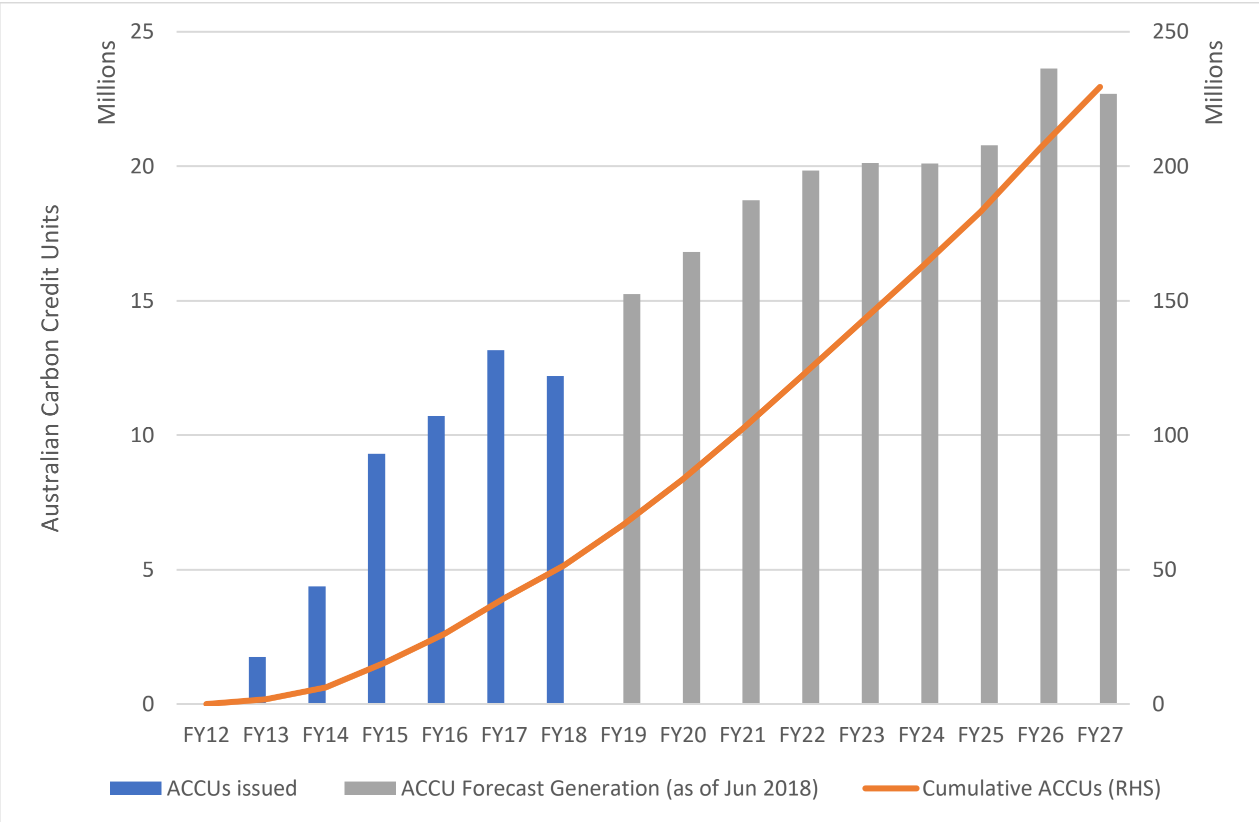
4. CURRENT OFFSET AVAILABILITY

4.1 Current offset supply in Western Australia

To date, most GHG abatement offsets issued in Australia are in the form of ACCUs, with issuance overseen by the Clean Energy Regulator (the Regulator). Following the conclusion of the Carbon Price Mechanism at the end of June 2014, the Commonwealth's Emissions Reduction Fund (ERF) has formed the primary market for ACCUs, with the Regulator entering into contracts to purchase offsets from developers active in land, waste and now industrial sector projects[22]. More recently, activity in a 'secondary' market has developed, underpinned by large facilities offsetting excess emissions over their safeguard mechanism baselines.

As shown in Figure 3, the ERF has contracted to purchase approximately 192 million ACCUs though 429 contracts,[23] with offsets to be issued and delivered over the next two to ten years. Around 12.2 million ACCUs have been issued in financial year 2017-18. National ACCU issuance over the next decade is anticipated to be over 15 million per annum, with growth in both the number of ACCUs issued per project and the total number of projects.

Figure 3: Forecast issuance of ACCUs in Australia under the Emissions Reduction Fund (Sep 2018).



Source: RepuTex Energy 2018

In Western Australia, annual ACCU issuance under the ERF has grown from around 500 thousand in 2016-17 to more than 700 thousand per annum in 2017-18. Of this, approximately 400 thousand ACCUs per annum have been issued to reforestation and savannah burning projects (55 per cent). Western

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[22] In September 2018 a method for industrial equipment upgrades method came into effect, providing an alternative method for upgrades to existing industrial equipment including compressed air systems, boiler systems or pumps to improve the energy efficiency of the upgraded system.

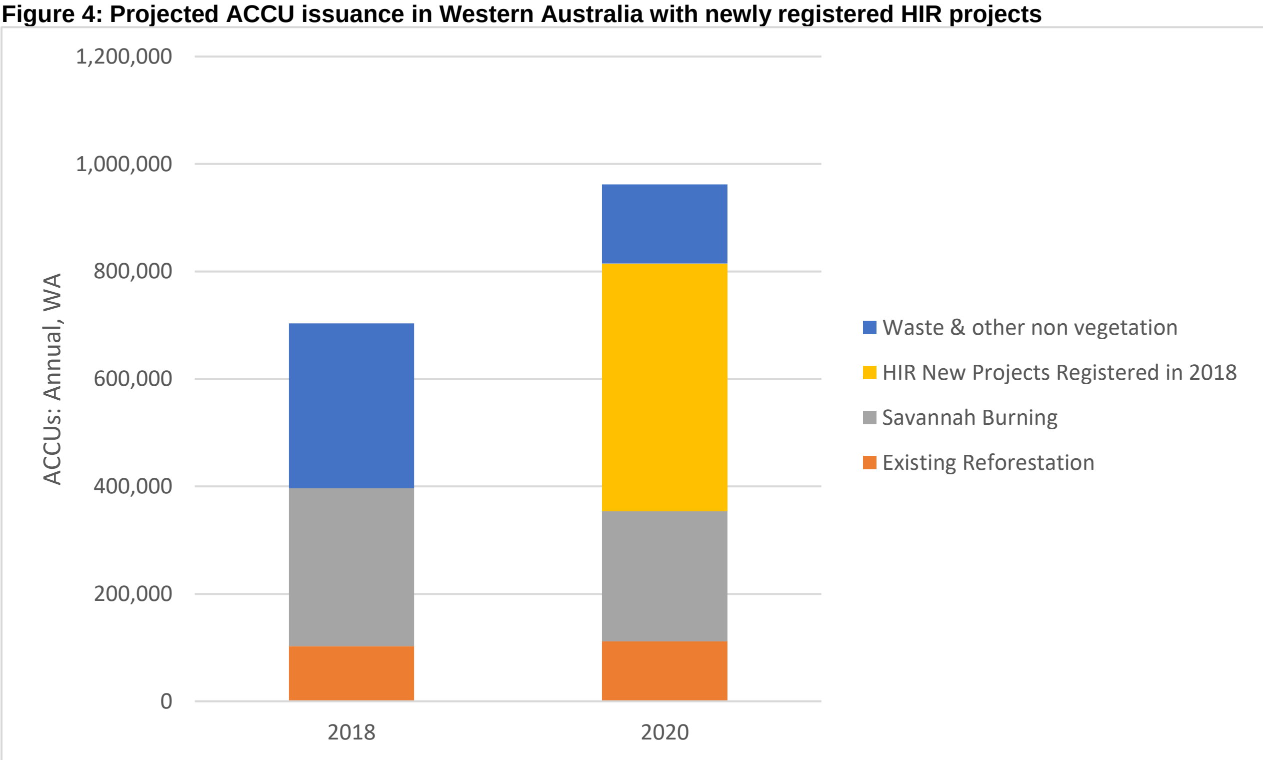
[23] As of 16 August 2018: Clean Energy Regulator, http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/carbon-abatement-contract-register

Australia therefore contributes less than 10 per cent per cent of national ACCU supply. This is largely because of historic supply constraints in the land sector, due to uncertainty around carbon rights on leasehold land[24], resulting in the state missing out on much of the available ERF funding.

The Western Australian government has recently clarified long-standing questions in relation to carbon sequestration projects on Crown land. Consequently, a sharp increase in ACCUs is forecast for projects utilising the ERF's Human Induced Regeneration (HIR) methodology, which is popular in the eastern states. In April 2018, the Western Australian government gave approvals for pastoralists to participate in the ERF, with a 12-month pilot program established as a first step towards creating an accessible carbon farming industry. However, further reform to land tenure will be required for carbon farming to reach its full potential by addressing the term of pastoral leases and native title implications.[25]

As shown in Figure 4, should carbon rights on lease-hold lands be resolved favourably, we estimate an additional 500,000 ACCUs could eventually be issued annually. Almost all these offsets are expected to be derived from sequestration activities undertaken on rangelands (yellow bar), however this growth is likely to be offset by reduced ACCU generation from the waste sector (blue bar), such as landfill gas.[26] This could see average supply from all activity types in Western Australia increase from 700,000 in 2018 (left hand column) to approximately 900,000 offsets per annum (right hand column). Assuming enough demand, we estimate these ACCUs could be made available at current secondary market prices[27].

Figure 4: Projected ACCU issuance in Western Australia with newly registered HIR projects



Source: Clean Energy Regulator and RepuTex, 2018.

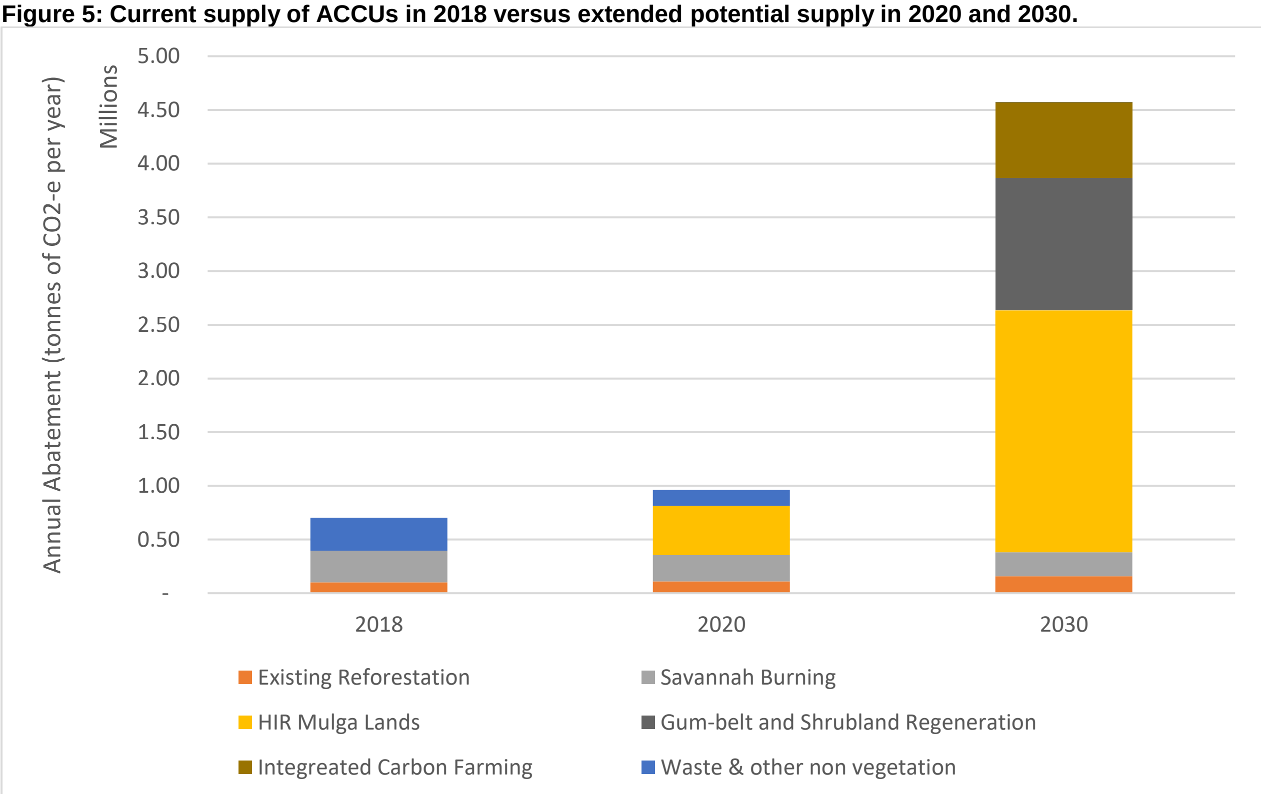
[24] ABC News: Courtney Fowler, Michelle Stanley, Tara de Landgrafft, Multi-billion-dollar potential for Western Australia's carbon farming industry - 20 April 018 (WA Country Hour); http://www.abc.net.au/news/rural/2018-04-20/carbon-farming-approval-for-western-australian-pastoralists/9672784
[25] ABC News, Multi-billion-dollar potential for Western Australia's carbon farming industry 20/4/18
[26] May – June 2018: Offset price survey, RepuTex.
[27] Current ACCU 'spot' prices are approximately $17.

4.2 Potential to expand current ACCU supply

Should current ERF methodologies be revised, and potentially extended, further increases to rangeland ACCU issuance are expected by 2020, beyond current registered projects. For example, should the current HIR methodology be revised to account for all above-ground carbon pools, and incorporate advancements in low-cost drone measurement technology, a 30-50 per cent increase in ACCUs generated from rangelands crediting areas may be achievable.[28] This would subsequently result in increased rangelands abatement, particularly within the Southern Rangelands[29], which has the greatest potential for carbon sequestration due to land degradation (as a result of overgrazing and other pressures).

In this region, the greatest potential for carbon sequestration is via mulga shrublands, which occupy 50 million hectares of the rangelands, or about 20 per cent of Western Australia. Using the current HIR method, around 40 Mt of CO2-e may be sequestered over 25 years[30], or 1.6 Mt per annum. A rate of 1.6 Mtpa is around 2.5 times the projected ACCU issuance to HIR projects by 2020, suggesting there is significantly more abatement potential that has not yet been registered under the ERF. Assuming a further increase of 40 per cent on this total potential, abatement may grow on average to over 2.25 Mt per annum, as shown in Figure 5. Of this, around 1.1 Mt, or half of this abatement, is expected to be derived from new mulga shrublands potential, and 600,000 from a new rangeland method, as shown in Figure 6.

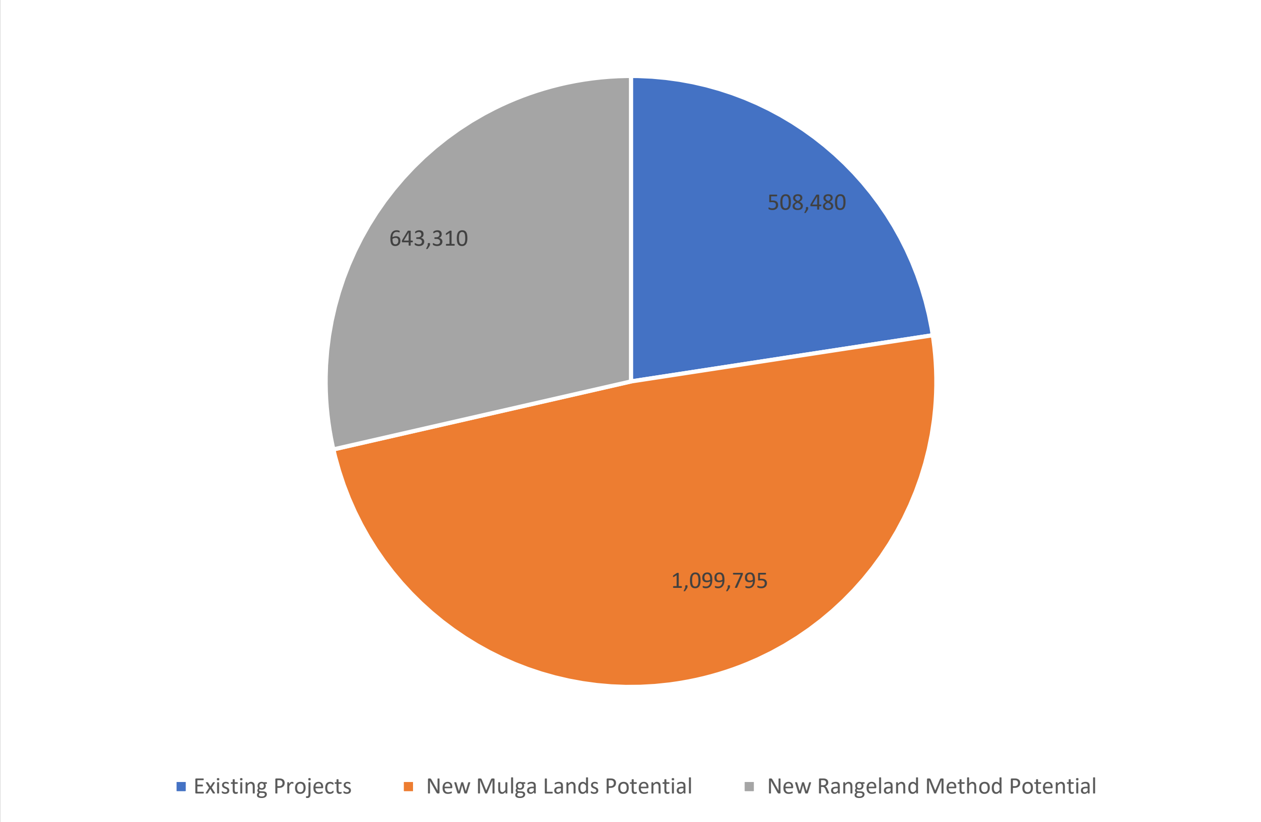
Figure 5: Current supply of ACCUs in 2018 versus extended potential supply in 2020 and 2030.



Source: RepuTex Energy 2018

[28] Correspondence with Dr Peter Russell estimates that there would be a 30-50% increase in ACCUs generated within the existing and potential HIR project Carbon Estimation Areas if a 'rangelands method' was developed.
[29] All WA rangelands south of the middle of the Pilbara.
[30] Estimate from Select Carbon Ltd.

Figure 6: Breakdown of modelled HIR Mulga Lands potential supply in 2030.



Source: RepuTex Energy 2018

Beyond expanded abatement from mulga lands, other areas with carbon sequestration potential include the gum-belt of Eucalypt woodlands in the Goldfields and salt bush and blue bush in the southern rangelands. These areas do not have vegetation that would meet the current HIR criteria, however if this criterion is expanded, the potential sequestration in these areas is projected to grow an additional 40 Mt.[31] We estimate this may contribute around 1.5 Mt per annum.

Potential also remains for additional supply from integrated carbon farming projects in Western Australia, which have combined diverse plantings with alternative, non-carbon revenue streams to recoup investments at lower prices than traditional environmental planting projects[32].

In aggregate, outcomes suggest the rangelands could generate a total potential supply of around 4.5 million tonnes per annum in Western Australia under new methodologies, should existing and planned methods be expanded and fully captured in Western Australia. This is a five-fold increase on the current projected baseline of 900,000 ACCUs per annum (should newly registered HIR projects be successful) but suggests that a considerable scale up of supply beyond the potential of Western Australia's rangelands will be required to meet the three demand reference levels identified in Section 3.2.

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[31] Correspondence with Dr Peter Russell via Mr. David Mackenzie.

[32] Developers estimate that increased contract prices, and acceptable escalating forward contracts, could result in plantings of around 5,000 hectares p.a. within two to three years. This may grow to around 30,000 hectares p.a. across multiple developers, delivering 120,000 to 210,000 ACCUs p.a. This assumes a ten-year payback period and 20 to 30 per cent up-front capital is available to assist with covering planting costs. Australian banks currently finance these types of projects in New Zealand on the basis of bi-partisan support for their Emissions Trading Scheme.

5. AVAILABILITY OF OFFSETS TO MEET DEMAND

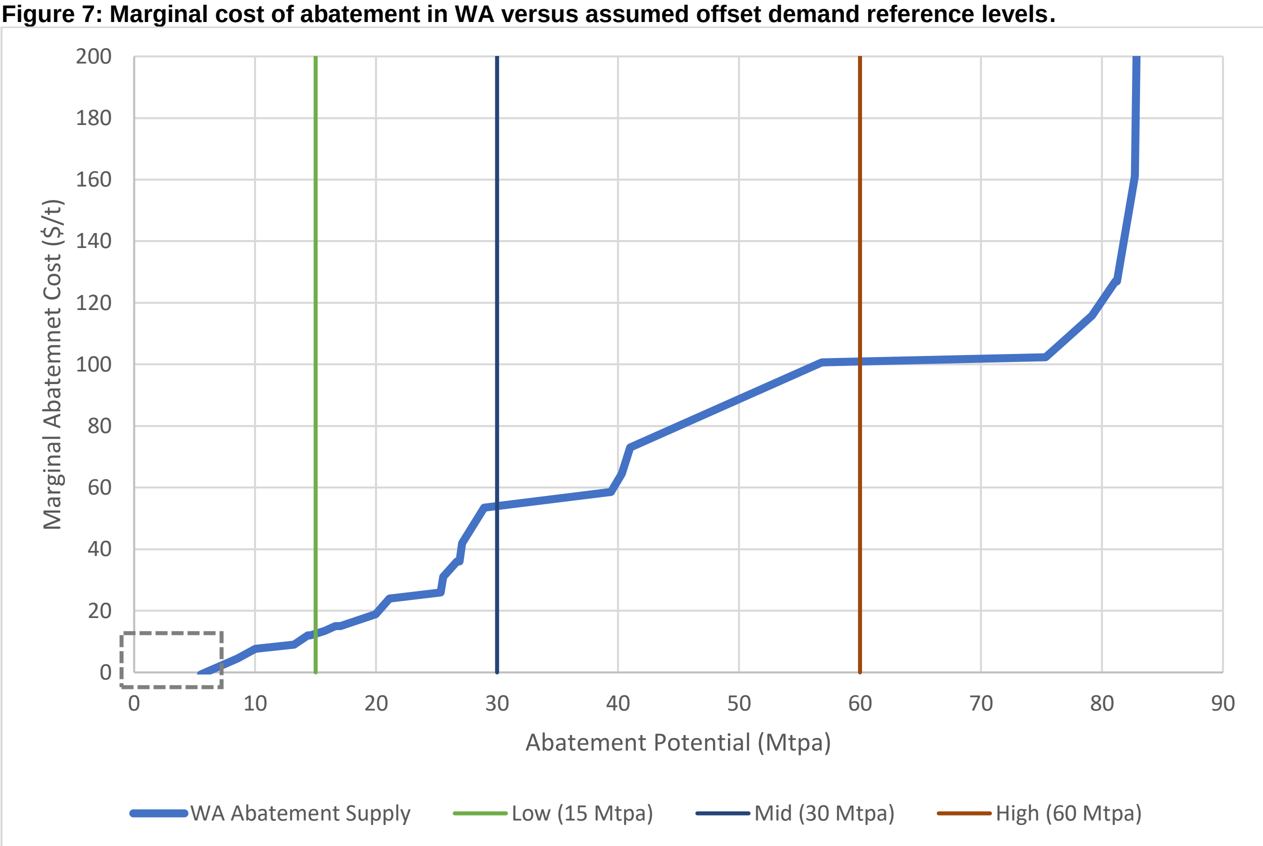
5.1 Offset supply and price scenarios in Western Australia

To understand the type and volume of GHG emissions offsets that may be available in Western Australia to meet modelled demand levels, below, we apply marginal abatement cost analysis to align estimated supply volumes with assumed demand for 15 Mt, 30 Mt and 60 Mt of abatement demand, outlined in Section 3.2. This enables a deeper understanding of what types of projects are likely to supply the bulk of emissions offsets in Western Australia, and the price at which offset supply and demand may be balanced.

Given West Australia's ACCU issuance of around 400,000 from the land sector in 2018, potentially growing to 900,000 per annum should newly registered HIR projects be successful, each demand scenario would require a considerable increase in offset supply from current levels. This reflects the large potential growth opportunity for the carbon offset industry in Western Australia, with a robust source of demand likely to trigger considerable large-scale investment to generate new offset supply.

As shown in Figure 6, should emissions conditions be tightened for Western Australian LNG production facilities, requiring projects to offset their direct emissions, analysis suggests that Western Australia has ample abatement potential to meet demand within the state. Findings indicate that approximately 80 Mt of emissions reductions are available across all identified activities (blue line), equivalent to Western Australian state-wide emissions in 2017. Western Australia therefore has considerable local abatement available to meet modelled demand scenarios, or to meet any future net-zero emissions reduction target.

Figure 7: Marginal cost of abatement in WA versus assumed offset demand reference levels.



Source: RepuTex Energy 2018.

The marginal cost of meeting modelled demand is shown via the intersection of each demand scenario (vertical lines) with supply (blue line). Although marginal abatement costs can be negative (shown via grey box in Figure 7), such as when the low carbon option is cheaper than the business-as-usual option, marginal abatement costs often rise steeply as more pollution is reduced. As more demand for offsets develops in line with the modelled scenarios, the price for offsets in Western Australia is therefore projected to increase, encouraging more supply to come become available to the market.

As shown in Figure 7, demand for 15 Mtpa of emissions reductions is expected to be fulfilled up to $15 per tonne, with the doubling of annual demand to 30 Mtpa likely to approximately triple marginal abatement costs, as the marginal cost of abatement grows to $50 per tonne. Under a high demand scenario of 60 Mtpa, abatements costs are projected to grow to $100 per tonne, underpinned by the need to unlock higher cost abatement at the far end of the supply curve.

Notably, findings indicate that Western Australia is well placed to supply a large quantity of low-cost offsets, with considerable supply of around 5 to 6 Mtpa available under $1 per tonne (grey box). This is mostly associated with agricultural efficiencies that increase yields, while also reducing cropland emissions. Even more significant is the availability of up to 15 Mtpa of supply (18 per cent of total abatement) under $15 per tonne, largely attributed to optimising grazing patterns and regenerating rangelands, potentially at the same time. This suggests Western Australia ample 'low cost' offset opportunities should policy be designed to capture these activities (refer to breakout box below).

Beyond the low scenario, the assumed price of offsets increases with each demand scenario as 'low-hanging' abatement is contracted and demand for offsets 'buys its way up the cost curve'. At the higher demand scenarios, we see two clear price plateaus become evident, a level encompassing large-scale renewable energy projects around $50 per tonne, and a large plateau at approximately $100 per tonne attributed to reforestation on higher value lands. Around half of all abatement is therefore available above $40 per tonne. Despite this, all scenarios reflect well against international carbon price benchmarks, with carbon prices in Europe projected to grow from about A$30 per tonne today to approximately A$60 per tonne by 2023, driven by the higher ambition of policy in these markets[33].

Interpreting marginal abatement cost (MAC) analysis, and 'negative costs'

Marginal abatement cost analysis is regularly used to measure the cost and emissions reduction potential of implementing activities to reduce greenhouse gas (GHG) emissions across an economy, or within a sector. Abatement costs and volumes are plotted in order from lowest to highest cost, forming a 'greenhouse gas abatement cost curve'. Market stakeholders may then compare relative abatement volumes and costs from different activities and technologies, and the potential for emissions reductions to be derived from different sectors. This can inform cost-efficient policy design and abatement planning, helping to identify the potential sources and costs of achieving specific emission reduction objectives.

Modelled MAC outcomes in this Report depict the technological potential of abatement measures, based on the maximum abatement potential of each activity, exclusive of behavioural aspects and institutional implementation barriers, often created by the design of policy. The exclusion of 'market imperfections' results in the representation of negative abatement costs - abatement measures that have a positive return over the lifetime of an investment. While these measures may be result in cost savings, in practice, savings can only be realised once market inefficiencies (such as split incentives, information gaps, policy design or upfront payments barriers) are overcome.

These inefficiencies are particularly important for carbon farming abatement activities, where physical abatement can take a long time to manifest and payback periods can be long. For example, integrated carbon farming activities have a 25-year project life, that typically experiences the highest carbon sequestration rate on the backend of the project (years 6 though 25), well after capital costs have been invested. The high cost and long payback period of these projects generally creates a large barrier for investment, often resulting in entities choosing to implement higher cost abatement projects that may offer greater certainty, such as projects with non-carbon revenue streams (such as electricity or gas sales).

The design of efficient policy can help to overcome these barriers. In doing so, policy could help unlock low-cost abatement in a sector or across an economy. For example, legislating an emissions reduction compliance obligation (such as an emissions reduction target, cap or baseline, or offset regulation), can provide certainty for investors that demand for abatement will still exist by the time that offsets are issued (i.e. in 6+ years for land-sector projects). This can make projects, such as integrated carbon farming

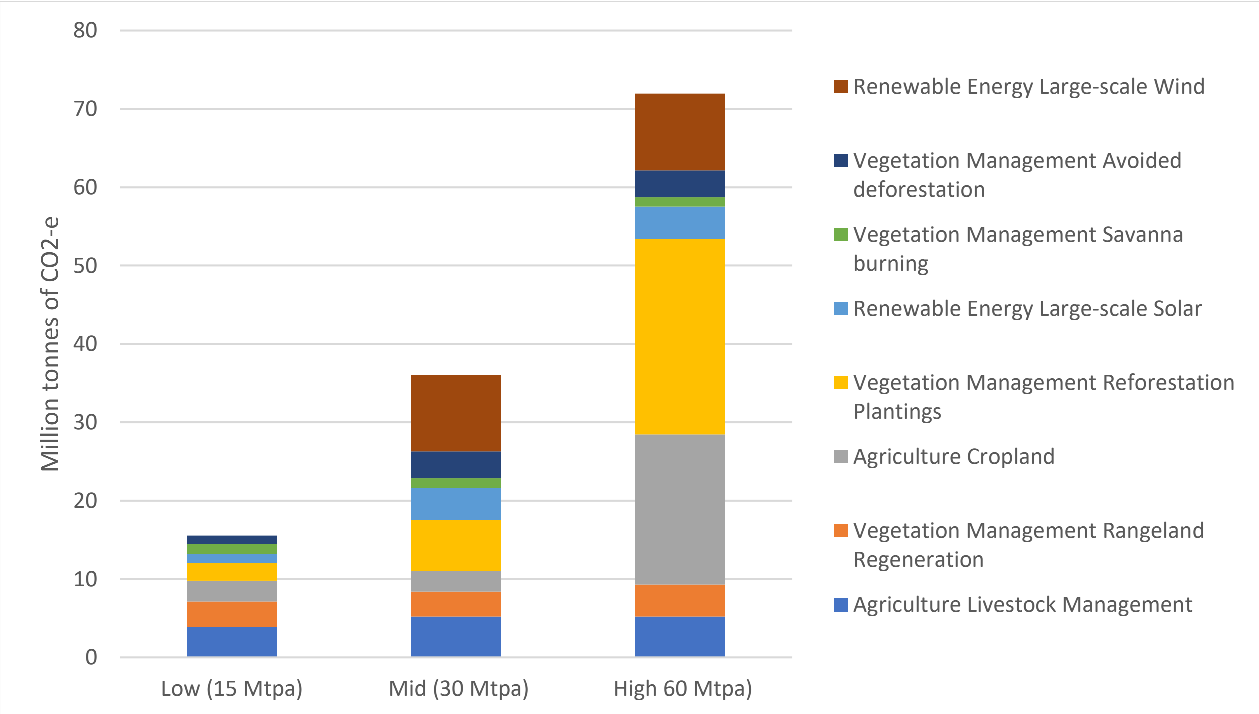
[33] Assumes exchange rate of 0.7 Euro to AUD. Carbon Price Outlook: December 2018, RepuTex Energy.

activities, more attractive for investment. Aside from setting a robust source of demand, policy must be clear and transparent, ensuring participants understand how any mechanism operates, while building certainty by ensuring access to information, such as levels of demand (individual facility emissions and targets), availability of supply, and the price paid to offset a liability. These parameters are not addressed under the Commonwealth ERF, limiting the effectiveness of the scheme[34].

For the purposes of analysing the abatement potential of offset activities within the Western Australian economy, modelled estimates in this Report assume that emissions reduction investments are made in an optimal market setting (low transaction costs and no barriers to implementing projects), underpinned by policy certainty and transparency. This ensures all potential abatement in the market is 'unlocked'. Large abatement volumes are therefore shown to be achievable, at the marginal costs identified, subject to the design of policy that can incentivise the identified emissions reduction opportunities.

5.2 Projected offset supply by type

Figure 8: Supply of GHG abatement offsets from Western Australia to meet demand reference levels.



Source: RepuTex Energy 2018.

As shown in Figure 8, the source of abatement - and consequently the price of offsets - changes based on modelled demand assumptions. Under a 'Low demand' scenario (15 Mtpa), emissions reductions are modelled to be achieved from a balance of low-cost renewable, vegetation and agricultural project types. Of these, pastoralists are expected to supply the largest portion of abatement, attributed to low-cost

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[34] To date, the effectiveness of the Commonwealth's ERF scheme has been constrained by low transparency, structural inefficiency and uncertainty over the continued source of demand. Rather than set a traditional demand obligation (such as an emissions reduction objective), the ERF operates as a voluntary reverse-tender process, with deferred payment of contract obligations (until delivery of abatement), and no transparent market price. While the Clean Energy Regulator discloses an 'average price of abatement' this does not reflect the true market price of abatement, i.e. the last or "highest" contract price accepted by the Regulator. Modelling suggests that a large spread of contract prices occurs within ERF auctions. As a result, the average price is not a robust signal for the true value of abatement in the Australian market. For example, RepuTex analysis of ERF auctions 1-3 suggested a lowest contract price of around $9 while highest clearing prices reached over $16, reflecting a significant premium over both the lowest contract price, and the reported average price ($11.83). Report link. Together, the voluntary nature of the scheme, combined with low investor certainty and transparency has subsequently limited the scheme's effectiveness.

livestock management (4 Mt), rangeland regeneration projects (3 Mt), cropland projects (3 Mt) and reforestation planting (2 Mt). Examples of activities with low marginal abatement costs include:

- **Livestock management**: establishing higher quality pasture, providing a feed supplement all year round, improving weaning percentage by culling unproductive cows, installing fences to control heard movements and improve joining practices, and expanding watering points to allow cattle to graze more widely and make better use of available pasture. This may generate offsets though more efficient cattle production reducing livestock emissions of methane associated with digesting feed and nitrous oxide from the dung and urine though shorter average lifetimes.[35]
- **Rangeland regeneration**: activities such as excluding livestock form the regeneration area, managing the timing and extent of grazing, manage feral animals and non-native plants and stopping clearing activities such as mechanical re-clearing of vegetation. This could generate offsets though the regeneration of native forest.[36]
- **Cropland**: activities that reducing cropland soil emissions like avoiding the burning of crop residues in favour of retaining them in the field, converting crops to pasture to reduce tillage, and increasing biomass yields through optimising fertiliser application.[37]
- **Reforestation plantings**: farm forestry activities that derive revenue from the regular harvesting of wood or provide shelter for agricultural activities. Other integrated carbon farming projects capture revenue from farm forestry to support additional pursuits including biodiverse tree plantings.

In addition, abatement from low-cost, non-ACCU generating activities could occur, including 'behind-the-meter' solar PV projects in the agriculture industry, particularly for common, large energy consuming processes such as irrigation and pumping, washing, processing, packing processes, cooling refrigeration and vacuum coolers in a factory.

For many of these activities, even relatively low-cost, small improvements in farming operations could result in a large volume of abatement. As noted, the challenge for policymakers to capture low-cost abetment is therefore not to just create demand for offsets, but to lower barriers for small livestock operations to quantity their abatement and receive payment for their credits. Should policy be designed to minimise transition costs, offset prices may reasonably be expected to remain in line with today's levels yet incentivise much larger supply volumes to do improved market efficiency.

While emissions reductions from livestock activities dominate low-cost opportunities in the 'low demand' scenario, under a 'medium demand' scenario, investment in renewable energy sector is projected to play a complementary role to the ACCU market, supplying around one third of all offsets. Around 14 Mtpa (39 percent) of all abatement is modelled to be supplied by allowing large-scale construction of solar and wind energy projects to create carbon offsets. In doing so, such investment can transition the Western Australian electricity sector, and change the way that the economy is fuelled, from legacy coal and gas-burning facilities into a clean-energy economy, underpinned by local renewable energy jobs and resources.

Examples of renewable energy abatement modelled here include large-scale (multi-MW) solar PV and wind projects on grasslands and degraded agricultural lands, underpinned by falling costs for solar PV. Significant projects of tens - or even hundreds - of MWs can combine to export electricity to the grid, potentially displacing GHG emissions from fossil-fuelled electricity generation earlier than currently forecast. These types of projects are now more economically feasible with only minimal carbon payments necessary, however, certainty afforded by small offset payments could help to maintain or accelerate the pace of renewable energy development as current renewable energy targets end.

Under a 'high demand' scenario, forest and rangeland sectors are modelled to supply a large volume of offsets though large-scale, long-term sequestration activities, that may begin to transform land-use practices. Notably, Western Australia has a significant amount of reforestation potential, with up to 25 Mtpa of emissions reductions available.

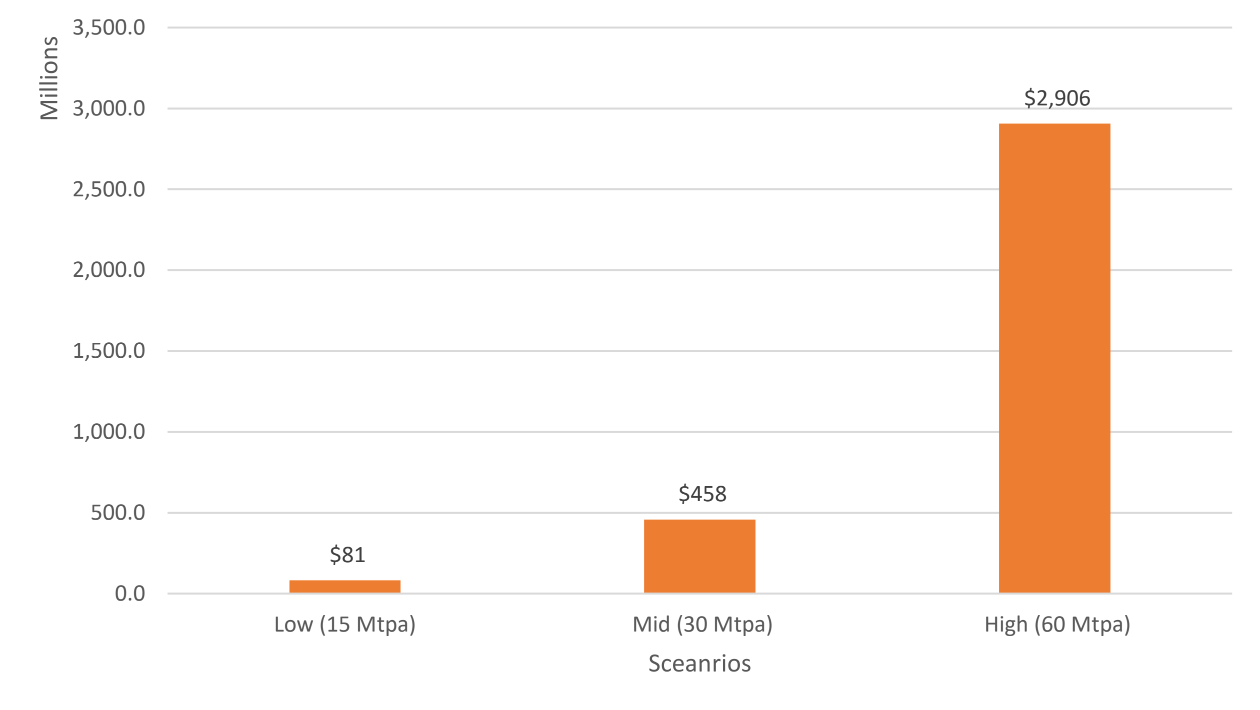
[35] See Australian Department of the Environment: Beef cattle herd management method.
[36] See Australian Department of the Environment: Human-Induced regeneration permanent native forest method.
[37] See Australian Department of the Environment: Estimating sequestration of carbon in soil using default values.

6. INVESTMENT AND ECONOMIC BENEFITS

6.1 Implied value of Western Australian offset industry

Should the above demand levels be realised, analysis indicates that value of the West Australian carbon offset industry may range between $81 million to $2.9 billion per annum, in line with the modelled price paths for abatement in Section 3.2.

Figure 9: Annualised Value of Western Australian Offset Market by Scenario.



Source: RepuTex 2018

As shown in Table 4, emissions reduction opportunities associated with carbon farming projects are estimated to receive the greatest share of investment, reflecting the larger potential of the land sector in each of the modelled scenarios. Should demand increase in line with a high scenario, this investment may grow to more than $2.9 billion annually, with the land sector capturing around $2.3 billion in offset investment. This suggests considerable opportunity for carbon farming proponents, with investment potentially flowing from large-scale LNG projects through to proponents on a long-term per annum basis, creating a basis for new and sustainable economic growth and job creation across the state, rather than more concentrated economic development in the coastal Pilbara and Kimberly offshore regions.

Table 4: Million dollars of annualised investment by category and demand scenario.

Category	Scenario		
	Low (15 Mtpa)	Mid (30 Mtpa)	High (60 Mtpa)
Agriculture	$20m	$26m	$1,660m
Renewable Energy	$1m	$18m	$627m
Vegetation Management	$60m	$414m	$619m
Total	**$81m**	**$458m**	**$2,906m**

Source: RepuTex 2018

6.2 Regional job creation from carbon offset industry

The development of a carbon offset market in Western Australia has the potential to provide significant benefits beyond GHG emissions abatement. These include large economic opportunities for investment and job creation across the state, particularly in regional communities, as well as co-benefits to biodiversity, landscape protection and water quality.

Increased economic activity is modelled to have considerable implications for both construction and long-term employment creation in Western Australia's regional economies. This may be in the form of direct construction jobs, needed to build new electricity infrastructure, and employment to operate and maintain large-scale solar and wind energy facilities. Investment is also able to spur permanent job creation associated with 'carbon farming' projects, such as aboriginal rangers, bee keepers, carbon foresters, land managers, stockmen and tree planting contractors, along with indirect employment that occurs along the value chain, such as the manufacturing of component parts, service industries, and so on.

To understand the impacts of increased investment in carbon farming on job creation, we identify employment multipliers from a range of primary and secondary sources for different activity types. Multipliers are aligned with operational and capital expenditure for each project type to derive a total employment figure per million dollars of investment.

Table 5: Job creation per million dollars of investment.

Project	Jobs/$M	Capital to labor spend ratio ($/person-yr)	Job Mix			Primary Investment Region
			Low skilled	Skilled	Professional	
Savanna Burning	12	90,000	5	4	4	Kimberley
Reforestation Plantings	10	100,000	3	2	5	Southern Rangelands
Rangeland Regeneration	9	120,000	3	4	3	Southern Rangelands
Renewable Energy	5	190,000	1	3	2	South West

Sourced from data provided by project developers. Multipliers consider direct job creation only.

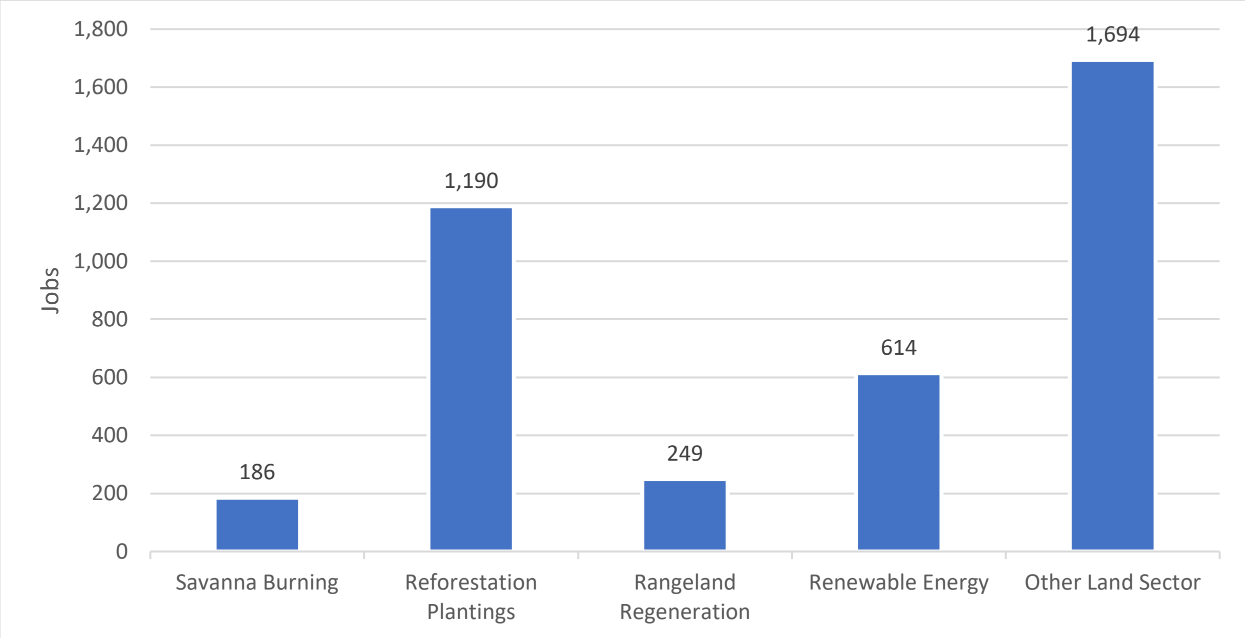
As shown in Table 5, on an employment per million dollars of investment basis, abatement from the land sector is expected to generate more labour-intensive projects than the electricity sector. Savana burning was found to have the highest number of jobs, averaging around 12 jobs per million dollars. Other land-sector projects were also found to create approximately double the number of jobs per dollar invested compared to renewable energy projects. This is because a larger portion of every dollar invested goes toward labour in the land sector, relative to the capital-intensive electricity sector.

Consequently, the land sector creates a wide differentiation of jobs across all skill levels. These jobs are concentrated in the Western Australian rangelands, with 'growing' projects in the Southern Rangelands and fire-management projects in the far north.

Renewable energy projects provide a larger proportion of skilled and professional construction jobs and can result in faster and larger emissions reductions than tend to occur in the land sector. Accordingly, renewable energy projects tend to create higher paying jobs - averaging over $70k per annum. These projects can also directly mitigate the negative economic effects of a transition to a clean energy economy, which tend to be concentrated in specific areas, e.g. the South West regions of the state.

Although categories such as renewable energy can create many jobs, the sheer size of potential land-sector investment and project types results in the forest planning projects having the larger job creation potential. As shown in Figure 10, other land-sector projects, such as forest management, are also labour intensive and have a high total employment potential, with 5 out of 6 jobs ultimately expected to be created in the land sector. While savanna burning has the highest jobs per dollar invested, below we see that job creation potential is larger for other project types, in line with absolute investment levels. Using the medium demand scenario for illustrative purposes, modelling finds that only 186 jobs could be created though savanna burning projects, whereas 1,190 may be associated with reforestation plantings, 249 with rangeland regeneration, 614 with renewable energy, and up to 1,694 in all remaining land sector projects.

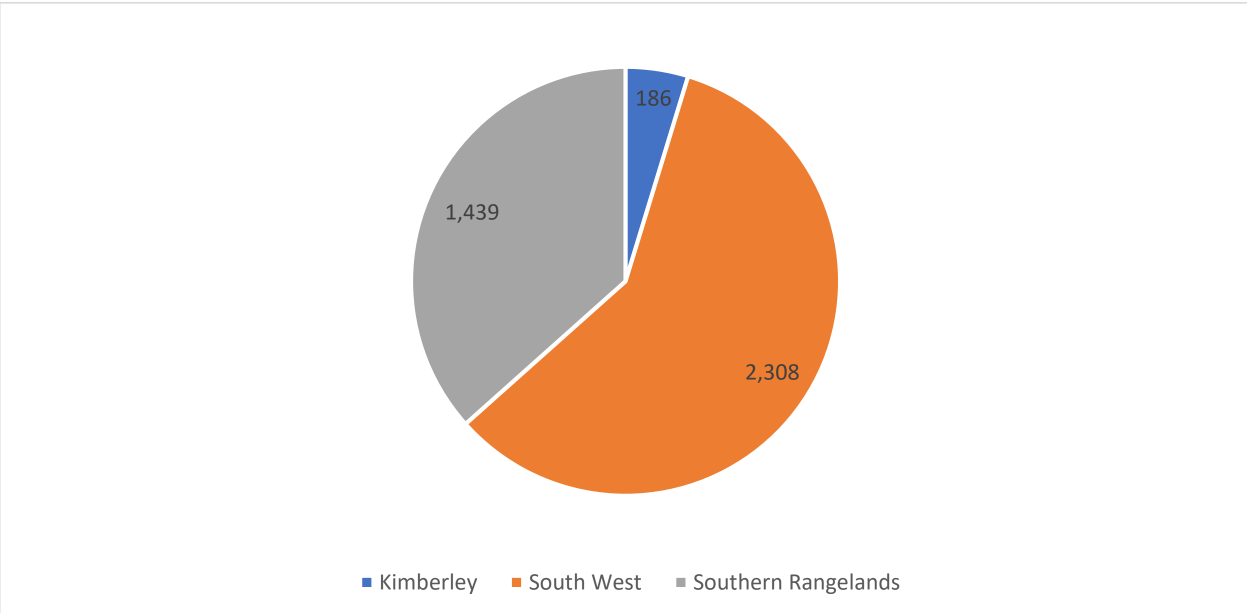
Figure 10: Job creation by category based on modelling of medium demand scenario.



Source: RepuTex 2018

Despite most jobs being associated with land-sector projects, job creation is modelled to be highest in the South West (non-rangeland) region of the state. This is because many of the largest opportunities for jobs associated with labour-intensive renewable energy, reforestation and forest management, are in the southwestern areas which contain both wetter agricultural areas and infrastructure associated with the more built-up parts of the state. Despite this, employment and regional development benefits are spread across the state, particularly in non-urban, regional areas that have in the past been overlooked and/or where job creation is traditionally in decline.

Figure 11: Illustrative job creation by primary investment region in the Medium scenario.



Source: RepuTex 2018

7. CASE STUDIES: ECONOMIC BENEFITS OF OFFSET INDUSTRY DEVELOPMENT

To understand specific economic, investment and employment opportunities created in Western Australia through the development of a carbon offset industry, we provide two case studies, detailing local opportunities associated with rangeland regeneration and renewable energy project development.

7.1 Bulga Downs Rangelands Restoration Project

Summary

- Bulga Downs is a 780,000 hectare (ha) pastoral lease, around 340 kilometres north of Kalgoorlie in Western Australia.
- In June 2018, the Bulga Downs rangelands restoration project was successful in the Emissions Reduction Fund (ERF) reverse auction, which will enable Bulga Downs to generate carbon offsets from revegetation activities on the land using the Human Induced Regeneration (HIR) method.
- The project is expected to generate an average of 80,000 metric tonnes of carbon offsets per year over 25 years.
- The project will bring substantial investment into the local economy, with the potential to generate three to four new full-time roles - a 50 per cent increase from current staff levels - and contract additional services from the local community. Further growth of similar projects also has potential for the increased contracting of specialists within the community for carbon measurement activities, such as contracting local pilots for flyover work monitoring forest canopy growth.

About Bulga Downs

Bulga Downs is a 780,000 hectare (ha) pastoral lease in Western Australia, around 340 kilometres north of Kalgoorlie. David McQuie has owned the lease since 1984, shifting from herding sheep to cattle on the property, in part as result of the impact from dingoes. Since the shift livestock, dingos are now recognised to have some benefit in controlling kangaroo and wild goat populations while having a much more limited impact to his own cattle herd.

Bulga Downs takes a holistic approach to land management on the property, allowing for certain tracts of land to regenerate while the herd is moved onto other parts. At any point in time, around 25 to 30 per cent of the property is under spell, meaning that the land is destocked for a period to enable vegetation to regenerate. The spelling period for any tract of land ranges from one to ten years depending on the condition of the land and how much time it needs to regenerate.

Fencing at Bulga Downs

Cattle are moved to different areas of the property based on several indicators, including the level of grazing and ground cover, rainfall patterns, and distribution of plants. Although this approach restricts cattle from grazing certain tracts of land for years, the size of the herd has increased over the long term as the land has regenerated.

Project Description

Western Australian rangeland projects have historically been precluded from participating in the Commonwealth Emission Reduction Fund (ERF) due to uncertainty over the carbon rights on leasehold land. In April 2018 the Western Australian government gave in-principle support for pilot carbon sequestration projects, enabling landholders to earn carbon credits for their practices. A decision will be made by the end of the year that may potentially pave the way for pastoralists to permanently exercise their carbon rights to the land.[38]

In June, the Bulga Downs rangelands restoration project was successful in the ERF reverse auction, enabling Bulga Downs to generate carbon offsets from revegetation activities on the land using the Human Induced Regeneration (HIR) method.[39] Through this project, current land management practices will be extended to encourage revegetation in the following ways:

- **Additional fencing -** Additional fencing will be built on the property to allow more precise livestock management across the property.

- **Water point placement -** Even within fenced-off tracts of land, cattle can graze the land unevenly if water sources are concentrated in certain areas, since cattle tend to stay near water sources. To encourage grazing to be spread more evenly across paddocks, more water points will be placed on the land and they will be placed more strategically to optimise grazing patterns.

- **Livestock management -** Livestock numbers per watering point will be managed to avoid overgrazing. While some tracts of land will be free of livestock, much of the land will be managed to promote carbon sequestration while also allowing limited grazing. While certain tracts of land will need to be livestock free for the first few years to establish themselves as forests, livestock integration with the forested land is ultimately viewed as key to the success of the forests. Without livestock grazing in these areas, the land runs the risk of woody weed invasions, higher risk of fire, and misses added nitrogen levels from cow manure as well as nutrients being compacted into the ground. The key is to monitor the land properly to balance the livestock levels.

Not all the property will be set aside for carbon sequestration. Out of the 780,000 hectares on the property, only 100,000 hectares are being targeted for reforestation, which is expected to sequester on average about 80,000 tonnes of carbon dioxide (CO_2) per year over 25 years. This sequestration rate also accounts for land already being reforested due to past land management practices and will not be eligible for generating offsets. Only land that will become reforested after the project has been accepted will be credited. While this will lower the potential for generating carbon offsets, it does mean there is good carbon sequestration potential for other rangeland properties in Western Australia that have degraded land and are considering similar land management practices.

Project Methodology

To measure the amount of carbon sequestered from this project, the HIR methodology was used for the Bulga Dows project. This methodology relies on the Full Carbon Accounting Model (FullCAM) software to model the carbon sequestration from changing land management practices to enable the regeneration of native forest. Forest cover that can be counted towards this methodology is defined as:

1. Land that has an area of at least 0.2 hectares; and
2. Land that has trees that:
    a. are 2 metres or more in height; and
    b. provides crown cover of at least 20 per cent of the land.[40]

Australian Integrated Carbon (AIC) is the project proponent, managing the monitoring, verification, and creation of carbon offsets for Bulga Downs. To create the Australian Carbon Credit Units (ACCUs), AIC establishes a baseline greenhouse gas inventory using remote sensing and airplane flyovers, which are then validated with on the ground field surveys. This survey also identifies which tracts of land are most suitable for sequestering carbon under the project. Follow-up measurements will then be taken throughout the 25-year crediting period to verify that carbon is being sequestered at the expected rates.

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[38] Government of Western Australia, 2018. *Rangeland regeneration to sequester carbon.* https://www.agric.wa.gov.au/climate-change/rangeland-regeneration-sequester-carbon
[39] Australian Government, 2018. *Human-Induced regeneration of a permanent even-aged native forest*. http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/human-induced-regeneration-native-forest
[40] Ibid.

Project Impacts

The Bulga Downs rangeland restoration project is expected to directly sequester about 80,000 tonnes of CO_2 per year over 25 years. Carbon sequestration is expected to be minimal in the first 3 to 5 years, then ramp up significantly from years 5 to 15 before tapering off from years 15 to 25. These sequestration activities can generate ACCUs for up to 25 years. In addition to direct carbon sequestration benefits, there are several co-benefits to the project:

- **Revenue generated from selling ACCUs:** ACCUs generated from the project will be split into three pools:
  - 20 per cent of the ACCUs will be sold through the ERF market
  - 50 per cent of the ACCUs will be sold on the open voluntary market
  - 30 per cent of the ACCUs will be set aside as a contingency fund in the case of fire or another 'reverse' event that could release carbon back into the atmosphere

  Annual ACCUs generated are projected to be valued at between $1.1 and $1.9 million, applied for employing on-site staff, infrastructure improvements (e.g., fencing, water point placements), and project monitoring.

- **Local employment:** Supported by the income stream from selling ACCUs to the market, Bulga Downs is expecting to hire a three to four new low-skilled staff, a 50 per cent increase from current staff levels (seven staff members). As most infrastructure is towards the end of its life, there is a backlog of work on fencing, replacement of yards, and water points, along with livestock management and mechanical maintenance.

- **Indirect economic impacts:** Given that the buyers of ACCUs from Bulga Downs are expected to come from outside the rangelands, ACCU revenues will create a net benefit for the regional economy and local community industries. In addition, project materials will be locally sourced for additional infrastructure improvements, and local specialists contracted. Further growth of similar projects also has potential for the increased contracting of professional and skilled specialists within the community for carbon measurement activities, such as contracting local pilots for flyover work monitoring forest canopy growth.

- **Land and soil benefits:** Given land spelling routing for livestock has been used, increased pasture has been observed in paddocks, along with greater soil stability and fertility, and less erosion during heavy rains. These trends are expected to continue with the implementation of the carbon offset project.

- **Biodiversity benefits:** When the landholder moved onto the property 34 years ago, there were five bird species present. The most recent bird survey showed a dramatic increase to 89 bird species, with these trends expecting to continue with the implementation of the offset project.

Additional carbon offset opportunities from more detailed methods

While the HIR method has been used on projects for a few years, the method covers only 'trees', i.e. vegetation above – or capable of growing above - two metres, with a canopy cover of at least 20 per cent. Management practices being used for rangeland restoration projects, however, are also increasing the carbon stock closer to ground level, e.g. non-tree vegetation (and below ground in the soil). Obtaining accurate measurements of all above-ground vegetation carbon stocks is more resource intensive and costly than monitoring and verification requirements of the HIR method, however, a more complete accounting methodology has the potential to significantly increase carbon offset generation potential. Current estimates suggest that a new rangeland method, that counts all above-ground carbon, could generate an additional 30 to 50 per cent more offsets in the crediting areas than just using the current HIR method, while using a method that measures all above-ground and below-ground carbon could generate an additional 30-90 per cent more.[41]

[41] Correspondence with Dr Peter Russell estimates that there would be a 30-50% increase in ACCUs generated within the existing and potential HIR project Carbon Estimation Areas under an improved rangelands method.

In the case of Bulga Downs, a more comprehensive above-ground methodology could increase average annual carbon offsets from 80,000 tonnes per year to between 104,000 and 120,000 tonnes. At a price of $15 per tonne, that would equate to an annual increase from $1.2 million revenue to between $1.56 and $1.8 million. This could result in the creation of five new jobs, up from three to four under the current methodology. The development of a more comprehensive and cost-effective rangeland method is anticipated to be two years away, while a above- and below-ground method could take another five years.

7.2 Renewable Energy Investment in Collie

Summary

- Supporting the growth of renewable energy in Collie will help drive a just transition for the region by providing investment, a net increase in jobs, and preventing premature deaths through cleaner air.
- The development of 200 MW of solar farms and 300 MW of wind farms in the Collie region is estimated to reduce greenhouse gas (GHG) emissions by 1 million tonnes CO_2e annually, provide $628 million of investment, 478 construction job-years, and 112 to 132 direct permanent jobs for operation and maintenance.
- The Collie region is seeking out the development of the renewable energy among others to diversify their economy, and they are well placed as an established energy hub in the state with the infrastructure and renewable resource potential in the region to support this development.

Background on Collie

The Collie region sits about 200 kilometres south of Perth and is an electricity generation hub for Western Australia. The region is host to three coal-fired power plant complexes (Muja, Collie, and Bluewaters) totalling 1,778 megawatts (MW). In 2017, generation from these plants made up about 50 per cent of all generation in the South West Interconnected System (SWIS), the electricity grid that handles 80 per cent of the electricity needs of Western Australia. All these plants are fed from two coal mines in Collie, which provide around 600 jobs for the region to complement around 400 jobs at the coal plants.[42]

As these coal plants age, however, Collie is looking for ways to diversify the economy and create a viable job replacement plan. Currently, 75 per cent of coal capacity in the Collie region is nearing retirement age, with the Muja AB component of the Muja power plant recently shut down.[43] Meanwhile, investing in renewable energy can result in a net gain in employment relative to the coal industry. Considering there is unlikely to be any commercial appetite for financing new coal-fired replacement capacity, the state government is promoting a few initiatives, including:

- **The $20 million Collie Futures Fund** – This fund was set up to diversify Collie's economy and provide long-term employment security. Currently up to $2 million is available through the Collie Futures Small Grants program.[44]
- **$30 million to support solar power** – The current state government made an election commitment in 2017 to commit $30 million to support the establishment of a solar farm in Collie.
- **$30 million to support biomass energy -** The current state government made an election commitment in 2017 to commit $30 million to support the building of a biomass energy plant in Collie and the planting of timber plantations in the region to support the plant.
- **$100,000 for pumped hydro demonstration plant -** The current state government made an election commitment in 2017 to commit $100,000 for an engineering pre-feasibility study for the deployment of a pumped hydro facility to be built on mine voids around Collie.

[42] The West Australian, 2018, *Collie Councillors Bin Solar Panels Savings Plan for Fear of Rocking Coal Town's Confidence.* Accessed 20 September, 2018: Link.
[43] Government of Western Australia, 2017. *Synergy to Reduce Electricity Generation Cap by 2018.* Accessed 20 September, 2018: Link.
[44] Government of Western Australia. *New Group to Power Collie into the Future.* Accessed 20 September, 2018. Link

Collie has the potential to support substantial renewable energy resources to support a Just Transition[45] away from coal as the industry faces increasing economic and environmental pressures. A 2017 report from Sustainable Energy Now (SEN) highlights the potential for 200 MW of solar generation, 1,000 MW of wind generation, and 400 MW from a biomass facility in the southwest region of Western Australia to displace the retirement of coal generators.[46]

While the potential for renewable resources in the Collie region are available, deploying these resources is also in line with providing clean, reliable electricity at a reasonable cost. A 2017 study found that transitioning as far as 90 to 100 per cent renewable energy grid in the SWIS grid could be nearly cost competitive with fossil fuel alternatives, even without a carbon price, while meeting reliability standards and security requirements. This relied on a mix of rooftop solar, solar farms, wind farms, biogas, and pumped hydro energy storage to achieve 90 to 100 per cent renewable energy penetration. While battery storage was considered, it was not incorporated into the assessment due to its early stages of deployment in Australia and was flagged as another technology that could provide complementary reliability resources at a lower cost if battery prices continue to fall.[47]

Collie has already started transitioning to renewable energy, as a 20 MW solar farm in an industrial area of Collie was approved in May 2018.[48] This project is expected to bring in 40 to 80 construction jobs to go along with four ongoing full-time jobs for the local community.[49]

Representative solar farm for Collie

Drawing on the size of recently approved projects and state government commitments, this case study will look at the potential costs and impacts of a 30 MW solar farm.

Total Investment

Solar installation costs have been dropping significantly in recent years, with ARENA noting that costs have gone down from about $1.60 per watt in 2015 to an expectation of $1 per watt over the coming year, or somewhere between $50 to $60 per MWh.[50] If prices drop as expected, the cost of building a 30 MW solar farm is expected to be around $30 million.

Electricity Generation and Displaced Emissions

To estimate electricity generation from the solar farm, we use a capacity factor of 18.4 per cent which assumes the solar modules use a polar type single-axis tracking system and the average irradiation for the region of 4.69 kWh per square metre per day. Based on a 30 MW solar farm, annual generation would be 48,355 MWh.

To calculate the annual emissions displaced by the solar farm, we took the weighted average emission intensity factor for the SWIS region from fossil fuel electricity since this form of electricity would be most likely to be displaced. The fossil GHG emission factor for the SWIS region for the 2017 financial year is

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[45] Just Transition is a framework that has been developed by the trade union movement to encompass a range of social interventions needed to secure workers' jobs and livelihoods when economies are shifting to sustainable production, including avoiding climate change and protecting biodiversity, among other challenges.

[46] Sustainable Energy Now, 2017. *Transition from Coal to Renewable Energy on the SWIS by 2021.* Accessed 20 September, 2018: https://d3n8a8pro7vhmx.cloudfront.net/sen/pages/185/attachments/original/1488364425/SWIS_Transition_from_Coal_to_RE_2021_presentation_edited_28-2-2017.pdf?1488364425

[47] Lu, Bin, Blakers, Andrew, Stocks, Matthew, 2017. *90–100% renewable electricity for the South West Interconnected System of Western Australia. Energy.* Accessed 20 September, 2018: https://www.sciencedirect.com/science/article/pii/S0360544217300774

[48] Government of Western Australia, 2018. *Southern Joint Development Assessment Panel Agenda*. Accessed 20 September, 2018: https://www.collie.wa.gov.au/wp-content/uploads/2018/04/20180424-Agenda-No-33-Shire-of-Collie.pdf

[49] Collie Mail, 2018. *Solar Farm to Mine Cryptocurrencies*. Accessed 20 September, 2018. https://www.colliemail.com.au/story/5461419/solar-farm-to-mine-cryptocurrencies/

[50] Renew Economy, 2018. *Australia Solar Costs Hit "Extraordinary" New Lows – $50s/MWh.* Accessed 20 September, 2018. https://reneweconomy.com.au/australia-solar-costs-hit-extraordinary-new-lows-50s-mwh-27007/

0.75 tonnes CO_2e / MWh, resulting in annual displaced emissions of 36,159 tonnes CO_2e which is equivalent to about 0.2 per cent of all power sector emissions in Western Australia, or 0.3 per cent of the SWIS region.[51]

Job Creation

There are a range of estimates regarding the potential for job creation from solar farm construction and operation. On the lower end, the developer of the solar farm in Collie is expecting to hire 40 to 80 workers for six months for construction of a 20 MW solar farm, with 4 ongoing roles for operations and maintenance (O&M) afterwards. On the higher end, SEN estimates 2.5 job-years per MW for construction and installation (C&I)[52] and 0.3 permanent O&M roles per MW of solar generation in the region. Table 6 summarises the range of different estimates of job creation for solar projects in Western Australia which are scaled up or down by capacity for a representative 30 MW project.[53]

Table 6: Job Creation Potential for a representative 30 MW Project

Project/Report	C&I (Job-Years)	Manufacturing (Job-Years)	O&M (Permanent Jobs)
Collie Solar Farm[54]	45		6
SEN Solar Potential – SWIS Region[55]	75	66	9
Emu Downs[56]	61		
Northam Solar Farm[57]	45		
Job Range	**45 to 75**	**66**	**6 to 9**

Note: Projects have been linearly scaled to normalise data at a 30 MW basis. C&I jobs have been converted to job-years where available.

Other Co-benefits

Solar farm development has the potential to bring in additional co-benefits to the region, including:

- **International industries seeking clean energy sources** – Many major corporations are committed to being powered completely by renewable energy in order to meet their corporate social responsibility and carbon neutrality goals, providing an opportunity for the Collie region to

[51] Australian Government Clean Energy Regulator, 2018. *Electricity Sector Emissions and Generation Data 2016–17*. Accessed 20 September, 2018: http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/electricity-sector-emissions-and-generation-data/electricity-sector-emissions-and-generation-data-2016-17
[52] Job-years represent the equivalent number of years that 1 worker would take to complete a job. So, for instance 10 job-years can represent 1 worker working 10 years full time to complete a job, or 10 workers working 1-year full time to complete a job.
[53] On average, jobs in renewable energy industries are more intensive per unit of energy produced than in the coal industry. A Climate Council report on renewable energy jobs estimated that in 2030, a scenario that moved Australia's electricity system to 50 per cent renewables would provide a net increase of about 28,000 construction and operation jobs in the electricity sector compared to 2014, while a business-as-usual scenario would only provide a net increase of 14,000 jobs compared to 2014. Source: Climate Council, 2016. *Renewable Energy Jobs: Future Growth in Australia.* Accessed on 25 September, 2018: https://www.climatecouncil.org.au/uploads/7b40d7bbefbdd94979ce4de2fad52414.pdf
[54] 40 to 80 construction jobs over 6 months and 4 ongoing jobs for a 20 MW project, scaled up to 30 MW. Source: Collie Mail, 2018. *Solar Farm to Mine Cryptocurrencies*. Accessed on 21 September, 2018: https://www.colliemail.com.au/story/5461419/solar-farm-to-mine-cryptocurrencies/
[55] 2.5 job-years/MW for C&I, 6.7 job-years/MW for manufacturing assuming 33 per cent of non-module parts manufacturing is in WA, 0.3 jobs/MW for O&M. Source: Personal Communication with Alastair Leith, Sustainable Energy Now, 25 September, 2018.
[56] 70,000 man-hours went into construction. Assuming 1,710 working hours per year, this comes to 41 job-years for a 20 MW solar farm, scaled up to 30 MW. Source: APA, 2018. *Emu Downs Solar Farm Official Opening.* Accessed 21 September, 2018: https://www.apa.com.au/news/media-statements/2018/emu-downs-solar-farm-official-opening/
[57] 30 construction jobs, assuming over a 6 months construction period for a 10 MW solar farm, scaled up to 30 MW. Source: Clean Energy Council, 2018. *Jobs and Investment in Large-scale Renewables.* Accessed 21 September, 2018: https://www.cleanenergycouncil.org.au/policy-advocacy/jobs-and-investment.html

host renewable energy projects with purchase power agreements for major companies, and to build data centres powered by renewable energy.[58,59]

- **Increased air quality and human health** – The addition of renewable energy to the region will improve the air quality and human health conditions the Collie region and elsewhere in Western Australia by displacing more polluting forms of electricity generation.[60] Four of the pollutants from coal power plants that most directly impact human health are coarse particles (PM_{10}), fine particles ($PM_{2.5}$), sulphur dioxide (SO_2), and nitrogen oxides (NO_x). These pollutants contribute to an increased rate of asthma, respiratory problems, stroke, heart attacks, and cancer. Studies have shown that residents that live within 50 kilometres of a coal plant are three to four times as likely to die prematurely, and in the Latrobe Valley in Victoria, the Hazelwood power station has been estimated to cause 18 deaths per year. Throughout Australia, the health impacts from coal-fired power stations are estimated to be $2.6 billion annually.[61]

Implications for Expanded Renewable Energy Presence in Collie Region

While utility-scale solar power development is not eligible to create offsets under the Emissions Reduction Fund (ERF), investment in this sector by the LNG sector could provide a significant opportunity to drive a Just Transition for the community of Collie, shift all of the south Western Australia to a clean energy economy, attract international investment to the state, and contribute to major emissions reductions toward Australia's pledge to keep global warming to less than 2°C.

Sustainable Energy Now estimates the potential for about 200 MW of utility-scale solar development within an 80-kilometre radius of Collie, which could be complemented by up to 300 MW of wind power development.[62] An investment from the LNG sector to help drive a combined 500 MW of renewable energy generation is estimated to have the following direct impacts:

- $628 million of investment into the Collie region
- 468 construction job years for building out the renewable energy generators
- 112 to 132 permanent jobs created to operate and maintain the renewable energy generators
- 1 million tonnes CO_2e reduced annually[63]

Development of the renewable energy industry in Collie will support a Just Transition for the community as coal generation declines in the long run. The Collie community recognises that there is a transition underway and they are generally supportive of this transition if it is done in a way that is fair to the 1 in 9 people in the community that are directly employed in the coal sector. To help in this transition, the Collie-Bunbury Economic Plan is currently being drawn up which will identify major industries to target for investing in the region. Running in parallel to this effort, the state Public Utility Office is developing a retirement schedule for the coal generators in the region that is due out at the end of 2018. Once this schedule is released, more clarity is also expected regarding the status of the state government's solar and biomass commitments for the region.

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[58] Data Center Knowledge, 2018. *Special Report: Data Centers & Renewable Energy.* Accessed 20 September, 2018: https://www.datacenterknowledge.com/special-report-data-centers-renewable-energy

[59] Deloitte, 2017. *Serious Business: Corporate Procurement Rivals Policy in Driving Growth of Renewable Energy.* Accessed 24 September, 2018*: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-corporate-procurement-renewable-energy-report.pdf*

[60] Government of Western Australia Environmental Protection Authority, 2017. *EPA Urges Tighter Environmental Controls in Collie Report 1607*. Accessed 20 September, 2018: http://www.epa.wa.gov.au/media-statements/epa-urges-tighter-environmental-controls-collie-report-1607

[61] Environmental Justice Australia, 2017. *Toxic and Terminal: How the Regulation of Coal-Fired Power Stations Fails Australian Communities.* Accessed 24, September, 2018: https://www.envirojustice.org.au/sites/default/files/files/EJA_CoalHealth_final.pdf

[62] Sustainable Energy Now, 2017. *Transition from Coal to Renewable Energy on the SWIS by 2021.* Accessed 20 September, 2018: https://d3n8a8pro7vhmx.cloudfront.net/sen/pages/185/attachments/original/1488364425/SWIS_Transition_from_Coal_to_RE_2021_presentation_edited_28-2-2017.pdf?1488364425
Personal Communication with Ian Porter of Sustainable Energy Now on 21 September, 2018.

[63] These impacts are limited to direct impacts for building out and operating renewable energy generation and does not account for the potential for increased manufacturing for renewable energy generation parts, establishing local biomass feedstocks, and indirect job creation in the community from increased economic activity.

8. APPENDIX A

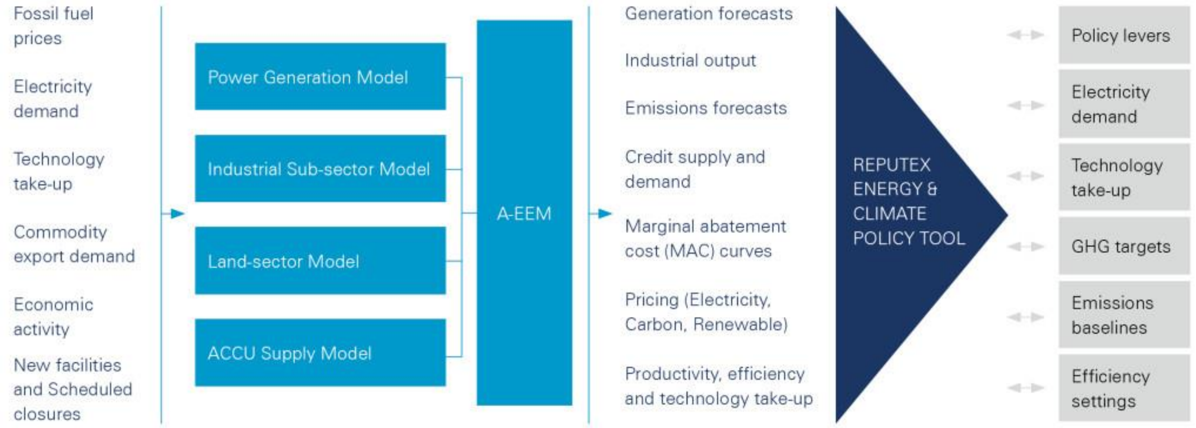
8.1 Australian Energy and Emissions Model (A-EEM)

Project cost and volume analysis is derived from our Australian Energy and Emissions Market (A-EEM) model. This model references current ACCU issuance and contracted obligations under the Emissions Reduction Fund, along with our ERF Auction Simulation Tool, which maps project cost and volumes, transaction costs and bidding behaviour to establish upper and lower price estimates for the competitive reverse auction scheme.

Our A-EEM model is comprised of three sub-sector models for the power, industrial, and land-use sectors, producing output and emissions forecasts for the Australian market through to 2050. A-EEM produces a range of outputs including:

- GHG emissions projections;
- Energy generation, consumption, and pricing projections;
- Industrial production projections;
- Supply and demand for carbon credits;
- Credit export and import dynamics; and
- Marginal abatement cost (MAC) curves.

Figure 12: RepuTex Australian Energy and Emissions Model (A-EEM) schematic



Our marginal abatement cost (MAC) resource, contained within our A-EEM model, was originally developed in 2012 and is subject to regular review. Review and output benchmarking is supported by consultation with around 50 industry participants, providing feedback on technology readiness, cost assumptions and barriers to investment for emissions reduction activities across the Australian economy.

Analysis covers all GHG emissions sectors of the Australian economy, with selected activity types filtered for the purpose of this project. A baseline of Australia's 2017 'business as usual' emissions projections is created, with emissions projected to 2030. Emissions reduction opportunities are then identified, and combined, to form our Australian abatement cost curve, with available abatement volumes benchmarked against our reference case emissions baseline.

8.2 Marginal Abatement Cost (MAC) methodology

A MAC curve depicts the emissions reduction potential and corresponding cost for abatement activities relative to a reference case in a specified year. The width of each bar represents the potential to reduce emissions in the stated year. The height of each bar reflects the annualised net cost of reducing one tonne of GHG emissions. The full MAC curve reflects the potential emissions reduction from all activities within the assumed scenario.

Analysis covers all GHG emissions sectors of the Australian economy, with a baseline of Australia's 2017 emissions projections. Emissions are projected to 2030, with the cost curve analysing the year 2030 specifically. In determining the readiness of a technology, analysis considers whether technologies currently at the pilot stage, or later, and whether there is consensus for a technology to be in place prior to the stated timeline. The modelling process is summarised below:

- The emissions baseline originates with the Government's 2017 emissions projections for Australia.
- Emissions reduction activities and technologies are based on opportunities identified through extensive consultation with industry.
- Abatement potential is defined as the annual reduction between the baseline emissions in 2030 and the emissions projection after the activity has been implemented.
- Abatement costs are defined as the annualised cost of reducing GHG emission by one tonne of carbon dioxide equivalent.
- Abatement costs assume an 'investor' approach, including annualized repayments for capital expenditure and operating expenditure, along with the project cost of implementing or installing a given activity or technology.
- Costs and opportunities therefore reflect the marginal cost per tonne faced by an investor to implement an emissions reduction opportunity, including the typical private costs of capital. Investment barriers faced by the market are considered, taking account of market constraints such as the availability of technology, along with energy demand forecasts, new and expanded facility production rates, power capacity forecasts, and expected learning curves.
- Transaction costs, institutional barriers and non-monetary costs (e.g. investment appraisal, procurement and legal costs, and regulatory compliance costs, administrative costs of finance, etc.) are not included.
- To calculate the total abatement potential and cost of abatement activities, a few measures which fall within a defined activity may be grouped together, with an average marginal abatement cost and quantity of emissions reductions calculated based on bottom-up analysis of different technical and economic potentials.
- Emissions reduction activities and technologies are ordered in terms of least marginal cost of abetment, with the maximum possible volume of emissions reductions determined from an assumed scenario analysis.

Key Assumptions

A MAC curve is a dynamic tool which needs to be regularly updated due to changes in emissions baselines, fuel and technology costs and technological developments. Subsequently, there are many uncertainties contained within MAC curves, including:

- Accuracy of current emissions data and projections,
- Changes to business-as-usual projection,
- Changes to energy prices for gas and oil,
- Development of new technologies, and
- Investment risk created by climate policy uncertainty.

Modelling assumes the following:

Behavioural change	No adjustments were made for opportunities involving lifestyle or behavioural changes (e.g. driving less) not because they are undesirable, but because their costs or benefits are largely non-financial and thus difficult to quantity.
Carbon Capture and geologic Storage (CCS)	CCS is not assumed to play a major role in Australian abatement before 2025. After 2025, CCS could be considered on a large scale, with the Power sector showing the largest CCS potential (55 percent of the total) due to large point sources, availability of cheap fuel/electricity and suitable infrastructure. There is high uncertainty on the cost side, as CCS technology has not yet been deployed on such a large scale successfully. Costs are assumed to decrease with development stages; we assume $224/tonne from a "cost to investor" perspective (i.e. 15 percent interest rate). Base capex for new-build coal-fired power plants equipped with CCS is $11,200/kW (assuming a 40-year lifespan). Storage availability is not assumed to be a significant bottleneck for long-term CCS-equipped plants that can sell CO2 for enhanced oil recovery (EOR) with additional revenue stream.
Discount rates	About four per cent depending on sector.

Distributed generation	Electricity costs continue to rise while solar PV persistently fall, positioning distributed generation as a dominant abatement technology from 2018 onwards.
Electricity consumption	Australian Energy Market Operator's 2017 neutral electricity consumption. In this projection increased electricity demand is largely offset by projected solar PV growth.
Electricity emissions	Electricity emissions are not expected to reach peak levels seen in 2009 due to a combination of relatively flat electricity demand and a decrease in the emissions intensity of the electricity sector.
Emissions projections	Baseline emissions resulting in 551 Mt of total domestic emissions in 2020 and 570 Mt in 2030. Note that figures are based on Australia's Emission Projections 2017.
Energy prices	Energy prices are critical to the calculation of the marginal abatement costs of each activity. These include the price of electricity and gas, which reflect our estimates at the beginning of 2018. Analysing in-scope measures involved a wide range of assumptions, including barriers to development, energy demand forecasts, new and expanded facility production rates, power capacity forecasts, expected learning curves, and initial generation costs.
Energy security	Cost of new power development favours demand-side management and energy storage.
Gas price	Average gas price of $10/GJ between 2018 and 2030.
Land clearing	Government projection (2017) for land clearing emissions;
Levelised cost of energy	Cost of new energy development favours renewables with wind and solar PV remaining the cheapest. The levelised cost for each generation technology is calculated based on a 20- to 40-year cost recovery period, using a real after tax weighted average cost of capital of 7.7 percent for comparison purposes. The actual cost of capital may vary by technology, e.g. the cost of capital for coal-fired facilities are likely higher than this, whereas the cost for solar PV expect around 7 per cent equity return for contracted plants.
Livestock activity	Increased herd numbers in agricultural linked to international demand.
Nuclear energy	Assumed no nuclear power development.
Oil price	Projected to average $80 a barrel (expressed in real 2018 dollars) over the projections period.
Renewable Energy Target	33 Terawatt-hour (TWh) Large-scale Renewable Energy Target for eligible production after 2020.
Solar PV	Engineering, Procurement, and Construction (EPC) costs of $1.15 per Watt and capacity factor dependent of mounting fixed tilt (lower end of range) or tracking (higher end of range).
Technology	All activities analysed are technologically feasible, meaning that in a projected year, greenhouse gas emissions reduction is projected to be possible with the technology.
Wind	EPC costs about $2,000 per kW, with an average capacity factor of 34 per cent.

9. REPUTEX CONTACTS

Project title	Offsetting emissions from LNG projects in Western Australia
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