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O&G Decommissioning Supply Chain: Current State Report and Scoping Study

December 2023

Disclaimer

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The findings in this report have been formed on the above basis.

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Thank You

It is acknowledged that Kent Engineering provided key perspectives and expertise for this study, in relation to quantifying Offshore O&G decommissioning activity into the demand on downstream industrial skills and services as well as in evaluating ports' current and future ability to support Australia's O&G decommissioning Industry going forward.

Thank you to each of the government and Industry stakeholders who have been consulted over the course of this report. KPMG appreciates the discussions on unpicking, exploring and contemplating challenges and opportunities that took place over the course of this engagement.

- ACOR
- AEP (former APPEA)
- Allseas
- Ausdecom
- Australian Steel Institute
- Birdon
- Bluescope Steel
- Chevron
- Cleanaway Waste Management
- CODA
- Cooper Energy
- Department of Climate Change Energy the Environment and Water (DCCEW)
- EPA Victoria
- ExxonMobil
- Flinders Ports
- Government of Victoria
- Kent Engineering
- Liberty Industrial
- McMahon Services
- NOPSEMA
- Norstar
- Northern Territory State Government
- Petrofac
- Port of Darwin
- Simms Metals
- South Australia Government
- TasPorts
- UGL Limited
- Woodside Energy

KPMG would like to specifically acknowledge and give thanks to CODA who have been generous with sharing insights and data they have built over several years across the Value Chain.

Content

Acronyms

AEP	Australian Energy Producers
AHECC	Australian Harmonised Export Commodity Classification
ALARP	As Low As Reasonably Practical
ATAP	Australian Transport Assessment and Planning
BMG	Basker Manta Gummy
C&D	Construction and Demolition
CBGS	Concrete Gravity-Based Structures
CCUS	Carbon Capture Utilisation and Storage
CNAF	Compressed Non-Asbestos Fibre
CODA	Centre of Decommissioning Australia
CoP	Cessation of Production
CSV	Construction Supply Vessel
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DISR	Department of Industry, Science and Resources
DITRDC	Department of Infrastructure, Transport, Regional Development and Communication
DWT	Dead Weight Tonnage
EF	Emission Factor
EP	Environmental Plans
EPA	Environment Protection Authority
Ex-HMAS	Ex "His Majesty's Australian Ship"; A ship prefix used for commissioned units of the Royal Australian Navy
FIFO	Fly-In Fly-Out
FPSO	Floating Production Storage and Offloading
GHG	Greenhouse Gases
HDPE	High-Density Polyethylene
HLV	Heavy Lift Vessel
IWDF	Intractable Waste Disposal Facility
kT	Kilo tonnes
LOA	Length overall
MODU	Mobile Offshore Drilling Unit
NDRI	National Decommissioning Research Initiative
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NORM	Naturally Occurring Radioactive Material
NSW	New South Wales
NT	Northern Territory
NZ	New Zealand
O&G	Oil and Gas
OHS	Occupational Hazard and Safety
OPGGSA	Offshore Petroleum and Greenhouse Gas Storage Act
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning

Acronyms

OSPAR	Oslo-Paris Convention
OSV	Offshore Supply Vessel
P&A	Plug & Abandonment
PE	Polyethylene
PET	Polyethylene Erephthalate
PP	Polypropylene
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
rHDPE	Recycled HDPE
RMF	Recycling Modernisation Fund
SA	South Australia
SEA	South East Australia
SSHTV	Semi Submersible Heavy Transport Vessel
STEM	Science, Technology, Engineering and Mathematics
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAS	Tasmania
VIC	Victoria
WA	Western Australia
WMRR	Waste Management and Resource Recovery Association of Australia
WOMP	Well Operations Management Plan

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Current State Report

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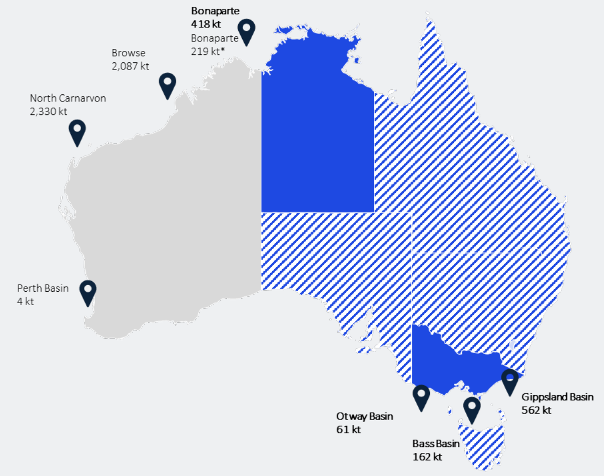
Executive Summary

This study was commissioned by the Department of Industry, Science and Resources to examine the Offshore Oil and Gas (O&G) decommissioning supply chain in Australia across demand, material recycling, end-of-life management, ports, workforce and regulatory context. It provides valuable insights into the challenges, opportunities, and considerations for this evolving sector.

The Offshore O&G assets in the scope of this study are spread across the Bonaparte Basin off Northern Territory (NT) and the Bass, Gippsland, and Otway Basins in South East Australia (SEA).



*Includes assets in Bonaparte basin excluded from this study

Legend

- Scope of study with Offshore O&G assets
- Scope of study without Offshore O&G assets
- Out of scope of this study

175 assets in scope

- **18** Platforms 63 kT
- **100** Subsea Infrastructure 12kT
- **56** Pipelines 817 kT
- **1** Montara FPSO 25 kT

Offshore Asset Removal

This demand is split into two key areas, SEA and NT due to the economical barriers of transporting material long distances. There should be further consideration to integrate NT demand with Western Australia (WA) decommissioning demand profiles to explore synergies.

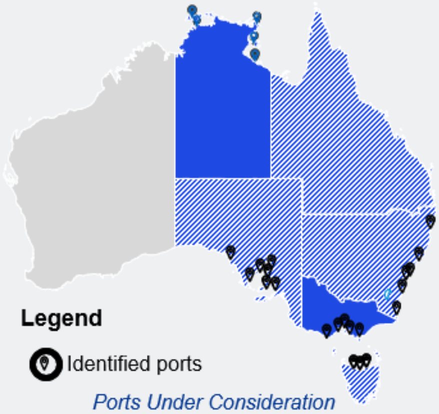
The demand profile is likely to be flexible and seasonal due to contracting and weather window considerations, with small volumes of infrastructure to come ashore as early as 2023. The volumes associated in SEA are 13% of Australia's total infrastructure, driving a more flexible strategy reliant on mobile equipment and "temporary" facilities.

Regulations allow for deviations to the full asset removal case, however there is not a clear expectation of what this could look like across all assets taking into consideration a holistic scenario assessment for impact on health and safety, environmental impacts, cost and carbon emissions. A comparative assessment between full removal and partial removal pathways and allowing concrete based gravity structures and pipelines to stay in-situ reduces the weight of the assets removed by 80%. This partial removal scenario is not deemed likely but illustrates the variability that exists in the actual volumes of material to come ashore. The reality is likely somewhere in between.

Vessel Availability & Costs

International vessel costs are a dominant driver in the decommissioning Value Chain and Australia's successful decommissioning Industry relies on these costs being minimised.

The relative size of Australia's O&G Industry is insufficient to sustain a competitive domestic specialised vessel market and as such continued access to the globalised market will be crucial for success. Barriers to attracting this capability include the Australian regulatory landscape, geographic distance from international demand and a seasonal demand profile.



Logistics, Handling and Dismantling at Port

Due to relatively small volumes, the most cost-efficient removal options rely on large vessels and rigs for lifting and transport of larger infrastructure pieces to shore for dismantling and management. SEA and NT ports in their current state are not suitable to accept the larger vessels and will require significant modifications or a "piece-small" removal approach. It is anticipated investment is needed for dismantling facilities including impermeable lay down areas, berths and material handling services. Port location with suitable characteristics is based on an optimisation of proximity to Offshore infrastructure, material recycling and disposal and the community. Specialised vessel day rates can be a key cost component, driving operators to prioritise port section for proximity to Offshore assets.

Dismantling capacity for large Offshore infrastructure to date is unproven in Australia, with current state experience centred around a model of "dismantle in-field" rather than in a dedicated facility, which will not be suitable for Offshore infrastructure. The capability for dismantling heavy Industry infrastructure exists and is required to be scaled up for decommissioning activity and located at ports.

Transport to Recycling and Disposal Facilities

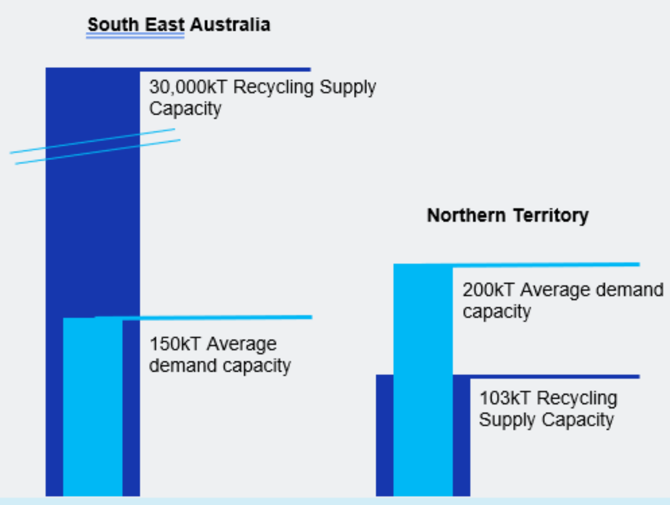
Recycling refers to a number of activities, including segregation of material, cleaning, cutting and crushing, that occur to prepare material to be used as a recycled feedstock in manufacturing. Majority of O&G infrastructure consists of steel and concrete which are large and heavy materials to transport. The economics of recycling material is strongly linked to reducing transport costs. While there is sufficient local recycling capacity to prepare materials as a commodity for export or use in domestic markets, the location of the port and the recycling facilities will be critical in optimising and reducing costs associated with recycling. If quantities are guaranteed, and contractual arrangements to lease land and minimise upfront costs can be achieved, some recyclers may be willing to establish temporary sites close to ports to minimise transport. Otherwise, costs associated with managing materials will increase as transport distances increase.

End-of-Life Management of Materials

There will be ample recycling capacity in SEA to handle the decommissioned assets. In NT, demand volumes are relatively small and driven by pipeline assets. Today's recycling capacity in NT is insufficient for the assets included in this scope. It is likely that WA has sufficient capacity to receive these volumes, which would be worth exploring for synergy.

The recycling capacities estimated represent existing recycling volumes and do not reflect the full potential of the recycling plants. Some of these facilities have the flexibility to expand their recycling capabilities by adding shifts or increasing daily throughput rather than further investing in facilities. Additionally, it is highly probable that recycling capacities for concrete, plastics and marine growth will expand in the future due to ongoing developments in the field.

Five Year Average Demand Capacity Versus Recycling Supply for Concrete and Steel Combined



End Markets for Materials

There is sufficient recycling capacity available in Australia for the materials, but presently, a significant portion of the steel and plastic is being exported to South East Asia for manufacturing. This is primarily because stakeholders in that region offer a higher value per tonne for this material, and because manufacturing sectors of finished goods and products are stronger in Asia than in Australia. For this material to remain in Australia and be used locally, it would require government support and incentives to make manufacturing economically feasible.

Given the use of a port to dismantle, the seasonal profiles and the requirement to undertake some level of processing of material at the port, it is likely that most of the steel, and potentially the plastics, will be exported. This would reduce the need to stockpile recycled material if there was excess supply and the port would provide a convenient location for packaging for export and minimise transport costs. Requiring this material to be domestically manufactured may not be economically feasible particularly given the relative small quantities that will be generated.

Workforce Readiness

Capabilities at the front end of the Offshore decommissioning Value Chain, such as engineering, environmental planning and wells expertise, tend to be more technical and specialised in nature, however, are consistent with existing construction, marine and O&G operations. Stakeholders expect these capabilities to readily transition from existing O&G operations.

Stakeholders involved with planning Onshore workforce demand for dismantling, material management and recycling are aiming for flexibility and leverage of existing workforce to cater for the seasonal demand profiles. It is acknowledged that there is a lack of practical involvement in-field for these capabilities, however, there is sufficient capacity and experience in relevant fields to enable a successful workforce. As decommissioning execution unfolds, transition and the upscaling of current capabilities to the Offshore Decommissioning Value Chain will need to be proven.

The workforce readiness sentiment is optimistic, however proactive measures for workforce readiness will be required due to challenges with O&G sector workforce attraction, brand, longevity of the decommissioning Industry and competition in the general jobs market.

Regulatory Landscape

The decommissioning Value Chain is a unique series of activities coming together, spanning across Commonwealth, State and Territory boundaries. Areas where the current regulatory landscape is not tailored to the unique characteristics of the Australian decommissioning challenge include assets spanning Offshore and Onshore jurisdictions; the seasonal demand profile for decommissioning infrastructure; and services leading to flexible, temporary and mobile business models.

A tailored and holistic view to regulations addressing the unique characteristics of the Australian decommissioning challenge is required near term to provide an aligned and efficient landscape for the stakeholders of the Value Chain. Onshore appears to be a secondary consideration from a regulatory standpoint compared with Offshore. One area stakeholders demonstrated concern was classification of plastic waste as hazardous and the need for permanent exemptions from export bans.

Cross Workstream Themes

During this analysis, four key themes emerged as consistent across the varying workstreams. These themes will form part of the Scoping Study as they can provide valuable insight into future discussion regarding Offshore Decommissioning Value Chain design principles, which could aid bridging regulatory, Industry and the community.

The need for flexibility along the Value Chain. Significant costs are associated with the Offshore component of the decommissioning Value Chain, dominantly spent on specialised international vessels. Optimisation of these costs will require flexibility in decommissioning timing. In addition, optimisation of execution will lead to a seasonal demand profile, which has a flow on impact downstream in the need for flexible, temporary and mobile business strategies.

Trade offs across the Value Chain can be optimised together. Optimisation of one pillar of the Value Chain is recognised to have an impact on other pillars of the Value Chain.
A successful and cost effective Australian Offshore O&G decommissioning Industry is dependent on the stakeholders across the Value Chain working together to find optimised solutions.

Stakeholders across the Value Chain have an appetite to explore challenges while being fairly aligned on objectives. However with the Value Chain being complex and diverse, progress at pace was often cited as a challenge **with the need for strong coordination of stakeholders in the near term** identified to meet decommissioning timeframes. The perspectives of most stakeholders during consultation is that Government has a prime position to coordinate and facilitate progress for this Industry with the challenges ahead.

The role of technology has been identified in several pillars of the Value Chain as a success enabler in reducing costs and readying the workforce.
Australia is a nation that values innovation and technology and although the North Sea is ahead of Australia in terms of experience, Australia can centre itself around local innovation and research for improved efficiency with thoughtful consideration and planning with the right stakeholders. These insights and experience can be exported to other jurisdictions facing the decommissioning wave in the next decade.

Seven Key Questions

Current state analysis provides valuable insight into the challenges, opportunities, and considerations for this evolving sector. Seven key questions result from the analysis and each will be interrogated in Part 2 - Scoping Study to identify further insight.

Table 1: Key Questions to explore and Corresponding Impact

Question	**What is the anticipated quantity of material arriving Onshore?**	**How might the availability of vessels influence costs for operators?**	**Given current state port infrastructure constraints, which port will be selected for Offshore Decommissioning?**	**How can we address the lack of recycling transparency and reporting to drive recycling initiatives?**
IMPACT	Leads to uncertainty in material volumes and is seen as a barrier for Industry to plan, invest and upskill in infrastructure and services.	International vessel costs are a dominant cost driver. Australia's successful Decommissioning Industry relies on these costs being minimised through the ability to collaborate for longer duration campaigns.	Low and intermittent volumes and timing uncertainty drive maximising the use of existing facilities with likely investment needed for dismantling facilities including impermeable lay down areas, berths and material handling services. Port selection is a trade-off of proximity to Offshore assets, material handling service centres and the community.	Minimal focus on material hierarchy performance may not drive optimal circular economy outcomes to the detriment of the environment and eliminate opportunities for Australia to develop and export technologies to expedite or optimise material recovery.

Question	**What strategies can be employed to boost demand for local steel and plastics manufacturing?**	**In what ways can legislation be tailored to address unique challenges specific to Australian Decommissioning?**	**While stakeholders express optimism about workforce readiness, can these sentiments be translated into actionable plans at the scale required for success?**
IMPACT	A significant portion of steel and plastic is being exported to South East Asia for manufacturing due to higher value per tonne. Requiring recycled material to be domestically used may not be economically feasible particularly given the relatively small quantities. Support will likely to be required to make it attractive.	A tailored and holistic view to regulations addressing the unique characteristics of the Australian decommissioning challenge is required near term to provide an aligned and efficient landscape for the Supply Chain stakeholders.	The workforce readiness sentiment of stakeholders is optimistic, given strategies include readily transitioning capabilities from existing operations and stakeholders aiming for flexibility and leverage of existing workforce to cater for the seasonal demand profiles. It is acknowledged that there is a lack of practical experience in-field. As execution unfolds, transition and upscaling of current capabilities to the Offshore decommissioning supply chain will need to be proven. Proactive measures for workforce readiness are required due to challenges with O&G sector workforce attraction, longevity of the decommissioning Industry and competition in the general jobs market.

The Value Chain

The Australian Offshore O&G Decommissioning Value Chain mapped below tracks the entire journey of the assets, spanning Offshore to Onshore and across states and federal jurisdictions. Commencing at planning and Offshore removal, the Value Chain follows the activities through the ports and until the material end-of-life destination. The uniqueness of the Value Chain is the diversity of stakeholders involved, with a broad range of skills, capabilities, technology and expertise. The chain establishes interconnection of organisations diverse in nature; both smaller and larger organisations with differing objectives, footprints and agility. Specific Australian capabilities are crucial, such as port operations, shipping and transport, dismantling operations, and material recycling, as well as areas which rely on certain international capabilities, such as heavy lift vessel operations and potential recycling technology.

		Offshore Activities			Onshore Activities			
	Planning	Preparation	Removal	Logistics to Port	Handling & Dismantling at the Port	Transport to Material service providers*	End of Life Management	Commodity Manufacturing & Market
KEY ACTIVITIES	• Innovation and technology research • Tender and contract award • Decommissioning planning and engineering design • Collaboration across operators for efficiency • Regulatory approvals including stakeholder consultation and environmental impact assessments	• Well plug & abandonment • Cleaning, purging & Isolation • Preliminary categorisation of material streams	• Topside preparation for removal activities (Cutting, Separation) • Heavy lift operations • Subsea asset lifting • Support vessel activities	• Transfer of material to barge as required • Transportation of materials to port • Transfer of material to shore	• Lifting and handling of structures • Cutting & dismantling of assets • Material sorting, handling & preparation	• Loading and transport of materials for final processing (road/rail) *as required	• Material reuse evaluation • Material processing & recycling • Waste disposal	• End market evaluation for materials (including steel, plastics) • Manufacturing of new product using recycled material • Product export

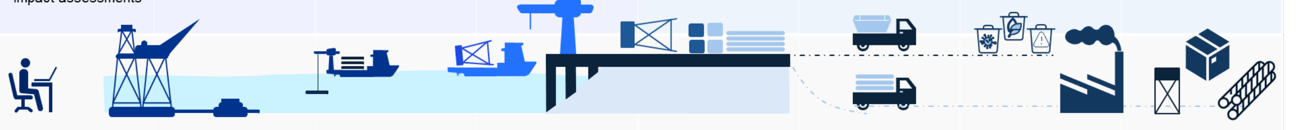


Figure 1: Australian Offshore O&G Decommissioning Value Chain

Australian O&G Decommissioning SWOT Analysis

STRENGTHS

- Excess ferrous recycling capacity within Australia
- Highly skilled legacy workforce in O&G development that can readily transition to decommissioning activities
- Technical and innovative capability compliments the challenge
- Stakeholders along the Value Chain engaged, willing to collaborate with fairly aligned objectives

WEAKNESSES

- Seasonal demand profile limiting economies of scale
- Material volume uncertainty slowing progress
- Dynamic regulatory landscape
- Local end market for materials challenged to compete with export; especially for ferrous metals where manufacturing capacity is mainly in SEA but volumes will come from WA
- Tight labour market generally
- O&G sector workforce attraction and attention challenged

OPPORTUNITIES

- Industry appetite to invest with volume certainty gained through removal framework across different assets
- Utilise existing ports infrastructure in a coordinated fashion to prevent over investment
- Strong technically skilled workforce and technology that can be exported to other countries in the region
- Drive successful recycling outcomes through transparency and reporting
- Leverage synergies in capabilities and infrastructure with Offshore Wind Industry

THREATS

- Inability to attract international vessels will increase decommissioning costs
- The pace of progress required to meet SEA decommissioning timelines
- Transition and upscale of dismantling and material management capabilities yet to be proven
- Collaboration between operators can be challenging
- Offshore wind construction will create competition for workforce, port infrastructure and vessels

Figure 2: Strengths, Weaknesses, Opportunities and Threats Associated with Decommissioning Activities in Australia

Investment and Strategic Overlay

Centre of Decommissioning Australia's (CODA) 2020 Liability study estimated that there was a potential for up to US$40.5 billion[1] of Offshore decommissioning across the entire Value Chain. As depicted in the investment distribution in Figure 3, the majority of this is captured in the upstream part of the Value Chain which is a dominant strategic strength currently for Australia. The significant costs are predominantly driven by expensive Offshore vessel day rates[2].

Australia's strategic strengths can be leveraged to capture value of various activity stages. Australia is a technical and educated population with strong innovation and engineering capabilities. There are a lot of challenges in the upfront planning, coordination, collaboration and innovation phase of the Value Chain which require a highly skilled workforce and so there is an expected high investment at this phase which can be captured by Australia.

The country's 60-year history of well drilling and workover experience is easily transferred into decommissioning well plug and abandonment work. Well work is expected to be 41% of the USD$40B liability estimate[1].

The vessel and well rig contractors are not based in Australia and there will be heavy reliance on global expertise. It is not seen as feasible to generate sufficient demand to enable an Australian vessel and rig contractor Industry.

For dismantling, material handling, recycling and/or disposal, there is capability in Australia, to what scale is not yet proven but there is clear evidence of interest locally to participate and collaborate. For end-of-Life management, Australia has the capability and capacity for the metal components, which constitute the vast majority of the material. There is a lack of capability and desire currently in recycling the small volume of umbilicals and plastics locally or for the downstream manufacturing of products.

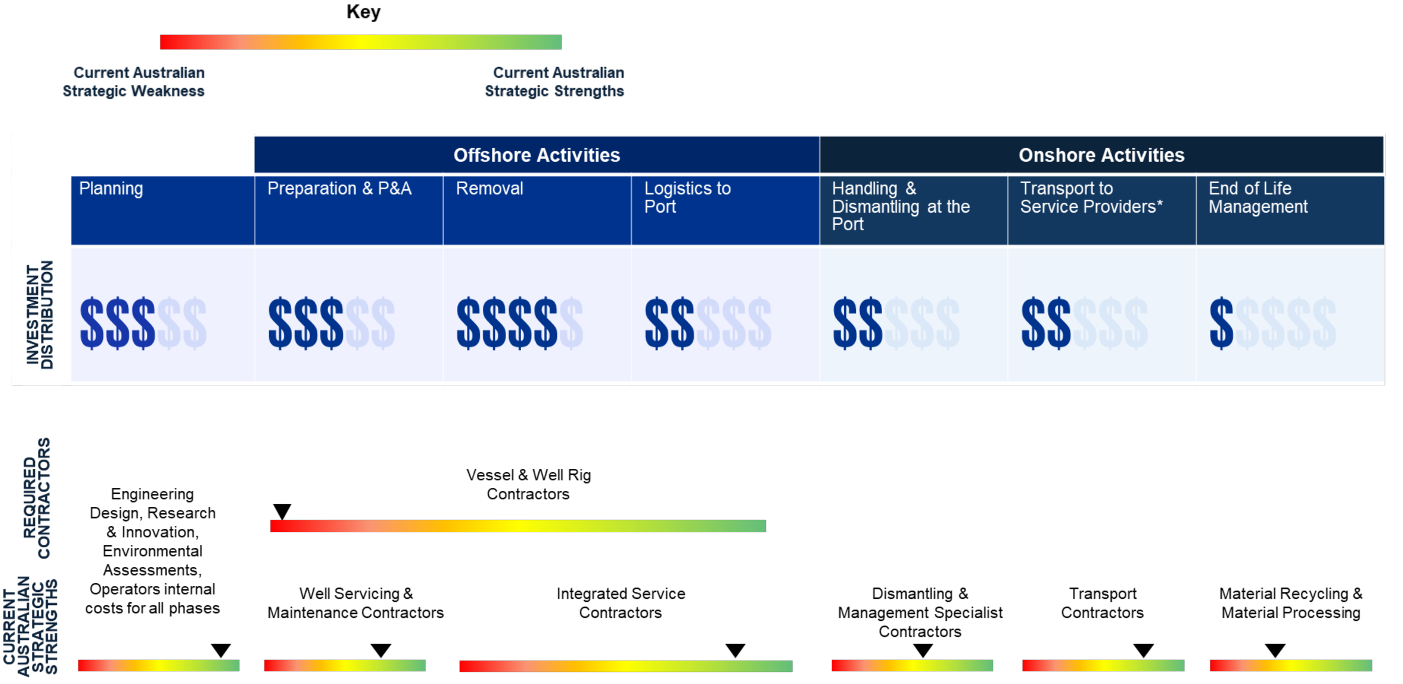


Figure 3: Decommissioning investment distribution versus current Australian strategic overlay

[1] CODA Offshore Oil and Gas Decommissioning Liability Report 2020 [2] OEUK Decommissioning Insight 2022

Australia's Offshore O&G Decommissioning

The Offshore O&G assets in the scope of this study is spread across the Bonaparte Basin off NT and the Bass, Gippsland, and Otway Basins in SEA.

Fields and operations situated off the coasts of Victoria (VIC), Tasmania (TAS) and NT are included in the study. Fields that have existing assets and have potential to be decommissioned by approximately 2040 (plus an additional five years) are included given the uncertainty that surrounds decommissioning dates due to reservoir end of field life uncertainty, Offshore contractor availability and regulatory approval timelines. Expected end of field life is taken from Environmental Plans (EP) and other resources from National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) website.

Table 2: List of Operations that have Offshore O&G Assets to be Decommissioned by Approximately 2040

Location	Basin	Operations	Current Operator	Production Start date	Expected field end-of-life
NT / WA	Bonaparte	Blacktip Operations	Eni Australia Ltd	2009	2034
Ashmore Cartier	Bonaparte	Montara Operations	Jadestone Energy (Eagle) Pty Ltd	2013	2032
NT / WA	Bonaparte	Bayu-Undan Pipeline	Santos Limited	2005	2030
TAS	Bass	Tasmanian Gas Pipeline	Tasmanian Gas Pipeline Pty Ltd	2002	2042
TAS	Bass	Yolla (Bass Gas Operations)	Beach Energy (Operations) Ltd	2006	2025
VIC	Gippsland	Gippsland Basin Joint Venture (Bass Strait Operations)	ExxonMobil Australia Pty Ltd	1960 - 2010	Tranche 1 2025 Tranche 2 2030-2035
VIC	Gippsland	Patricia Baleen Operations	Cooper Energy	-	Field life end reached
VIC	Gippsland	Longtom Operations	SGH Energy	2009	2036~
VIC	Gippsland	Basker Manta Gummy (BMG) Operations	Cooper Energy	2005	2023*
VIC	Gippsland	Sole Gas Operations	Cooper Energy	2019	2044^
VIC	Otway	Thylacine and Geographe (Otway Offshore Operations)	Beach Energy (Operations) Ltd	2007	2035
VIC	Otway	Minerva Gas Field	Woodside Energy (Victoria) Pty Ltd	2005	2020
VIC	Otway	Casino, Henry and Netherby Operations	Cooper Energy	2006 - 2010	TBD

TBD – To be determined
~ Longtom field is currently non operating
** Represents commencement of decommissioning date*
^ Estimated end of field life based on 25 year field life

Assets Excluded from Scope

The below assets are excluded from scope for reasons outlined:

- All fields in WA given they are currently addressed in ongoing CODA studies. The exception are three operations in the Bonaparte Basin, listed in Table 2 above. These have been included as they are close to the NT / WA border and have proximity to Port of Darwin in the NT.
- Northern Endeavour Floating Production Storage and Offloading (FPSO), as directed by DISR.
- All drilling activities and production well developments (e.g. Barossa Field Development) listed on the NOPSEMA website, considering the designed asset end life in these developments extends well beyond 2040.
- All surveys for potential future exploration and development listed in NOPSEMA website, considering the lack of clarity on the timelines when the field will be developed and operational.
- The decommissioning of some of the operations listed above are also noted to have associated Onshore processing plants that will require decommissioning at a future date. Though Onshore asset decommissioning is a consideration in Australia's decommissioning plans it is not a primary driving force and as such has been excluded from the material quantification scope. The Onshore asset decommissioning challenges faced are different with reduced regulatory rules, societal impacts and the ability to conduct decommissioning activities within the existing facility boundary.

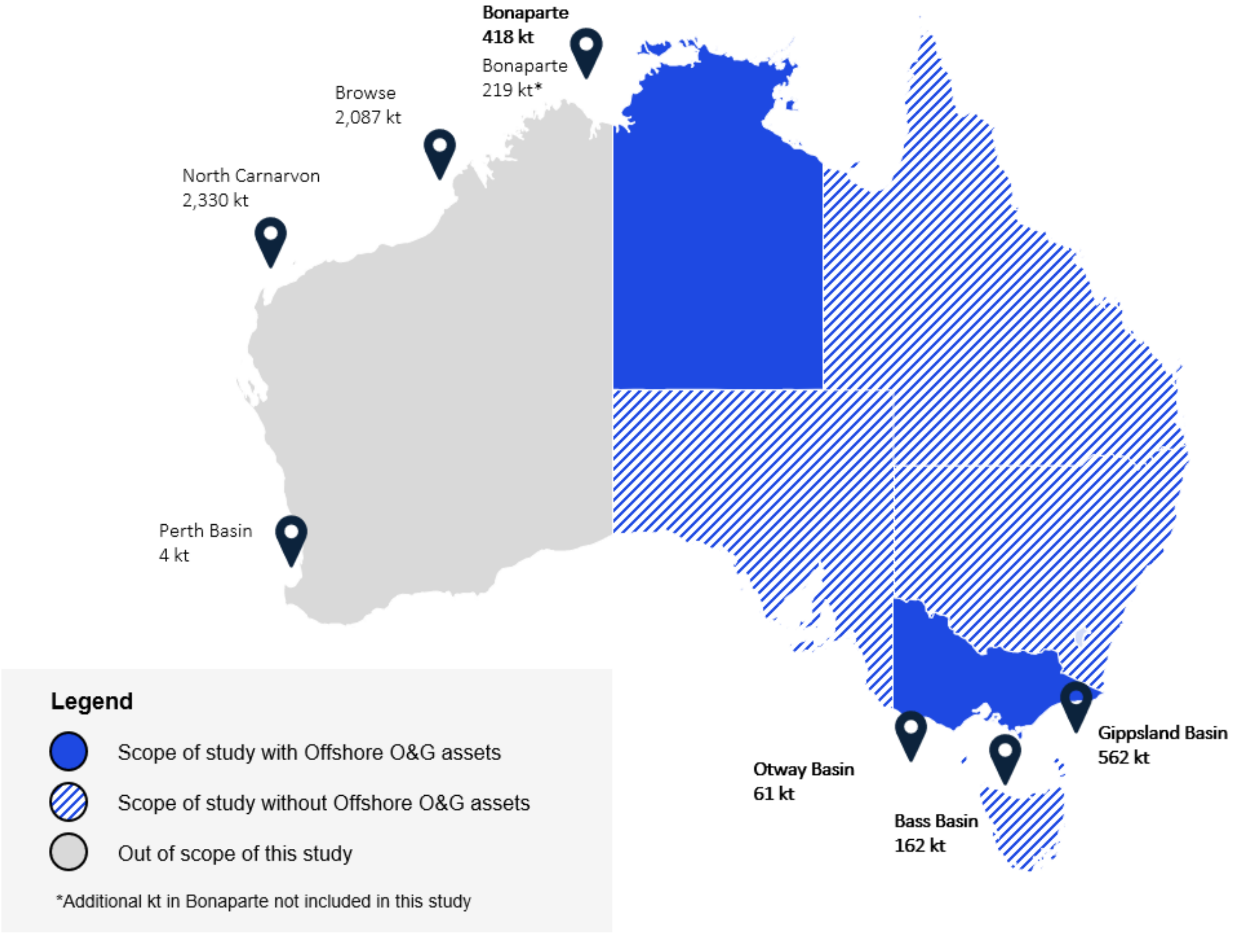


Figure 4: Geographical Distribution of Assets and Associated Weights

Per Figure 4, from a pan-Australia perspective, the demand of the assets is led by WA with 87% of the total weight coming from Northern Carnarvon, Browse and Bonaparte regions, with the assets in SEA contributing only 13% of the total weight. The weights of assets from fields excluded from the study are referenced from the CODA report[3].

3 CODA – Understanding the Opportunity for Local Disposal and Recycling Pathways

Demand Assessment

This report has identified that by 2040 there will be 175 assets decommissioned, generating over 1,204 kilotonnes (kT) to be processed at recycling facilities[3].

The assets within scope have been assessed to determine:

1. The type of assets and their decommissioning timeline;
2. The timeline of decommissioning activities; and.
3. The material makeup of these assets.

The two key areas of operations concerned within this report are the Bonaparte Basin and the Basins off SEA. These two regions have been separated into two different demand profiles due to their geographic distance. The cost of transport for large components or dismantled material between the different areas of operations is not considered practical, pragmatic, or economically viable.

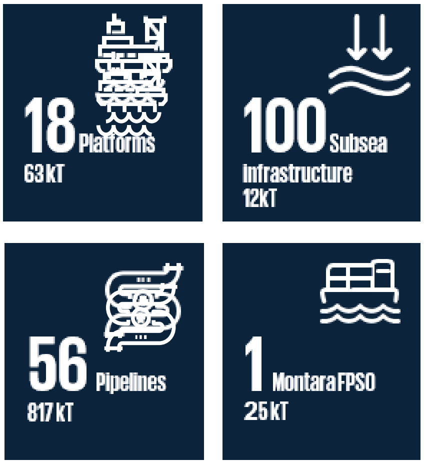


Figure 5: Offshore O&G Asset Profile In Scope of Report

Asset Types

In accordance with the Offshore Petroleum and Greenhouse Gas Storage (OPGGS) Act all assets must be removed when decommissioning when not in operation, although there are provisions such as Sections 270 and 572 to allow some property to be left in-situ subject to the satisfaction of NOPSEMA and an equal or better environmental outcome can be demonstrated, respectively.

Section 572 (3) - 'A title holder must remove from the title area all structure that are, and all equipment and other property that is, neither used nor to be used in connection with the operations.'

However, the estimates of this study are based on full removal scenario for the purpose of conservative estimates of assets. For the ease of the reader and to ensure the reports are compatible, the assets have been categorised using typology norms similar to those employed by CODA, which are platforms (including platform wells), floating facility, pipelines and subsea. Stabilisation such as concrete mattresses were also considered in the analysis but their weights were not materialistic to make an impact on the overall demand. For the assets within scope of this study, the demand is expected to peak by 2035.

The different types of assets and their decommissioning timelines are shown in Figures 6 and 7. Where the planned decommissioning dates were not available, the assets are assumed to have a 25 year design life and have a decommissioning timeline of five years post design life. When a Cessation of Production (CoP) date was available, the decommissioning execution is assumed to start five years post CoP and completed in two to five years[5]. The graph below shows the decommissioning activity commencement dates and it is assumed that the decommissioning of the assets will be completed in the five year window in which it commences.

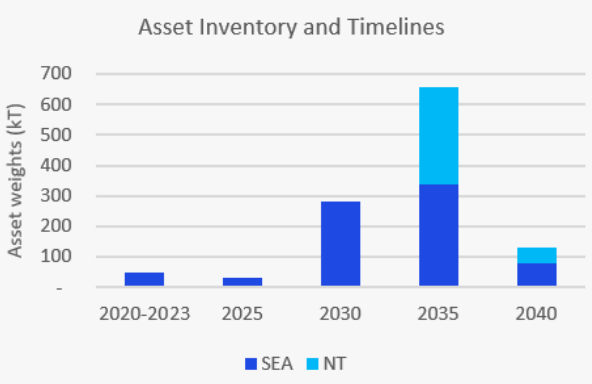


Figure 6: Quantity of Assets to be Decommissioned up to 2040

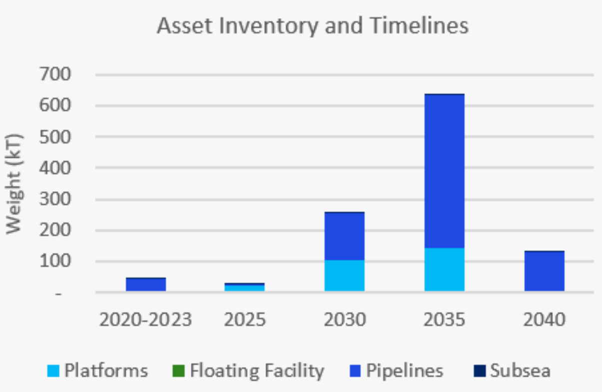


Figure 7: Decommissioning Asset Types and Timelines

4 KPMG has utilised the NOPSEMA website and relevant environmental plans to generate the data
5 NOPSEMA Planning for Proactive Decommissioning

Timing of Decommissioning

The Offshore decommissioning of assets will typically take many years starting from regulatory approvals, project management, engineering and planning, plugging and abandonment of wells, dismantling platforms into larger pieces Offshore and transport to Onshore dismantling locations via the port. Assets in the Gippsland Basin will be the first to be decommissioned commencing decommissioning activities from 2023 and the overall demand for decommissioning activities is anticipated to peak in 2035 as depicted in Figures 8 and 9. There are other factors that may impact the decommissioning timeline that include but are not limited to availability of support vessels, seasonal variations (due to weather) and contracting strategies.

Given the geographically diverse areas within scope, SEA and NT have been assessed individually. Based on EPs from NOPSEMA website and assumptions around end of field life, decommissioning activities in SEA is expected to commence from 2023 and lasting till 2040 and beyond. NT however, is expected to have assets decommissioned from 2035 onwards. In both cases, pipelines are the heaviest structures to be decommissioned with one FPSO to be decommissioned in NT by 2040. The expected peak in the weight or volume of assets are also similar across both regions peaking at 350kT in SEA by 2030 and slightly above 300kT in NT by 2035.

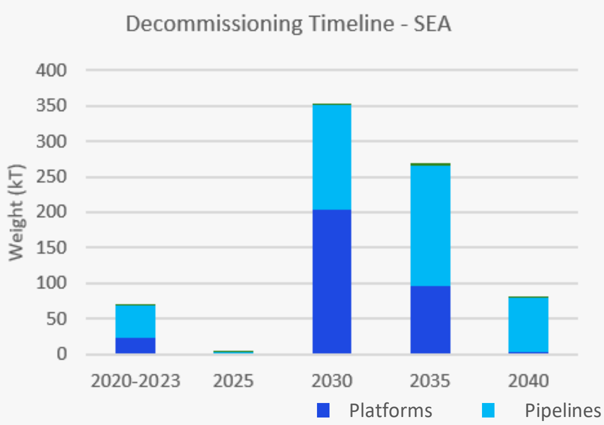


Figure 8: Asset Types and Timelines of Decommissioning in SEA

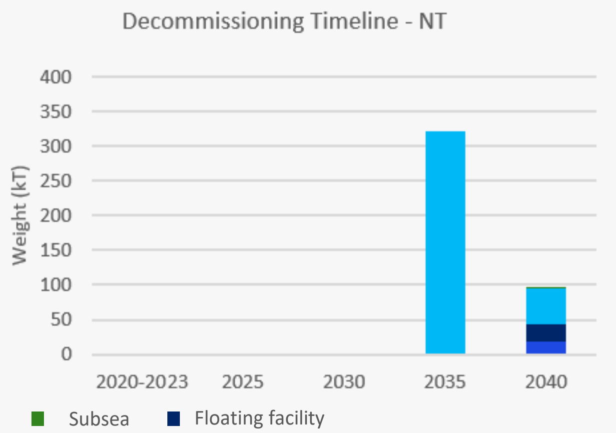


Figure 9: Asset Types and Timelines of Decommissioning in NT

Material Inventory Breakdown

A total of 1,204 kT of material has been identified for removal and with 98% represented for steel and concrete. From the analysis, concrete constitutes the largest material stream by weight at 52% followed by steel with 46% of the total asset weight. Plastics and non-ferrous are the smallest material streams with both together making up close to 2% of the total asset weight. Apart from the pipeline concrete weight coating, the large volume of concrete for this sub-group of assets is driven by the two concrete gravity-based structures (CGBS) situated in Gippsland which are West Tuna and Bream B. In comparison WA has only 1 CGBS [6] which determines a different profiling of the materials in the CODA report [7]. The average demand capacity target for the combined material streams come to 240kT per five years.

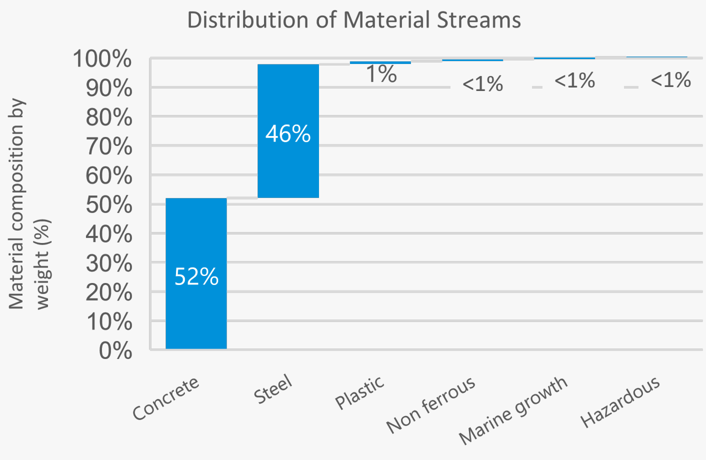


Figure 10: Material Composition of the In Scope Assets

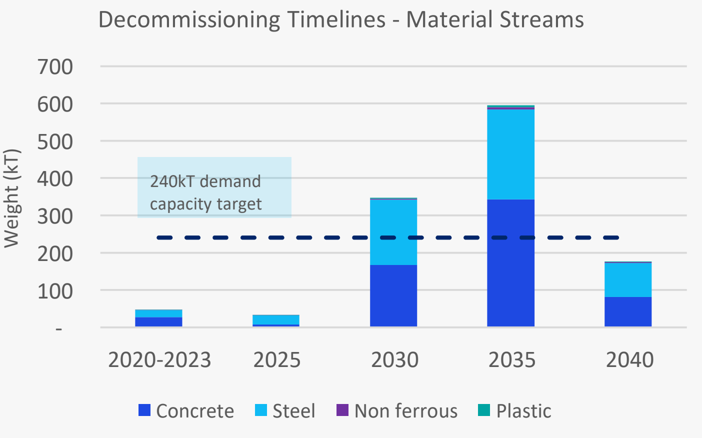


Figure 11: Decommissioning Timelines of Material Streams

6 CODA –Western Australia Dismantling Hub Location Study
7 CODA – Understanding the Opportunity for Local Disposal and Recycling Pathways

Demand Capacity Targets

Capacity targets for the largest two material streams have been mapped to derive an average demand capacity target over five year timeframes. The split between SEA and NT show the difference in the demand capacity requirement and associated timeframes. The average demand targets were calculated for the five year windows for each material stream per region. SEA's average demand capacity targets were determined from now till 2040 while for NT it was averaged from 2035-2040 as the supply is expected to be needed only during this time period.

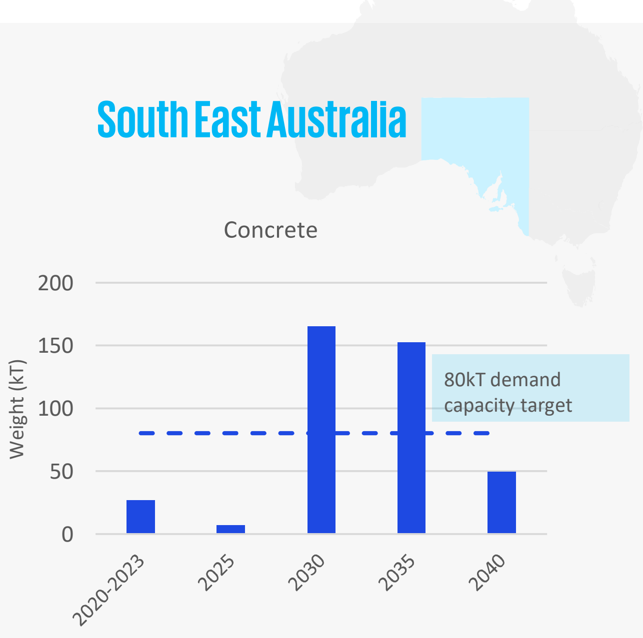


Figure 12 Concrete Demand Capacity Targets in SEA

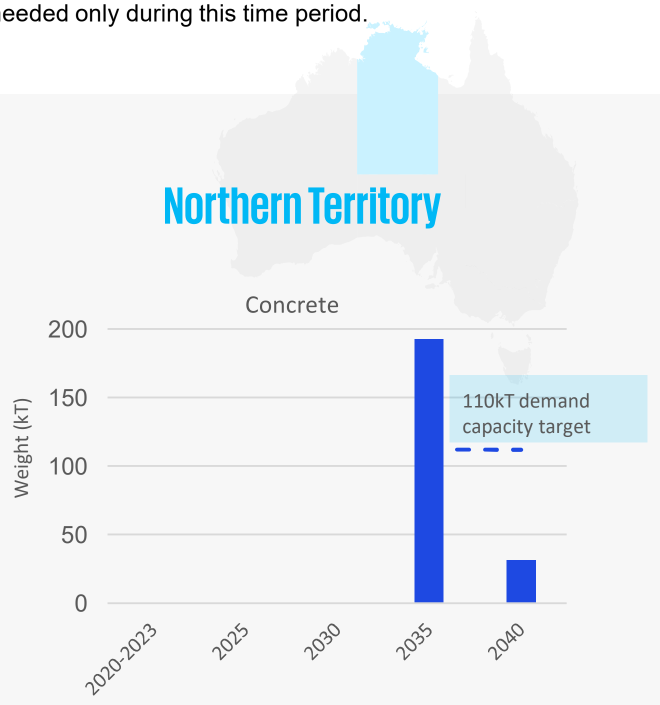


Figure 13: Concrete Demand Capacity Targets in NT

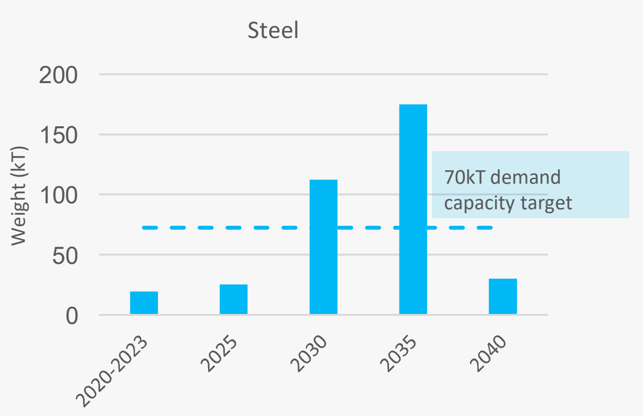


Figure 14: Steel Demand Capacity Targets in SEA

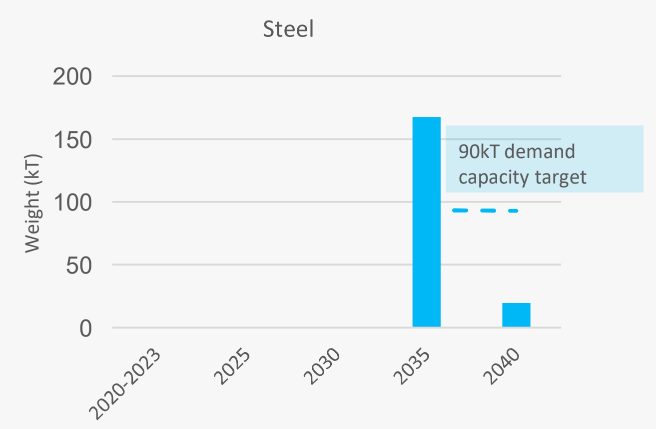


Figure 15: Steel Demand Capacity Targets in NT

In SEA, the demand for decommissioning services and material management is immediate and at a significantly larger scale. Total material generated in the region is 785kT which is ~350kT greater than the material generated in NT.

SEA has a more levelised supply of assets from 2023 until 2040 with demand capacity averages at 80kT and 70kT for concrete and steel materials.

Within the NT there is no demand until 2035.

The total weight generated in the region is only half of the material generated in SEA. However, the average demand capacity required to deliver over the 10 years is higher due to the group decommissioning timeline concentrated between 2035 - 2040.

Material Inventory Breakdown Methodology

The material inventory for the decommissioned assets together with additional material streams such as marine growth, hazardous waste and NORM has been estimated from publicly available data sets, Kent Engineering databases, North Sea Decommissioning Programs and close out reports and NOPSEMA EPs.

Sensitivity Analysis

The base assumption in the analysis is full removal which requires that all assets be removed from the title area, and this includes CGBS and pipelines. CGBS and pipelines together represent a total of 80% (or 958 kT) of the material requiring removal. For example, the West Tuna CGBS is estimated to be a total of 97kT tonnes comprising of concrete, steel, and ballast.

The removal of CGBS is complex and has several elements of risks, liability, personnel safety, and the potential to cause more harm to the environment in removal rather than being left in-situ. In addition, pipelines also have anti-corrosion coatings in addition to the concrete weight coatings. These anti-corrosion coatings are often polymer-based.

A sensitivity case was run assuming that all CGBS and pipelines are left in-situ (termed as 'in-situ' in the following graphs) to understand the impact on the demand capacity. This partial removal scenario is not deemed likely but illustrates the variability that exists in the actual volumes of material to come ashore. The reality is likely to be somewhere in between. The analysis shows that for the in-situ scenario, the target capacities for concrete in SEA and NT drop in the orders of almost 98% and 100% respectively as the concrete mainly comes from CGBSs and pipeline coatings. The target capacities for steel in SEA and NT drop by almost 52% and 78% respectively mainly driven by the reduction in pipeline quantities. steel quantities have not dropped as much as concrete because the platforms comprising of steel still need to be removed in both scenarios.

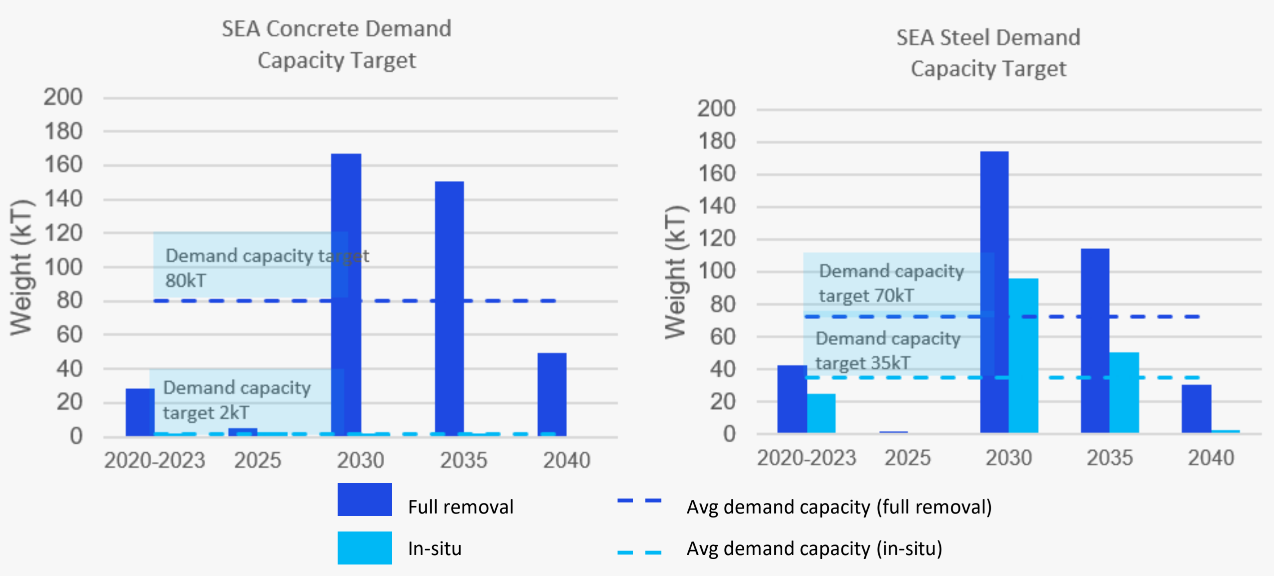


Figure 16: Sensitivity Analysis of Concrete and Steel Material Streams in SEA

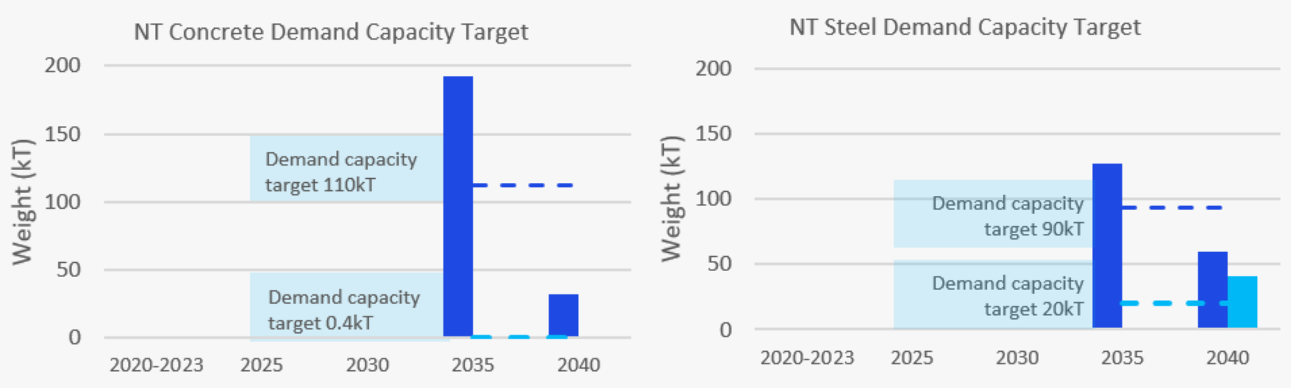


Figure 17: Sensitivity Analysis of Concrete and Steel Material Streams in NT

Key Takeaways

Overall, our analysis has identified:

- The decommissioning activity is expected to peak between 2030 to 2035. Compared to the quantities for 2023-2025, the supply will be 3 times more in 2030 and 6 times more in 2035.
- Assuming all the assets from Offshore SEA are expected to come Onshore to Victoria, the state needs an average demand capacity target of 80kT and 70kT per five years for concrete and steel material streams respectively.
- Similarly, assuming the assets considered in the Bonaparte region of the study will come Onshore in NT, the state needs an average demand capacity target of 110kT and 90kT per five years for concrete and steel respectively.
- A comparative assessment between full removal and partial removal pathways and allowing CGBSs and pipelines to stay in-situ could reduce the weight of the assets Onshore by 80%.
    - The demand capacity targets in SEA reduce to 2kT and 35kT for concrete and steel respectively.
    - The demand capacity targets in NT reduce to 0.4kT and 20kT for concrete and steel respectively.

Supply Assessment

Vessel Supply Assessment

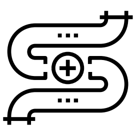
Similar to today's Offshore O&G development projects, majority of the Offshore decommissioning activity requires highly specialised vessels such as Heavy Lift Vessels (HLVs) and Semi Submersible Crane Vessels (SSCV). The relative size of Australia's O&G Industry is insufficient to sustain a competitive domestic market for many of these specialised services and as such continued access to the globalised market will be crucial for the successful execution of decommissioning in Australia..

Stakeholders are receiving feedback from the international market that campaigns more than two years are required to attract competitive vessel day rates. Providers are already prioritising the contracting of vessels operating in Australia to optimise campaign costs, capitalise on safety case and regulatory efforts, and minimise emissions associated with the lengthy mobilisation to Australian waters. Creating a campaign approach, can produce sufficient volume of work to attract the international capability and optimise decommissioning costs, however, this hampered by regulatory expectations (discussed later) and lack of a coordinated regulatory framework. In addition, concerns of breaching antitrust legalisation is viewed by many Operator stakeholders as a barrier to collaborating and contract sharing.

Challenges exist for Australian operators accessing the limited supply of global vessels expertise:

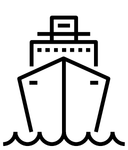
Australia's proximity to global markets in the North Sea, Gulf of Mexico and South America	Uptick in Offshore activity globally tightening supply and increasing cost
Vessel contractors perceive regulatory expectations to be challenging compared to other regions	Ability to collaborate for longer duration campaigns is challenged by decommissioning timelines

Offshore Infrastructure Removal Options and Vessel Selection



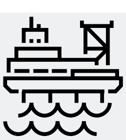
Pipelines and Subsea Infrastructure

Pipelines and subsea infrastructure have significantly reduced removal requirements when compared to platforms and FPSOs. Pipelines and subsea infrastructure can typically be removed with the use of Construction Supply Vessels (CSVs), Offshore Supply Vessels (OSV) and Heavy Lift vessels (HLV). The requirement alters depending on the amount, type and depth of equipment being removed. For pipelines, practicalities for removing could depend on whether they are buried, have concrete coating and their current day condition.



Floating Production Storage and Offloading (FPSO)

A FPSO is typically decommissioned through towing the vessel to shore or transport utilising a Semi-Submersible Heavy Transfer Vessel (SSHTV). The FPSO will need to undergo decontamination, a process occurring either on shore or berthed for a period of time. Demolition can take place either using a slipway, Drydock or at Quayside. Due to the size requirements, facilities need to be suitable to handle the size, decontamination and demolition requirements. Precaution will also need to be taken to ensure proper contamination of hazardous materials. Unlike other assets, decommissioning of FPSOs can require berthing for a period of time (in the order of months) adding to wharf space competition.



Platforms

Single Lift

A single lift operation could be conducted to remove the entire medium to large Offshore platform in one operation; requires a Semi Submersible Crane Vessel, of which there are limited number in the world due to their size, cost and complexity.

Piecemeal Operation

The platform and other large fixed infrastructure is partially dismantled at sea into more manageable pieces and transported to port facilities for complete dismantling.

- **Piece-Large -** Naturally require larger vessels including HLVs and SSHTV. The benefit of this options is the reduced time required for Offshore operations when compared to small piece removal. The exact amount of material required to be removed would also impact the vessel requirements.
- **Piece-Small -** This method has similar vessel requirements compared to pipelines and subsea infrastructure requiring CSVs, OSVs and HLVs. Requires a significant Offshore workforce for extended period.

Ports Analysis Overview

Ports that could be utilised for decommissioning activities have been reviewed for their suitability. These ports need certain quayside characteristics including laydown areas and suitable draft and length allowances. Commercial trading ports within New South Wales, Victoria, Tasmania, South Australia and NT have been included within the suitability assessment due to their proximity to the O&G fields off Victoria and NT. Their proximity to Offshore assets, functionality, current infrastructure and compatibility with existing or proposed future trades have been assessed.

Ports excluded from the assessment include:

- Ports within Queensland, due to the challenging proximity to the Offshore assets; and
- Ports in WA, due to insight and detail from ongoing CODA studies and will be overlayed at the opportunity screening assessment phase to ensure an optimised Australian solution is considered

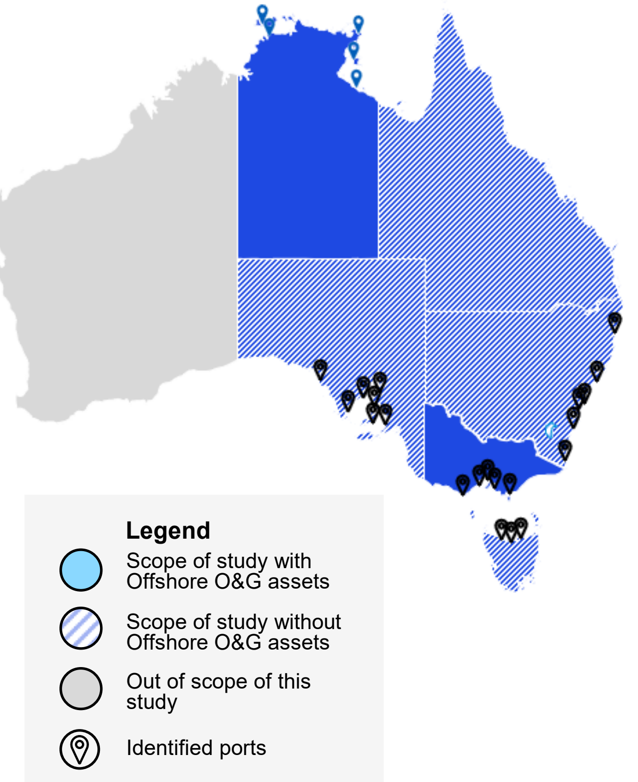


Figure 18 Map of Ports Under Consideration

Decommissioning Options

The port requirements greatly depend on the removal method of the Offshore facilities. Vessels utilised for decommissioning vary greatly in their beam, Length Overall (LOA) and draft and therefore have different port berthing requirements. These vessels can also be supported by transferring materials to shallow draft barges where vessels are unable to approach ports. Vessels that can support Offshore decommissioning, and their characteristics are outlined in Table 3. This also includes typical FPSO characteristics which would need to be directly berthed for components of decommissioning.

	Support barges	Operations Support Vessels (OSV)	Construction Support Vessel (CSV)	Heavy Lift Vessels (HLV)	Semi-Submersible Heavy Transport Vessel (SSHTV)	Semi-Submersible Crane Vessels (SSCV)	Floating Offshore Production Ship (FPSO)
Comment	• 300 – 400ft barges used to support other vessels. • Utilised as Offshore support and transfer to port.	• Logistics support • Shuttle scrap recovered	• Crane equipment vessel	• Monohull crane vessels • Can be used for modular deconstruction or removal of large subsea assets	• Specialised vessel used for transporting structures long distances	• High capacity cranes can remove facilities in a single lift	• Floating Production Vessel would require a port berth for decontamination and decommissioning
LOA (m)	90 – 130	80 – 90	110 – 160	> 210	150 – 275	–	250>
Beam (m)	28 – 40	< 20	20 – 32	> 40	36 – 75	–	40>
Draft (m)	4 – 6	< 7	6 – 9	8 – 11	7 – 11	~24	12>

Table 3: Port Requirements Based on Removal Vessel Employed

Port Facilities to Service Dismantling Activities

Port facilities will also require significant laydown areas to conduct dismantling. Dismantling refers to the process of breaking down decommissioned Offshore structures into smaller components or manageable pieces and undertaking any pre-treatment and material management activities required before the material is transported for further material end-of-life recycling. There are several specialised service providers that are equipped to manage the dismantling process. Typically, these service providers will also engage with downstream material recycling operators and end-of-life management operators. They are a critical stakeholder to enable an effective decommissioning sector.

The size of the laydown area required for dismantling will depend on the size and amount of infrastructure brought to shore at any given time. Dismantling will also include preliminary material management activities to separate different material streams prior to transport to material end-of-life facilities. This includes the management of steel and non-ferrous metals, plastics, NORMS, marine growth and hazardous materials. Due to the nature of the activities a suitable laydown area will be required that ensures material run off does not occur and there is significant strength to withstand the equipment required to undertake the work.

Consultation with dismantling service providers indicated that the equipment, skills, labour and recycling avenues and end markets are not constrained. The biggest constraint is identifying a suitable port and obtaining the necessary authorisations and approvals to enable the dismantling to occur at the port. The regulatory barriers are further discussed in chapter Regulatory Context.

Port Analysis Methodology

A two staged analysis of port facilities in Australia has been undertaken to determine the most suitable facility to undertake decommissioning activities and is outlined below. Stage 1 suitability screening represents the piece-large removal option for berth and laydown areas. A more granular suitability screen for different removal solutions is included in Stage 2.

The Stage 1 Port analysis of 26 ports across the relevant jurisdictions, included analysis on the following characteristics outlined below. This will be undertaken utilising a traffic light system of suitable, possible and not suitable.

Proximity to Offshore assets

The proximity to Offshore assets is conducted through a relative comparison of port location with reference to Gippsland, Otway, Bass and Bonaparte Basins. This isa significant consideration due to the high cost of Offshore support vessels and transportation.

Berth types

A high level review of available general and breaking berths currently located at facilities was undertaken, however, this does not include a review if the berth has the required strength and requirements to undertake these activities. It has also been noted if there are any current proposals to develop new berths. This high-level review notes that a significant number of ports only have jetties or berths with fixed ship loaders that would not be suitable for decommissioning activities.

Laydown area availability

A high level review of the availability of lay down areas with access to current general/breaking berths that would be required for the offloading of equipment and for dismantling activities to take place.

Proximity and impact to communities

The proximity and impact to the surrounding community of port facilities including noise and smell due to Offshore decommissioning activities. This can be of particular importance to ports such as Geelong that are in immediate proximity to the surrounding community.

Proximity to material recycling and end-of-life facilities

The proximity of the port to material recycling and end-of-life facilities is included due to the high cost of transporting materials. Scenarios range from recycling facilities being co located at the port to no recycling facilities located within close proximity.

Preliminary Ports Analysis

Utilising the Ports analysis methodology above, the ports within scope have been identified as either suitable or removed from consideration based on their ability to support O&G decommissioning activities. The summary of this analysis can be seen in Table 4 below.

In the summary, ports in their current state are not suitable to accept larger vessels and will require significant modifications or a “piece-small” removal approach. There are, however, eight facilities that could potentially be used across Victoria, South Australia, Tasmania and NT. Given the lower volumes and timing uncertainty of decommissioning activities, there is unlikely to be the demand for new build decommissioning port infrastructure investment. It would be more economical to maximise the use of existing facilities with likely investment needed for dismantling facilities including impermeable laydown areas, berths and material management services.

Port	Proximity to Offshore assets	Berth	Proximity to Material Recycling / Disposal	Proximity to Community	Laydown areas
Botany Bay	Possible	Not suitable	Possible	Not suitable	Not suitable
Newcastle Harbour	Possible	Possible	Suitable	Suitable	Possible
Port of Eden	Suitable	Not suitable	Possible	Not suitable	Not suitable
Port Kembla	Possible	Not suitable – Expansion planned*	Possible	Possible	Not suitable – Expansion planned*
Port of Yamba	Possible	Not suitable	Possible	Not suitable	Not suitable
Sydney Harbour	Possible	Not suitable	Possible	Not suitable	Not suitable
Barry Beach	Suitable	Possible	Possible	Suitable	Possible
Port of Geelong	Suitable	Possible	Possible	Not suitable	Possible
Port of Hastings	Suitable	Not suitable – Expansion planned*	Possible	Not suitable	Not suitable – Expansion planned*
Port of Melbourne	Suitable	Not suitable	Possible	Not suitable	Not suitable
Port of Portland	Suitable	Not suitable	Possible	Not suitable	Not suitable
Bell Bay	Suitable	Possible	Possible – Additional transport likely required	Suitable	Possible
Burnie	Suitable	Possible	Possible – Additional transport likely required	Not suitable	Not suitable
Devonport	Suitable	Not suitable	Possible – Additional transport likely required	Not suitable	Not suitable
Port of Adelaide	Possible	Possible	Possible	Possible	Possible
Port Giles	Possible	Not suitable	Possible	Not suitable	Not suitable
Port Lincoln	Possible	Not suitable	Possible	Not suitable	Not suitable
Port Pirie	Possible	Possible	Suitable	Suitable	Possible
Port of Thevenard	Not suitable	Not suitable	Possible	Not suitable	Not suitable
Port of Wallaroo	Possible	Not suitable	Possible	Not suitable	Not suitable
Port Whyalla	Possible	Possible	Suitable	Suitable	Possible
Alyangula Port	Not suitable	Not suitable	Possible – Additional transport likely required	Suitable	Not suitable
Bing Bong	Not suitable	Not suitable	Possible – Additional transport likely required	Suitable	Not suitable
Gove	Not suitable	Not suitable	Possible – Additional transport likely required	Suitable	Not suitable
Port of Darwin	Suitable	Possible	Possible – Additional transport likely required	Suitable	Possible
Port Melville	Suitable	Not suitable	Possible – Additional transport likely required	Suitable	Not suitable

Key: Suitable (green) | Possible (yellow) | Not suitable (red)

Table 4: Port Facilities Suitability Based on Range of Criteria

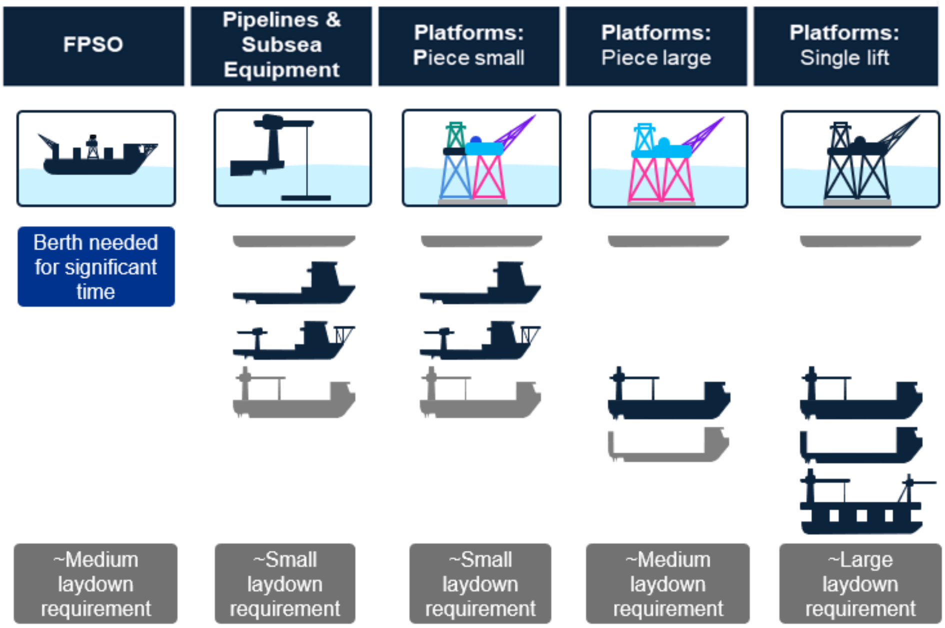
Preliminary Assessment Results

Through conducting Stage 1 Port screening the following ports have been marked as potentially suitable to conduct decommissioning activities:

- Newcastle Harbour
- Port Kembla, if proposed quayside upgrades were undertaken, suitable and timed
- Barry Beach
- Port of Hastings, if proposed quayside upgrades were undertaken, suitable and timed
- Bell Bay
- Port of Adelaide
- Whyalla
- Port of Darwin

Marine Accessibility Assessment

These eight ports have been reviewed in Stage 2 for marine accessibility of the vessels required for decommissioning. This is based on the requirements of the various decommissioning options. As shown in Table 5 below, the assessment has been conducted as a high level review of the current size of laydown areas, port access including allowable vessel draft, beam and LOA. This is intended to be a high level screening assessment and further detailed assessments would be recommended. Channel depth and the potential for dredging is also a consideration for Port Infrastructure but has not been included in the following accessibility screening exercise. Note: the vessels depicted in Table 5 are characterised in Table 3.



Port	FPSO	Pipelines & Subsea Equipment	Platforms: Piece small	Platforms: Piece large	Platforms: Single lift
Newcastle Harbour	Not suitable	Suitable	Suitable	Possible	Not suitable
Port Kembla	Not suitable	Quayside upgrades*	Quayside upgrades*	Quayside upgrades*	Not suitable
Barry Beach	Not suitable	Suitable	Suitable	Possible	Not suitable
Port of Hastings	Not suitable	Quayside upgrades*	Quayside upgrades*	Quayside upgrades*	Not suitable
Bell Bay	Not suitable	Suitable	Suitable	Possible	Not suitable
Port of Adelaide	Not suitable	Suitable	Suitable	Not suitable	Not suitable
Whyalla	Not suitable	Suitable	Suitable	Possible	Not suitable
Port of Darwin	Not suitable	Suitable	Suitable	Possible	Not suitable

Key

Suitable | Possible | Not suitable

Table 5: Shortlist of Ports Accessibility Based on Decommissioned Asset Type and Size

FPSO Decommissioning

It should be noted that current facilities in Australia would likely be unsuitable for FPSO decommissioning. The size, decontamination and demolition requirements of the vessels would present a significant challenge to current port facilities in Australia. The requirement to utilise a dry dock, slipways or quaysides likely exceed current Australian capabilities and it is likely that significant investment would be required to undertake this work. In addition, decommissioning activities of FPSOs can utilise berths for periods of time, competing for wharf space. The largest dry dock in Australia, Captain Cook Graving Dock is unlikely to have the availability or size requirements for use. In regards to slipways, there are potential locations, however these are also not currently suitably sized for FPSOs. Ex-HMAS Success was recently decommissioned at the Whyalla slipway but is notably smaller than FPSOs. Quaysides can also be utilised in conjunction with lifting the hull to shore, however, this is also unlikely given the size requirements. It can be noted that the largest vessel to be decommissioned in Australia is ex-HMAS Sirius which was completed in Henderson, WA. FPSOs are substantially larger in comparison.

Ports Analysis Overview

Newcastle Harbour

Newcastle would be suitable for decommissioning activities with general breaking berths and laydown areas available. The berths and laydown would need to be reviewed in detail to determine their exact suitability. Proximity to Offshore assets is a downside.

Port Kembla

Port Kembla is currently unsuitable but has the potential to undertake activities depending on the timing and suitability of the proposed Offshore wind staging area. It is noted that these activities might overlap in timing and could be difficult to conduct concurrently.

Barry Beach

Barry Beach could be suitable for decommissioning activities if facility upgrades were undertaken. The Barry Beach asset is very mature and talking to stakeholders, significant investment is required on existing facilities to accommodate an uptick in port and decommissioning activity. In addition, channel and laydown areas would need to be upgraded to undertake significant decommissioning activities. Channel dredging in proximity to RAMSA wetlands is a consideration.

Port of Hastings

Port of Hastings is currently unsuitable but has the potential to undertake activities depending on the timing and potential suitability of the proposed Offshore wind staging area. It is noted that these activities might overlap in timing and could be difficult to conduct concurrently. Channel dredging in proximity to RAMSA wetlands is a consideration. As to is the Port of Hastings community concern with proximity to O&G decommissioning activity.

Whyalla

Whyalla is advantageous in its proximity to Industry and steel manufacturing, however, suitable berths and laydown areas would need investment. It is also a significant distance from Offshore platforms and facilities. Proximity to Offshore assets is a downside.

Bell Bay

Bell Bay would be suitable for decommissioning activities with general breaking berths and laydown areas available. The berths and laydown would need to be reviewed in detail to determine their exact suitability.

Port of Darwin

The Port of Darwin is likely the only suitable port within the NT. Laydown and berth upgrades are likely to be needed to support decommissioning activities.

Port of Adelaide

Port of Adelaide could potentially be utilised for decommissioning activities if berth and laydown areas were established for suitable use. Proximity to Offshore assets is a downside.

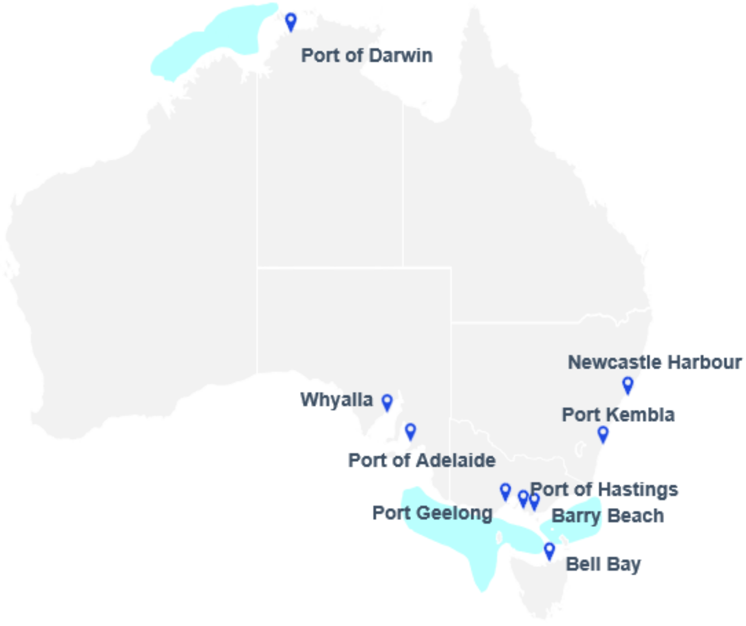
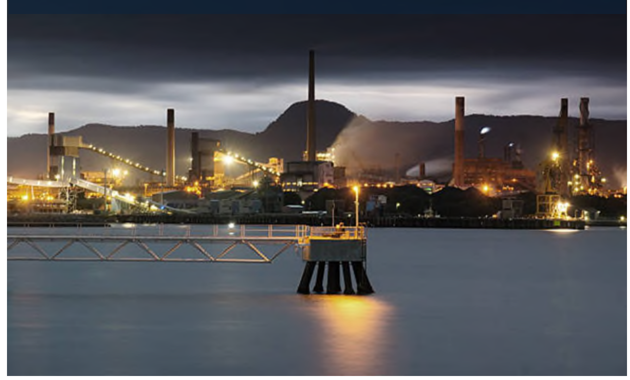
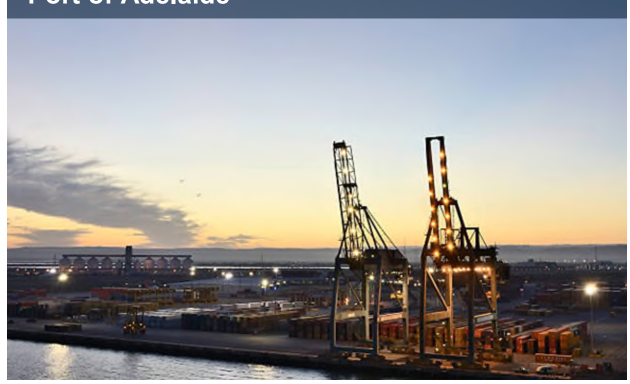


Figure 19 Geographical Location of Shortlist of Ports

Port Kembla



Port of Adelaide



Adjacent Industries

Offshore Wind

Offshore wind port facilities typically require large, strengthened laydown areas and berths suitable for Heavy Lift Vessels. These are similar requirements to decommissioning activities and therefore, in theory there would be the potential to utilise the same facilities. The opportunity potentially exists for efficient investment in SEA for a dual purpose port to service both industries. However this would depend on the timing and ultimate suitability to utilise these facilities given both operations will look to operate in the summer months and compete for port capacity.

One unique difference in these industries is the proximity to community considerations, given Offshore wind is generally accepted, whereas O&G decommissioning can have potential smell and noise impacts resulting in community unacceptance. The port facility operational timing also differs with decommissioning in SEA to occur from 2023 and Offshore wind in the late 2020s.

As an aspect of the consultation with port operators, the impact to adjacent industries will need to be considered, including Offshore wind. Current announcements for Offshore wind staging areas at ports under consideration, include;

Port of Hastings

Plans announced for a Victoria Renewable Energy Terminal to support the State Government’s commitment to deliver 9GW of Offshore wind energy by 2040. This includes a target of 2GW by 2032 requiring the facility to be completed and ready to support construction activities by the late 2020s.

Port of Geelong

Port strategy includes plans for a wind farm construction feeder port to support the construction of Offshore wind facilities.

Port Kembla

NSW ports has unveiled plans to construct an Offshore wind port facility to support proposed Offshore wind projects. These projects include the Hunter Coast and the Illawarra region. The Hunter Coast project is expected to generate up to 5GW with generation expected from 2030. The Illawarra region has the potential to generate up to 4.2GW.

Key Takeaways

In summary, this analysis has shown:

Each port facility currently under review would require different levels of investment to be suitable for decommissioning activities. Whilst is has been determined that there currently no readily available dismantling facilities, it would be viable to construct temporary or semi-permanent facilities at existing ports to conduct decommissioning. The requirements of these facilities would need to be determined in hand with the determination of how the assets will be removed Offshore. This will stipulate the draft, berth and impermeable laydown area requirements.

The selection of the most suitable port facility is a trade-off between the various activities of the decommissioning Value Chain. Selection will depend on the various economic, regulatory and social impact of each option when comparing potential increase transportation requirements of Offshore vessels versus requirements for transport of material after demolition to end-of-life facilities. It is likely that selection of the port facility will be driven by Offshore O&G operators in consultation with port operators. The decision for SEA is likely to be determined over the next 12 months in preparation for ExxonMobil’s Offshore assets due for decommissioning by 2025. The volumes in SEA are relatively small and as such it is not likely that investments will be made in more than one port. Therefore, the decision by ExxonMobil will likely drive the solution for SEA decommissioning.

Material Supply Assessment Methodology

This chapter outlines the state of the recycling sector to absorb the materials produced from O&G decommissioning. In the absence of publicly available data, 2020-21 data from the National Waste Report[8] together with the National Waste and Resource Recovery Infrastructure database[9] were used to develop the most recent list of relevant facilities and their throughput data.

The data used in this report serves as a conservative estimate as it is based on existing throughput, rather than facility capacity. Facility capacity is often commercial in confidence, and based on targeted consultation with the sector, it is assumed that facilities do not operate at capacity and often have ability to accept additional throughput.

These datasets were supplemented with targeted consultations with key stakeholders and peak bodies to bridge any gaps and to better understand supply chain sentiment for Offshore decommissioning.

Material Recycling and End-of-Life Management

The majority of material streams generated by O&G decommissioning will be concrete (52%) and steel (46%), with plastics and non-ferrous metals making up close to 2% of total asset weight. Therefore, the quantitative supply assessment has focused on the most material streams; being concrete and steel.

Transportation costs are one of the main factors to be considered when assessing the economic viability of recycling. For this reason, the supply assessment is grouped into two regions based on where the majority of Offshore assets are located; SEA and NT. The opportunities for materials end-of-life management can be split into three key use cases: reuse, recycling or disposal.

Reuse

Reuse is a higher-order management avenue and to be prioritised in a circular economy. Reuse is likely to be a feasible option for furnishings, rather than structural elements, which will be high risk to reuse and are likely to need processing and cleaning due to the wear and tear and harsh environment that these materials have been subject to over the years. Therefore, there has been minimal focus on reuse as a sector as it is unlikely to be a viable option for majority of materials.

Recycling

Recycling refers to a number of activities, including the segregation of material into separate streams, cleaning and processing activities such as cutting or crushing that occurs to prepare material to be used as a recycled feedstock into manufacturing of products or construction of infrastructure or building.

Materials are typically taken to recycling facilities where processing and preparation activities are undertaken, also referred to as ‘recycling’. Once ready to the required specification as a saleable commodity, the material is then transported to their end market, either for export or to be used in domestic manufacturing or construction activities.

Each material stream has its own requirements for recycling and end market dynamics which drive activity. This is of specific relevance for steel, concrete, plastics and uncontaminated marine growth.

Disposal

Some material such as contaminated marine growth and Naturally Occurring Radioactive Materials (NORMs) will need to be disposed of to ensure safe end-of-life management.

8 National Waste Report 2022, Blue Environment
9 Australian waste and resource recovery infrastructure database, Australian Government DCCEEW, 2022

South East Australia Overview

Assuming all SEA assets come Onshore to Victoria Ports, there is sufficient recycling capacity in Victoria to receive them. Figure 20 highlights the recycling capacity for steel and concrete within Victoria for five years against the demand generated in SEA.

Figure 21 shows the spread of scrap steel and concrete recycling facilities in Victoria, highlighting that there are more facilities located in metropolitan areas than regional. The more suitable ports are not located in metropolitan areas. The location of the port will play an important role in determining the distances that material needs to be transported and therefore the economic viability of domestic recycling.

Despite there being sufficient recycling capacity, the larger issue is there is uncertainty in the volumes coming ashore which is a barrier for facilities to plan, invest and upskill.

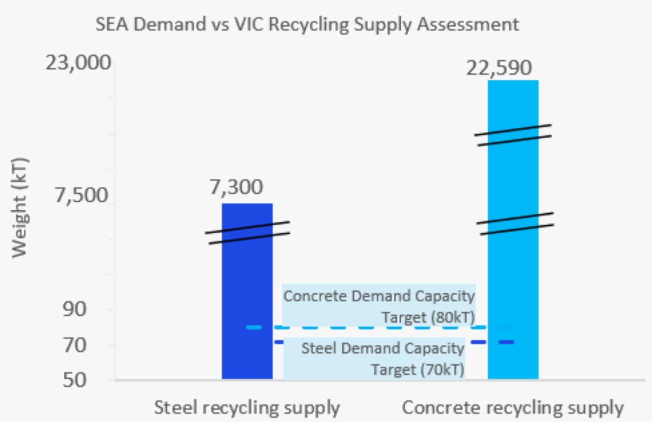


Figure 20: Average SEA Demand Vs Victorian Recycling Supply for Steel and Concrete

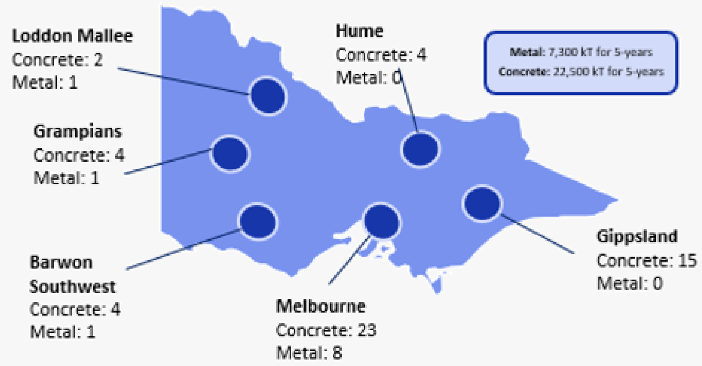


Figure 21: Geographical Distribution of number of Concrete (Construction and Demolition) and Metal Recycling facilities across Victoria

Northern Territory Overview

Figure 22 shows total supply for recycling steel and concrete in NT for five years, against the total demand generated in Northern Territory. The analysis highlights:

- Although the demand volumes are relatively smaller, they are concentrated in time. There in insufficient recycling supply capacity in NT to receive the demand volume.
- The majority of the material generated will be from pipeline assets. These assets are cut to sections and hence are easier to transport than components of fixed assets. Therefore, there is further flexibility as to which port these assets can be transported to.
- There is sufficient recycling supply capacity in WA to receive these volumes and transportation to a port in WA could be an option exploring for synergies.
- In the scenario of pipelines remaining in-situ, where volumes could be reduced by 80%, the supply in NT is likely to be sufficient to manage concrete and steel material recycling as shown in Figure 23.

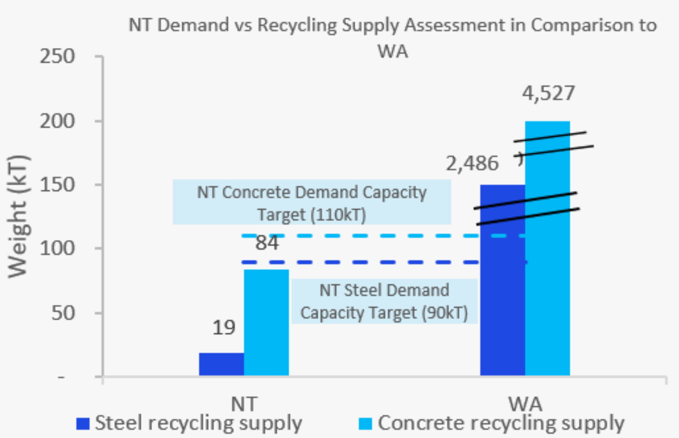


Figure 22: Average NT Demand Vs Recycling Supply for Steel and Concrete

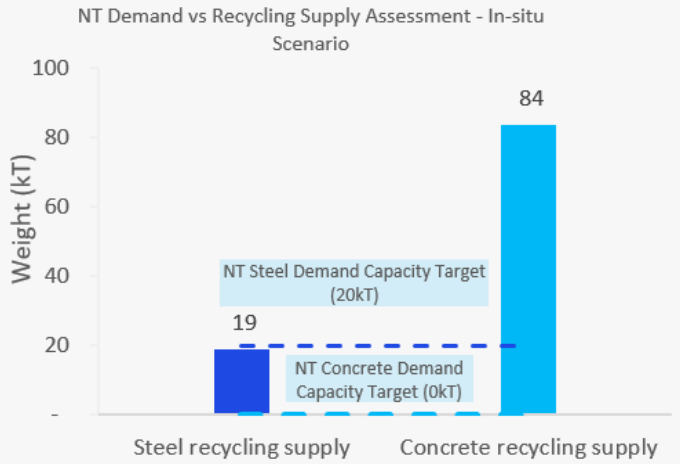


Figure 23: Average NT Demand Vs Supply for Steel and Concrete – In-situ scenario

Metals

The metals recycling sector is a vital component of the Australian economy. Scrap metals consistently exhibit high recycling rates in Australia, reaching a 87% recycling rate in 2020-21[10]. The metals recycling sector in Australia primarily deals with two primary categories of scrap metals; ferrous (for example, steel) and non-ferrous (for example, aluminium). This report focusses on recycled scrap steel (or scrap steel) as it forms the majority of O&G assets. The total average steel demand from O&G assets every five years is 160kT. This represents a fraction of the total steel recycled in Australia of approximately 4,369 kT per annum or 21,845kT across five years.

Of the total scrap steel recycled, approximately 51% is used as feedstock in Australian steel mills for steel manufacturing (approximately 2,200 kT per annum) and 49% is exported (approximately 2,100 kT per annum), as provided in the National Waste Report 2022. The high level recycling supply chain for steel is shown in Figure 24 below.

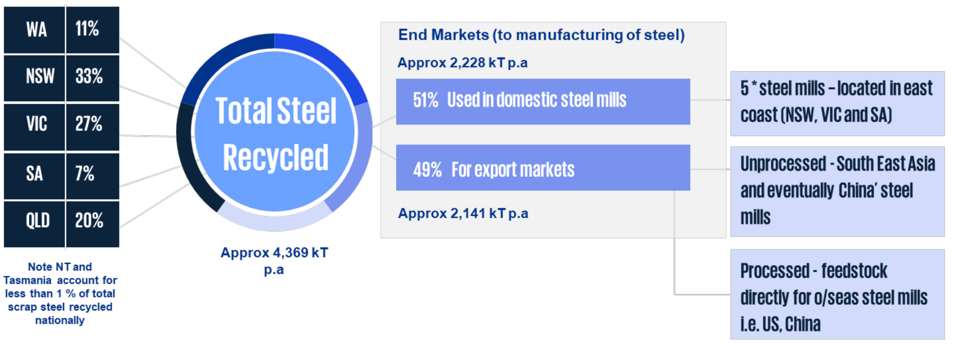


Figure 24: High Level Summary of Australia's Current Scrap Steel Metal Supply Chain using figures from National Waste Report 2022
** 5 steel mills as of 2023, will be reduced to 4 from January 2024 – see below for further information.*

Understanding the Supply Chain

To recycle scrap steel, some level of processing is required:

- For scrap steel from O&G assets, at a minimum, steel would need to be cut or densified sufficiently to enable efficient packaging in a cargo container to be shipped or to transport on public roads to a recycling facility. This cutting and densifying can happen at the point of generation (i.e. the port for O&G equipment), or at a consolidation point for other items such as cars (i.e. the recycling facility).
- Recycled scrap steel will ultimately be used as feedstock in steel manufacturing and will either be exported and used in overseas or domestic steel mills:
  - Some items, such as cars will have mixed materials such as plastics or textiles that need to be removed, before it can be used in a steel mill. Where this happens overseas, the scrap steel will be exported as 'unprocessed scrap'. O&G scrap steel will be sufficiently clean that this extra level of 'cleaning' is unlikely to be required.
  - In the case where scrap steel is exported as furnace ready for steel manufacturing, the scrap steel will have undergone enough recycling to be of sufficient quality to enter a furnace, typically through shredding, shearing, and use of magnets to separate.
  - In the case where recycled scrap steel is used in domestic steel mills for manufacturing of steel, it is recycled ready for the mill requirements. Industry noted that in 2023, approximately 6,000 kT of steel product is manufactured per annum, using around 2,228 kT per annum of scrap steel as feedstock across five key locations: Port Kembla NSW (BlueScope), Rooty Hill NSW, Laverton VIC (InfraBuild) and Whyalla SA (Liberty Primary) Waratah (Molycop). Molycop is due to close by end of 2023. Molycop is the smallest of the mills with an annual production of ~250kT, all based on scrap steel feedstock. When it shuts down, an additional 250kT of scrap steel will be available to the other steel mills if transport distances make feasible.
  - Whether recycled scrap steel is exported or used in domestic steel mills is dependent on a range of factors such as price, mill capacities and stockpiling ability. These are discussed in more detail on the next page.

Current State and Key Drivers of Domestic Steel Recycling Sector

Within the context of the current supply chain, there are several factors at play that will influence how scrap steel from O&G assets is recycled and where it goes. These are discussed below.

- **Some level of cutting and densifying of steel has to happen at the port:** Scrap steel from O&G assets will be relatively clean (i.e. large steel frames), however it will need to be cut and densified at the port, before it can be transported and put on to a cargo container for export, be transported to a local recycling facility for further processing (if required), or directly transported to a steel mill for steel manufacturing.

10 National Waste Report 2022, Blue Environment

- **There is sufficient domestic scrap metal recycling capacity.** If additional capacity is needed, stakeholders noted that this can be accommodated for with additional shift crews and/or overtime. New equipment may need to be invested in if shredding capabilities need to be improved, or if major increase in capacity is needed.
- **Exports of recycled steel scrap is a key enabler of a thriving domestic metal recycling sector.** The majority of global steel manufacturing happens in China. Australia's steel manufacturing represents only 0.3% of total global steel production.

  The domestic steel manufacturing Industry has indicated that they would prefer to domestically source recycled steel scrap as it is cheaper than importing. The Australian steel Industry is incentivised and has prioritised use of recycled scrap steel as it is one of the enablers in its decarbonisation pathway and supports the drive towards 'green steel'. It is estimated that a further 2.5 million tonnes of recycled scrap steel will be required annually (provided the mill infrastructure could accept more scrap) in the next 3-10 years[11] for manufacturing of renewables infrastructure[12] however there are a number of factors that inhibit immediate increased uptake, some specifically relating to scrap steel from O&G:

  - **The market value of recycled scrap steel is sensitive to global metal prices.** The cost of recycled scrap steel fluctuates based on a global market. There is more demand for recycled scrap steel from overseas and Australia's recycled scrap steel is understood to be of high value, therefore demanding higher unit values ($/tonne) from overseas than local mills can afford. Local mills face high labour and energy costs compared to Asia.
  - **There are limits on how much recycled scrap steel Australian steel mills can currently accept.** Some of Australia's steel mills are already at capacity for the amount of recycled scrap steel they can accept. To accept more, significant capital investment to upgrade equipment (for example, to change all furnaces to electric arc) and technological breakthroughs are needed. As recycled scrap steel competes on a global market, unless the scrap steel recycling sector is subsidised, they will often find better value and more demand for their commodity overseas.
  - **There are proposed 'green steel' facilities in WA and QLD, however consultation with Industry has indicated that O&G scrap steel use will be limited as feedstock.** O&G scrap steel is considered 'heavy melting scrap', and due to their thickness takes longer to melt in furnaces. Therefore, there is a limit on the percentage of heavy melting scrap that can be used. The emerging green steel facilities will be small to meet the demands of the regional areas they are located in, and limited in how much heavy melting scrap they can use. There is also much uncertainty as to the future viability of these, especially considering the high capital costs and operating costs (labour, electricity) in Australia.
  - **The seasonal profile of demand may create storage challenges and limit how much recycled scrap steel can be domestically used.** Seasonal profiles will be a feature of the scrap steel from O&G decommissioning. Steel manufacturers are limited in how much recycled scrap steel they can use per month and this cannot be ramped up to absorb what is available. Some stockpiling on manufacturing sites does occur, however this is difficult to manage and expensive. Regulators enforce strict controls and approvals for recycled scrap metal storage, to manage various occupational hazard and safety (OHS) and dust pollution risks. One manufacturer indicated that their efforts to increase storage capacity of recycled scrap metal on their site will take at least 12 months. Scrap metal recyclers indicated that they do not stockpile material and operate a first in first out model, exporting excess recycled scrap if domestic markets cannot absorb it in time, to minimise any holding costs and optimise their business operations.

Transport needs to be minimised. One mill noted that it sources

70%

of its recycled scrap steel from within

200 km

of its site

- **Transport from the port must be minimised if feeding domestic steel mills, otherwise exporting is the most financially viable option.**
  - Metal is heavy and difficult to transport especially in Australia where there are vast distances between cities, according to Industry most is moved relatively short distances by road (truck). After cutting the metal at the port so it can legally be transported on road, the transport itself must be minimised to keep costs down.
  - Whether or not shredded steel would need to be transported to a recycling facility for 'further processing' prior to export or feeding domestic mills, will depend on the space available for adequate shearing, cutting machinery at the port and the level of cleaning and processing required for the mill. It may be that the shredding done at the port is sufficient to feed mills directly. Scrap metal recyclers noted that there is no long-term business case to build a new long-term facility near a port, particularly if the port is in regional Victoria, as it will not be viable to receive other feedstock at that location, after decommissioning activities are finished.
  - The majority of domestic steel mills are located in the South East. One mill noted that 70% of its recycled scrap feedstock is sourced from only within 200 kilometres, while one major metal recycler noted that almost all of the steel it recycles on the west coast, it exports as it is not financially feasible to transport this steel to the east coast mills. This highlights that if the steel mill, or the metal recycling facility is not located within relatively short distance of the port, it is more likely to be economically viable to export metal.

11 Australian Steel Industry, Interview 2023
12 Submission to the Roadmap to establish an Australian decommissioning Industry – Issues paper, Australian Steel Institute, 2023

Concrete

Concrete recycling occurs in the Construction and Demolition (C&D) recycling sector which is a reasonably mature sector in Australia. Concrete is just one of many materials that C&D material recycling facilities accept, often along with other inert materials such as timber, aggregate and asphalt. According to the 2022 Australian National Waste Report, the annual recycling rate for C&D materials was 80%[13]. Exporting concrete would be infeasible due to the bulky nature of the materials and sufficient local opportunities to use recycled content. The total average concrete generation from O&G assets every five years is 190kT. This represents a fraction of Australia's total annual C&D (concrete, bricks and pavers) recycling of 10,500kT per annum or 52,500 kT across five years.

There are well established markets in Australia for recycled concrete. Recycled concrete aggregate, which can be comprised of recycled concrete and other C&D materials such as brick and masonry, are useful in the construction of hardstand areas and road bases due to the composition drying down to a harder, more stable and durable surface than virgin aggregate.

While Australia does not have a national C&D material recycling target, some states and territories have set C&D specific recycling or recovery rate targets such as:

- NSW Government: 80% C&D recycling rate by 2022[14]
- WA Government: 80% C&D recovery rate by 2030[15]
- Queensland Government: C&D recycling rate of 75% by 2025, and 80% by 2030[16]
- SA Government: 90% C&D landfill diversion by 2023[17]

To support achieving these targets, governments have increasingly promoted the use of recycled concrete (and other C&D materials) in construction activities. For example, the Victorian Government's Recycled First Policy, established in 2020, mandates major transport and infrastructure project bidders to exhibit how they plan to maximise the use of recycled or reused Victorian material in their proposed projects[18]. Innovative recycling concrete recycling solutions are already being identified in the market.

Ausdecom is an Australian company offering demolition, decommissioning, waste management, environmental remediation, and recycling services. They recover 500,000 tonnes of C&D waste per year at their Laverton North facility, transforming 99.5% of received material into either uniformly crushed concrete or a cement treated product compliant to meet Department of Transport requirements in Victoria, which is used on government projects. Once the mixed C&D is sorted, the materials are processed through a multi-stage process. Steel rebar is removed from concrete and the sent to a local steel mill, while the concrete and rock is crushed, to make road base aggregate used in building road and building foundations. They also operate mobile modular crushing plants and have the capacity to process over 500 tonnes of material per hour.

There is a well established and accessible C&D recycling sector in Australia. Landfill levies which are a tax per tonne of material sent to landfill, does go some way to deter heavy material such as concrete from going to landfill, although it does not always fully make recycling break even. If recycling facilities are located far away, transportation costs can drive landfill to be the most affordable option.

A case study to compare different disposal options for 2kt of concrete generated in metropolitan Melbourne found that landfilling waste within close proximity is still more economically viable than recycling[19]. In this case study, landfilling locally was 76.6 per cent cheaper than recycling. The case study highlights that:

- **Higher landfill levies** are a strong disincentive to encourage recycling. The above case study was completed in 2020, when Victoria's levies were the lowest of all mainland states. Since then, Victoria's levies have doubled, the driver being to make recycling more economically viable.
- **Increasing the market value of recycled concrete** together with higher landfill levies, will continue to drive the economics for developing more recycling facilities. A key lever is within government's control. As a large purchaser of construction materials for large infrastructure project, government can demand greater recycled content as part of its procurement process.
- **Transportation costs are an instrumental factor in selecting the method to manage concrete**. If transport costs are too high, it can diminish other benefits such as lower landfill levy rates and encourage recycling if closer recycling options exist.

13 National Waste Report 2022, Blue Environment
14 Waste and Recycling 2021, NSW EPA
15 Construction and demolition management in Australia: A mini review, Xianbo Zhao, Ronald Webber, Pushpitha Kalutara, Wesley Browne and Josua Pienaar
16 Waste Management and Resource Recovery Strategy, Queensland Government
17 Circular Economy Resource Recovery Report 2020-21, Green Industries SA
18 Recycled First Policy, Victoria's Big Build EcologiQ
19 Construction and Demolition Waste Management in Australia, SBEnrc

Plastics

The plastic recycling sector is diverse and complex. There are a variety of components that must be taken into consideration such as collection and sorting, recycling facilities, plastic types, transport logistics and end markets. In 2020-21, the recovery rate for plastic was 13%, with 35% of recycled plastic exported[20]. HDPE is the predominant type of plastic used in O&G infrastructure, with common applications being construction, pipes and fittings. The recycling rate for HDPE is 17.9%[20,] and it is one of the most exported plastics in Australia with trading prices at an all time high over the past decade.

In July 2021, Australia implemented a ban on the export of unprocessed mixed polymer scrap plastics. In addition to this, Australian Harmonised Export Commodity Classification (AHECC) codes were updated to enable recycled plastics, which have been processed into clean pellets or flakes, to be exported under the same code as virgin plastics.

Stakeholders noted that, plastics which form a small proportion of total materials, are the most difficult material to recycle and find suitable end markets for. More details on the regulatory challenges are noted in the Regulatory Context Section.

With the plastics export ban, there is a need to grow Australia's plastics recycling and remanufacturing capacity to increase Australia's domestic ability to pelletise and flake clean streams of plastics at a minimum. The federal government has already committed funding of over $60 million nationally towards plastics recovery through the Recycling Modernisation Fund (RMF).

Marine Growth

Marine growth refers to the accumulation of living organisms and organic material on submerged surfaces in marine environments. There are several ways that marine growth can be removed from structures at the port, including through the use of high-pressure water jets, mechanical scraping or brushing or chemical treatments. The choice of method will depend on the type and extent of marine growth and the configuration of the structure. Marine growth can either be composted or spread directly on land if uncontaminated, or if contaminated must be disposed of in landfill.

The main challenge with respect to marine growth is managing odour concerns at the port, impacting proximity to community, ensuring that there are no invasive marine species present on the structures which could pose a biosecurity risk for the coastal environment, and identifying if the removed marine growth is considered hazardous. The high-pressure jets used to remove the marine growth, can also remove contaminants. For example chemical cleaning agents and corrosion coatings on the surface of structures may also be removed with the growth. This contamination would mean that the marine growth would need to be disposed of to landfill and handled as other hazardous wastes are. If classified as a hazardous waste, transportation will be subject to regulatory requirements, which differ in each state.

The presence of invasive marine species (IMS) is typically managed with marine surveys of the structures prior to decommissioning and potentially pre-emptive cleaning. It is noted that there are several mitigating factors which reduce the likelihood of this being a risk for individual structures, including that the marine environment at the Offshore structures (deeper, colder water) is typically different from the sensitive coastal environments and species may not survive if introduced, and it is more likely that the IMS may already be present from being introduced from vessels coming from the ports.

Naturally Occurring Radioactive Materials (NORMs)

NORMs are naturally existing radioactive elements and their isotopes. NORMs can be found present in the material bought ashore through a range of means including accumulation in pipelines, storage tanks, production equipment and drilling equipment. NORM sources and radiation levels will need to be assessed during the decommissioning process. There are stringent requirements around handling NORMs, set by jurisdictional regulators that manage radiation safety regulations.

Equipment with NORMs that are brought Onshore are likely to be decontaminated to the extent possible, stored, and aggregated. There are limited options for the treatment of NORMS with permeant storage currently the only viable 'disposal' option. In Australia, typically there is an aggregation point on site for NORMs before they are transferred for final disposal. Options include:

- Disposal at the Mt Walton East IWDF which operates on a campaign basis and only accepts wastes generated in WA. This facility is located 475 kilometres northeast of Perth and is managed by the WA Department of Finance.
- Disposal at Tellus Holdings disposal site at Sandy ridge, 240 km northwest of Kalgoorlie-Boulder, which can accept waste from anywhere in the country. This facility has been in operation since 2021.
- Exported for disposal to an international facility. International transport of radioactive waste is heavily regulated, hence would be higher risk and cost prohibitive.

20 Australian Plastics Flows and Fates Study 2020-21 – National Report, Blue Environment

Key Takeaways

In summary, the key insights are:

Demand versus supply:

- There will be ample recycling capacity in SEA to handle the materials generated by the O&G decommissioning activity, with enough capacity in Victoria alone currently.
- In NT, demand volumes are relatively small and driven by pipeline assets. The recycling capacity in NT is insufficient but cut pipelines material streams are predominantly easier to transport creating more flexibility on port selection. It is likely that there is sufficient recycling capacity in WA to receive these volumes.
- There is sufficient recycling capacity in NT to manage volumes if pipelines remain in-situ.

Transport costs:

- The economics of recycling material is strongly linked to reducing transport costs. This is critical for steel and concrete in particular as they are heavy items to transport. The location of the port and recycling facilities will be critical in optimising and maximising the value from recycled material.
- Whether or not shredded steel would need to be transported to a recycling facility for 'further processing' prior to export or feeding domestic mills, will depend on the space available for adequate shearing, cutting machinery at the port and the level of cleaning and processing required for the mill. It may be that the shredding done at the port is sufficient to feed mills directly. Otherwise, export will likely be more economically viable than transporting to a recycling facility for further processing if the facility is not located within local proximity to the port.

Export markets enable a thriving domestic scrap metal recycling sector and are necessary to find viable end markets for plastics:

- A significant portion of steel and plastic is exported to South East Asia primarily because a higher value per tonne can be offered, as there is stronger demand and manufacturing of finished goods and products overseas.
- Plastics form a small quantity of total O&G decommissioned material but is the most difficult to recycle and lack viable end markets. Australia does not have a large plastics manufacturing sector, as majority of goods are made in Asia. There are some end markets for plastics, but export ban and hazardous waste export restrictions are barriers to O&G plastic assets being easily recycled.
- Requiring recycled material to be used domestically for manufacturing may not be economically feasible, particularly given the overall relatively small quantities that will be generated.

Concrete recycling is well established in Australia, but more can be done to drive demand

- Recycling infrastructure, energy and transport costs play a big role in determining the economic viability of recycling concrete versus landfilling. To increase the revenue from recycled concrete, government can use its purchasing power to increase its procurement or requirement for recycled concrete to be used in its state and federal infrastructure projects. This is a key end market for recycled concrete.

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Marine Growth and NORMS have limitations on how they are managed

- There is existing infrastructure and capability in the market to appropriately treat, handle and dispose of these materials as they are generated.

Workforce Readiness

Workforce Requirements Along the Decommissioning Value Chain

Specific phases of the Offshore decommissioning Value Chain have unique demand and supply narratives. The net extent of growth will depend on current workforce size, ease of skill transition, individual company investment decisions and advances in technology and automation. The analysis primarily focuses on crucial capabilities within the Value Chain that are enablers for a successful execution of Offshore decommissioning. These capabilities, if faced with capacity constraints, could significantly impact the ability to deliver these projects effectively.

The high level assessment of decommissioning workforce reveals a mixed landscape spanning workforce needs both Offshore and Onshore. Capabilities at the front end of the Offshore decommissioning Value Chain, such as engineering, environmental planning and wells expertise, tend to be more technical and specialised in nature, however, are consistent with existing construction, marine and O&G operations. Even though increased demand is expected as the decommissioning Industry grows, stakeholders expect these capabilities to readily transition from existing operations.

Onshore workforce demand for dismantling, material management and material recycling, is expected to increase as the Offshore decommissioning Industry grows, but due to the seasonal demand profiles, stakeholders are aiming for flexibility, to leverage the current workforce and to use Offshore decommissioning activity to even out peaks and troughs in demand.

Some targeted skills development is expected for unique characteristics that play out for Onshore activity of Offshore infrastructure, such as dismantling at a port location, decontamination of large infrastructure and recycling of unique assets like umbilicals, consisting of various metals and polymers.

Australia is well positioned with the right capabilities to service Offshore decommissioning, however, it is acknowledged that there is a lack of practical involvement in-field. Stakeholder sentiment was clear that workforce was not considered to be a key issue, however, as decommissioning execution unfolds, transition and the upscaling of current capabilities to the Offshore decommissioning Value Chain will need to be proven.

An important overlay to all capabilities across the decommissioning Value Chain, is the increase in competition for all skill sets in the general jobs market, with large renewable and mining infrastructure projects forecast over the coming decades and a existing tight labour market. This overlay drives the need for proactive measures to attract and retain the workforce and to sustain development of these capabilities for future decommissioning.

The critical Value Chain capabilities for both Offshore and Onshore activities identified are detailed over the page with accompanying exploration of unique characterisation and influencing considerations.

Australia's Strategic Capability Considerations

Australia's engineering and technical services sector is a global leader, underpinned by abundant natural resources, advanced technological capabilities, and a skilled workforce. Australia's abundant resources have driven the growth of the resources sector and the accompanying engineering and technical workforce that services this sector. The engineering workforce in Australia is highly skilled and adaptable, with expertise in areas such as civil, mechanical, electrical, and chemical engineering. This has enabled the country to undertake complex infrastructure projects and provide specialised engineering services globally.

In large-scale heavy industries such as boat building and manufacturing steel products, Australia faces limitations. The country's geographical isolation poses logistical challenges for exporting large vessels, making it less competitive compared to more connected regions. The high costs of operating in Australia, along with regulatory requirements, create difficulty for domestic boat builders to compete with lower-cost manufacturing hubs.

Plastics and umbilical recycling represents significant challenges in Australia. Addressing plastic recycling demands specialised infrastructure and resources, making it resource-intensive. Umbilical recycling, mainly used in the Offshore O&G Industry, presents another challenge, as complex structures comprise of various materials including metals and polymers.

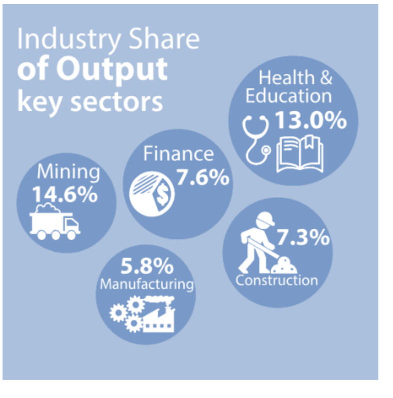

Figure 25: Industry Share of Output Key Sectors

	Offshore Activities			
	Planning	Offshore Operations	Well Servicing	Vessel Operations
Key Skills	Engineering design and construction Environmental specialists Project Management	Maintenance and construction trades Technical specialists	Operational and technical well specialists	Maritime and vessel contractors
Skill Characterisation	▪ Technical and specialist ▪ Onshore office based ▪ Operators' internal management across all phases	▪ Trade and technical specialists ▪ Offshore based rotational roster work ▪ Certified for Offshore ▪ Male dominated	▪ Operational and technical specialists ▪ Offshore based rotational roster work ▪ Certified for Offshore ▪ Male dominated	▪ Trades and technical specialist ▪ Offshore based rotational roster work ▪ Certified for Offshore ▪ Male dominated ▪ International workforce ▪ Seasonal profile
Directional Growth	▪ 150+ workers per fixed asset ▪ Needs consistent with existing scenario and easily transferable	▪ Cleaning and isolation: 30-50 per fixed asset ▪ Topsides preparation: 30-50 per avg fixed asset operation	▪ Plug and Abandonment (P&A) requires 20-30 workers per fixed asset ▪ Needs international vessel and capability	Moderate growth expected; limited opportunity for accelerating multiple programs at once Local demand linked to smaller vessels
Australian Overlay	▪ Highly skilled engineering and technical background ▪ Strong educational backing ▪ R&D capacities ▪ Innovative culture	Existing workforce familiar with assets	Long history with O&G assets which can be transitioned easily	Australia's expertise centred on smaller vessels; International capabilities to accompany international vessels Competition with Offshore wind Industry
Potential Shortfall	▪ Can readily transition to decommissioning activities ▪ Increased competition with other large infrastructure projects	▪ Can readily transition to decommissioning activities ▪ Seasonal variation in jobs may affect availability of workforce	Can readily transition to decommissioning activities	Requires attention to attract international and local capabilities

Table 6: Offshore Australian Capability and Gap Assessment

	Onshore Activities		
	Dismantling	Hazardous Waste handling	End-of-Life Operations
Key Skills	Machine operators / labour	Hazardous waste specialists	Labour Recycling facility operators
Skill Characterisation	• Ports: limited additional workforce • Dismantling: Temporary due to seasonal profile • Regionally based • Labour workforce • Male dominated	Specialists	Drip feed into recycling and disposal due to seasonal demand profile
Directional Growth	20-50 additional workforce per dismantling operation for parts of the year	Minor additional workforce needs given relatively small volumes	Limited additional needs Minor growth expected with seasonal increase Plastics and umbilicals need specialised resources, although volumes expected to be small
Australian Overlay	Seasonal demand; Opportunity to leverage dismantling workforce in amongst other sector demand to level profile Capability not specialised	Proven capability Unproven upscaling requirements for Offshore infrastructure	Has sufficient steel and concrete recycling capacity Plastic recycling is a key priority for Australia near term
Potential Shortfall	No major concerns Increased competition with other large infrastructure projects	Potential workforce gap	No major concern Strengthening plastic and recycling capability is the focus

Table 7: Onshore Australian Capability and Gap Assessment

Other Challenges to Value Chain and Workforce Development

The decommissioning sector in Australia faces increasing competition from other industries, primarily due to a tight labour market and high demand for skilled workers. Specifically, the demand for skilled workers in remote areas is surging, with projections indicating a peak in 2027 (over 450% its current level).

There is heightened competition due to similar skill requirements between Offshore wind and O&G decommissioning sectors. The overlapping demand for resources and specialised knowledge is in areas such as engineering, safety protocols, and environmental compliance. Additionally, the mining, O&G sector offers competencies that intersect with decommissioning, including engineering design, project management, Health and Safety, and other technical wells experience. However, younger generations may be discouraged from pursuing careers in the oil Industry due to concerns about its environmental impact, the perception of a physically demanding job, cyclicality, lack of innovation and gender imbalances.

Additionally, housing challenges in regional areas near where Offshore O&G infrastructure is located pose a significant obstacle to building a stable decommissioning workforce. The regional housing shortage is a result of imbalances between demand and supply, limited infrastructure investment and geographical constraints. Vacancy rates in areas where O&G workers reside are low, making it difficult to accommodate a substantial workforce in these regions.

APPENDIX A
Workforce
Other Considerations

Appendix A contains additional workforce competition analysis including: competition from other sources, Offshore wind and other renewable energy, mining, workforce attraction barriers and housing in local regional catchments.

Key Takeaways

Our review has revealed:

The sentiment of stakeholders on the topic of Offshore decommissioning Value Chain workforce readiness was optimistic. The primary drivers for optimism include:

- Offshore capabilities being readily able to transition from existing construction, marine and O&G operations. However there will be a need to utilise specialised international workers for large vessel operations.
- Australia is well positioned with Onshore capabilities for dismantling and material recycling of the dominant material streams, steel and concrete; Seasonal demand profiles are driving Onshore capability stakeholders to aim for flexibility and to leverage existing workforces.

The optimism does not remove the need for proactive measures to ensure workforce readiness. Several identified pressures could impact the success of Offshore decommissioning projects:

- Some targeted skills development is expected for unique characteristics of Onshore dismantling and material recycling, such as dismantling at a port location, decontamination of large infrastructure and recycling of unique assets like umbilicals, consisting of various metals and polymers.
- While capabilities exist locally, there is a lack of practical involvement in the field to date. Capability transition and the upscaling of current skills and capabilities to the Offshore decommissioning Value Chain will need to be proven.
- Increase in competition for all skill sets in the general jobs market with large renewable and mining infrastructure projects forecast over the coming decades and a existing tight labour market.

This overlay drives the need for proactive measures to attract and retain the workforce within the middle of the Value Chain where Australian contractors lack practical involvement in the O&G decommissioning industries. Sustaining development of these capabilities will be critical future decommissioning success.

Regulatory Context

Key regulations and international conventions as listed in Figure 26 were critically reviewed as part of this Current State Report and along with consultations with key stakeholders across the Value Chain. There are different geographical layers to regulations applied to O&G decommissioning activities (i.e., international, commonwealth, and state regulations). Each regulation is unique and covers different Value Chain stages. Understanding coverage of each regulation in the Value Chain helps to unpack the existing regulatory gaps and potential environmental and transboundary risks.

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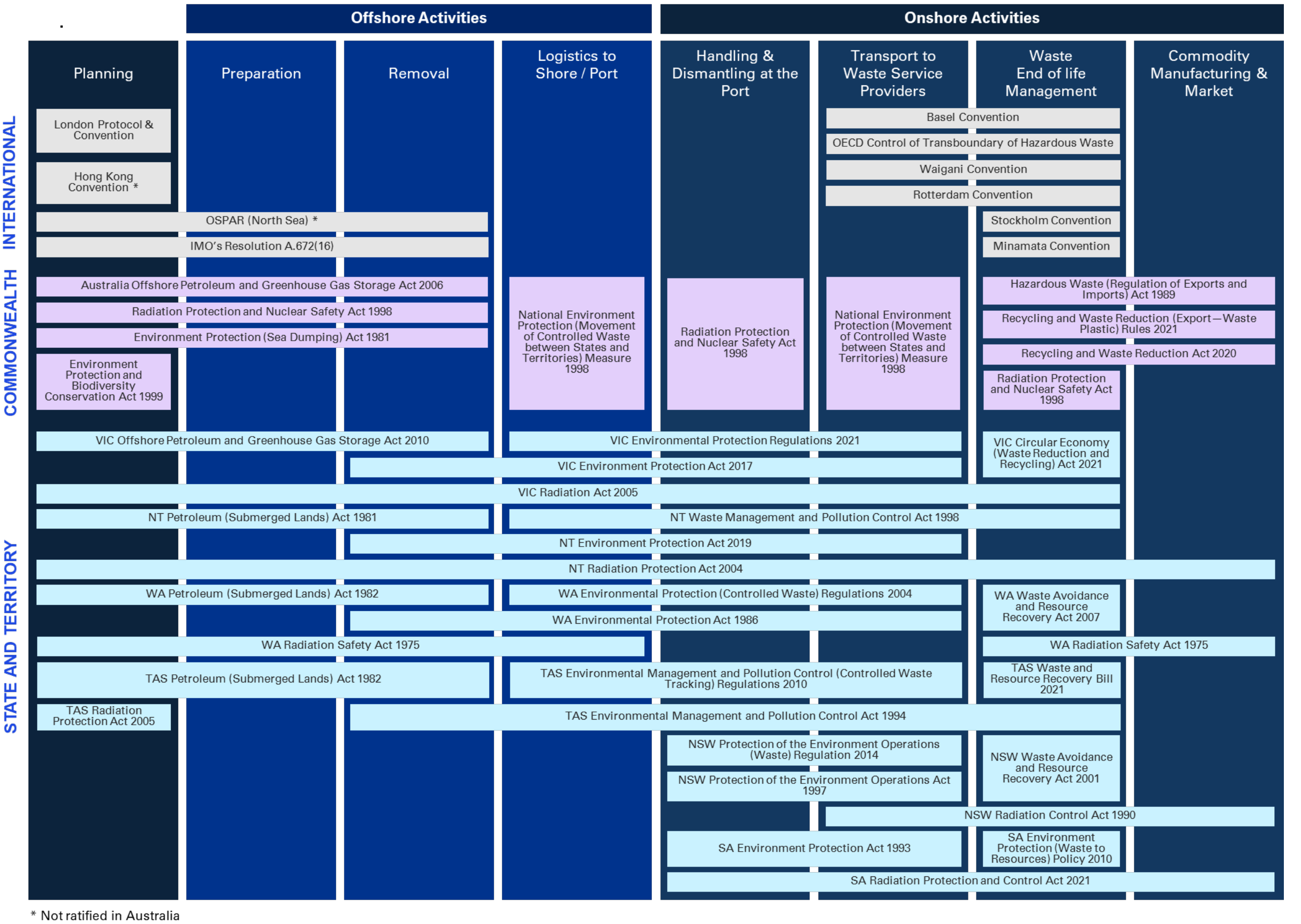


* Not ratified in Australia

Figure 26: International, Commonwealth, State and Territory O&G Decommissioning Legislation across the Value Chain

While the image above represents the legislations used in Australia and internationally, it is worth noting that the Hong Kong Convention and OSPAR are not ratified in Australia. They have been considered for the purpose of researching the relevant practises taken up globally.

Each state and territory has different scopes across the Value Chain. In general, there is consistency between states and territories around Offshore asset removal mandate, hazardous waste transport and management, recycling and circular economy, and radioactive material regulations. While many legislative elements have broad consistency, the number of legislations creates a layered and challenging landscape to navigate. Despite the degree of regulations and coverage across the Value Chain, the following regulatory constraints were identified and explored below through analysis and stakeholder engagement.

Key Regulatory Constraints

Legislation is not tailored to Decommissioning

The decommissioning Value Chain is a unique series of activities coming together, spanning across Commonwealth, State and Territory boundaries. In the current landscape, there is a patchwork quilt of regulations to navigate; Most elements of the decommissioning Value Chain are covered and touched upon however, the landscape provides expectations in the form of policies and guidelines, rather than tailored legislation. Some examples of how the current landscape is not tailored to the unique characteristics of the Australian decommissioning challenge are explored below.

Existing O&G infrastructure spans across Commonwealth and state waters. This is challenging when applying regulations and passing responsibilities from the Commonwealth to the State. The difference in requirements between Commonwealth and State waters and lack of a hierarchy of legislations, makes it difficult to plan the decommissioning activities through the Value Chain. One such example centres around decommissioning of Offshore pipelines that cross state boundaries and come Onshore; assets whose EPs are approved by NOPSEMA with no guidance provided to the interface with Onshore Pipeline removal regulations. There is also no mention of where the disposal will be taking place. This creates ambiguity in planning for the approvals required for the Onshore components of the assets.

The Value Chain is heavily reliant on some global specialised capability, seasonal profiles, and the drive for circular economy. The seasonal demand profile of Offshore decommissioning may likely lead to temporary and mobile facilities being set up at ports and the permits associated with temporary facilities is undefined. Considering the timelines ahead of the decommissioning campaigns, addressing this need is near term.

Recommendation

A tailored and holistic view to regulations addressing the unique characteristics of the Australian decommissioning challenge is required near term to provide an aligned and efficient landscape for the Value Chain stakeholders.

Lack of framework for removal and comparative assessments of in-situ options

The OPGGSA dictates complete removal of the property when not in use or connected to any operation. There is no prescribed framework for the removal of Offshore assets identified by asset type, weight, or condition like, for instance, the Oslo-Paris Convention (OSPAR) in the North Sea. However, Section 572 of the OPGGS on maintenance and removal of property policy allows for a deviation from removal requirements given the EP submitted to NOPSEMA demonstrates that a deviation delivers equal or better environmental outcomes compared to complete property removal. Through consultations it was observed that there is a perceived difference in the “equal or better” philosophy from traditional ALARP philosophy, giving rise to a higher standard.

This has a significant impact on the weights and types of assets to be removed as individual operators need to conduct individual scenario assessments and put forward the case for non-removal on a case-by-case basis. Allowing some assets to remain in-situ such as the concrete gravity-based structures and pipelines, could reduce the weights to be removed by 80%. Such uncertainty on volumes to come ashore is a barrier to better planning and investment in the downstream Value Chain and currently this debate creates significant uncertainty for dismantling and recycling organisations keen to pre invest ahead of the decommissioning wave.

Additionally, there exists a parallel regulatory approval process around the Sea Dumping regulation which prohibits disposal of material considered harmful to the marine environment including abandonment of platforms at sea and regulates placement of artificial reefs. There are several overlaps and duplication of efforts stemming from these processes.

Approvals from different regulatory bodies sit on the critical path of planning with a general timeline of about two years in securing all necessary approvals. Delays in obtaining approvals have cascading effects on having contractors, vessels, and sequencing further downstream activities.

Finally, the permissioning documents (the Environmental Plans) are focussed on the marine environment and do not extend to the terrestrial space (i.e., they do not cover the Onshore dismantling or disposal aspects). Additionally, if operators choose to request a deviation to the S572 requirements, the permissioning documents do not need to document other non-environmental factors such as inherent risks, personnel safety, or community impacts.

Uncertainty for permit requirements to enable temporary dismantling facility establishment at ports

Typically, dismantling of Onshore O&G equipment occurs at the O&G plant which are licensed major hazard facilities. In these cases, the authorisations and approvals required are less onerous to undertake dismantling activities, as the site is established for such activities to take place. However, Offshore O&G decommissioning services will require 'temporary' dismantling facilities and storage space at a port, temporary in nature due to the seasonal demand profile. This type of activity at scale, is a new concept for most Australian jurisdictional regulators and there is uncertainty from both regulators and Industry on how to approach managing the risks and obtaining necessary authorisations. To streamline processes, create clarify and confidence, there is a need for Collaboration between Industry and regulators to identify a solution that manages the risk appropriately, without being unnecessarily onerous.

Given the various parties involved in the dismantling process, there are various complexities associated with site, operation, and material ownership. Guidance on how the various regulations outlined in Figure 26 will be applied for O&G decommissioning will help navigate complexities and provide clarity to Industry on the process required to obtain necessary authorisations.

Key Waste Regulatory Considerations

Limitations and prohibitions on hazardous waste export

At an international level, Australia is signatory to the Basel Convention which puts prohibition on import and export of hazardous waste (wastes with specific contaminants listed in the Annex I of the convention). In Australia, imports or exports of hazardous waste can be permitted through the Hazardous Waste (Regulation of Exports and Imports) Act 1989 if operators can demonstrate that the hazardous waste is destined for recovery and reprocessing.

For non-hazardous wastes, Australia has in place several export bans for materials, including plastics. The primary purpose of the ban is to target domestic sources. From 1 July 2022, only plastics that have been sorted and processed (for example into flakes or pelletised) can be exported, once a waste plastic export licence is obtained.

Plastics that contain chemicals or additives that make them hazardous require a hazardous waste permit, prior to their export (as per the Hazardous Waste Act 1989). Stakeholders noted that there is some ambiguity and confusion as to the classification of some plastic wastes as hazardous that are generated through O&G decommissioning, and whether they are really 'hazardous'. These wastes have reliable end markets overseas, and the export ban and hazardous waste classification places a more onerous process on the disposal and recovery efforts of this material. One stakeholder noted that they were able to receive an exemption to the export ban, by demonstrating that O&G sector plastics were from industrial sources, less contaminated and that viable end markets only exist overseas.

Lack of transparency and reporting to drive recycling

Current permissioning documents do not require operators to report on performance (reuse, recycle, or dispose) to the regulator or public; this is inconsistent with peers (UK and Norway).

Due to the high percentage of metals, achieving a high recycling percentage such as 95% is comprehensible. Achieving incremental recycling percentages (98 / 99%) with coverage across the various material streams is significantly challenging.

Minimal focus on material hierarchy performance may not drive optimal circular economy outcomes to the detriment of the environment and eliminate opportunities for Australia to develop and export technologies to expedite or optimise material recovery.

Key Takeaways

At a high level, insights include:

The decommissioning Value Chain is a unique series of activities coming together, spanning Commonwealth, State and Territory boundaries. Areas where the current regulatory landscape is not tailored to the unique characteristics of the Australian decommissioning challenge include: assets spanning Offshore and Onshore jurisdictions, the seasonal demand profile for decommissioning infrastructure and services leading to temporary and mobile business models.

A tailored and holistic view to regulations addressing the unique characteristics of the Australian decommissioning challenge is required near term to provide an aligned and efficient landscape for the stakeholders. Onshore appears to be a secondary consideration from a regulatory standpoint compared with Offshore. One area stakeholders demonstrated concern was classification of plastic waste as hazardous and the need for permanent exemptions from export bans.

APPENDIX A Workforce – Other Considerations

Part 1

Workforce – Other Considerations

Competition from Other Sectors

Amid the current tight labour market, many industries are grappling with the challenge of attracting and retaining skilled workers. In particular, the decommissioning sector is facing significant competition from other sectors. As evidenced in the charts below, which utilise the Accessibility/Remoteness Index of Australia (ARIA), the labour demand in Australia's remote areas is experiencing a considerable surge. These projections indicate that the demand will peak in 2027, increasing to over 450% of its current level.

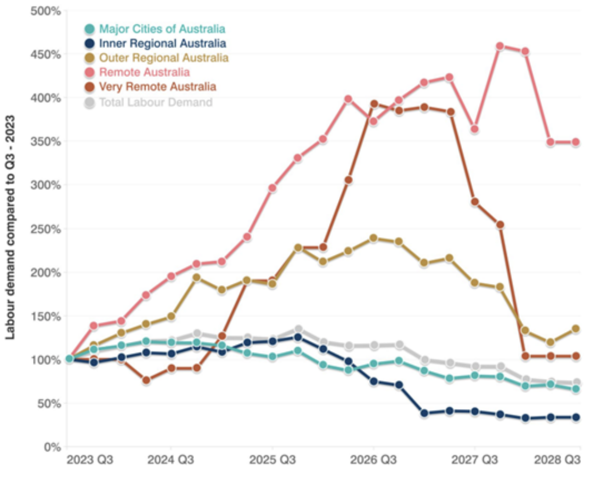


Figure 27: Labour Demand Australia

Source: Infrastructure Partnerships Australia, 2023

Figure 28: Dispersion of Remoteness in Australia

Source: ABS, 2023

Offshore Wind and Other Renewable Energy

Australia is increasingly recognising the immense potential of Offshore wind and other renewable energy sources to meet its growing energy demands while simultaneously reducing greenhouse gas emissions. The country has begun to establish a robust pipeline for Offshore wind and renewables, reflecting its commitment to transitioning towards a sustainable and clean energy future.

Both industries, Offshore wind farm construction and Offshore O&G decommissioning, share similarities in terms of skills and expertise required. Consequently, there could be an overlapping demand for vessel resources by both sectors.

Furthermore, both Offshore wind and Offshore decommissioning industries demand strong engineering and project management capabilities. Professionals in these fields must have the ability to plan and execute complex projects, assess structural integrity, and perform risk assessments. They must also possess knowledge of environmental considerations to ensure compliance with regulations and minimise any potential impact on marine ecosystems. Additionally the Offshore wind decommissioning market may be the next market for within Australia with an estimated decommissioning to start in 2050 (2030 installation date plus 20 year service life).

There are a range of skills required for the Offshore wind and other renewable energy sectors which overlaps with decommissioning such as

- Planning procurement and project management specialist
- Marine specialists
- Health and Safety specialists
- Port services
- Handling, welders, and metal workers
- Heavy lift vessel workers

Mining and O&G Sector

Australia is known for its established mineral resources, including iron ore, coal, gold, copper, and emerging commodities such as lithium. These resources remain in substantial demand globally, leading to investment opportunities within the mining sector.

Furthermore, within the domestic landscape, there exists a confluence of competencies that intersect with the field of decommissioning. These competencies encompass:

- Project Management: Proficiency in planning, execution, and comprehensive oversight of mining projects, spanning their inception to their successful completion.
- Health and Safety: Expertise in safety protocols, risk assessment, and the adept handling of emergency response procedures, ensuring the well-being of all stakeholders involved in mining activities.
- Trades and Technical Skills: This includes a broad array of roles, such as boiler makers, welders, electricians, heavy equipment operators, mechanics, and other specialised trades relevant to the mining Industry. These individuals contribute their specialised skills to ensure the smooth operation of mining activities.

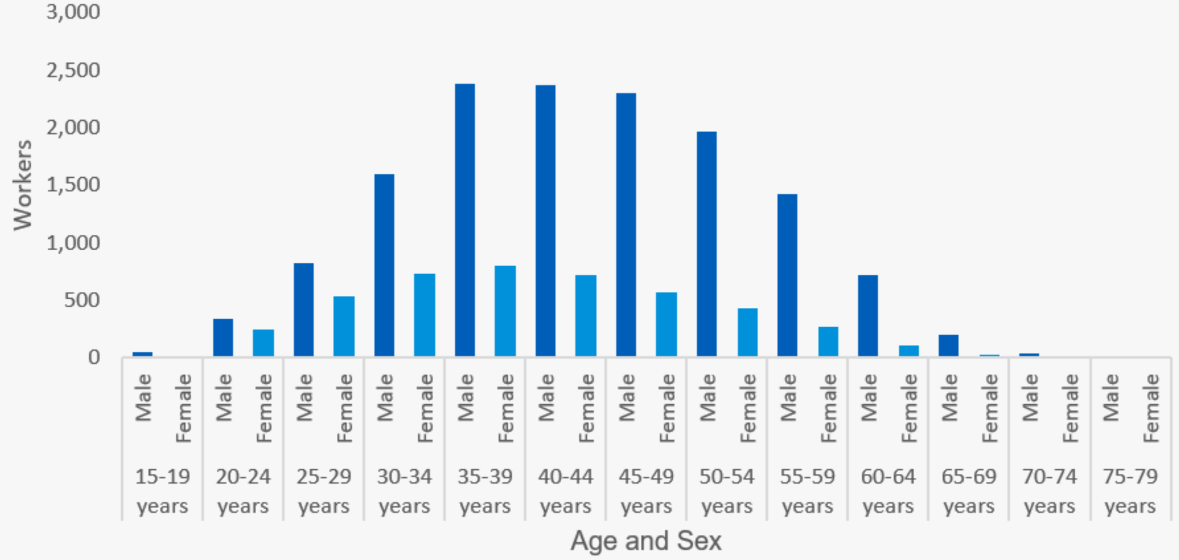
Workforce Attraction Barriers

There are several factors that may discourage younger generations from pursuing careers in the oil Industry. Firstly, a growing awareness and concern about the environmental repercussions if the oil sector have emerged. Younger generations tend to exhibit a heightened commitment to environmental sustainability. As a result, they are likely to be disinclined to engage in an Industry that is widely seen as a contributor to climate change, pollution, and the depletion of natural resources.

The oil Industry is often associated with a high degree of risk and physical demands. Offshore drilling, for example, can involve challenging working conditions and accidents. Younger individuals may seek employment in industries perceived to be less physically demanding.

The broader mining, O&G sector is often perceived as having a cyclical nature, with periods of boom and bust. This cyclicality can lead to job instability and uncertainty, especially during economic downturns when layoffs and job losses are common. Younger workers may prefer industries that offer more stability and long-term career prospects.

The sector is sometimes seen as lacking innovation and technological advancement. Younger individuals who are tech-savvy and interested in cutting-edge industries may be drawn to sectors that offer more opportunities for innovation, such as renewable energy or technology.



Source: ABS Census 2021

Figure 29: O&G Workers by Age and Sex

Furthermore, the perception of the sector can deter young people. The Industry's reputation for being male dominated may not align with the values and expectations of younger generations seeking inclusive and progressive work environments. As seen in Figure 29, workers in the O&G Industry and predominately men between 35 and 50, an older skew to other similar professions.

First Nations is another demographic that is often discussed in workforce development plans for the Mining, O&G sector. However, First Nations, people make up 600 of the 19,000 people with a similar demographic breakdown to the wider population.

Housing in Local Regional Catchments

The location of Offshore O&G infrastructure means that any local workforce catchment will be regional areas. Housing in regional areas is currently facing numerous challenges, making it increasingly difficult to meet the growing demand for affordable and quality accommodation. These issues stem from various factors that affect both supply and demand in regional housing markets.

One of the primary challenges is the lack of available housing stock in regional areas. The growth in population, fuelled by factors such as lifestyle choices, increased job opportunities, and decentralisation efforts, has not been matched by an equivalent increase in housing supply. This has led to a significant imbalance, with demand far outstripping the available housing options. Vacancy rates in areas where O&G workers often reside have declined to around 1% in Northern WA, 2% in Gippsland and 1.0% in Darwin.

Another factor contributing to the housing challenge in regional areas is the limited investment in infrastructure and development. Infrastructure projects such as improved roads, public transportation, healthcare facilities and educational institutions are essential for attracting people to regional areas. However, the lack of these amenities hinders population growth and investment in housing development.

Furthermore, regional areas often face geographical constraints that limit the expansion of housing. Natural features such as mountains, coastlines, or national parks impose restrictions on land availability and development, leading to higher land costs and limited construction options. This, in turn, drives up housing prices and reduces housing affordability.

The lack of housing in regional areas presents a significant challenge when it comes to developing a large permanent local decommissioning workforce in these regions. The limited availability of housing means that it would be difficult to accommodate a substantial number of workers who would be dedicated to the decommissioning activities in these areas. The housing shortage not only hampers the recruitment and retention of skilled professionals but also adds complexity to establishing a stable workforce within the regional catchment. Addressing the housing issue becomes crucial in order to overcome this challenge and create a sustainable and efficient decommissioning workforce in these regional areas.

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APPENDIX B
Stakeholder Insights

Part 1

Stakeholder Insights

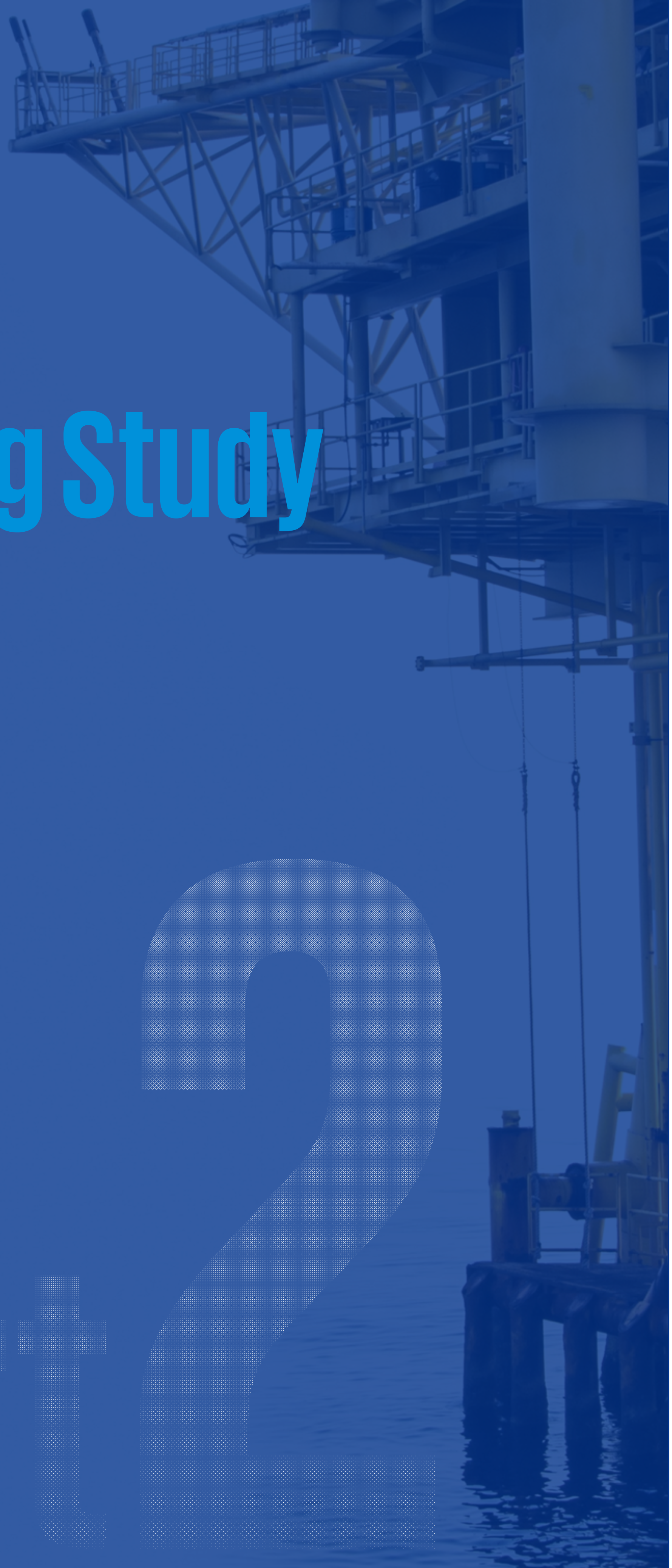
The primary focus, opportunities and challenges outlined by the various stakeholders as shown in Figure 30 is dependent on where the stakeholders activities lie along the Value Chain.

The Value Chain is complex and unique with many diverse capabilities and stakeholders. During consultation one dominant theme noted was the need for strong coordination near term to facilitate progress at pace and maximise Australia's value in this Industry.

	Offshore Activities				Onshore Activities			
	Planning	Preparation	Removal	Logistics to Shore / port	Handling and Dismantling at the port	Transport to Material service providers	End-of-Life Management	Commodity Manufacturing and Market
O&G Operators	• Uncertainty on removal expectations • Little flexibility with decommissioning timing preventing collaboration • Breaching antitrust legislation if collaborating for decommissioning campaigns • Regulatory overlap leading to inefficiency • No existing port infrastructure to accept larger vessels creating port uncertainty							
International Vessel Contractors		• Onerous regulatory safety case regime • Lengthy campaigns to make the mobilisation worthwhile						
Ports				• Competition with Offshore wind				
Dismantling Contractors					• Material volumes uncertainty and seasonal demand profile driving the need for flexible business model • Regulatory uncertainty on flexible and temporary facilities • No existing port infrastructure to accept larger vessels creating Port uncertainty • Competition for workforce in the general jobs market			
Material Recycling Contractors							• Uncertainty on material volumes • No existing port infrastructure to accept larger vessels creating Port uncertainty • Transport costs between Port and local material facilities • Limited business case to increase local steel and concrete recycling performance	

Figure 30: Stakeholder Distribution Along Value Chain and Key Areas of Concern

Scoping Study



Part 2

Content

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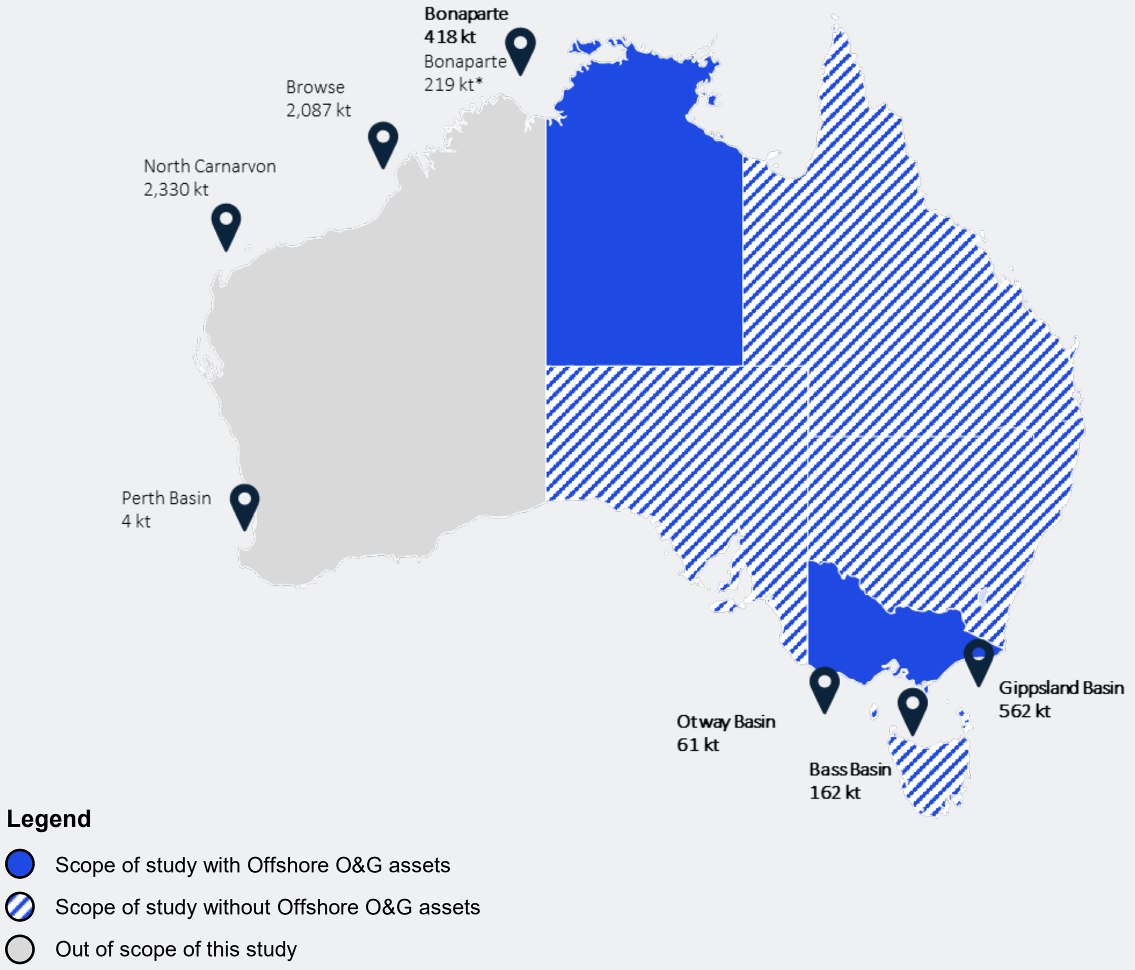
Executive Summary

This Part 2 - Scoping Study, was commissioned by the Department of Industry, Science and Resources (DISR) to examine the Offshore Oil and Gas (O&G) decommissioning supply chain in Australia across demand, material recycling, end-of-life management, ports, workforce and regulatory context. It delves into key facets of Australia's O&G decommissioning sector, examining critical considerations for optimal port location, increased domestic recycling, regulatory frameworks, workforce dynamics as well as DISR's role going forward.

The Offshore O&G assets considered in scope of this study are spread across the Bonaparte Basin off Northern Territory (NT) and the Bass, Gippsland, and Otway Basins in South East Australia (SEA) with anticipated decommissioning timings up until 2040. Assets in Western Australia are excluded from the scope of this Study.



*Additional kt in Bonaparte not included in this study

Part 1 - Current State Report

Australian Offshore O&G assets are maturing and reaching life end, resulting in Australia facing a wave of decommissioning activity in the coming decade. The complexity of the geography, ports positioning, regulatory environment, workforce capabilities and downstream infrastructure are challenges that need practical solutions to overcome.

Part 1 – Current State Report, looked at the infrastructure, services and workforce demand generated from decommissioning assets in SEA and NT and then overlaid this with the supply from existing facilities in the form of ports, material recycling and disposal as well as the Australian workforce. Understanding the demand and supply side allowed for a gap assessment, highlighting strategic challenges in meeting Australia's wave of decommissioning. In addition, Part 1 defined a regulatory matrix, identifying regulatory considerations and interactions across state, federal and relevant international jurisdictions.

Seven Key Questions

From Current State analysis, seven key questions emerged, forming the focal points of this Scoping Study, to deepen understanding and insight. This Study commenced with the review and assessment of these seven key questions.

These questions were examined for relevance, significance and ability to influence, resulting in a prioritised list to take forward for further investigation in the Scoping Study.

A deep dive into the prioritised questions marked with ticks in the table below, involved research, data analysis, and further stakeholder consultation to unearth nuanced insights. This methodology ensures that the Scoping Study investigates pertinent and influential issues and provides a comprehensive understanding to practical recommendations for the targeted enhancement of the O&G decommissioning sector.

	1	What is the anticipated quantity of material arriving Onshore?
	2	How might the availability of vessels influence costs for operators?
✓	3	Given current state port infrastructure constraints, which port will be selected for Offshore Decommissioning?
✓	4	How can we address the lack of recycling transparency and reporting to drive recycling initiatives?
✓	5	What strategies can be employed to boost demand for local steel and plastics manufacturing?
✓	6	In what ways can legislation be tailored to address unique challenges specific to Australian Decommissioning?
✓	7	While the workforce readiness sentiment of stakeholders is optimistic, can it be executed at the scale required?

Optimal Port Location

The analysis reveals that Offshore costs surpass domestic in-land costs, prompting a careful consideration of port location selection. Western Australian (WA) ports, despite their strategic significance, prove economically challenging for SEA and Northern Territory (NT) assets, with transport costs more than tripled compared to their closest port. The synergy of key metrics offers a comprehensive macro view for optimising the O&G decommissioning Value Chain's transport components. While distance remains a pivotal factor influencing both cost and carbon emission aspects, the efficiencies of Onshore and Offshore operations exhibit notable variations. Cost dynamics are chiefly Offshore-driven, stemming from the high day rates of vessels required for in-field operations and asset transfer to shore, with volatility introduced by weather and port congestion. Conversely, the Onshore component predominantly influences carbon emission considerations, given the small-batch nature of container and truck movements or ship export to South East Asia, for equivalent material tonnage. Ensuring the availability of the nearest recycling facility, particularly in ports like Port of Onslow and Whyalla, stands out as a key strategy to significantly reduce the carbon emission impact in Onshore transport.

Increased Domestic Recycling

The study highlights opportunities and challenges in domestic recycling of the three dominant materials recovered from decommissioned O&G assets: High-Density Polyethylene (HDPE), steel and concrete.

Exporting the recycled HDPE (rHDPE) is currently the most economical route due to the high international sale price. Incentivisation is required to create a domestic market demand for rHDPE and to drive a more competitive environment with fossil-based virgin HDPE. Educating manufacturers on the parity between recycled and virgin HDPE is also essential for market growth.

Additionally economic instruments could further help stimulate a rHDPE market in Australia. Domestic consumption is the most optimal from an emissions perspective due to the abated emissions from the unproduced fossil-based virgin plastic. There is adequate recycling capacity for the estimated demand from O&G decommissioning between now and 2040.

Onshore disposal of the material at a Victorian Port is most economical on a per tonne basis compared to a Tasmanian or a NT port, due to the proximity of recycling services to Victorian Ports. In the Tasmanian Port scenario, the material is required to be shipped to Victoria for recycling. In the NT, the material is transported by rail to WA for recycling.

Export provides higher potential profit on the sale of steel from all port locations considered and this has created a small market shortfall for scrap steel in Australia. In 2021, despite 2.2 million tonnes of scrap metal being exported, Australia imported 100,000 tonnes.

There are challenges associated with the domestic steel Industry however, the environmental benefits of domestic consumption of scrap steel are significantly higher than exports. This is due to less transport requirements, as well as the avoidance of importing scrap metal to supplement Australian steel manufacturing

For concrete, the current recycling rate is around 80%. There is opportunity to minimise the carbon emission intensity of the recycling process by encouraging port adjacent processing and use of recycled aggregate, as this minimises the transport emissions associated with the additional transport journeys. The higher the population density, the cheaper the disposal of concrete at recycling facilities due to the high demand for the aggregate.

The study underscores that incentivising local or domestic recycling is crucial for fostering sustainability and economic value within the country.

Regulatory Framework

The analysis reveals critical gaps in Australia's O&G decommissioning framework, providing insights for tailored improvements:

- *Tailoring Removal Framework:* Consultations and this study against best practice, identified that current regulatory permissioning documents are not an ideal fit for decommissioning activities and that no single regulatory authority held the end-to-end view of decommissioning activities. The regulatory body has advised that making amendments to the Environmental Plans (EP) to better tailor for decommissioning activities requires legislative change.
- *Licence for Temporary Facilities:* Stakeholders highlighted challenges in establishing dismantling facilities at ports, citing regulatory uncertainties and backlog. Consideration to developing guiding principles for applicants, fostering collaboration between regulators and Industry for smoother approvals and a streamlined process across states is recommended.
- *Plastic Waste Export:* Opportunities to optimise plastic waste export regulations are identified. Assessing the current export scenarios on O&G plastics and exploring streamlined processes with the broader government and Industry stakeholders for obtaining licenses and permits, is a consideration for efficiency in this landscape.
- *Higher-Order Recovery and Reporting:* Circular economy principles are key in Australia's transition journey and are highly relevant to O&G Industry too. A pan-agency collaboration to promote circular economy strategies, guiding Industry to prioritise higher-order recovery, material management and recycling performance in decommissioning planning is encouraged.

Workforce Dynamics

The size of the O&G sector's decommissioning workforce is expected reach 1000 strong and to fluctuate by as much as 800 workers between peak periods – this is due to timing of the end of Offshore assets' useful lives. The workforce requirement profile holds uncertainty and can be significantly impacted by asset decommissioning timing, removal approach and asset removal vs in-situ decisions. Noting this uncertainty, it is thought to be unlikely that a peak demand scenario will occur due to assets being decommissioned in parallel. This is because of the need to mobilise special vessel capability, of which there is limited global supply. It is most likely that one specialised vessel will mobilise at a time to the region for a campaign, driving the pace of decommissioning activity.

Roles such as engineering, environmental specialists, project management, vessel contractors, labour and construction workers are in demand in other competing industries such as Offshore wind, mining and renewable energy infrastructure build. Other key skills in demand for these sectors, such as electrical professionals, truck drivers and drillers / miners, are not deemed to have a large demand in O&G decommissioning.

More detailed workforce data is required for further accuracy and insight. This activity is best timed when decommissioning timelines and volumes are better understood, given the levels of uncertainty existing today. This includes a greater level of engagement with stakeholders across the Value Chain to survey data unavailable for this analysis, as well as to better understand workforce attraction barriers. With deeper insight on workforce needs and barriers, targeted strategies can be developed to boost female, First Nation and regional workforce involvement.

Moving Forward

It's acknowledged the important role CODA has played in recent years, promoting and advancing Australia's O&G decommissioning profile. CODA will continue to provide an important leadership role for O&G decommissioning success in Australia and together with Government, Regulatory, Industry and Community stakeholders, can continue to advance best practice learning, legislative and regulatory reform, drive efficiency, innovation and success along the Value Chain.

Promote Best Practices

Collaborative peer support and highlight Industry and regulatory best practice within the Australian context.

- Leaning on globally matured practises, the nuances of decommissioning activity could be incorporated into the regulatory landscape, driving efficiency and optimised cost and environmental outcomes.
- Partner globally with Government and Industry (e.g. UK) to accelerate Australian learnings and provide an Australian view.
- Creating guidance for material hierarchy performance reporting helps drive recycling and circular economy outcomes.

Achieve Efficiency

Optimised and streamlined regulatory and process practices tailored to Australian O&G decommissioning.

- Consideration to further supporting collaboration amongst Operators for "campaign" approaches to decommissioning helps to attract international vessels at a competitive price.
- Establishing streamlined regulatory and process practises helps bring an aligned perspective and achieve efficiencies for all stakeholders.
- Showcase on international platforms, how to navigate the perceived challenging regulatory landscape in Australia.

Drive Innovation

Opportunities to incentivise innovation to meet the demand locally.

- Bringing incentivisation measures to encourage local adoption of recycled steel and plastic to stimulate market growth.
- Enable investment and viability to secure smaller Onshore players to make their operations sustainable across the Value Chain.
- Developing connections in adjacent industries enables opportunities in reuse and shared infrastructure.

In summary, this study not only identifies challenges but also presents actionable considerations. A central role is needed in orchestrating a coordinated, standardised, and sustainable approach that ensures the longevity and success of Australia's O&G decommissioning sector. The collaborative efforts of government, Industry, regulators, and workforce development initiatives will be pivotal in achieving a resilient and environmentally responsible decommissioning landscape.

Port Location and Trade Offs along the Value Chain

Part 1 – Current State Report identified that given the lower volumes, seasonal demand profile and timing uncertainty of decommissioning activities across SEA and NT, there is unlikely to be the demand for new build decommissioning port infrastructure investment. It would be more economical to maximise the use of existing facilities, with likely investment needed for dismantling facilities, including impermeable laydown areas, berths and material management services. Consultations with dismantling service providers indicated that the equipment, skills, and global recycling avenues are not currently constrained. This coupled with the low volumes and seasonal demand are barriers to plan, invest and upskill in large new infrastructure and services and as such why this Study does not analyse the concept of a "Decommissioning Hub", but rather utilisation of existing infrastructure with modifications and flexibility.

Part 1 also identified that there is not a clear port of convenience to support Offshore decommissioning. Port selection is a significant driver in the cost, carbon emission and community impact across the Decommissioning Value Chain, below in Figure 1. This is because it becomes the nucleus for required Offshore and Onshore activities. An analysis was carried out against the eight ports identified in Part 1 to understand the cost and carbon emissions generated per tonne if that port was selected.

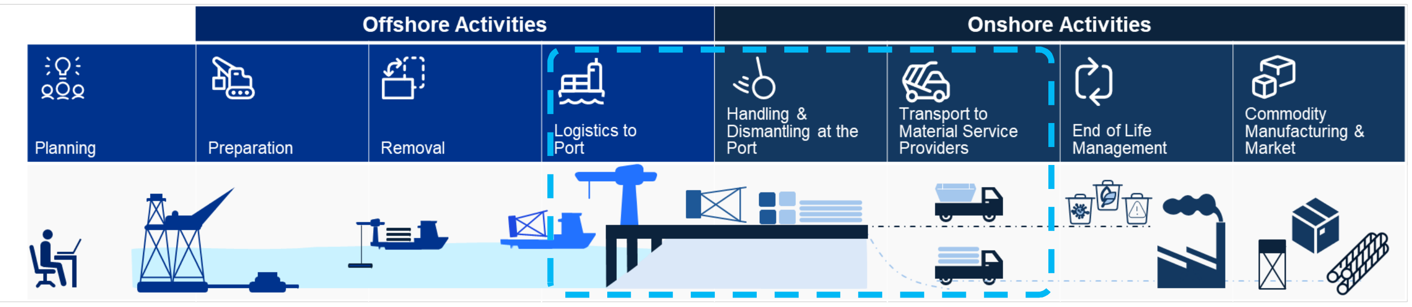


Figure 1: Components of the Value Chain under the Scope of Study

Identifying the most efficient port location, requires optimisation across the Value Chain including:

Cost

Which port would allow for the most optimal cost profile across sea and road transport to material management providers?

Carbon

Which port may result in the lowest carbon footprint of transport across the Value Chain?

Community

Assessed against community proximity to port (as per their assessment rating in Part 1)

Adjacent Industry Review

Adjacent industries can impact port use including channel, berth and workforce availability

Offshore Wind

Several ports under consideration have preliminary plans or expression of interest in developing terminals to support staging of offshore wind developments

Hydrogen hub developments

Ports identified have plans for hydrogen facilities including green hydrogen export terminals or production facilities

CCUS facilities

Carbon Capture, Utilisation and Storage (CCUS) facilities have been identified for the Bass and Bonaparte Basins with nearby ports expressing interest to support these activities

Refer Appendix A for further details

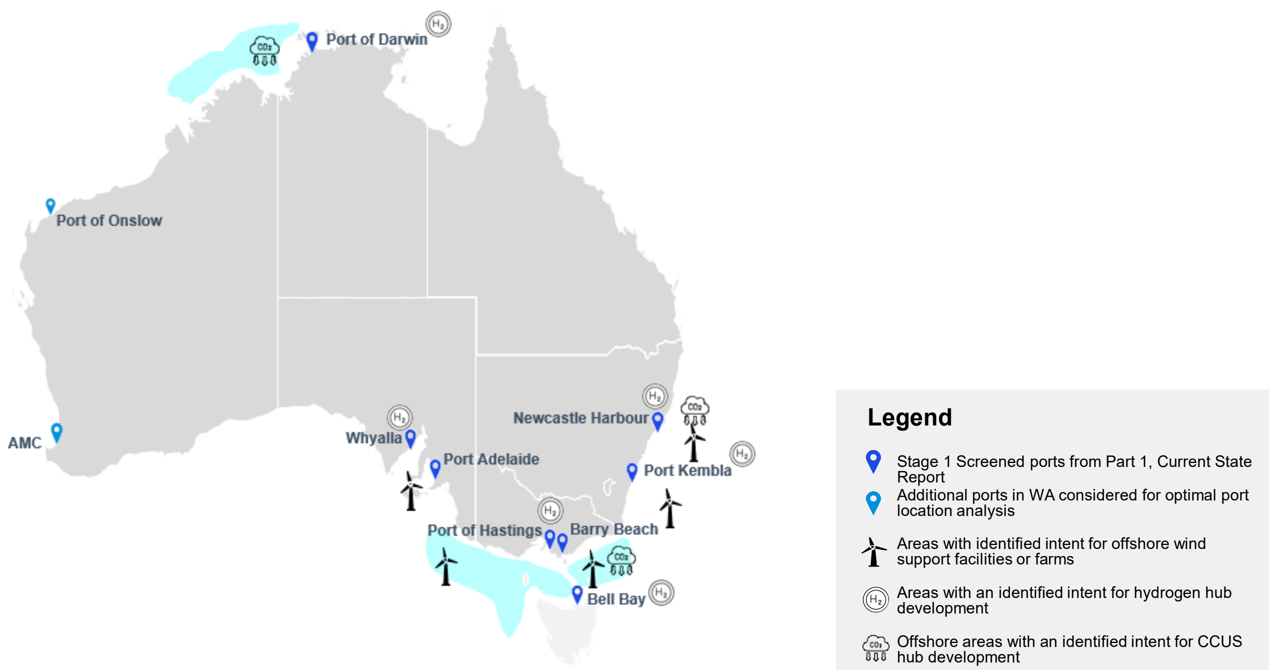


Figure 2: Ports, Basins and Adjacent Industries

Offshore Operations

The estimated Offshore platform removal cost is the primary driver of total costs across the Value Chain and can vary significantly, ranging from $5,300 through to $12,000 per tonne[1]. The variability of this number is due to the corporate, safety and risk decisions that will be made for platform, pipeline and subsea infrastructure removal.

This analysis is limited to the transport costs ($200 - $1,200 per tonne) of materials to ports, through to delivery to suitable material recycling facilities. It does not consider the cost impact of the Offshore in-field removal activities but is considered a proxy for understanding cost and carbon optimisation across the Value Chain, given the levels of uncertainty in removal costs per tonne.

Methodology

There are two components that drive the transport costs to ports. First is the type of removal operation utilised in-field as this determines the vessels used, their duration and corresponding day rates. This component is the single largest driver of cost across the Value Chain. The second component is the distance from the Basin to the port. Operators prefer to reduce this time to lower not just the cost, but also the duration of Offshore activities to reduce financial and personnel risks.

[1] UKCS Decommissioning Benchmarking Report 2023

Assumptions

The following assumptions have been applied to the analysis:

- Costs were determined for the removal of an average platform weight for Bass, Bonaparte, Gippsland and Otway Basins
- Offshore costs were considered for a piece-large scenario and associated vessels as shown below
- Distances to ports were considered from the centre of assets in each Basin and an average distance to Basins applied
- Removal lift capacities, vessel duration, vessel day rates and their speed of travel were considered from publicly available resources and from Kent Engineering databases

Average Platform Weight

Average of 3,600 tonnes (across both NT and SEA) considered as a representative basis of the type of assets to enable an analysis of typical transport costs.

- Emissions for Offshore travel are a factor of the vessel used, type of fuel and duration of sail. An Emission Factor (EF) of 73.3 kgCO2e/km was applied as derived from US Environmental Protection Authority (EPA) and public sources
- Additional ports of the Australian Marine Complex (AMC) and Port of Onslow in WA were considered for transporting the assets from SEA and NT respectively, to compare the costs, duration, emissions and the feasibility of using a decommissioning hub in WA

Piece – Large Transport

The platform is typically broken up into 5,000 T pieces[2] and requires shorter time in-field.

Heavy Lift Vessel (HLV)
Utilised to transfer the pieces either directly to ports or onto barges for transfer to port.

Tug + Barge
Used to transport to port where Heavy Lift Vessels (HLVs) cannot navigate the port channel.

Historically, piece-small removal techniques, which comprised of cutting up assets into 20tonne lifts, was largely adopted in early North Sea campaigns. But has since paved the way to piece-large operations because of reduced labour costs and less time needed Offshore, which reduces financial risks and increases personnel safety[3].

This study and stakeholder consultation has highlighted that the mode of removal choice is complex and is determined by asset type, region and weather conditions. This study considers a piece-large transport with transit time, distances and day rate of an HLV used.

Distance to Ports

Even though the transport to ports costs are significantly less than Offshore removal operation costs, distances still determine port selection as operators tend to reduce the time spent Offshore. This study looked at the average distances (as shown in Table 1) of transport to each port, their costs and carbon emissions impact.

Table 1: Average Distance to Ports

State	Port	Travel Distances (km)				
		Gippsland	Bass	Otway	Bonaparte	Average
VIC	Port of Hastings	370	185	259		271
VIC	Barry Beach	213	213	426		284
TAS	Bell Bay	333	185	435		318
NSW	Port Kembla	537	824	1083		815
SA	Port Adelaide	1241	963	685		963
NSW	Newcastle Harbour	713	1000	1259		991
SA	Whyalla	1546	1296	1056		1299
WA	AMC	3417	3102	2872		3130
NT	Port of Darwin				306	306
WA	Port of Onslow				1796	1796

[2] ABB Offshore Oil and Gas Decommissioning Report
[3] CODA Western Australia Decommissioning Hub Location Study

Results

Table 2 shows the costs and carbon emissions associated with transporting one tonne of platform to each port.

Table 2: Transport Costs Associated with Ports

State	Port	Average Distance (km)	Transit Time (Days)	Cost ($/tonne)	Carbon Emissions (kgCO2e / tonne)
SEA Region					
VIC	Port of Hastings	271	0.5	200	6
VIC	Barry Beach	284	0.5	200	6
TAS	Bell Bay	318	0.6	200	6
NSW	Port Kembla	815	1.5	450	20
SA	Port Adelaide	963	1.8	450	20
NSW	Newcastle Harbour	991	1.9	450	20
SA	Whyalla	1299	2.4	500	30
WA	AMC	3130	5.9	1200	65
NT Region					
NT	Port of Darwin	306	0.6	200	6
WA	Port of Onslow	1796	3.4	750	37

South East Australia

With the shortest average distance to the Basins, Port of Hastings, Barry Beach and Bell Bay are the most suitable. Transportation costs to Port Adelaide and Whyalla in South Australia (SA) and Port Kembla and Newcastle Harbour in New South Wales (NSW) are doubled compared to a Victorian port. The feasibility of utilising as decommissioning hub concept in WA for SEA assets is low as its deemed cost prohibitive.

Northern Territory

As identified within Part 1, the options for the NT are limited and the Port of Darwin is the most suitable option from a cost and carbon emission perspective. The costs and carbon impacts of shipment to WA would be tripled.

Additional Considerations

- Offshore activities will drive the total cost of the Value Chain. Whilst port selection is crucial, how the assets will be decommissioned Offshore will be the primary cost driver across the Value Chain. There is limited ability to model or assess the quantum of these figures as it varies based on the decisions made by the operator and decommissioning service provider to minimise risk.
- Transit time between the Basin and port can vary significantly due to primary factors as detailed below:
  - Transit delays – Can increase the cost significantly as there are penalties for vessels not coming off charter on time.
  - Weather – Can delay Offshore activities, reduce transit speed and limit the ability of vessels to enter harbour.
  - Port congestion – Delays at ports when alongside can occur (e.g. wharf) especially if it is a shared facility with other industries.
- Consolidation to a single decommissioning facility within WA is not a cost or carbon effective solution for SEA or NT assets. The increased distance would also introduce the complexity of the Value Chain, requiring additional vessels to facilitate Offshore activities, increased risk for longer duration at sea and the potential for additional strengthening works to be conducted Offshore to enable transport.

Onshore Operations

Optimising across the Value Chain requires the identification of the distance and effort to transport materials to recycling providers. Part 1 identified that there is ample recycling capacity within the SEA region, but there is not enough capacity within NT to meet the demand generated. The total capacity of states was identified from 2020-21 data from the National Waste Report[4] and the specific recycling providers in these states were identified from the National Waste and Resource Recovery Infrastructure database[5].

To identify the transport cost and carbon impact of port selection, this analysis compares the transport distances to metals, concrete, plastics, marine growth and NORM recycling facilities. Within the Offshore analysis a typical platform was utilised to estimate the cost and carbon impacts, and this typical platform has been broken down into its typical material streams below to support the Onshore analysis.

Typical Platform Weight

Average of 3,600 tonnes

Utilised to analyse the typical types of wastes and their associated onshore transport $/tonne and (kgCO2e)/tonne.

Steel 1,647 tonnes	**Plastics** 36 tonnes	**Marine growth** 21 tonnes	**NORMs** <1 tonne
Concrete 1,861 tonnes	**Non-ferrous** 21 tonnes	**Hazardous** 14 tonne	

In the absence of information on individual recycling facility capacities, a high-level assessment was conducted using the sources noted above, to determine the number of recycling facilities needed to meet the demand generated, using the major states as a sample. Comparing this with the anticipated material volume from decommissioning activities, a 25% uplift factor was applied for a conservative estimate. Results suggest that, on average, 1.5 facilities (ranging from 0.5 to 3) could adequately handle the annual demand from O&G decommissioning as shown in Figure 3.

Noting the commercial nature of these facilities, it is unlikely that facilities would be 100% available for decommissioning activities. As such, this analysis has identified the nearest five facilities to accommodate the total volume of material generated.

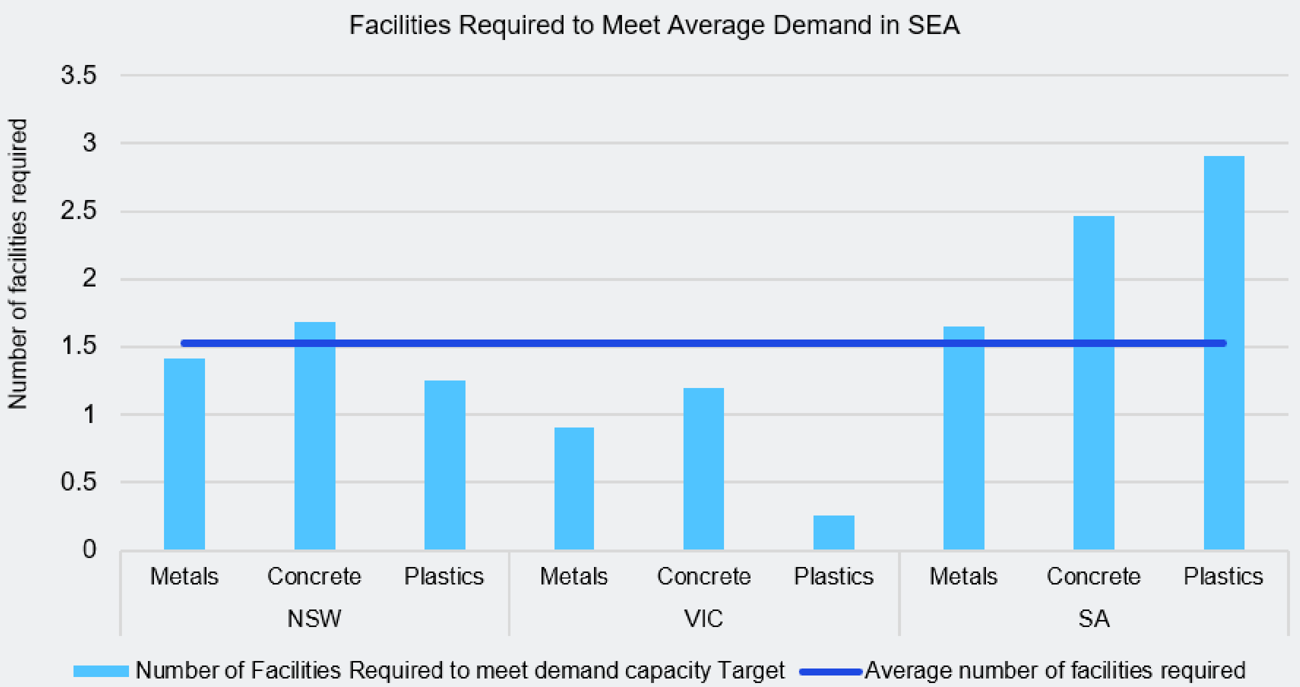


Figure 3: Assumed Approximate Number of Facilities Required to Meet Demand Capacity Target

[4] National Waste Report 2022, Blue Environment
[5] Australian waste and resource recovery infrastructure database, Australian Government DCCEEW, 2022

Methodology

To estimate transport distances, a dual approach was utilised, considering the nearest recycling facility from each port and the average distance to the five closest facilities from each port, based on the rationale outlined. The average was not determined for Bell Bay (Tasmania) and Port of Darwin (NT), due to limited available facilities. Instead, the closest facility or reasonable assumptions were used.

Assumptions

- All dismantling occurs at the port. Transport to a separate dismantling facility is not considered.
- All transport of materials occurs in a 20ft container and not as bulk cargo. The 20ft container can hold 24 tonnes which is standard. It is assumed that a semi-trailer truck would be fully utilised in one trip.
- The base assumption is that all material other than NORMs, will be transported to a suitable initial domestic recycling facility. Further travel is likely to be required after initial recycling, for material to be fully repurposed, although this has not been considered. NORMs irrespective of the port will be required to travel to WA.
- Ports where the local recycling facilities are insufficient to support, have additional assumptions as detailed below:
    - Bell Bay – All materials, excluding marine growth, are transhipped to Port of Melbourne.
    - Darwin – Metals are 50% exported as only one metal recycling facility identified and 100% of plastics exported as no suitable facility identified.
- To enable a comparison of alternative options the following scenarios have been considered:
    - NT Assets – Sea transport to Port of Onslow, to compare feasibility of using a decommissioning hub in WA.
    - SEA Assets – Sea transport to AMC to compare feasibility of using a decommissioning hub in WA.
    - 50% Export – For both metals and plastics, 50% are exported and the remainder of material streams utilise local facilities; except in the case of Darwin.
    - 100% Export – For both metals and plastics, 100% are exported and the remainder of waste streams utilise local facilities.
- Hazardous materials transport cost were not analysed due to the complex permitting that would require specific waste facilities.

Trucking Analysis


Pic: Container Trailer, Source: FEMMERR

Capacity

Each 20ft container can hold 24 tonnes of scrap material. In practice this will vary slightly based on the density of material.

Cost

Cost per km derived from Freight Australia estimates

$6/km for <50kms $5/km for <200kms $3/km for >200kms

Trucking Transport Emissions – Trucking and Shipping

Utilising the Australian Transport Assessment and Planning (ATAP) Emission Conversion Facts, it assumed that 1.87 kg of CO_2e is generated per km travelled for trucking.

Shipping Analysis

Emissions

Utilising the ATAP Emission Conversion Facts, it is assumed that 0.36 kg of CO_2e is generated per km travelled for shipping.

Costs

$400 per container from Tasmania to Port of Melbourne based on a Department of Infrastructure, Transport, Regional Development and Communication (DITRDC) Monitoring Report 2020 (for Bell Bay).

Although prices for international container shipping have been extremely volatile over the past five years, an estimate of $1,800/TEU was based on analysis of the Shanghai containerised freight index, and includes proxy values for port fees and charges; utilising Freight Metrics. Container trade routes are limited and pricing will not significantly vary between these ports..

Results

Figure 4 and 5 show the total (absolute) cost and emissions profile to transport an average weighted platform from each port and shows the difference between transporting to the nearest facility (where feasible) and the average distance of the closest five facilities.

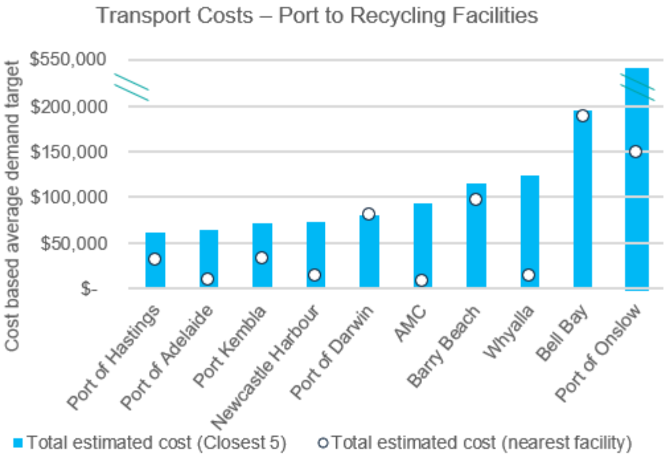


Figure 4: Transport Costs – Onshore to Recycling Facilities

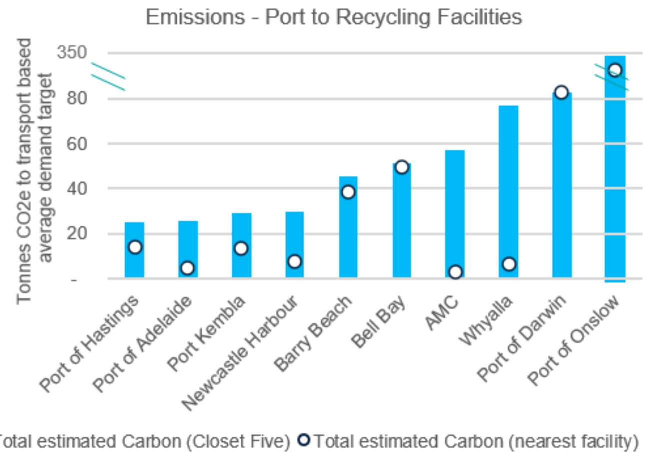


Figure 5: Emissions – Onshore to Recycling Facilities

Table 3 shows the average cost and carbon (kgCO2e) associated with transporting one tonne of material from each port to a suitable recycling facility from an average of 5 closest facilities. Given the current market for domestic recycling is limited for some materials, a comparison to export is provided.

Table 3: Average Transport Cost and Emissions from Onshore to Recycling Facilities

Region	Port	Closest 5 Facilities		Nearest Facility		50% Metal & Plastic Export		100% Metal & Plastic Export	
		Cost $ / tonne	Emissions kgCO2e)/tonne	Cost $ / tonne	Emissions kgCO2e)/tonne	Cost $ / tonne	Emissions kgCO2e)/tonne	Cost $ / tonne	Emissions kgCO2e)/tonne
SEA	Port of Hastings	17	7	9	4	31	40	45	74
	Port Adelaide	18	7	2	1	28	42	39	78
	Port Kembla	20	8	9	4	34	39	49	69
	Newcastle Harbour	20	8	4	2	34	38	48	67
	AMC	26	16	2	1	32	38	38	60
	Barry Beach	32	13	27	11	40	43	49	74
	Whyalla	34	21	4	2	45	56	55	91
	Bell Bay	54	14	52	14	60	46	65	78
NT	Port of Darwin*	22	21	22	21	22	21	40	39
	Port of Onslow	148	92	41	26	130	95	113	98

Port of Darwin* - already considers 50% metal exported and 100% Plastics exported.

Key insights include:

- Having capacity at the closest facility significantly changes the total Onshore cost and carbon emission profile. An inability to access Port Adelaide, AMC and Whyalla's closest facilities significantly decreases the viability of these ports. Port of Hastings and Barry Beach, are less reliant on a single facility, showing a consistent cost and carbon footprint when utilising the closest facility or the closest five facilities.
- When looking at the total optimisation of cost and carbon across the Value Chain, export scenarios more significantly impact the total carbon footprint rather than total cost, because the offshore costs per tonnage dwarf the onshore costs per tonnage.
- In the export scenarios, Port of Onslow faces more expensive onshore transport costs as compared to export transport costs, driving the 100% export scenario to be most cost effective.

Key Takeaways

Combining the key metrics identified allows a macro view of optimisation across the transport components of the O&G decommissioning Value Chain. Given that a key desire of this study is to identify opportunities to onshore waste management, and it is a significantly smaller carbon footprint, only the domestic options are shown. Whilst distance is the key driving factor for both cost and carbon, the efficiencies of Onshore and Offshore vary significantly.

- Cost: Driven by Offshore due to the high day rates of the vessels required for in-field removal operations and to transfer assets to shore. Costs are volatile due to weather and port congestion.
- Carbon: Driven by the Onshore component due to the small-batch nature of container and trucks to move the same tonnage of material. Assuring availability of the closest facility will significantly reduce this impact in ports like Whyalla.

Table 4: Cost, Carbon Emissions, Community, Facilities and Adjacent Industries per Port

State	Port	Offshore Sub-Totals		Onshore Sub-Totals		Totals		Current State Report		
		$/tonne	kgCO2e/ tonne	$/tonne	kgCO2e/ tonne	$/tonne	kgCO2e/ tonne	Community	Facilities[6]	Adjacent Industries
		a	b	c	d	a + c	b + d			
South East Australia										
VIC	Port of Hastings	200	6	17	7	217	13		Expansion Planned	W, H, C
VIC	Barry Beach	200	6	32	13	232	19			W, H, C
TAS	Bell Bay	200	6	54	14	254	20			W, H, C
SA	Port Adelaide	450	20	18	7	468	27			None
NSW	Newcastle Harbour	450	17	20	8	470	25			W, H, C
NSW	Port Kembla	450	20	20	8	470	28		Expansion Planned	W, H
SA	Whyalla	500	26	34	21	534	47			H
WA	AMC	1200	64	26	16	1226	80	Not Assessed		
Northern Territory										
NT	Port of Darwin	200	6	22	23	222	29			H, C
WA	Port of Onslow	750	37	148	91	898	128	Not Assessed		
Key										
Suitable		Possible		Not Suitable		W- Wind		H- Hydrogen		C - CCUS

Lowest Cost & Carbon

Barry Beach

One of the ports with closest proximity to assets, least Onshore costs and emissions impact. Community sentiment may be favourable, however there is no evidence as yet of adjacent Industry developments.

Port of Hastings

The most desirable from a combined Offshore and Onshore Value Chain with the least costs, carbon emissions and opportunities with other industries. Part 1 identified that the community and facilities available may not be favourable for O&G decommissioning.

Ports of Note

Bell Bay

Desirable for Offshore operations from a cost and distance perspective but has larger impacts due to additional transport costs to recycling facilities.

Newcastle, Port Adelaide & Port Kembla

Though higher Offshore transportation costs, they have lower Onshore carbon and costs due to the proximity of recycling facilities.

Darwin

The only NT port available for northern assets, higher costs and carbon due to export requirement.

Port of Onslow & Whyalla

If closest facility is used, onshore costs are significantly less.

[6]Facilities is a combination of the berthing and lay down facilities identified in Part 1, the Current State Report

Feasibility of Domestic Consumption of Recovered Materials

Introduction

As the global landscape evolves towards sustainable practices, the O&G decommissioning Value Chain presents a unique opportunity for economic and environmental considerations. This chapter delves into the opportunities and limitations of increasing the domestic consumption of recovered materials. The breakdown of expected materials to be recovered from O&G decommissioning between now and 2040 include 625kT of concrete, 551kT of steel, 12kT of plastic, 7kT of non-ferrous metals, 8kT of marine growth, and 4kT of hazardous materials.

In this chapter, we aim to develop a snapshot of the economic and commercial drivers behind each of the three key material streams which are concrete, steel and HDPE plastics, testing the hypothesis that Australia may seize the opportunity to support the development of a domestic recycling Industry. Most materials coming from O&G decommissioning have high value if efficiently recycled and also face export challenges due to regulatory constraints. Our overarching hypothesis is centered on the premise that strategic interventions and innovations could transform these material streams into valuable resources, aligning with global sustainability goals.

The deep dive review will examine the most "desirable" material pathway for each of the three material streams. This analysis will be grounded in considerations of domestic economic benefits and the potential for reduced carbon emissions. The study will outline existing barriers hindering the preferred material pathways and propose actionable insights to overcome these challenges. Through the identification of opportunities and strategic actions, the aim is to make these pathways more accessible, laying the foundation for a sustainable and economically viable O&G decommissioning Industry in Australia.

HDPE Plastic

HDPE Current Waste Pathways

HDPE is a type of thermoplastic polymer commonly used in packaging and various industrial applications such as pipes. Of the total material generated from decommissioned O&G assets in the NT and SEA, plastics constitutes <1% by weight, estimated at approximately 12kT[7]. While actual variety of plastic recovered spans a range of plastics, this analysis focuses on HDPE due to its prevalence.

In Australia, the majority of HDPE waste is sent to landfill. Traditionally landfill was the only pathway and was considered an attractive route due to the low complexity and historically affordable prices.

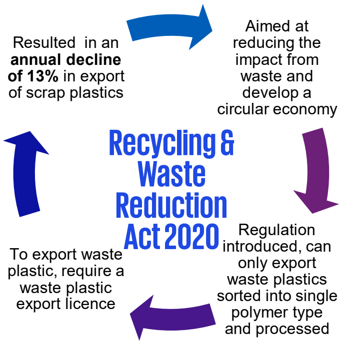


Figure 6: Recycling and Waste Reduction Act 2020 – Aim, Regulation and Impact

[7]Offshore O&G Decommissioning Supply Chain - Current State Report
[8]Australian Plastics Flows and Fates Study 2020-21 – National Report, Blue Environment
[9]Australian exports of waste and recovered materials in 2021-22 (dcceew.gov.au)

Of the low proportion (18%) of HDPE that does not end up straight in a landfill, 8% is exported and the remainder is recycled domestically[8] as seen in Figure 7. Noting, that due to the introduction of the ban on export of mixed waste plastic in July 2022, the volume of exported scrap plastic fell by 13%[9]. It is likely that this volume of waste has been redirected in the short-term to landfills.

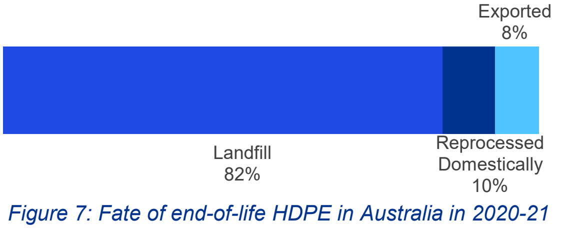


Figure 7: Fate of end-of-life HDPE in Australia in 2020-21

Generally the recycling rate of plastic from 'Built Environments' is below the average rate and in 2020-21 it was only 6.7%[8]. Some ongoing Australian O&G decommissioning projects have obtained a waste plastic export ban exemption, meaning all waste plastic recovered is being exported pre-sorting and pelletising. This exemption has not been based on insufficient recycling capacity. In fact, in Australia, recycling facilities have an average of 37% spare capacity for HDPE recycling.

Additionally, these facilities have a planned approximate doubling (98% increase) of capacity over the next five years[8]. Based on current domestic recycling rates, to adequately handle the HDPE from O&G decommissioning projects, on a 5 yearly basis, there would only be a 4% demand increase on recycling facilities[8].

HDPE Potential Pathways from Different Regions

The financial and carbon impact of using Victoria, Tasmania and NT ports for Onshore HDPE recycling has been investigated as well as the impact of using different disposal pathway.

Pathway 1 – Exporting

This pathway assumes that when the HDPE arrives Onshore it is sorted at (or adjacent to) the port. It is then transported to a recycling facility for pelletising. For Victoria, this transport occurs by road only, however, for Tasmania, this involves shipping to Victoria followed by road transport to the recycling facility. For NT, the transport is firstly by rail to WA followed by road transport to the recycling facility where it is pelletised. In all regions, the recycled material is then transported by road to a nearby port for export to South East Asia. This analysis tracks the costs and carbon emissions up to arrival at the gates of a manufacturing facility in SEA.

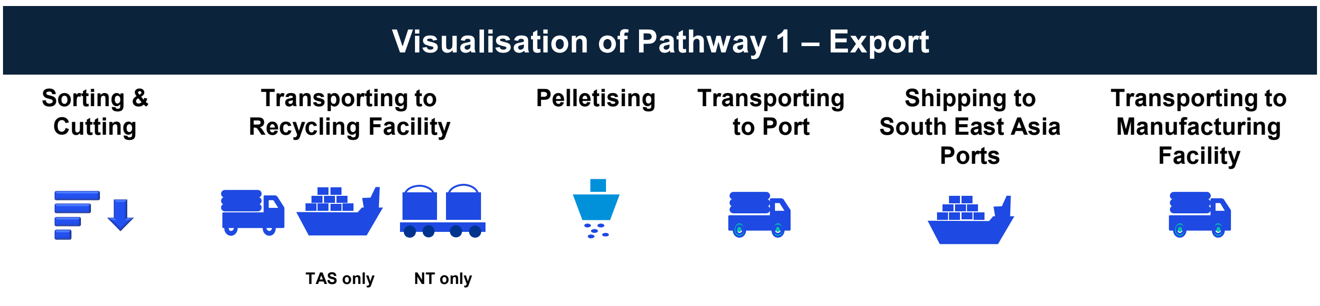


Figure 8: Visualisation of Pathway 1 – Export

Pathway 2 – Domestic Consumption

This pathway for each port is the same as Pathway 1 up until the HDPE is pelletised. However, after pelletising, in all regions, the recycled HDPE (rHDPE) is then transported by road to a nearby manufacturing facility. As with Pathway 1, costs and emissions up until the arrival at the gates of the manufacturing facility are considered.

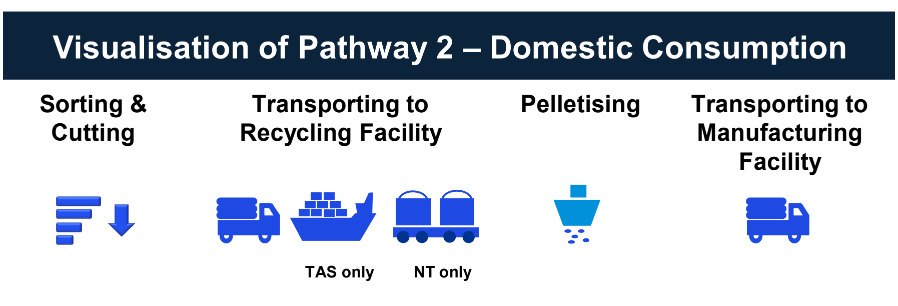


Figure 9: Visualisation of Pathway 2 – Domestic Consumption

Pathway 3 – Landfill

This pathway assumes for all three regions, when the HDPE arrives Onshore, it is transported by road to a nearby landfill.

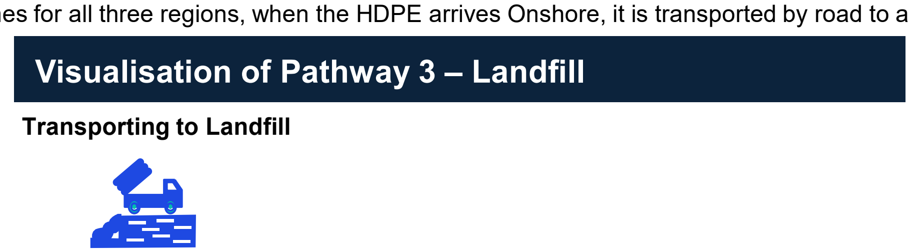


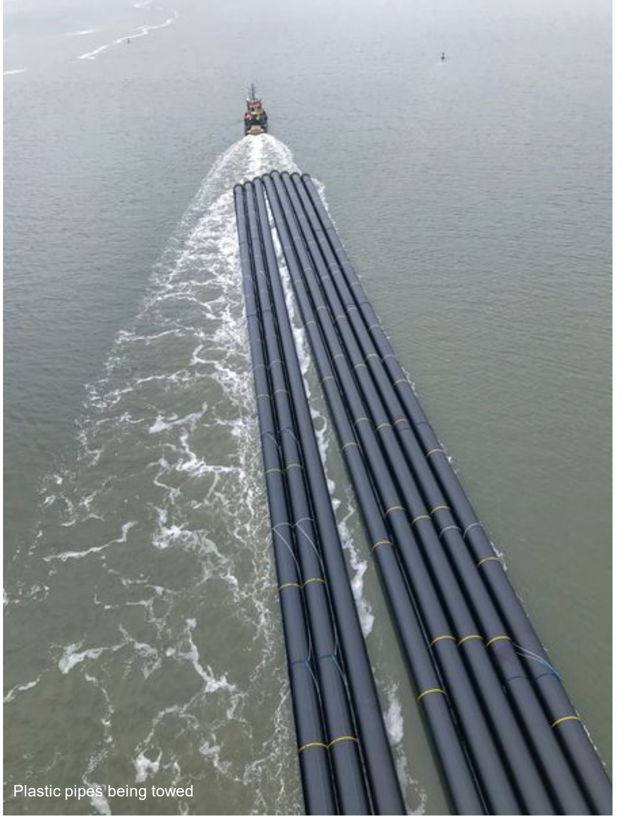
Figure 10: Visualisation of Pathway 3 – Landfill

The specifics of the handling stages for each port and pathway are outlined in Appendix B.

Pathway Analysis – Simplifying Assumptions

Several simplifying assumptions are taken in this analysis.

- In this investigation, a generic Victorian, Tasmanian and NT Port is considered and the cost and environmental impact of exporting, domestically recycling and landfilling were explored. Distances between ports and recycling facilities, landfills and manufacturing facilities are estimated based on average distances in regions.
- The analysis focuses on a subsection of the HDPE's lifecycle for each pathway:
  - For exporting, the analysis is centred on the emissions generated through pelletising and transporting to the gates of a South East Asian manufacturing facility. It therefore omits emissions from manufacturing and final distribution as well as emissions from the subsequent fate of the plastic; whether that be future recycling or landfilling. No abated emissions are accounted since the recycled plastic is manufactured in South East Asia.
  - For the domestic recycling pathway, the analysis focuses on the emissions generated through recycling minus the emissions abated from the virgin plastic not produced. It only considers the plastics emissions up to the point of arrival at the manufacturing facility. The analysis omits subsequent manufacturing, distributing and recycling or landfilling emissions.
  - For landfilling, all emissions released as the HDPE anaerobically breaks down in the landfill are considered in the analysis.
- The 'profit / loss margin' refers to total money in (sale price of HDPE per tonne) minus money out (processing and transport costs per tonne of HDPE) for the specific period of the lifecycle analysed. It does not describe the profit or loss of a specific stakeholder or its total lifecycle as this is dependent on the specific operating model employed.
- Shanghai Port was the assumed South East Asian Port accepting the HDPE for recovery.
- For a conservative approach, the carbon emissions associated with recovering the material are based on the 2022 carbon intensity electricity in the respective states[10,11]. While this value is expected to trend downwards, to what degree cannot be accurately quantified.



Plastic pipes being towed

- The cost of energy is based on average commercial 2023 pricing[12].
- As landfills continue to reach capacity, states have continuously increased the cost of disposing waste in a landfill; and this is expected to continue to rapidly increase. The 2022 highest cost per tonne in Australia is in metropolitan NSW therefore, for a conservative result, this rate was used to estimate costs.
- The expected domestic and international price per tonne of recycled and virgin HDPE is based on November 2023 estimations.
- The energy intensity of sorting, cutting and pelletising rHDPE are based on 2023 technology specifications.
- It is estimated that the stages of plastic production before product manufacturing constitutes 60%[13] of the energy consumed in virgin plastic production.
- The carbon intensity of each mode of transport is based on the 2023 UK Government Greenhouse Gases (GHG) Conversion Factors for Company Reporting data set.
- The cost of each mode of transport per km tonne is estimated using database available on 'Freight Metrics'[14].

[10] Greenhouse gas co-efficient 2022 (esc.vic.gov.au)
[11] aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem
[12] Shell Energy Default Rates (shellenergy.com.au)
[13] Plastic Europe Estimation (Note the range is 1.6 – 6.4kg CO2e/kg Virgin Plastic therefore a conservative estimation has been used)
[14] freightmetrics.com.au

HDPE Potential Pathways from Different Regions

Net Cash Flow Along Each Pathway

When analysing the cashflow along each pathway it is apparent that exporting is the most economically attractive option, since it has the highest profit margin. This is due to the higher international price offering per tonne compared to the current domestic value. The sale price of the HDPE is therefore the determining factor for the optimal pathway. Both Pathway 1 and Pathway 2 have a positive net cashflow whereas Pathway 3, where the material is sent to landfill, results in a net negative cashflow due to the high assumed landfill levies. Figures 11 to 13 show the net cashflow generated for each scenario and pathway.

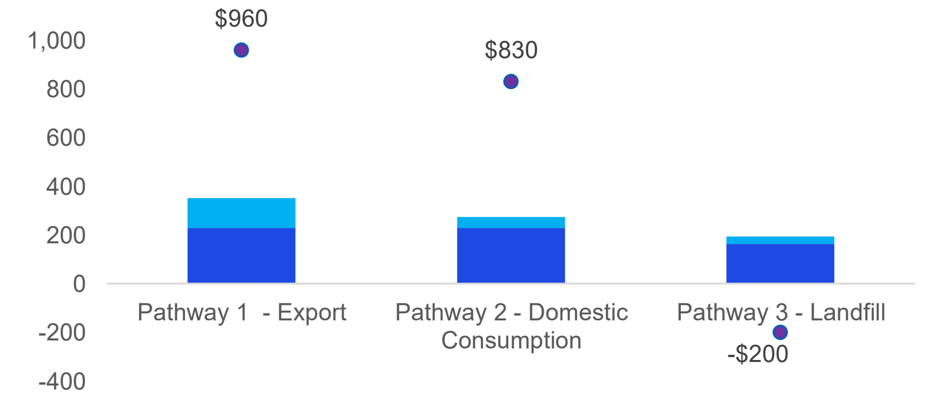


Figure 11: Cost and Profit/Loss for Each Pathway – HDPE Disposal at Victorian Port

Exporting is the most economically favourable pathway.

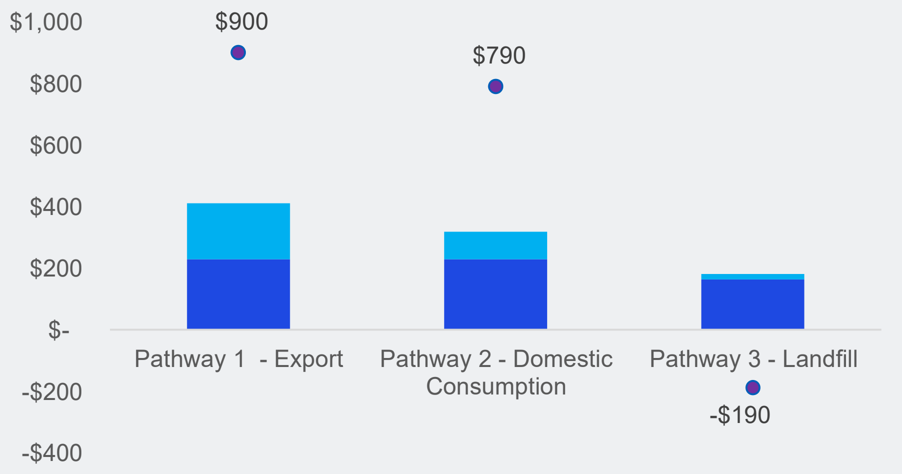


Figure 12: Cost and Profit/Loss for Each Pathway – HDPE Disposal at Tasmanian Port

HDPE requires shipping to Victoria for recycling, resulting in Victoria Ports being most cost effective.

As shipping from Tasmania to Victoria is heavily subsidised, this additional transport requirement does not majorly impact the overall cost.

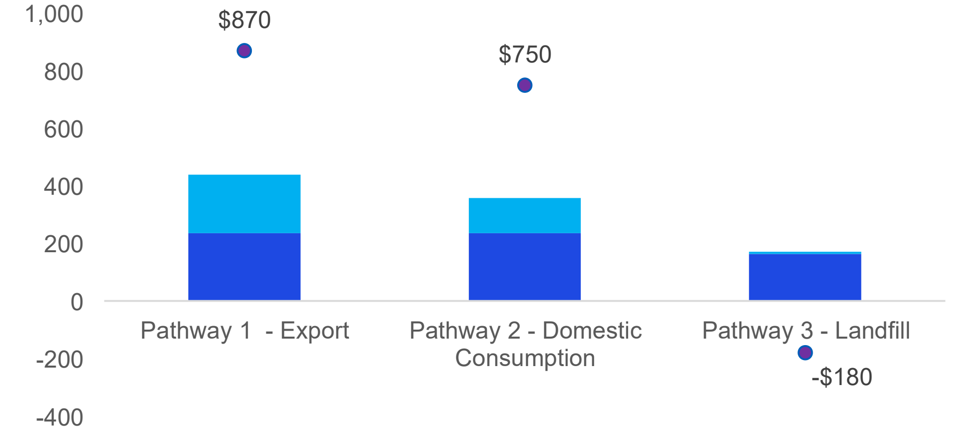


Figure 13: Cost and Profit/Loss for Each Pathway – HDPE Disposal at Northern Territory Port

NT Port is less economically attractive due to the lack of recycling capacity in NT and the higher transportation costs

Transport Costs | Processing Costs | Profit / Loss Margin

Net Carbon Flow Along Each Pathway

Figures 14 to 16 show the net carbon emissions generated for each scenario and pathway. When a tonne of HDPE is recycled domestically, it is considered to have displaced a tonne of fossil-based virgin HDPE. In this analysis, the path assumed for domestic consumption at each port, premanufacturing (including sorting, cutting, transporting and pelletising) produces approximately 400 kgCO2e per tonne HDPE recycled. Based on a conservative estimation for virgin plastic emissions[15], it is estimated to produce approximately 950 kgCO2e per tonne.

Domestic recycling and consumption is the most optimal path, regardless of which port the materials are disposed.

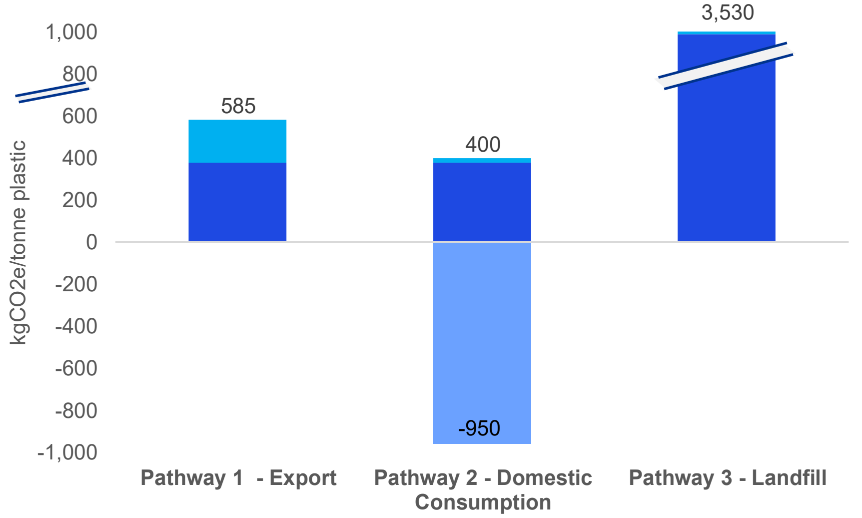


Figure 14: Carbon Emission Breakdown of Pathways for Waste Disposal at Victorian Port

Although a large proportion of plastics exported will likely be recycled, this “abatement” is not captured in Australia and therefore results in net positive emissions.

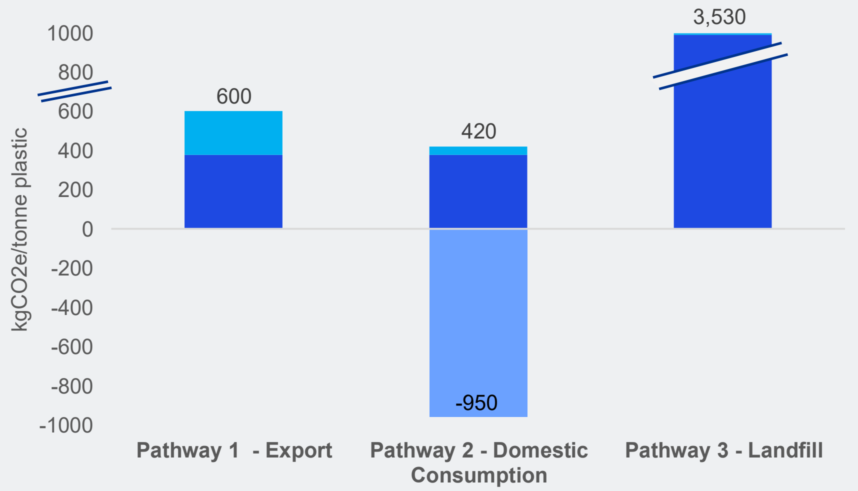


Figure 15: Carbon Emission Breakdown of Pathways for Waste Disposal at Tasmanian Port

Landfilling is carbon intensive as plastics break down anaerobically and hence, is the least attractive option for all port scenarios.

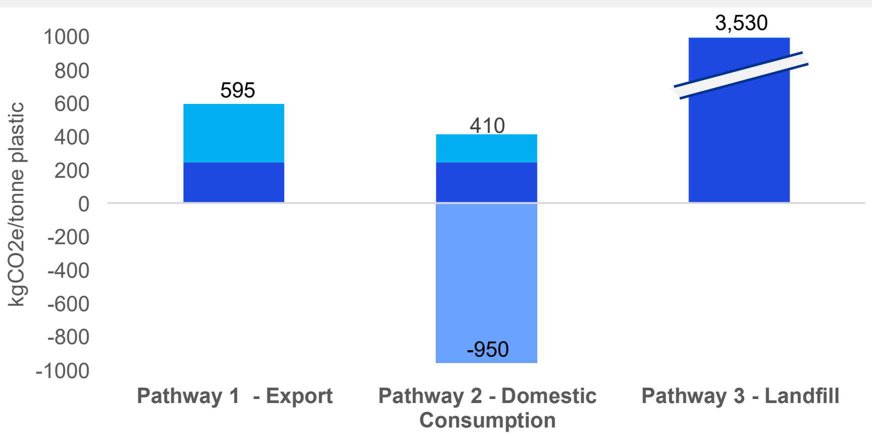


Figure 16: Carbon Emission Breakdown of Pathways for Waste Disposal at Northern Territory Port

Transport Emissions | Processing Emissions | Abated Carbon (Virgin Plastic Unproduced)

[15]Plastic Europe Estimation (Note the range is 1.6 – 6.4kg CO2e/kg Virgin Plastic therefore a conservative estimation has been used)

Abated Emissions

The effect of abated emissions on the net carbon flow is further explained. Figure 17 illustrates the emissions reduction achieved through domestic recycling compared to the utilisation of virgin HDPE. Consequently, rHDPE emerges as the less carbon-intensive option, with abated emissions approximately amounting to 550 CO2e per tonne. Therefore, the emissions associated with the domestic consumption pathway become net negative.

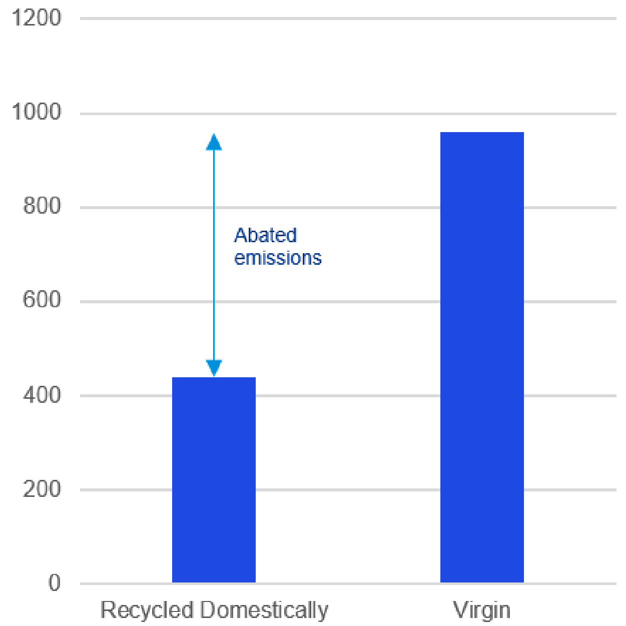


Figure 17: Estimated Premanufacturing Emissions per Tonne of rHDPE vs Virgin HDPE

Domestic Consumption: Challenges and Opportunities

From an economic perspective, exporting is the most attractive pathway in all port scenarios. However, from a carbon abatement and circular economy standpoint, recycling the HDPE domestically is most optimal. There is a macrotrend in declining manufacturing in Australia[16], due to the high costs of labour and energy which makes the production costs uncompetitive compared to many competing countries. However due to the forecast 54% domestic increase in demand for HDPE between 2021 and 2040, the increased plastic waste export regulation and the rapidly increasing landfill levies, there is a nationwide plan to double the capacity in domestic plastic recycling facilities over the next 5 years[17]. Figure 18 shows the significant variance in the estimated demand from HDPE recovered from decommissioned O&G assets[18] and the domestic recycling capacity.

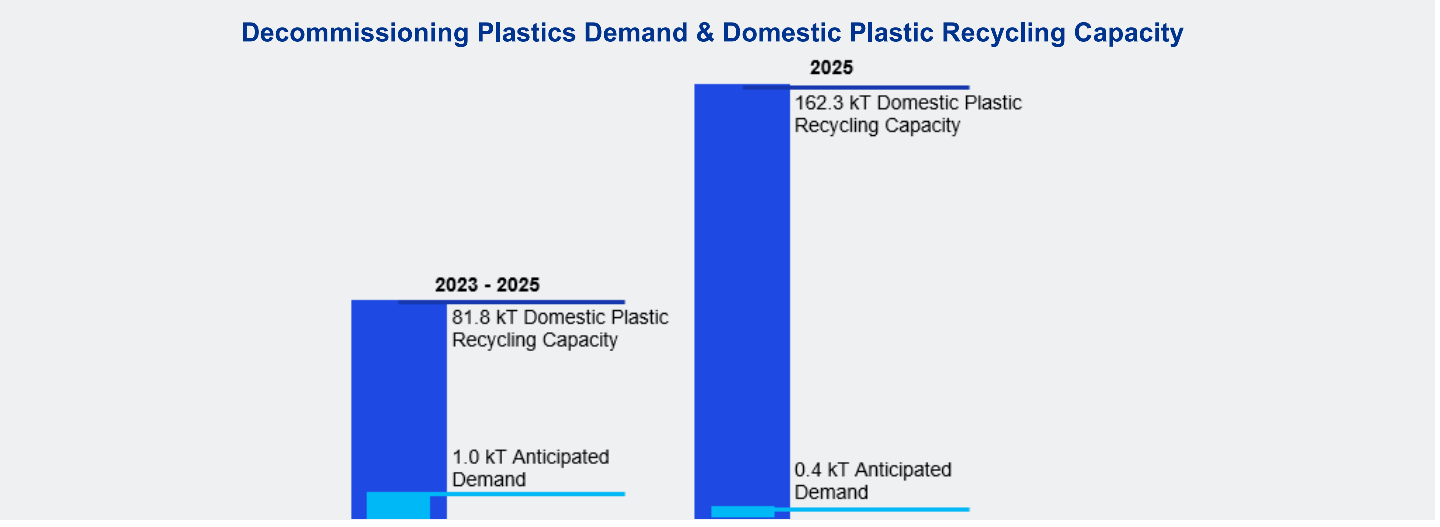


Figure 18: O&G Decommissioning HDPE Demand vs rHDPE Market Size and Recycling Capacity

While it is only at developing stages in Australia, the domestic recycling Industry is expected to grow organically. The rHDPE Industry does have a number of challenges to overcome, with the specific HDPE material streams recovered from decommissioned O&G platforms facing additional challenges. For each challenge, a corresponding opportunity was identified.

16 Australian Bureau Statistics
17 Australian Plastics Flows and Fates Study 2020-21 – National Report, Blue Environment
18 KPMG has utilised the NOPSEMA website and relevant environmental plans to generate this data

Challenges		Opportunities
The expected volumes of plastic from decommissioned O&G assets are low compared to other waste plastic sources[19,20]. Discussions with stakeholders revealed this low volume has resulted in only a limited interest to receive these streams.	1	Although the low volume of the material streams presents a challenge for market interest, it also presents an opportunity as volumes constitute a minor proportion of the planned HDPE recycling capacity at recycling facilities meaning there is significant capacity to absorb the low volumes recovered from O&G decommissioning projects (Figure 18).
The current sorting and cutting processes of the material at the port is inefficient and often laborious and so can significantly impact the cost of recycling. Due to the nature of the removal process, there can be unwanted and contaminated materials that increase the cost of sorting. The lower the purity of the HDPE stream (mixed with other plastics or contaminants) the higher the recycling cost.	2	There is a move towards adapting automatic handling systems which reduce the complexity of the separation and cutting process, including the need for hazardous waste experts[21]. This will have a positive impact on the cost of plastic recycling Value Chain due to a reduction in processing costs at the port.
Industry has concerns over the quality discrepancy between virgin and rHDPE. There is a misconception amongst some Industry players that virgin plastic is more reliable.	3	Opportunity to educate Industry players on the parity between recycled plastic and virgin plastic, once they both meet the required technical specifications.
Virgin HDPE is currently on average more economically competitive in Australia compared to rHDPE due to its large existing market with high production volumes.	4	Virgin HDPE price is strongly linked to the price of the hydrocarbon feedstocks and energy used to produce (i.e. price of oil). In the past the price of oil was relatively stable however over the last decade, this price is increasingly volatile.
	5	Recycling technologies are advancing year on year, along with increasing efficiency and cost reductions[22]. Specific policy measures and economic instruments can help accelerate the uptake of rHDPE instead of virgin HDPE.
There is often a higher value offered for rHDPE internationally compared to domestically resulting in close to 50% of rHDPE being exported in 2021.	6	There is growing government demand to incorporate recycled content into new products which, combined with policy measures, will help grow the domestic demand for rHDPE and reduce its exports to South East Asia.

[19] Australian Plastics Flows and Fates Study 2020-21 – National Report, Blue Environment
[20] KPMG has utilised the NOPSEMA website and relevant environmental plans to generate this data
[21] The recycled plastics market: global analysis and trends – CSIRO
[22] Advanced recycling technologies to address Australia's plastic waste - CSIRO

Key Takeaways

This analysis identified:

- There is adequate recycling capacity for the 12kT of plastic material due to be recycled Onshore up to 2040.
- The Victoria Port scenario is the most economically attractive. Disposal at a Tasmanian Port results in a lower profit margin due to additional transport requirements to bring it to Victoria for recycling. The NT Port scenario is the most expensive due to the long-distance rail transport to the recycling facilities.
- Sale of recycled plastics domestically is a profitable route, and it is the most optimal from an emissions perspective due to the abated emissions from unproduced fossil-based virgin plastic.
- Virgin plastics are currently more economically attractive compared to rHDPE however specific economic instruments could be implemented to reverse this trend and support the uptake of rHDPE in new products.
- Manufacturers often have a false perception that recycled plastic is of inferior quality to virgin plastic, assuming it lacks the same strength, durability, or has a different visual appearance. There is an opportunity to develop quality standards and specifications and educate Industry players on the parity of the two materials and encourage the use of recycled plastic by manufacturers.

Plastic pellets

Steel

Steel Current Material Pathways

Steel is estimated to make approximately 46% of the total materials recovered from the O&G decommissioning in scope, equating to over 551kT of material. Scrap steel in Australia have an exceptionally high recycling rate (at close to 90%) and are recycled either locally or exported. Although highly variable, scrap steel has a current global commodity price of approximately A$450-$700/tonne[23] and domestic price of A$250-400/tonne[24].

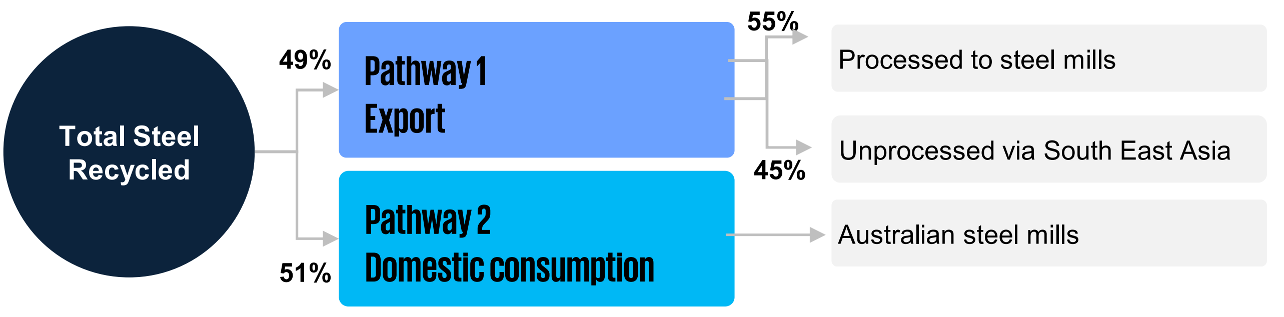


Figure 19: Steel Material Stream Pathways

Pathway 1 Export
~49% of steel

Lighter-gauge materials are baled into 600mm cubes and containerised for export. When exported, lighter-gauge materials are generally not pre-processed and often include non-metallic contaminants such as rubber, plastic and glass.

Heavier-gauge materials are cut into pieces smaller than 1m in length by hydraulic shears or oxy cutting, and either containerised or shipped as bulk scrap.

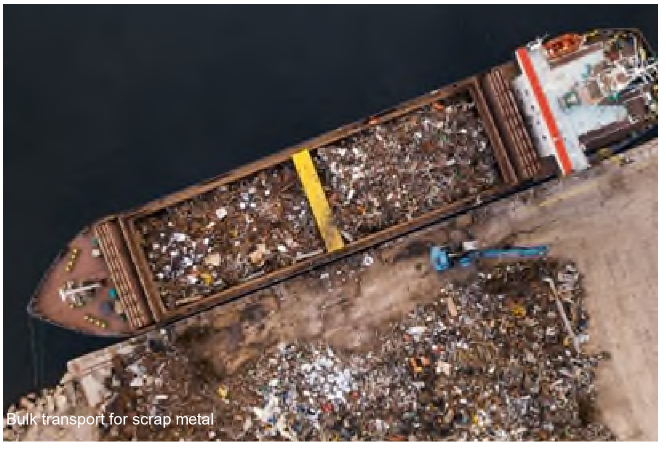
Due to the highly fragmented nature of the scrap metal market (including many smaller providers), it is difficult to determine the exact percentage of scrap steel that is exported; however, Industry estimates show this may be around 50%[25] (of mostly unprocessed stock).

Pathway 2 Domestic Consumption
~51% of steel

Lighter-gauge materials shredded and separated into steel and non-ferrous metals, with a by-product created called 'shredder floc' which includes fine metal material and other contaminants. Similar to exports, heavier-gauge materials are cut into pieces smaller than 1m in length for processing in local smelters for refining and reuse.

In Australia, lighter-gauge materials make up ~75% of steel scrap, however it is estimated that the O&G decommissioning would include a higher proportion of heavier-gauge metals.

The domestic consumption of steel should be the preferred material pathway as it reduces the need for consumption of virgin materials and the emissions generated to mine them.



Bulk transport for scrap metal

Light-gauge material in a container

[23] mepsinternational.com/gb/en/products/ferrous-scrap-prices
[24] southerncrossmetalrecyclers.com.au/scrap-metal-price-calculator/
[25] nwric.com.au/2021/08/25/time-to-ban-the-export-of-unprocessed-scrap-metal/

Steel Potential Pathways from Different Regions

Similar to HDPE plastics, there are implications of using different ports around Australia for the O&G decommissioning.

Notably, this is due to the limited availability of steel manufacturing facilities in Australia where the steel will be recycled (heightened by the Molycop facility in NSW ceasing steel production in September 2023).

Table 5: Australian Steel Manufacturing Facilities

Location	Typical Production	Feedstock Requirement
Port Kembla, NSW *BlueScope*	3.2 million tonnes	~20% scrap steel
Rooty Hill, NSW *Infrabuild*	0.6 million tonnes	~20% scrap steel
Whyalla, SA *Infrabuild*	1.2 million tonnes	~20% scrap steel
Laverton, VIC *Infrabuild*	0.7 million tonnes	~90% scrap steel

With the steel manufacturing facilities located in mainland south-eastern Australia, this will create additional transport legs to enable domestic recycling if the chosen decommissioning port is in other areas of Australia (including Tasmania).

Pathway 1 – Exporting Recovered Steel

This pathway assumes that when the steel arrives Onshore it is sorted and containerised at (or adjacent to) the port. For Victoria, it will be transported by road to the Port of Melbourne for export, however in Tasmania the analysis assumes the container will be transhipped from Burnie to the Port of Melbourne for international export. The NT has a similar path to Victoria, where the steel will be containerised or exported bulk via the Port of Darwin. Assuming export to South East Asia, the scrap metal container is then taken by truck to an overseas steel manufacturing facility to be recycled.

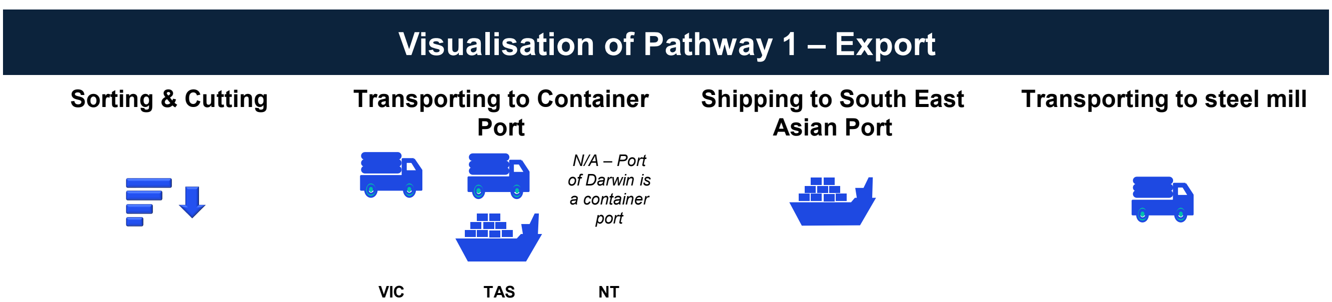


Figure 20: Visualisation of Pathway 1 - Export

Pathway 2 – Domestic Consumption of Recovered Steel

This pathway assumes that when the steel arrives Onshore it is sorted and at (or adjacent to) the port. For Victoria, it will be transported by road to the steel manufacturing facility (e.g. Laverton), however in Tasmania the analysis assumes the container will be transhipped from Burnie to the Port of Melbourne and then transported by road to the steel manufacturing facility. For O&G material arriving at a port in the Northern Territory, the steel would be sorted and containerised at (or adjacent to) the port, and then transported by rail to Adelaide. The container would then be trucked to the steel manufacturing facility (e.g. Whyalla).

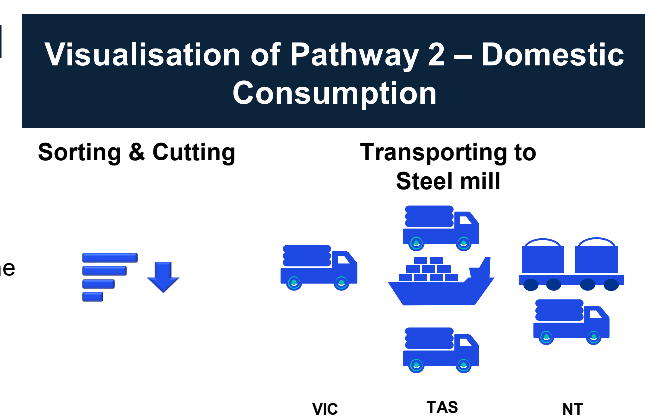


Figure 21: Visualisation of Pathway 2 – Domestic consumption

Material Chain Cost

Decisions around the potential port for O&G decommissioning will have small impacts on the commercial return on recycling steel. The additional transport required from the Tasmanian port (requiring transhipment from Burnie to an international container service from Melbourne) adds approximately $40/t of cost to the supply chain, although when compared to the total global price (~$600/t) and local price (~$350/t) of scrap metal it does not significantly impact its overall commercial return. For export, the additional ~$65-$80 in cost to export scrap metal would likely be re-couped from stronger export prices which reduces its influence on decision making. For steel recovered at a NT Port, it is ~$20 cheaper to export the metal directly (due to proximity to nearest international steel mill).

Victorian Port

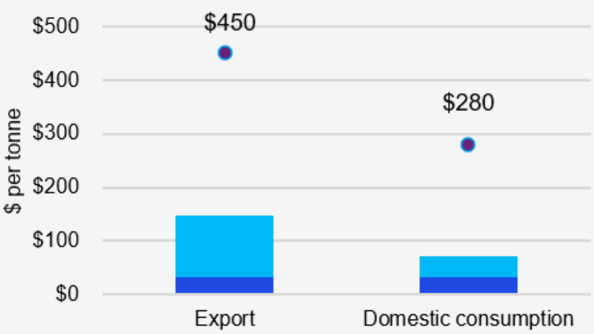


Figure 22: Cost of Pathways for Steel Disposal at Victorian Port

Tasmanian Port

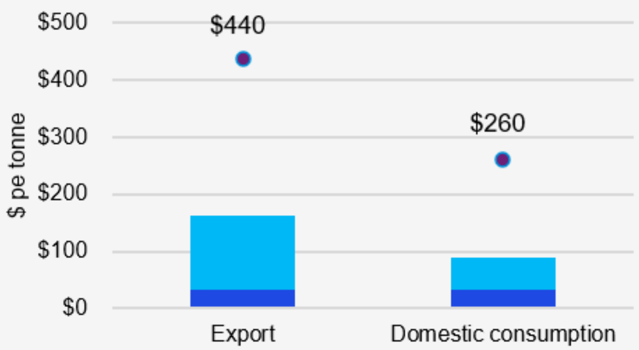


Figure 23: Cost of Pathways for Steel Disposal at Tasmanian Port

Northern Territory Port

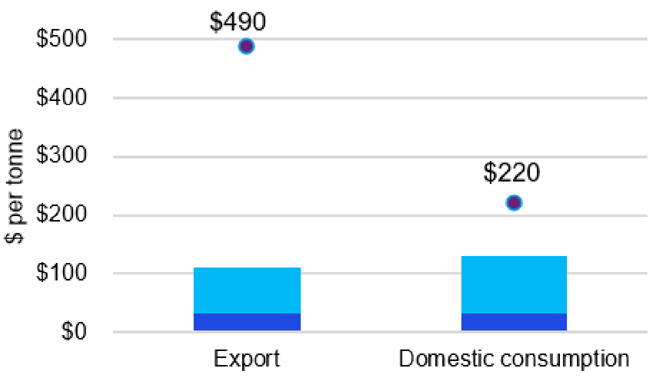


Figure 24: Cost of Pathway for Steel Disposal at Northern Territory Port

Legend

- Transport Costs
- Processing Costs
- Profit / Loss Margin

Material Chain Carbon Emissions

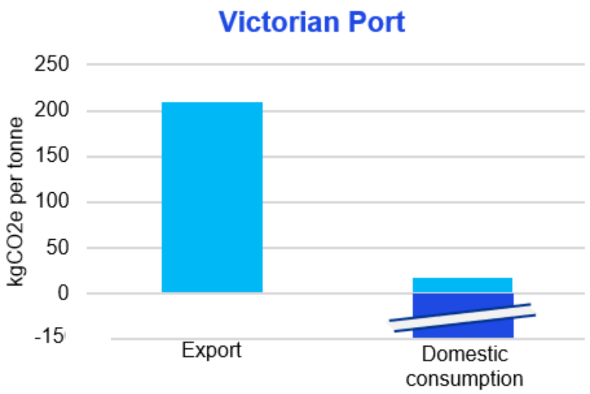


Figure 25: Carbon Emission Breakdown of Pathway for Steel Disposal at a Victorian Port

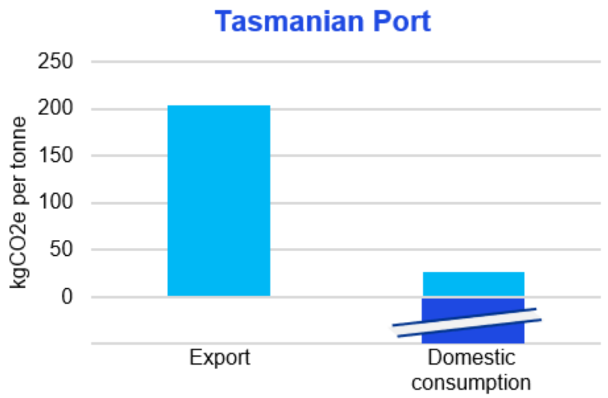


Figure 26: Carbon Emission Breakdown of Pathway for Steel Disposal at a Tasmanian Port

Victorian and Tasmanian Ports

The carbon emissions generated to export these metals is significantly higher than the domestic consumption pathway. This is due to the emissions generated by international shipping from Melbourne to South East Asia.

In line with cost, the outlier in this analysis is steel recovered at a Northern Territory port. The required 2,800km rail journey from Darwin to Adelaide and 380km road journey from Adelaide to Whyalla steel mill generates more carbon emissions than exporting the steel to Asia directly.

Despite the transport emissions from all ports and pathways, there is still a net-benefit to recycling steel. This is as every tonne of scrap used for steel production has been calculated to avoid the emission of 1.5 tonnes of carbon dioxide[26].

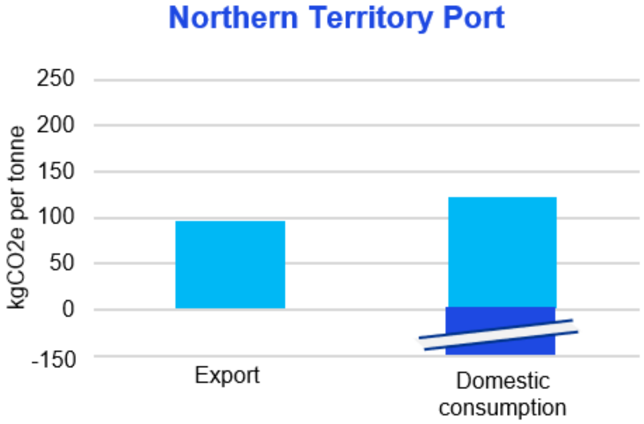


Figure 27: Carbon Emission Breakdown of Pathway for Steel Disposal at a Northern Territory Port

Legend

Transport Emissions　Abated Emissions　Processing Emissions

Note: Processing emissions are included in the analysis but are not visible in the chart.

Abated emissions: Australia currently imports ~100kT of scrap steel each year, mostly from New Zealand, USA and India[27]. Domestic consumption of scrap steel recovered from O&G decommissioning is assumed to avoid the emissions associated with importing scrap metal to Australia.

[26] worldsteel.org/steel-topics/raw-materials/
[27] dcceew.gov.au/sites/default/files/documents/waste-imports-2021.pdf

Domestic Consumption: Challenges and Opportunities

Challenges

- Australia exists in a global market for scrap steel. With export shipping costs at approximately $75/t (when containerised) and the current sale price at over $600/t, there are clear drivers for why approximately half of scrap steel is currently exported.
- In 2021, Australia's steel Industry produced 5.8 million tonnes of steel, however that is overshadowed by the global consumption of steel which was 1.96 billion tonnes in the same year. Additionally, forecasts show that global demand for steel will grow to 2.11 billion tonnes by 2027, spurred by ongoing construction and the energy transition towards renewables[28]. This increasing demand for steel will only increase the global demand for scrap steel (which makes up between 20%-90% of the feedstock required in steel production).
- As countries focus on their own recycling efforts, this will further reduce the availability of scrap steel from traditional sources (USA, Europe, Japan) for scrap-deficient countries (such as China and Turkey), increasing the appeal of exporting scrap from Australia.
- Australia is in a current market shortfall for scrap steel. This is evident through close to 100,000 tonnes[29] of scrap metal being imported to Australia in 2021, despite over 2.2 million tonnes of processed and unprocessed scrap metal being exported in the same year[29].

Opportunities

- The greatest benefit of increasing the use of recycled steel in Australia is the reduction in cost and carbon emissions associated with mining, and transporting mined products to steel manufacturing facilities, typically from WA to SEA. Blast furnace type mills such as Whyalla and Port Kembla have higher requirements for mined products, and lower scrap metal feedstock requirements.
- This means that domestically manufactured steel using high volumes of recovered steel, such as the Laverton mill, will lower the greenhouse gas emissions for the Industry. Every tonne of scrap used for steel production avoids the emission of 1.5 tonnes of carbon dioxide, and the consumption of 1.4 tonnes of iron ore, 740kg of coal and 120kg of limestone[30].
- Despite these benefits, global pressures and the ability to export unprocessed steel means Australia would not be able to increase the percentage of steel which remain Onshore without some intervention. However, steel recovered from O&G decommissioning activities will have a greater chance of being used in domestic steel production due to the nature of the materials recovered. O&G steel material streams will have higher portion of heavier-gauge metals in larger pieces, and as such will be easier to process, with consideration to decontamination prior.

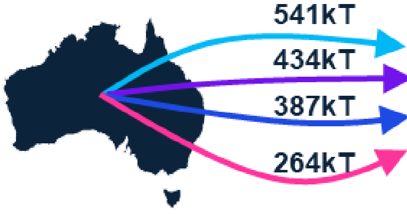


Figure 28: Main Flows of Australian Scrap Steel Exports (2021) – NWRIC

Key Takeaways

This analysis identified:

- Export provides higher potential profit on the sale of steel from all port locations, including Tasmania which requires additional transport.
- Despite this, the environmental benefits of domestic consumption of scrap steel are significantly higher than exports. This is due to less transport requirements, as well as the avoidance of importing scrap metal to supplement Australian steel manufacturing.
- As evidenced by the Molycop facility in NSW which will cease steel production at the end of 2023, there are broader structural issues present in the Australian steel manufacturing market. Imported steel products produced with cheaper energy and labour means further intervention may be required to support the Industry.

[28] Industry.gov.au/publications/resources-and-energy-quarterly
[29] nwric.com.au/2021/08/25/time-to-ban-the-export-of-unprocessed-scrap-metal/
[30] worldsteel.org/steel-topics/raw-materials/

Concrete

Concrete Current Material Pathways

Recovered concrete is estimated to make up majority of materials recovered from in scope O&G decommissioning activity, totalling over 625kT of material or 52% of the total materials recovered from now until 2040. Out of this approximately 502kT is expected from pipeline coatings and 123 kT from concrete GBS.

Although this will be the largest material by volume recovered from O&G decommissioning activities, it is insignificant compared to the capacity of the construction and demolition waste recycling market in Australia, which is estimated at 10,500 kT per annum[7].

Recovered concrete is not exported due to the low value and international prevalence of its end-product, and all remains in Australia which is either landfilled (<20%) or recycled (>80%).

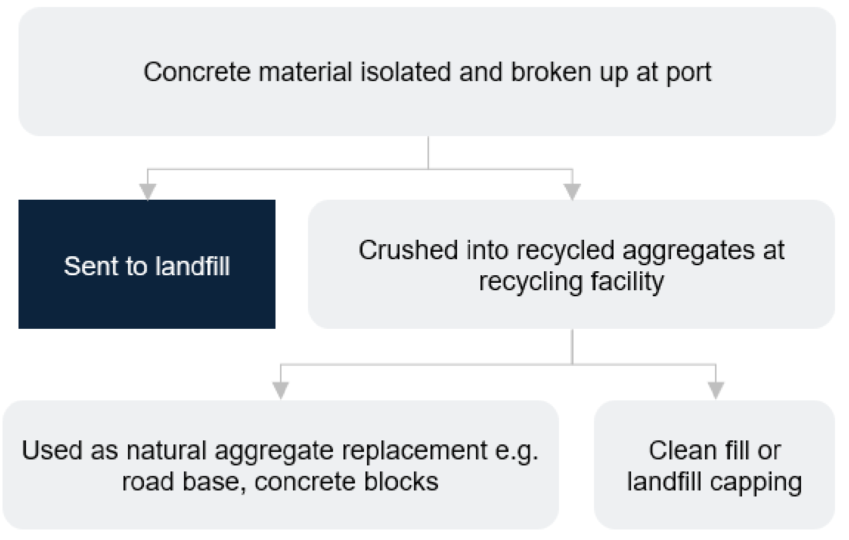


Figure 29: Concrete Material Pathways

It is estimated up to 81% of building and demolition materials such as asphalt, bricks and concrete in Australia are diverted from landfill and recycled[31]. Although relatively high, some recyclers and global benchmarking shows this can be improved. For example, some civil contractors state they have a diversion rate of 99%[32] and Japan recycles up to 98% of recovered concrete material[33].

Some reasons concrete may be landfilled include:

- Concrete has to be isolated before it can be recycled and will most likely be landfilled when the concrete is mixed in with other waste materials, for example when generated as part of smaller, less specialised works.
- Contaminated concrete, for example mixed in with asbestos products, can limit the ability for it to be recycled[34].
- Recycled concrete products are not as desirable compared to natural aggregate. Variability and uncertainty in the quality and properties of the recycled aggregate may reduce the relative density of recycled concrete by 7-9% compared to concrete made with natural aggregate. This can prevent recycled concrete from being used for higher-order uses (e.g. structural concrete)[35].

Recycling concrete should be the preferred pathway as it can be used as a direct replacement to many quarried natural aggregate products. This will both avoid materials sent to landfill and the emissions generated from quarrying new aggregate.

[7] Offshore O&G Decommissioning Supply Chain – Part 1, the Current State Report
[31] dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf
[32] deltagroup.com.au/wp-content/uploads/Delta-Recycling-Pty-Ltd-Capability-Statement-FY22-Waste-Management-Resource-Recovery.pdf
[33] sciencedirect.com/science/article/abs/pii/S0959652608002904
[34] assets.sustainability.vic.gov.au/susvic/Factsheet-Waste-Concrete-Rubble.pdf
[35] sciencedaily.com/releases/2016/02/160208183451.htm

Recycling Concrete Recovered from O&G Decommissioning Activities

From Industry consultation, it was found that the concrete isolated from decommissioned platforms and other infrastructure can be broken up for ~$10/t - $15/t at the port and prepared for transport, to either a recycling facility or landfill.

Disposing of concrete into landfills attracts different levels of levies across Australia.

The price to recycle concrete also varies across Australia. For example, it is generally free to drop-off concrete for recycling in metropolitan Melbourne, however costs ~$40/t in Perth and ~$100/t in Port of Onslow. This is due to the demand for recycled aggregate products being directly linked to more populated areas and subsequent greater levels of construction activity. Despite this cost, it will remain cheaper to recycle concrete compared to sending the material to landfill, especially as waste levies increase.

As a direct replacement for natural aggregate, recycled aggregate products are also cheaper to buy. Although prices vary between product types, an example Sydney-based retailer charges $82/t for road base made with quarried materials, compared to $55/t for road base made with recycled concrete[36].

In addition to cost savings, using recycled concrete would be eliminating the carbon intensive production process of quarrying aggregate.

Figure 30: Australian Waste Levies (2023-24) – WMRR

[36]turtlenursery.com.au/quarry-products/

Challenges and Opportunities for Recycling Concrete

As it is likely, highly skilled contractors would be appointed to facilitate the decommissioning task, it is likely close to all concrete recovered from the O&G assets would be recycled.

This already happens with some government civil works contracts, where for example all concrete material from construction and demolition activities as part of Victoria's Big Build must be recycled.

However, as identified above, the costs for 'dropping off' recovered concrete at a recycler may vary depending on which port is used for decommissioning. Ports which have the easiest access to metropolitan areas will likely have the lowest costs associated with recycling concrete.

There may also be an opportunity to use the recycled aggregate on site at the decommissioning port. If a mobile crusher is used, concrete recovered from O&G decommissioning could be used to facilitate development activities at or close to the port without requiring significant road transport, potential costs and carbon emissions. This opportunity may vary based on the port selected, however owing to the broad use of recycled aggregate products this may be an opportunity to consider.

Figure 31: Mobile Crusher used for Creating Recycled Aggregate Products - Rock Processing Solutions

Figure 32: Comparison of Recycled vs Natural Aggregates

Key Takeaways

This analysis identified:

- Where possible, on-site processing and use of recycled aggregate products at or close to the port selected for decommissioning activities should be the preferred option. Examples include the use of aggregate in the facilitation of land reclamation, site grading, or as road base for re-paving activities. This would avoid the transport cost and emissions for the recycled material, as well as avoiding emissions for bringing new material in.
- In a wider context, encouraging the utilisation of recycled aggregate products instead of naturally quarried materials whenever feasible is suggested. Discouraging the use of quarried materials and actively promoting the substitution with recycled aggregates could be a proactive approach. This approach aims to boost the demand for recycled products, subsequently lowering disposal costs as recyclers can sell these products more quickly and profitably.
- The planned series of Government infrastructure projects in the coming decades present a substantial opportunity for incorporating recycled aggregates. This could potentially encourage a wider adoption of these products in private sector developments, showcasing their practicality to civil contractors.

Tailoring Regulatory Policy

Tailored Decommissioning Frameworks

The decommissioning Value Chain is a unique series of activities coming together, spanning across Commonwealth, State and Territory boundaries and Part 1 identified that the current regulatory landscape is not tailored to decommissioning's unique characteristics. Consultations identified that Industry stakeholders did not view the current regulatory permissioning documents as an ideal fit for decommissioning activities and that no single regulatory authority held the end-to-end view of decommissioning activities. As such, questions arose around who was driving optimisation across the Value Chain. In conjunction, the regulator was aligned with this sentiment, not being clear on who currently held the end-to-end oversight and was open to the development of decommissioning specific template(s).

With these observations as context, a comparative assessment between governing regulations and practises for decommissioning in the United Kingdom (UK), New Zealand (NZ), and Australia was undertaken to generate further insight into opportunities for tailoring Australian regulatory policy. UK was selected to take the learnings from an Industry which has had several decommissioning projects and NZ recently amended legislation to be more prescriptive influenced by the UK approach. Table 6 highlights that the process in the UK is naturally more mature and tailored to decommissioning activities compared to Australia and NZ. Appendix C provides an example of guidelines and templates for decommissioning in the UK to give granularity on how UK regulatory frameworks have evolved with experience.

Table 6: Decommissioning Framework Comparison

		UK	New Zealand	Australia
Regulatory Authority	Legislation	Petroleum Act 1998 accompanied by Guidance Notes - Decommissioning of Offshore Oil and Gas Installations and Pipelines	Exclusive Economic Zone and Continental Shelf (Environmental Effects - Decommissioning Plans) Regulations 2021	Offshore Petroleum and Greenhouse Gas Storage (OPGGS) Act 2006, Information Paper on Planning for Proactive Decommissioning
	Regulatory process	Decommissioning plan to be approved by Offshore Petroleum Regulator for Environment and Decommissioning (OPRED)	Decommissioning plan to be approved by Environment Protection Authority (EPA)	EP to be approved by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) with key decommissioning activities to be covered by an approved Safety Case and Well Operations Management Plan (WOMP).
Approval Requirements	Approval body	OPRED	EPA	NOPSEMA
	Permission documents required	Decommissioning Plan, Environmental Appraisal and Comparative Assessment.	Decommissioning Plan	Environmental Plan, Safety Case and WOMP.
	Document focus areas	Decommissioned assets, environmental impacts, stakeholder consultation and material disposal options.	Mainly environmental and safety impacts.	Mainly environmental and safety impacts.
	Material end state considerations	Identifies removal and disposal options in compliance with waste hierarchy.	Prescribes reporting on end state of materials including reuse, recycling and disposal.	No clear expectation on reporting of material end state.
	Guidelines	Guidelines prescribes specific decommissioning practises based on asset types. There is a focus on removal and end-of-life management.	No guidelines exist.	Guidance exists on expected timelines of removal but does not focus on types of assets and material end-of-life management.
	Document templates	Detailed decommissioning plan template exists.	Not available as there was no Industry preference to it.	Submission cover sheet exists but is not tailored to decommissioning.

Table 6 Continued: Decommissioning Framework Comparison

		UK	New Zealand	Australia
Alternatives	Alternatives to full removal	Exists through assessment of options considering safety risks, environmental impacts, technical feasibility, community or social risks, economic impacts, and stakeholder consultation.	Exists through assessment of options, however focuses mainly on environmental and safety impacts.	Exists through assessment of options, focussing on mainly equal or better environmental outcomes, well integrity and safety requirements.
	Type of assets that can be left in-situ	Reviewed on a case-by-case basis however there is more guidance on the types and conditions of assets that could be left in-situ via Oslo-Paris (OSPAR) convention	Reviewed on a case-by-case basis; however no prescriptive type of assets that can be left in-situ.	Reviewed on a case-by-case basis; however no prescriptive type of assets that can be left in-situ.
	Guideline to prepare in-situ assessment	Annex A of the guidance notes consists of a comparative assessment framework and processes to consider.	Schedule 12 provides limited guidance on information required in the comparative assessment.	Schedule 6 of the Section 572 Maintenance and Removal of Property provides guidance on in-situ consideration but is not detailed.
Close out Activities	Project Closure Requirements	Close out report seeks information on decommissioning program outcome, its variances, environmental sampling results, and cost summary.	Decommissioning completion report is required; but lacks clarity on the details of information needed.	Close out report seeks information on decommissioning program outcome, its variances and environmental sampling results.
	Post-Decommissioning monitoring and maintenance	Surveys required to identify levels of hydrocarbons, heavy metals or other contaminants and clear any debris or obstructions on the seabed.	Surveys required to monitor levels of hydrocarbons, heavy metals, and other contaminants; but do not have debris clearing requirements.	Surveys required to monitor levels of hydrocarbons, heavy metals, and other contaminants; but do not have debris clearing requirements.
	Monitoring of assets left in-situ	Post-decommissioning monitoring and maintenance approach required to assess in-situ asset condition such as marine colonisation and potential risk to fishing.	Inspection and maintenance program needs to be submitted in the decommissioning plan but lacks clarity on what all need to be monitored.	EPs require a close out report and performance monitoring but do not prescribe ongoing monitoring of assets in-situ.

Analysis Insights

This analysis coupled with consultations highlights several points in comparison to jurisdictions more advanced in decommissioning:

- EP, together with Safety Case and WOMP are the main permissioning document in Australia under the OPGGS Act 2006 and cater for a variety of different Offshore activities rather than specific and holistic end-to-end decommissioning activities.
- Removal vs in-situ assessment of assets is complicated, with broad views amongst stakeholders. Australia could benefit from a form that encourages a multifaceted assessment inclusive of the end-to-end decommissioning Value Chain.
- Close out report and performance reporting is limited to Offshore environment outcomes and does not track the downstream Value Chain like material streams and their end-of-life management. This does not drive transparency on material recycling outcomes.
- In Australia, the expectation is set for a full removal case. Guidelines for types of assets and their conditions for remaining in-situ lacks clarity, resulting in significant uncertainty for downstream Onshore stakeholders to plan, invest and upskill in infrastructure and capabilities. The broad gap in alignment between stakeholders on this subject is seen as a threat to Australia's progress at pace for optimised and successful decommissioning.
- Making amendments to the EP to better tailor for decommissioning activities requires legislative changes. This can be time-consuming and impedes the pace needed for the imminent surge in decommissioning activities. An expedited action is required so that regulations are tailored to decommissioning as the timeline approaches.

Deep Dive: UK Guidance on Decommissioning of Offshore Oil and Gas Installations and Pipelines

The UK guidance notes are tailored to the nuances of decommissioning and provide requirements of what is expected of operators at the different stages of decommissioning.The process tracks the entire Value Chain of activities from Offshore to removal and disposal methods of material streams.

The regulatory authority, OPRED has streamlined document submissions by providing a template for use which aids efficiency for operators and for easier comparison between submissions. Templates are tailored to specific assets and foresee future scenarios.

OPRED requires operators to conduct a comparative assessment approach for justifying other alternatives than full removal. Figure 33 is extracted from the guidance notes which shows a comparative assessment against environmental impacts, technical feasibility, community and social risks and economic impacts. There is a mention of stakeholder consultation with experts in relevant fields to add robustness to the comparative assessment outcome.

Guidelines also prescribe criteria for removal options of installations and pipelines as shown in Table 7.

Gravity-based structures (GBS) are allowed to consider a derogation subject to an assessment that shows sea disposal is preferable to reuse, recycling or disposal on land. Global studies have indicated that removal of GBS poses technical feasibility issues, safety risks and higher emissions during refloat and transport[37].

		DECOMMISSIONING OPTIONS			
ASSESSMENT CRITERIA	Matters to be considered	Complete removal to land (red/yellow/green)	Partial removal to land (red/yellow/green)	Leave wholly in place (red/yellow/green)	Disposal at sea * (red/yellow/green)
Safety	risk to personnel				
	risk to other users of the sea				
	risk to those on land				
Environmental	marine impacts				
	other environmental compartments (including emissions to the atmosphere)				
	energy/resource consumption				
	other environmental consequences (including cumulative effects)				
Technical	risk of major project failure				
Societal	fisheries impacts				
	amenities				
	communities				
Economic					

HIGH (red) MEDIUM (yellow) LOW (green)

Figure 33: UK's Comparative Assessment Framework[38]

Table 7: Removal Options for Different Assets in the UK

Asset type	Weight (Tonnes)	Full Removal to Land	Partial Removal to Land	Leave Wholly in-situ	Reuse	Disposal at Sea
Installation (excl topsides)						
Fixed steel	<10,000	Yes	No	No	Yes	No
	>10,000	Yes	Yes	No	Yes	No
Concrete - gravity	Any	Yes	Yes	Yes	Yes	Yes
Floating	Any	Yes	No	No	Yes	No
Subsea	Any	Yes	No	No	Yes	No
Pipeline						
Flexible flowline, cables, umbilicals	Any	Yes	No	No	No	No
Buried and trenched	Any	Yes	Yes	Yes	Yes	No
Structural damage prohibits safe and efficient recovery	Any	No	Yes	Yes	Yes	Yes

[37] MCP-01 Decommissioning Programme
[38] UK Department of Business, Energy and Industrial Strategy – Guidance notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines

Operating Licence for Dismantling Facilities

Approvals and authorisations are required for dismantling activities that take place at ports. The regulatory landscape for these activities is dictated by the requirements set forth by each state's regulatory body. For example, in Victoria, a development licence is required to construct a facility and an operating licence, registration or permit is required to operate certain recycling facilities. Licenses provide certain operational conditions and can last for up to five years before they need to be renewed.

Stakeholders emphasised during consultations that confusion and a backlog exist within some state regulatory bodies in approving authorisations, acting as an impediment to the establishment of dismantling facilities at the port. These facilities, identified by Industry as having a temporary and seasonal use profile, prompt the consideration of alternative pathways to address these challenges.

Targeted consultations with key state regulators have yielded valuable insights:

1. Despite the Industry's perception of these facilities as temporary, it is anticipated that they will be required for a period exceeding five years, triggering the need for standard facility approvals akin to any permanent facility.
2. Generally, obtaining necessary approvals should not pose significant challenge, provided there is a comprehensive understanding of the materials that will be brought Onshore, and how they will be managed.
3. One of the regulators key drivers for concern lies in demonstrating the appropriate management of combustible materials or activities, such as stockpiling of plastic and metal grinding. However, given the highly mature nature of the O&G sector, this should be relatively straightforward to establish.
4. Hazardous (e.g. Asbestos) and flammable (e.g. long-term storage of plastics) draw closer regulatory attention to understand the contractor’s risk mitigation measures. However, these are expected to be generated in small quantities and therefore not considered high risk.
5. The responsibility falls on the applicant to demonstrate to regulators their adoption of leading practice material management / separation practices to secure approvals.

Plastics Waste Exporting

The plastics resulting from O&G decommissioning primarily consists of engineering plastics tailored to specific mechanical and thermal properties. While our assumption for this report centres on the prevalence of HDPE, the actual variety spans a range of plastics, including but not limited to PolyEther Ether Ketone (PEEK), PolyTetraFluoroEthylene (PTFE), Nylon, PolyVinyl Chloride (PVC), PolyEthylene (PE), PolyPropylene (PP), and PolyEthylene Terephthalate (PET). Composites such as gaskets and gratings, made from materials like Compressed Asbestos Fibre (CAF) or Compressed Non-Asbestos Fibre (CNAF), also contribute to the O&G plastics landscape.

Challenges with the domestic plastic recycling landscape

The predominant plastic recycling method in Australia for single polymer plastics like HDPE and PP (commonly found in packaging) is mechanical recycling. However, plastics from the O&G sector, often comprising multiple polymer types, pose challenges for mechanical recycling. Stakeholders have historically highlighted challenges with recycling low volume, challenging plastics from sectors such as the building and construction sector. The cost of aggregating and transporting such low volume material (compared to packaging) is deemed prohibitively high; even if recycling facilities exist.

Overcoming the challenges with obtaining permits and licences

O&G assets are expected to utilise comparable plastic types. Once the composition and specifics of the plastics are identified, if export licenses are necessary, a standardised application approach might be contemplated instead of the current case-by-case application method.

The process to obtain the required licences or permit are complex and lengthy. This may be a barrier for Industry, even if there are viable end markets overseas. In this case, a lack of domestic recycling capacity, will ultimately result in plastic being landfilled, making the difference between achieving 95% or 98% recovery rates. Ultimately, driving a domestic recycling sector for problematic materials would be key.

Exports of plastics are a necessary alternative

In the absence of robust domestic recovery options, stakeholders have noted that exporting certain plastics can be a viable option. To export plastic, detailed information on the plastic is needed. If it can be demonstrated that the plastic is a single polymer and not contaminated (for example, HDPE) and the plastic is flaked and pelletised, a plastic export licence must be obtained prior to export. Stakeholders have noted that export licenses currently take around six months to be issued.

Otherwise, if the plastic is mixed, contaminated or contains any hazardous contaminants, a hazardous waste export permit must be obtained. O&G assets may contain plastics with flame retardants and additives which may be classified as hazardous.

Stakeholders noted ambiguity around classification of plastic wastes as hazardous, leading to uncertainty about whether they require a hazardous waste permit or a plastic export licence. Responsibility of the operator or contractor to undertake this and demonstrate to the regulator.

Higher-Order Recovery and Reporting

The existing Australian regulatory framework on decommissioning is limited on how it regulates and prioritises higher order recovery. Despite recycling rates from some O&G decommissioning activities being noted as being as high as 98% from overseas examples[39], the likely end fate of materials is currently largely market driven and there are no incentives or requirements for Australian operators to report on their recycling performance or to identify higher-order recovery opportunities.

Leading Global Practices

A few countries such as the UK and NZ have decommissioning regulatory frameworks in place which prioritise best practice management of materials once Onshore.

In the UK, *Guidance Notes - Decommissioning of Offshore Oil and Gas Installations and Pipelines* from OPRED exists to help operators prepare a decommissioning plan[40]. As part of the decommissioning plan, operators must ensure materials are "*legally transported, recycled, reused or disposed of safely by competent, authorised organisations and personnel*". It also requires an indication of how the principles of the waste hierarchy (Figure 34), which prioritise prevention and reuse, will be met alongside meeting regulatory requirements.

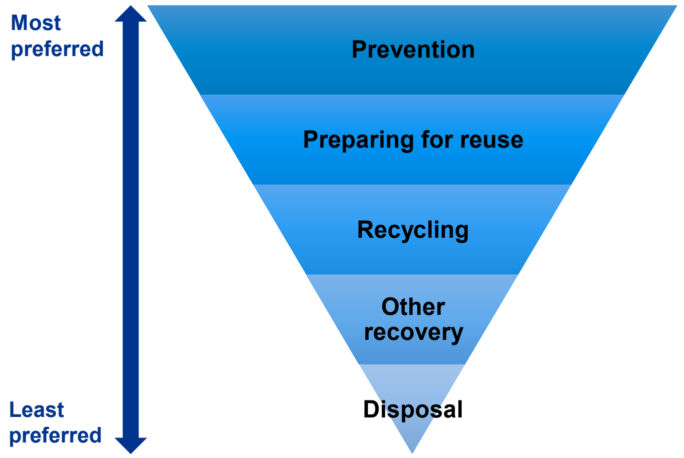


Figure 34: UK's Waste Hierarchy[41]

Existing guidelines exist for UK businesses to apply the above waste hierarchy[41]. Preferred best practice is identified for each waste stream based on the hierarchy pathway, prioritising prevention and reuse, over recycling, use in energy recovery, and disposal.

While there is no mandatory requirement to report on operator recovery performance in the UK, existing regulatory framework sets an expectation for operators to disclose and identify best practice recovery options of their materials. The Brent Delta's topside decommissioning close out report is an example of where this has been demonstrated.

Similarly, in NZ the *Exclusive Economic Zone and Continental Shelf (Environmental Effects—Decommissioning Plans) Regulations 2021* outlines that a decommissioning plan must describe how under the operators decommissioning approach, materials will be disposed of, including identifying any practicable opportunities (if any) to reuse or recycle waste and avoid or mitigate effects of disposing of the material[42].

CASE STUDY – Shell UK (2019) Brent Delta Topside Decommissioning Close out Report[43]

Brent Delta, operated by Shell, released its Close Out Report in 2019. Their decommissioning operation included returning material Onshore for reuse, recycling and disposal, with details provided in their report. The report provides a detailed inventory of material generated, quantities and their end fates (Figure 35)[43]. The report also provides a more detailed breakdown of the specifics of non-ferrous metal and steel. 23,560 tonnes of material was recovered from the decommissioning project – with the project achieving a 97% recovery rate. While the report does not provide extensive detail on exactly how materials are recycled and reused, it highlights how even niche material streams such as smoke detectors and batteries can be recycled. Only a small portion of mixed general waste, asbestos, insulation waste (MMMF) and NORM waste was landfilled.

Waste Type	Total (Tonnes)	Percentage (%)	Fate
Ferrous	20,538.13	87.2	Recycled
Non-Ferrous	1,650.11	7	Recycled
Ni-Cd Batteries	6.54	0	Recycled
Smoke Detectors	0.55	0	Recycled
Waste Recovery Recycled	287.48	1.2	Recycled
Waste Recovery (WtE)	196.84	0.8	Waste to Energy (WtE)
Gases	0.01	0	Recycled
Reuse Items	320.72	1.4	Reused
NORM Waste	21.12	0.1	Landfilled
Asbestos Waste	64.62	0.3	Landfilled
MMMF	147.26	0.6	Landfilled
General Waste	304.96	1.3	Landfilled
Other Waste	21.66	0.1	Landfilled

Figure 35: Brent Delta's Waste Reporting Example

The case study is taken from an available set of decommissioning projects that provides transparency into the types of materials generated and demonstrates the potential to achieve high recovery rates, provided materials are separated and opportunities are identified with partners to recycle material.

[39]SEPA (2019) Oil and Gas Decommissioning Sector Plan
[40]OPRED (2018) Guidance Notes - Decommissioning of Offshore Oil and Gas Installations and Pipelines
[41]DEFRA UK (2011) Guidance on applying the Waste Hierarchy
[42]NZ Legislation (2021) Exclusive Economic Zone and Continental Shelf (Environmental Effects Decommissioning Plans) Regulations 2021
[43]Shell UK (2019) Brent Delta Topside Decommissioning Close out Report

Embracing the Circular Economy

Australia is still in the early stages of implementing a circular economy and the current regulatory and policy landscape reflect this. However, there is growing momentum in Australia. In November 2022, the Federal Government announced a Ministerial Advisory Group on the Circular Economy to guide Australia as it transitions to a circular economy by 2030[44].

The circular economy is a more developed framework than the waste hierarchy as it goes beyond considering how materials are simply managed once generated. Aligning with the principles of the circular economy, rather than the waste hierarchy, aligns with Australia's overall ambitions. Embracing circular strategies require strong sectoral collaboration across the Value Chain. Table 8 provides examples of alignment of the O&G decommissioning sector with circular economy principles, relevant strategies and some practical examples.

Table 8: Relevant Circular Economy Principles and Potential Applications in O&G Sector

Principle	Description
Redesign & Procurement	Redesign or procure products and infrastructure that use less resources and are made from renewable (biobased or recycled) resources, to last longer, have multiple useful lives and eliminate waste relative to standard Industry practices. For example, procure sustainable materials and implement design for decommissioning principles (i.e. facilitate better decommissioning process at the end-of-life).
Eliminating pollution	Reduce emissions and other pollutants. For example, considering how materials are best managed once Onshore to reduce harm to environment
Regenerating Nature	Ensure business activity does not threaten biodiversity and instead supports nature to thrive. For example, investigating impacts on nature from In-situ verses full removal.
Reuse	Given the risk profile of the Industry, reuse can be challenged by the preference to buy new to ensure specific equipment design for reservoir and fluid characteristics. For example, offshore structures might be reusable for Offshore wind and reuse of wellheads and tubulars could be investigated.
Value from Waste	Taking waste by-products and transforming them into new products offerings. For example, prioritising maximising value from materials once Onshore, working with recyclers to derive value from difficult to recycle material such as plastics.
Recycling & Composting	Recycle or compost waste materials into reusable materials. This is the basic consideration in end-of-life management to avoid material from going to landfill.

[44] Australian Government (2022) New expert group to guide Australia's transition to a circular economy

Key Takeaways

In summary, key insights include

Tailoring Removal Framework

Consultations and this analysis of best practice, identified that current regulatory permissioning documents are not an ideal fit for decommissioning activities and that no single authority held the end-to-end view of decommissioning activities. Making amendments to the EP to better tailor for decommissioning activities is an extensive process and requires legislative change.

As also noted by CODA, a multi-agency regulatory working group can share lessons learnt and drive alignment between regulatory challenges identified.

Plastic waste export

Plastic export licences and hazardous waste export permits play a critical role in driving responsible management of waste. However, they may present a barrier to enabling recovery of difficult to recycle plastics that currently may only have viable markets overseas. To help overcome these barriers the following could be considered:

- A sectoral deeper understanding of the types of plastics used by O&G assets needs to be developed, noting that this is likely to be similar across all assets. If export licences are required, a standardised approach to applications could be considered, rather than having case-by-case applications, which is the current approach. This would help streamline processes for Industry and government. Where obtaining licences and permits to export plastic presents a significant barrier to Industry, this plastic is likely to be landfilled. Ultimately, driving a domestic recycling sector for problematic materials would be key. A broader view to this problem is to be considered, reviewing how other problematic plastics generated from other adjacent sectors (such as building and construction or utilities), could be aggregated to form a domestic recycling solution that could continue beyond the lifespan of decommissioning activities.

Licence for temporary facilities

Through consultation, stakeholders noted challenges with establishing dismantling facilities at the port, particularly relating to the regulators' understanding of the approval process to establish the required infrastructure. From a regulators' perspective, consultation insights identified that more information is required on the specifics of materials brought Onshore and understanding of how these materials should be best managed to minimise environmental and safety risk.

Having streamlined guiding principles, that the applicants can adhere to, thereby serving as a reference point for state regulators, can prove to be efficient for all applicants.

These principles might include considerations for thorough planning and management practices, contributing to a smoother approval process and fostering collaboration between regulators and Industry.

Higher-order recovery and reporting

Adopting circular economy principles in the Australian O&G decommissioning Value Chain aligns with Australia's ambitions to transition to a circular economy by 2030.

Government can work collaboratively across agencies and jurisdictions to ensure Industry are aware of and influenced to leverage the principles and strategies of a circular economy, and not just the traditional waste hierarchy.

Developing requirements or guidance for preparing EPs can be considered to encourage prioritising of higher-order recovery and management of materials once Onshore, as part of decommissioning planning. This could assist with clearly articulating the O&G sector's role to contributing to Australia's overall circular economy ambitions.

Workforce

Demand Profile for Various Capabilities along the Value Chain

Due to the limited availability of publicly accessible data on workforce needs for O&G decommissioning along the Value Chain, an estimate has been derived based on several assumptions and stakeholder consultations. The workforce numbers presented in this study are derived from applying generalised averages of absolute workforce needs per type of asset in the decommissioning profile assumed for SEA and NT in Part 1. This high-level view to capability needs gives insight into the order of magnitude workforce requirements and how they compare to adjacent industries, but it must be noted that it carries orders of uncertainty as discussed below. These numbers specifically pertain to the removal of platforms, subsea infrastructure, and pipelines. It should be noted that the decommissioning of the Montara Floating Production Storage and Offloading (FPSO) is excluded from this study, given assumptions for this asset to be decontaminated and dismantled overseas, due to a current lack in infrastructure for effective FPSO decommissioning in Australia.

The below profile of workforce requirements can be significantly impacted by asset decommissioning timing, removal approach and asset removal vs in-situ decisions, all Operator decisions that carry levels of uncertainty today. Noting this uncertainty, it is thought to be unlikely that a peak demand scenario will occur due to assets being decommissioned in parallel. This is because of the need to mobilise special vessel capability, of which there is limited global supply. It is most likely that one specialised vessel will mobilise to the region for a campaign, driving the pace of decommissioning activity.

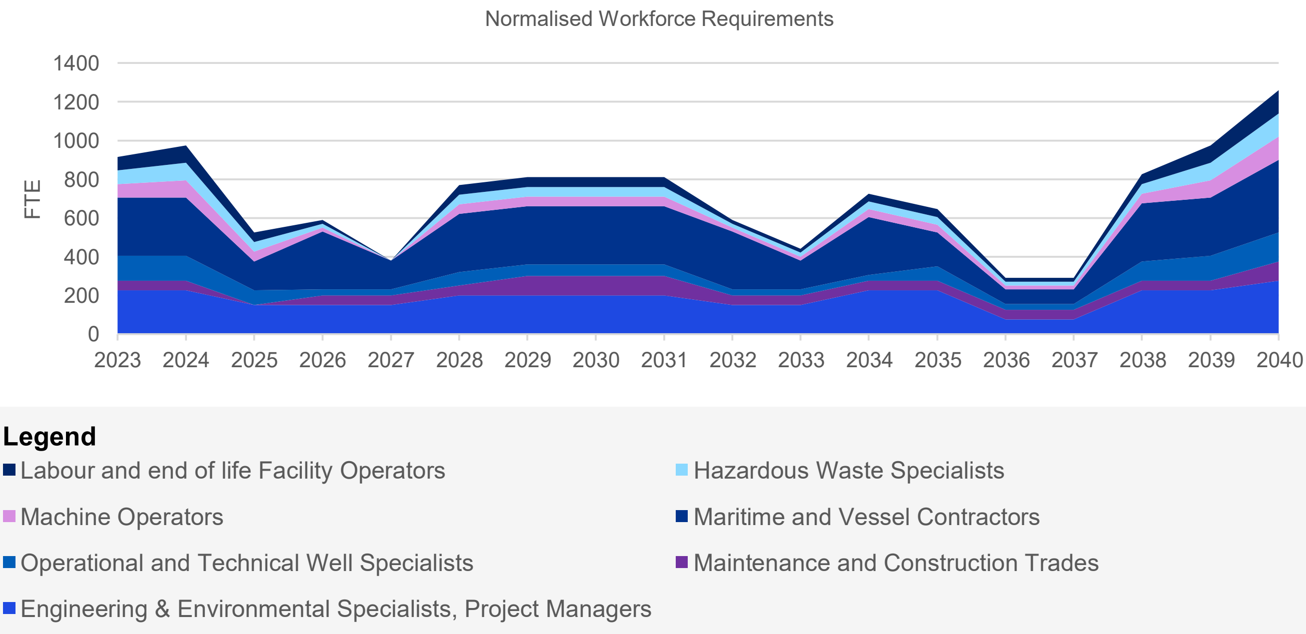


Figure 36: Normalised Workforce Requirements for Australian Decommissioning

Acknowledging the uncertainty in the above profile, the projection indicates a requirement for around 1,000 workers across the Value Chain in 2024, followed by a gradual decline to 400 workers by 2027. Subsequently, the workforce experiences fluctuations, with an approximate range of 800 workers until 2040, including intermittent peaks and troughs linked to asset removal timing assumptions.

It is important to note that the above profile is an absolute view to workforce requirements and as discovered in Part 1, stakeholders along the Value Chain are optimistic on workforce readiness. Capabilities at the front end of the Offshore decommissioning Value Chain, such as engineering, environmental planning and wells expertise, tend to be more technical and specialised in nature, however, are consistent with existing construction, marine and O&G operations. Stakeholders expect these capabilities to readily transition from existing operations.

Stakeholders involved with planning Onshore workforce demand for dismantling, material management and recycling are aiming for flexibility and to leverage existing workforce to cater for the seasonal demand profiles. As decommissioning execution unfolds, transition and the upscaling of current capabilities to the Offshore decommissioning Value Chain will need to be proven.

Comparison of the workforce needs of O&G decommissioning to other adjacent sectors demonstrates decommissioning needs are relatively small. For instance, the workforce in the renewable energy sector is projected to experience substantial growth, increasing from 37,000 in 2023 to 85,000 in 2030[45], and eventually reaching 194,000 in 2040. The Figure 37 below presents the forecast occupation mix for 2030 (which will total 85,000) workers.

The mining sector also currently employs around 330,000 workers and that will grow to almost 400,000[46] over the next decade. There are no forecasts available for future mining employment by occupation. However, the Table 9 below provides the current occupational profile as a reference point.

While this analysis only illustrates workforce needs associated with decommissioning activity rather than the holistic O&G sector, it does paint a picture that decommissioning activity workforce growth is significantly smaller than adjacent industries.

The competition between sectors for different skills sets is discussed in more detail on the following pages.

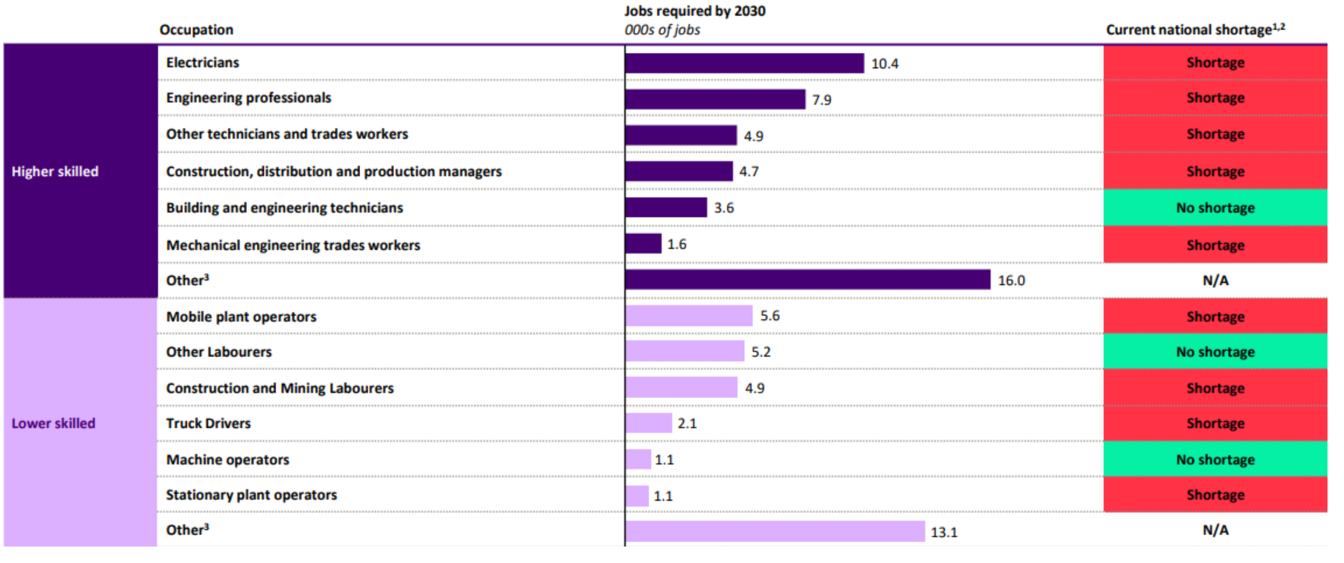


Figure 37: Top Occupations Required in the Renewable Energy Sector by 2030[45]

Table 9: Top Occupations in the Mining Sector 2022[46]

Occupation	2022 FTE
Drillers and Miners	47,500
Metal Fitters and Machinists	25,800
Other Building and Engineering Technicians	17,100
Electricians	11,100
Mining Engineers	9,400
Production Managers	9,300
Truck Drivers	9,200

[45] arena.gov.au/assets/2023/02/skilling-australian-Industry-for-the-energy-transition-accenture-report-for-australian-Industry-eti-phase-3.pdf
[46] labourmarketinsights.gov.au/our-research/employment-projections/

Heatmap of Competition for Skills Across Sectors

The heatmap, presented in Table 10, provides a high-level assessment of the competition for skills facing the O&G decommissioning sector. It covers key phases such as planning, Offshore operations, well servicing, vessel operations, dismantling, hazardous waste handling, and material operations, highlighting the required skills and key competing sectors.

Overall Insights from the Heatmap

The heatmap assessment overall reveals that O&G decommissioning faces moderate levels of competition for skills associated with energy projects projected over the coming decades as well as general labour:

- Vessel operations in O&G decommissioning require a combination of technical capability and an international workforce. O&G decommissioning faces strong competition from Offshore wind for this limited capability. Vessel operations receives a 'red' rating in the heatmap as a result.
- Technical planning skills, including engineering and design, environmental and project management, are highly desired across the Offshore wind, mining, renewables and general economy sectors, given the magnitude of energy projects anticipated near term. Similarly, O&G decommissioning must compete against the mining sectors for skills in dismantling, hazardous waste handling, and material operations. All of these sectors receive a 'yellow' rating across the board.
- In contrast, O&G decommissioning faces more modest competition from other sectors for specialised skills in Offshore operations and construction. Offshore Wind will require expertise in construction Offshore and as such this results in a 'green' rating.
- Overall O&G decommissioning skills may face lower competition from the renewable energy and mining sectors, as the skills requirements of these sectors are more focused on electrical (renewable energy) and geological drillers, fitters and machinists' roles (mining).

Table 10: Capability Heatmap

Offshore Activities	Skills Requirements	Key Competitors	Offshore Wind	Renewable Energy	Mining	Broader Economy
Planning	• Engineering design and construction • Environmental specialists • Project management	There are several other industries that offer similar opportunities for professionals with these skills. For example, the renewable energy sector and in particular Offshore wind. These skills will see competition from all major infrastructure build in Australia more generally.	🟡	🟡	🟡	🟡
Offshore Operations & Construction	• Maintenance and construction trades • Technical specialists	Offshore operations & construction demand a specialised knowledge of Offshore activities, with competitors including Offshore wind operations & construction.	🟡	🟢	🟢	🟢
Well servicing	• Operational and technical well specialists	Specialised wells capability is specific to Offshore O&G operations and project activity. Limited overlap with other sectors.	🟢	🟢	🟢	🟢
Vessel Operations	• Maritime and vessel contractors	Vessel operations involve a mix of vessel size and expertise drawn from both international and local workforces. Offshore wind would be a key competing sector given the competition for similar vessels.	🔴	🟢	🟢	🟢
Dismantling	• Machine operators • Labours	Dismantling often requires labour located across different regions in Australia, rather than concentrated in a single location. Limited additional workforce with competition from mining and the general economy.	🟢	🟡	🟡	🟡
Hazardous Waste Handling	• Hazardous waste specialists	Hazardous waste handling is a specialized field, and the O&G decommissioning should focus on attracting and retaining specialists. There could be some competition from mining decommissioning and hazardous waste generated from the general economy.	🟢	🟢	🟡	🟢
Material Operations	• Labour • Recycling facility operators	These skills sets may face moderate competition from decommissioning of other assets in mining sector and other sectors. However, Australia has current recycling capacity or is expected to grow capacity near term.	🟢	🟢	🟡	🟡

🔴 **Significant competition** 🟡 **Moderate competition** 🟢 **Little to no overlap**

Boosting Workforce Involvement

Female Workforce

Historically the O&G Industry has been male dominated with barriers to female participation including remote working schedules, as well as the sector having a large percentage of engineering roles, of which female participation is generally lower. Increasing the female workforce requires a multifaceted approach and a range of retention strategies could be investigated, including

- Flexible working arrangements accommodating diverse life circumstances (e.g. childcare assistance)
- Promotion of the diversity of Engineering, Science, Technology and Mathematics (STEM) careers, particularly amongst females from as young as primary school age. There is a perceived view by young females that engineering careers are in-field and hands on, whereas engineering careers are diverse from corporate problem solving through to in-field experience
- Provision of scholarships and internships targeted at female participation in education or apprentice level opportunities

Implementing these types of strategies can increase the female workforce and leverage a broader pool of talent in the community. It's important to note that these strategies should be tailored to the specific context of each organisation or project.

Higher Education

Worldwide, a decline in the enrolment for higher education studies of fossil fuel related degrees has been observed in recent times, including petroleum engineering[47]. The comparatively higher salaries in the O&G Industry for petroleum engineers, are observed to no longer be enough to attract interest. This is being attributed to the lifestyle implications and concerns about climate change and the Industry's long-term prospects[48]. Consequently, it has resulted in Australian universities reducing their intake or no longer offering courses in Petroleum Engineering.

Trends in enrolments are a proxy to workforce attraction in general to the O&G Offshore decommissioning sector and is likely to impact meeting decommissioning activity workforce growth if required. As observed in Figure 39, the number of graduates in the United States is predicted to decline to 2025, even with relatively high oil prices, creating pressure on the Industry to attract and retain talent[49]. This is predicted to be similar in an Australian context. In turn this creates increased competition for more traditional degrees including chemical, mechanical and electrical engineering degrees which have more opportunities across various industries.

First Nations Workforce

First Nations demographics are frequently considered in workforce development planning. Within the O&G sector, First Nations people constitute 600 of the 19,000 workers[50], mirroring the representation found in the wider workforce. Given the projected scale of the O&G decommissioning sector, the First Nations workforce would be relatively small; however, targeted initiatives could significantly improve representation.

Promotion of the sector to potential First Nations workers, coupled with broader efforts to promote STEM education, could help increase numbers in the workforce. Additionally, highlighting First Nation businesses to stakeholders in the decommissioning Value Chain presents an opportunity to boost involvement.

There is potential for First Nations businesses and individuals to support key decommissioning activities through other complementary means such as supplying consumables, facilitating business engagement with Acknowledgement to Country and Reconciliation Action Plans and providing logistics and transport services. An increased reference to such organisations may help to promote First nations involvement with key stakeholders along the Value Chain[51].

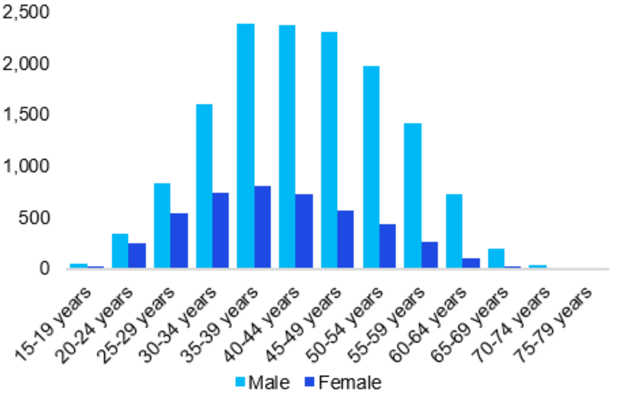


Figure 38: O&G Workforce by Sex and Age group 2021[50]

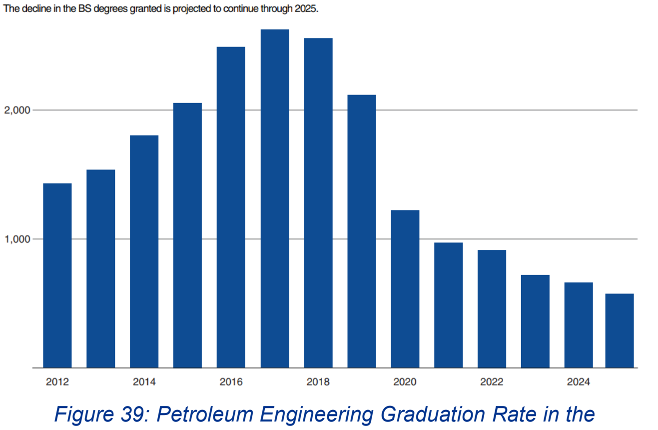


Figure 39: Petroleum Engineering Graduation Rate in the United States[49]

[47] US Petroleum Engineering Graduation Rates – JPT
[48] Big Oil's Talent Crisis: High Salaries Are No Longer Enough - WSJ
[49] Maintaining Petroleum Engineering Education to Support the Energy Mix of the Future – JPT
[50] Australian Bureau of Statistics 2021 Census
[51] Supply Nation | Australia's largest national directory of Indigenous businesses

Regional Workforce

Boosting regional workforce participation necessitates an understanding of local supply chain opportunities within the O&G decommissioning sector. While engineering and design clusters critical to the O&G decommissioning Industry are often scarce in regional areas, there exist clusters of blue-collar workers who could be engaged in the supply chain (e.g. waste management, port, logistics and support services for offshore activities).

To leverage regional supply chain strengths, it is imperative to provide training programs with curricula tailored to the needs of the O&G decommissioning sector, along with partnerships offering practical training, such as apprenticeships. Establishing clear career advancement pathways can also attract and retain a regional workforce. Better understanding where there is the potential for workforce growth will allow targeted strategies.to be implemented to drive regional economic growth.

Attraction Narrative

O&G companies have not historically needed to create a narrative to attract a greater workforce pool. Historical high oil prices, good salaries and a global career have made the sector very competitive and attractive. Sentiment has now changed, and the O&G sector needs to consider a narrative involving the role of gas in providing reliable and affordable energy and commodities. The decommissioning sector more specifically, has an opportunity to link decommissioning activity to being a positive contribution towards lowering emissions in a safe and effective way, a value that many Australians today are looking for in careers.

Next Steps

To deepen insight, next steps could include collection of detailed data to understand O&G decommissioning workforce needs on a more granular basis. This activity is best timed when decommissioning timelines and volumes are better understood, given the levels of uncertainty existing today. For example, primary research, surveys and data-driven analyses is recommended to better understand the number of workers required for O&G decommissioning and their likely skill profile.

Further data gathering and analysis may also assist in identifying potential challenges facing the sector in attracting and retaining a suitably skilled workforce. For example, it could provide insight into relevant experiences and motivations for working in the sector, or potential barriers such as perceptions of the O&G decommissioning sector longevity and vision of housing / Fly-In Fly-Out (FIFO) arrangements.

Given a lack of public data, Government and Industry can work collaboratively to assess potential workforce demand and supply. This assessment would include more detailed workforce planning and supply/demand profiling, considering both local and international context. It would also identify gaps in local capability and develop collaboration with stakeholders and Institutions to build necessary expertise. This collaboration can encourage deliberate actions to address workforce challenges and capitalise on emerging opportunities.

Key Takeaways

Fluctuations in the O&G decommissioning sector workforce

The size of the O&G sector's decommissioning workforce is expected to fluctuate by as much as 800 workers between peak periods, due to timing of the end of Offshore assets' useful lives. The workforce requirement profile carry's uncertainty, and is significantly impacted by asset decommissioning timing, removal approach and asset removal vs in-situ decisions.

Noting this uncertainty, it is thought to be unlikely that a peak demand scenario will occur due to assets being decommissioned in parallel. This is because of the need to mobilise special vessel capability, of which there is limited global supply. It is most likely that one specialised vessel at any given time, will mobilise to the region for a campaign, driving the pace of decommissioning activity.

The workforce profile within this study is an absolute view rather than a net view. Stakeholders across the Value Chain held an optimistic sentiment on workforce readiness despite the challenges in attracting new talent, as they look to utilise current workforce in the O&G, dismantling and recycling industries. Little to moderate growth in workforce is expected.

Competition from other industries for labour

Roles such as engineering, environmental specialists, project management, vessel contractors, labour and construction workers are in demand in other industries such as Offshore wind, mining and renewable energy infrastructure build. Other key skills in demand for these sectors, such as electrical professionals, truck drivers and drillers / miners, have little demand in O&G decommissioning.

Further detail is required on workforce

More detailed workforce data is required for further accuracy and insight. This activity is best timed when decommissioning timelines and volumes are better understood, given the levels of uncertainty existing today. This includes a greater level of engagement with stakeholders across the Value Chain to survey data unavailable for this analysis, as well as to better understand workforce attraction barriers. With deeper insight on workforce needs and barriers, targeted strategies can be developed to boost female, First Nation and regional workforce involvement.

Moving Forward

In the development of this Study and in consultation with stakeholders, common themes and specific activities have been identified that would be suitable for further consideration.

It's acknowledged the important role CODA has played in recent years, promoting and advancing Australia's O&G decommissioning profile. CODA will continue to provide an important leadership role for O&G decommissioning success in Australia and together with Government, Regulatory, Industry and Community stakeholders, can continue to advance best practice learning, legislative and regulatory reform, drive efficiency, innovation and success along the Value Chain.

Stakeholders' Insights on Incremental Beneficial Actions

- Have educational sessions to stakeholders on the recycling opportunities that could exist in Australia.
- Enable investment and viability to secure smaller Onshore players to make their operations sustainable across the Value Chain.
- Develop connections in adjacent industries, enabling opportunities in reuse and shared infrastructure.
- Showcase on international platforms, how to navigate the perceived challenging regulatory landscape in Australia.


Offshore Platform

- Partner globally with Government and Industry (e.g. UK) to accelerate Australian learnings and provide an Australian view.

The three key themes that emerge for a thriving decommissioning journey:

Promote Best Practises

Collaborative peer support and highlighting Industry and regulatory best practice within the Australian context.

Achieve Efficiency

Optimised and streamlined regulatory and process practices tailored to Australian O&G decommissioning.

Drive Innovation

Opportunities to incentivise innovation to meet the demand locally.

Key Takeaways

This Study and our engagement with stakeholders has identified consideration of next steps for each of the key questions. Government, Industry, regulators and stakeholders are engaged and want to drive towards a more cost effective, environmentally conscious and efficient Value Chain. However, progress at pace is required and support in collaboration and driving discussion across the Value Chain on key challenges would be beneficial.

	Key Questions	Recommended Next Steps
1.	What is the anticipated quantity of material arriving Onshore?	**Tailored Decommissioning Framework** The current regulatory landscape is not tailored to the unique characteristics of decommissioning and no single authority holds an end-to-end view of decommissioning activities. A fast-tracked change to better tailor regulatory frameworks to decommissioning would drive clarity on volumes, efficiency and optimised cost and environmental outcomes.
2.	How might the availability of vessels influence costs for operators?	**Campaign Enablement** Consideration to further supporting collaboration amongst Operators for “campaign” approaches to decommissioning would be beneficial. The consolidation of decommissioning activity should enable attraction of international vessels at a competitive price, providing the additional benefit to Operators of a lower cost per tonne for Offshore decommissioning activities. Coordination support for operators would alleviate concerns regarding perceived anti-trust risks while also ensuring optimisation for successful decommissioning and promote a common supply chain to be established across Offshore activities, transport, ports and waste management.
3.	Given current state port infrastructure constraints, which port will be selected for Offshore Decommissioning?	
4.	How can we address the lack of recycling transparency and reporting to drive recycling initiatives?	**Develop Materials Performance Transparency for Decommissioning** Development of guidance for material hierarchy performance reporting through regulatory and industry collaboration would drive recycling and circular economy outcomes for Australia, which in turn drives technologies and a recycling industry.
5.	What strategies can be employed to boost demand for local steel and plastics manufacturing?	**Drive Australian Demand for Local Steel and Plastics** At present, exporting steel and plastics from Australia is more financially lucrative, and without intervention, it is improbable that domestic demand will rise. Exploring incentivisation measures to encourage the local adoption of recycled steel and plastic can be considered to stimulate market growth.
6.	In what ways can legislation be tailored to address unique challenges specific to Australian Decommissioning?	**Tailoring Removal Framework** Drive a regulatory framework that is optimised across the end-to-end Value Chain of decommissioning activities, using insights from international best practice and stakeholder consultation. Leaning on globally matured practises, the nuances of decommissioning activity could be incorporated into the regulatory landscape. As also noted by CODA, multi-agency regulatory working groups to share lessons and bring an aligned view to a change in process or legislation can be beneficial.
7.	While stakeholders express optimism about workforce readiness, can these sentiments be translated into actionable plans at the scale required for success?	**Detailed O&G Decommissioning Workforce Analysis** More detailed workforce data is required for further accuracy and insight. This activity is best timed when decommissioning timelines and volumes are better understood, given the levels of uncertainty existing today. This includes a greater level of engagement with stakeholders across the Value Chain to survey data unavailable for this analysis, as well as to better understand workforce attraction barriers. With deeper insight on workforce needs and barriers, targeted strategies can be developed to boost female, First Nation and regional workforce involvement.

APPENDICES

Part 2

APPENDIX A
Adjacent Industry Study

Part 2

Adjacent Industry Study

	Wind	Hydrogen	CCUS
Newcastle Harbour	Preliminary plans for an offshore wind staging berth	Preliminary plans in place for clean energy precinct including hydrogen export	Preliminary plans in place for clean energy precinct including carbon capture technology
Port Kembla	NSW ports has unveiled plans to construct an Offshore wind port facility to support proposed Offshore wind projects[7]	There is a hydrogen production plant and refuelling station within BlueScope Port Kembla steel works site[52]	
Barry Beach	Identified as a good base for support operations for OSV support[56]	Port Anthony, next to Barry Beach, has been identified as a potential green hydrogen base[53]	Potential to support bass strait CCUS operations if it becomes viable
Port of Hastings	Plans announced for a Victoria Renewable Energy Terminal to support the State Government's commitment to deliver 9GW of Offshore wind energy by 2040[7]	Preliminary plans for a hydrogen liquefaction and shipping facility[54]	Potential to support bass strait CCUS operations if it becomes viable
Bell Bay	Some interest to support operations	Hydrogen hub planned[55]	Potential to support bass strait CCUS operations if it becomes viable
Port of Adelaide			
Whyalla		Port Bonython, 16km north of Whyalla, has plans for a hydrogen export facility[57]	
Port of Darwin		Plans for a Darwin hydrogen hub at Middle arm facility[58]	Potential to support Bonaparte CCUS operations[59]

[7] Offshore O&G Decommissioning Supply Chain – Part 1, the Current State Report
[52] Port Kembla Hydrogen Refuelling Facility (csiro.au)
[53] New hydrogen facility
[54] Port of Hastings – HESC
[55] Tasmania's Green Hydrogen Hub Vision (stategrowth.tas.gov.au)
[56] Star of the South identifies five ports to support Australia's first offshore wind farm
[57] Port Bonython export hub | Energy & Mining
[58] Middle Arm Sustainable Development Precinct | Department of Infrastructure, Planning and Logistics
[59] Carbon Capture Utilisation and storage | Our Territory Gas Strategy (nt.gov.au)

APPENDIX B
HDPE Potential Pathways

Part 2

Pathway 1 – Exporting

Visualisation of Pathway 1 – Export

Sorting & Cutting	Transporting to Recycling Facility	Pelletising	Transporting to Port	Shipping to South East Asian Port	Transporting to Manufacturing Facility

Figure 8: Visualisation of Pathway 1 – Export

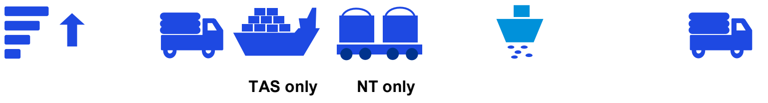
Pathway 1 – Stages of Material Handling depending on Disposal Location

Victorian Port	Northern Territory Port	Tasmanian Port
Mixed plastic material unloaded at Victorian Port	Mixed plastic material unloaded at Northern Territory Port	Mixed plastic material is unloaded at Tasmanian Port
HDPE sorted from other plastics and cut and loaded into HGV	HDPE sorted from other plastics and cut and loaded into freight train	HDPE is sorted from other plastics and cut and loaded into HGV
Truck transports HDPE to recycling facility	Train transports HDPE to WA rail terminal	Truck transports HDPE to container port
HDPE unloaded and processed into pellets	HDPE loaded in HGV and transported to recycling facility	HDPE is unloaded from HGV and loaded into container vessel
HDPE pellets loaded into HGV and transported to port	HDPE unloaded and processed into pellets	HDPE is shipped to Victorian port
HDPE pellets loaded to container vessel	HDPE pellets loaded into HGV and transported to port	HDPE pellets loaded into HGV and transported to port
HDPE pellets shipped to South East Asia Port	HDPE pellets loaded to container vessel	HDPE pellets loaded to container vessel
HDPE pellets unloaded and loaded on to HGV	HDPE pellets shipped to South East Asia Port	HDPE pellets shipped to South East Asia Port
HDPE pellets transported to manufacturing facility	HDPE pellets unloaded and loaded on to HGV	HDPE pellets unloaded and loaded on to HGV
	HDPE pellets transported to manufacturing facility	HDPE pellets transported to manufacturing facility

Pathway 2 – Domestic Consumption

Visualisation of Pathway 2 – Domestic Consumption

Sorting & Cutting	Transporting to Recycling Facility	Pelletising	Transporting to Manufacturing Facility



Pathway 2 – Stages of Material Handling

Victorian Port

1. Mixed plastic material unloaded at Victorian Port
2. HDPE sorted from other plastics and cut and loaded into HGV
3. Truck transports HDPE to recycling facility
4. HDPE unloaded and processed into pellets
5. HDPE pellets loaded into HGV and transported to manufacturing facility

Northern Territory Port

1. Mixed plastic material unloaded at Northern Territory Port
2. HDPE sorted from other plastics and cut and loaded into HGV
3. Truck transports HDPE to container port
4. HDPE unloaded from HGV and loaded into container vessel
5. HDPE shipped to Victorian port
6. HDPE loaded in HGV and transported to recycling facility
7. HDPE unloaded and processed into pellets
8. HDPE pellets loaded into HGV and transported to manufacturing facility

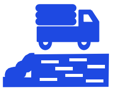
Tasmanian Port

1. Mixed plastic material is unloaded at Tasmanian Port
2. HDPE sorted from other plastics and cut and loaded into freight train
3. Train transports HDPE to WA rail terminal
4. HDPE loaded in HGV and transported to recycling facility
5. HDPE unloaded and processed into pellets
6. HDPE pellets are loaded into HGV and transported to manufacturing facility

Pathway 3 – Landfill

Visualisation of Pathway 3 – Landfill

Transporting to Landfill



Pathway 3 – Landfill

All Ports

Mixed plastic material unloaded at port

↓

Waste is loaded into HGV and transported to landfill

↓

Waste is unloaded from HGV into landfill

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APPENDIX C
UK Decommissioning Program Template

Part 2

UK Decommissioning Program Template

November 2018
Version 3

Offshore Petroleum Regulator
for Environment & Decommissioning
Replace with operator logo and picture of asset

Standard Decommissioning Programme(s) Template

(Non-Derogation)

Insert date
Consultaion/pre-draft

Offshore Petroleum Regulator
for Environment & Decommissioning

1 EXECUTIVE SUMMARY

1.1 Decommissioning Programme/Combined Decommissioning Programmes

This document contains ______ decommissioning programme(s) for ______installation(s) and _______ pipeline(s).

Combined Decommissioning Programmes: Please provide a clear statement confirming that there is a separate programme for each set of associated notices served under Section 29 of the Petroleum Act 1998.

1.2 Requirement for Decommissioning Programme(s)

Delete appropriate paragraph below if only one decommissioning programme.

Installation(s):
In accordance with the Petroleum Act 1998, the Section 29 notice holders of the _______________ installation(s)/field (see Table 1.2) are applying to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) to obtain approval for decommissioning the installations detailed in Section 2.1 and 2.2 of this programme. (See also Section 8 - Partner Letter(s) of Support).

Pipeline(s):
In accordance with the Petroleum Act 1998, the Section 29 notice holders of the _______________ pipelines (see Table 1.4) are applying to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) to obtain approval for decommissioning the pipelines detailed in Section 2.3 of this programme. (See also Section 8 – Partner Letter(s) of Support).

In conjunction with public, stakeholder and regulatory consultation, the decommissioning programme(s) is/are submitted in compliance with national and international regulations and OPRED guidelines. The schedule outlined in this document is for a _____ year decommissioning project plan due to begin in _______________.

1.3 Introduction

Insert introductory paragraphs outlining the background of the decommissioning proposal with information on topsides, jacket and pipelines (where applicable). Freeform text as per example paragraphs below. (Suggested maximum of 250 words)

The Welland Field is located in the Southern Basin of the UKCS in license block 53/4a. Welland was discovered in 1983 and consists of three gas reservoirs with condensate traces. It received Annex B approval in 1989 for a single platform remotely operated from Thames platform. The platform was installed, and production started in 1990. Production ceased in 2003 due to excessive water rates and equipment failures. Cessation of Production notification was submitted in 2004.

Welland Platform is a 1000 Te topside minimum facilities structure in 37m water depth. It was designed and operated as a normally unattended satellite installation. Gas was exported to the nearby Thames complex. Subsea tie-backs to 3 remote wells comingle with production from the 2 platform wells.

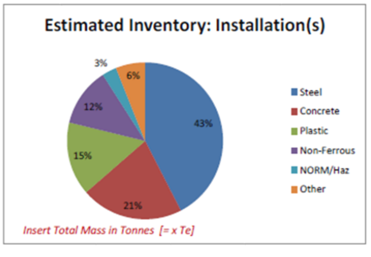
Following public, stakeholder and regulatory consultation, the decommissioning programme(s) is/are submitted without derogation and in full compliance with OPRED guidelines. The decommissioning programme(s) explains the principles of the removal activities and is supported by an environmental appraisal (EA).

Offshore Petroleum Regulator
for Environment & Decommissioning

2.6 Inventory Estimates

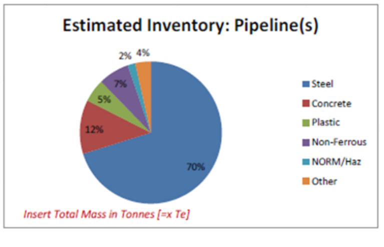
Provide a table or graph (see pie chart example shown) giving the inventory estimates for the decommissioning programme(s) contained in this document. Refer to tables or data in the supporting Environmental Appraisal. Please list the inventories in both tonnage and percentage.

Figure 2.1: Pie Chart of Estimated Inventories (Installations)



Reference the Environmental Statement for detailed data.
NORM/Hazardous Waste - reference the supporting evidence in EA.

Figure 2.2: Pie Chart of Estimated Inventory (Pipelines)



Reference the Environmental Statement for detailed data
NORM/Hazardous Waste – reference the supporting evidence in EA.

Link to template - Non_Derogation_Decommissioning_Programme_Template_-_November_2018.pdf (publishing.service.gov.uk)

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Contact us

Partner
James Arnott
Mobile: +61 418 281 752
Email: jamesarnott@kpmg.com.au

Director
Erin Wild
Mobile: +61 437 984 699
Email: ewild2@kpmg.com.au