Construction and Demolition Waste Management in Australia

Final Industry Report, Project 1.65

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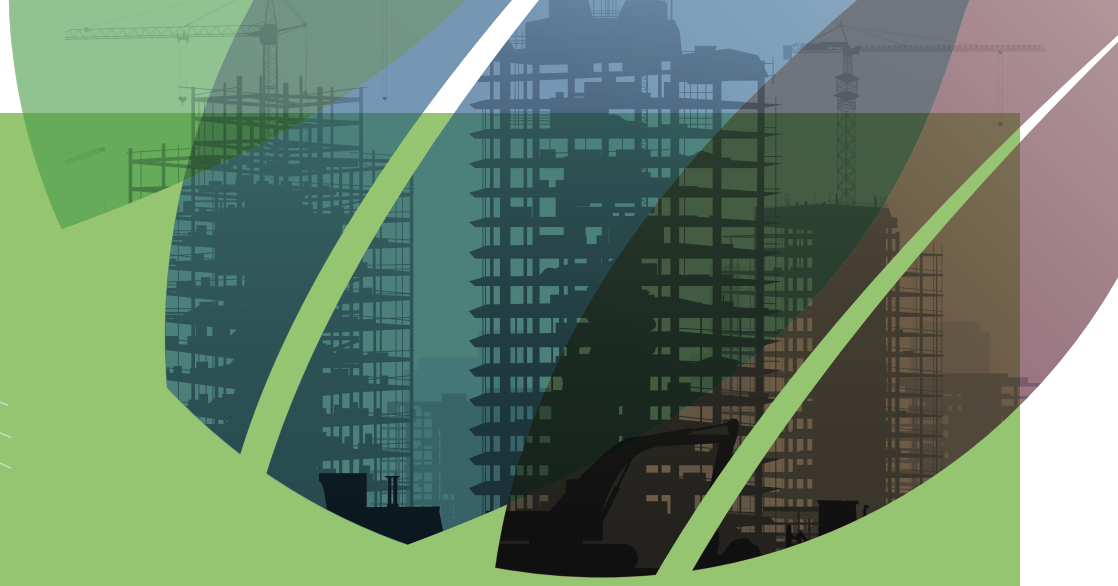
This research would not have been possible without the ongoing support of our core industry, government and research partners.



Message from the Chair

The project focused on the management of construction and demolition waste nationally and the capacity and opportunity to address economic barriers and drivers to national harmonisation. In my opinion, the real strength of this project was the ability to bring together industry, government and academia to look at how we solve issues and challenges with construction development. It was also a great opportunity to help the waste management and resource recovery industry by highlighting what is the largest waste stream in Australia and the ways to deal with this not at the end of the pipeline but at the outset, in how we can design differently to reduce waste materials or make them re-usable.

Gayle Sloan, CEO, Waste Management and Resource Recovery Association of Australia

Preface

The Sustainable Built Environment National Research Centre (SBEnrc), the successor to Australia's Cooperative Research Centre for Construction Innovation, is committed to making a leading contribution to innovation across the Australian built environment industry. We are dedicated to working collaboratively with industry and government to develop and apply practical research outcomes that improve industry practice and enhance our nation's competitiveness. We encourage you to draw on the results of this applied research to deliver tangible outcomes for your organisation. By working together, we can transform our industry through enhanced and sustainable business processes, environmental performance and productivity.

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Executive Summary

A holistic national approach is required to handle the growing issue of construction and demolition (C&D) waste in Australia. Through this project, the discrepancies and inconsistencies related to C&D waste management regulations in each jurisdiction were identified, and recommendations for harmonising reforms were made accordingly. The specific objectives were:

1. Review regulations and their application in practice in different jurisdictions governing C&D waste management, identifying discrepancies and making recommendations for reforms.
2. Develop a consistent approach to define and measure C&D waste across different jurisdictions.
3. Identify economic factors that govern the disposal and reduce/reuse/recycling of C&D waste.
4. Conduct a feasibility study on creating a marketplace to connect organisations and industries across jurisdictions for trading waste.
5. Identify opportunities to integrate supply chains and develop an integrated supply chain lifecycle model espousing a cradle-to-cradle approach.

Comprehensive analysis of literature, regulations, policies and best management practice guidelines are the basis for results presented here. Notably, desktop research focused on the regulatory framework in eight jurisdictions of Australia was conducted to understand their similarities and inconsistencies. According to this review, several recommendations were made that are both national and state-specific. Furthermore, economic barriers and enablers towards the establishment of a domestic C&D waste market were explored, and a set of recommendations were proposed accordingly. Subsequently, a comprehensive review was performed to know the Australian and worldwide experience in the establishment and performance of the C&D waste market.

Furthermore, an economic evaluation was conducted based on the mathematical modelling of various C&D waste management techniques (landfilling vs. recycling). In this evaluation, the economic performance of these waste management methods was analysed and compared, while keeping associated costs in mind. Next, a case study approach was adopted to analyse and identify opportunities for reducing C&D waste throughout the supply chain of five typical construction materials — brick, concrete, glass, timber and steel. For each case study, a conceptual model, called LowMor (Low of Waste More of Resources) was developed to picture the application of cradle to cradle approach to C&D waste management in the light of circular economy principles. Lastly, a survey was conducted to capture the perception of main stakeholders of C&D waste management on the relevant issues and reforms. The survey captured the responses from 132 participants who were based across Australia. Participants were active in the construction industry, waste management and recovery industry, waste collectors, designers and the construction material manufacturing industry at the time of the survey. An important finding from the study was to seriously consider the development of a domestic marketplace for trading C&D waste in Australia. Overall, the project findings contribute to Australia's understanding of effective management of C&D waste by providing a clear picture of C&D waste state of play and how it can improve. The findings can be further analysed and used by policymakers and whoever has an interest in C&D waste to better plan for innovative and efficient C&D waste management resulting in the further diversion from landfilling.

Introduction

The construction industry in Australia has grown significantly in the past two decades in the wake of population growth, migration and expansion in the tertiary education industry. The growing population has necessitated extensive property development, better public transport and improved infrastructure. Analysis of different construction subdivisions reveals a constant annual growth rate.

For instance, the historical data from the Australian Bureau of Statistics (ABS) indicates that the value of work done in building construction activities had progressively increased by 33% from 2012 to 2018. In the Heavy and Civil Engineering Construction subdivision, the annual revenue was estimated to be $394.3 bn, which provided over 1 million jobs in Australia. Road and bridge construction was recorded to have benefited 5.3% in annual growth and $28.9 bn revenue (IBISWorld, 2019a). In the construction engineering sector, the annual value of work commenced (all subdivisions) had an average annual growth rate of 19.9% from 2015 to 2018 (June) (ABS, 2018a). This increase is reported to be significantly larger in some states such as Victoria (up to 80%) and Western Australia (39%). All these activities have resulted in substantial growth in construction and demolition (C&D) waste that needs to be sustainably managed. Despite a high rate of C&D waste diversion from landfill, there is still room for improvements.

Aim

The project aimed to develop national-level understanding and recommendations for harmonisation of economic drivers across jurisdictions governing the disposal and reuse/recycling of construction and demolition (C&D) waste. This enables closing the loop through an integrated and shared understanding across Australia and informed by international best practice.

Industry motivation

The construction and waste management and resource recovery industries are advocating for harmonisation of C&D waste management systems in Australia. The move towards harmonisation clearly has not achieved the desired outcome. The inconsistency in landfill levies across different jurisdictions exacerbates the problem, as organisations can transport their waste across borders. This is just shifting a problem to a different place and does not resolve the critical national industry issue. The industries involved in C&D waste management and resource recovery need a complementary approach which considers market-driven strategies along with command–and–control regulation, where it makes economic sense to minimise fresh extraction and reduce, reuse or recycle C&D waste material more. It can be achieved by identifying the economic factors and financial incentives that affect C&D waste material management and leading change across jurisdictions rather than seeking to resolve the issue only from a technical perspective.

Objectives

1. Review regulations and their application in practice in different jurisdictions governing C&D waste management, identifying discrepancies and making recommendations for reforms.
2. Develop a consistent approach to define and measure C&D waste across different jurisdictions.
3. Identify economic factors and drivers that govern the disposal and reduce/reuse/recycling of C&D waste.
4. Conduct a feasibility study on creating a marketplace to connect organisations and industries across jurisdictions for trading inevitable waste.
5. Identify opportunities to integrate supply chains and develop an integrated supply chain lifecycle model espousing a cradle-to-cradle approach.

Jurisdictional Regulations: Discrepancies and Applications

Jurisdictional Regulations: Discrepancies and Applications

C&D waste policies and regulations are mostly developed at the state and territory level. The waste management hierarchy is the primary notion that underpins waste strategies followed by Australian jurisdictions. The waste hierarchy is a universally accepted concept used to prioritise and guide efforts to waste generation and management. This framework, as shown in Figure 1, contains six levels of waste management.

The following sections outline the discrepancies in different state and territories in relation to C&D waste management. The first discrepancy is the variation in the number and type of agencies involved in policymaking and authorising waste management practices. Historically, the main authority to regulate C&D waste has been the various jurisdictions' Environmental Protection Authority (EPA). Gradually, the EPAs have engaged other specialised agencies in the process of decision-making, policies and strategies development (Figure 2).

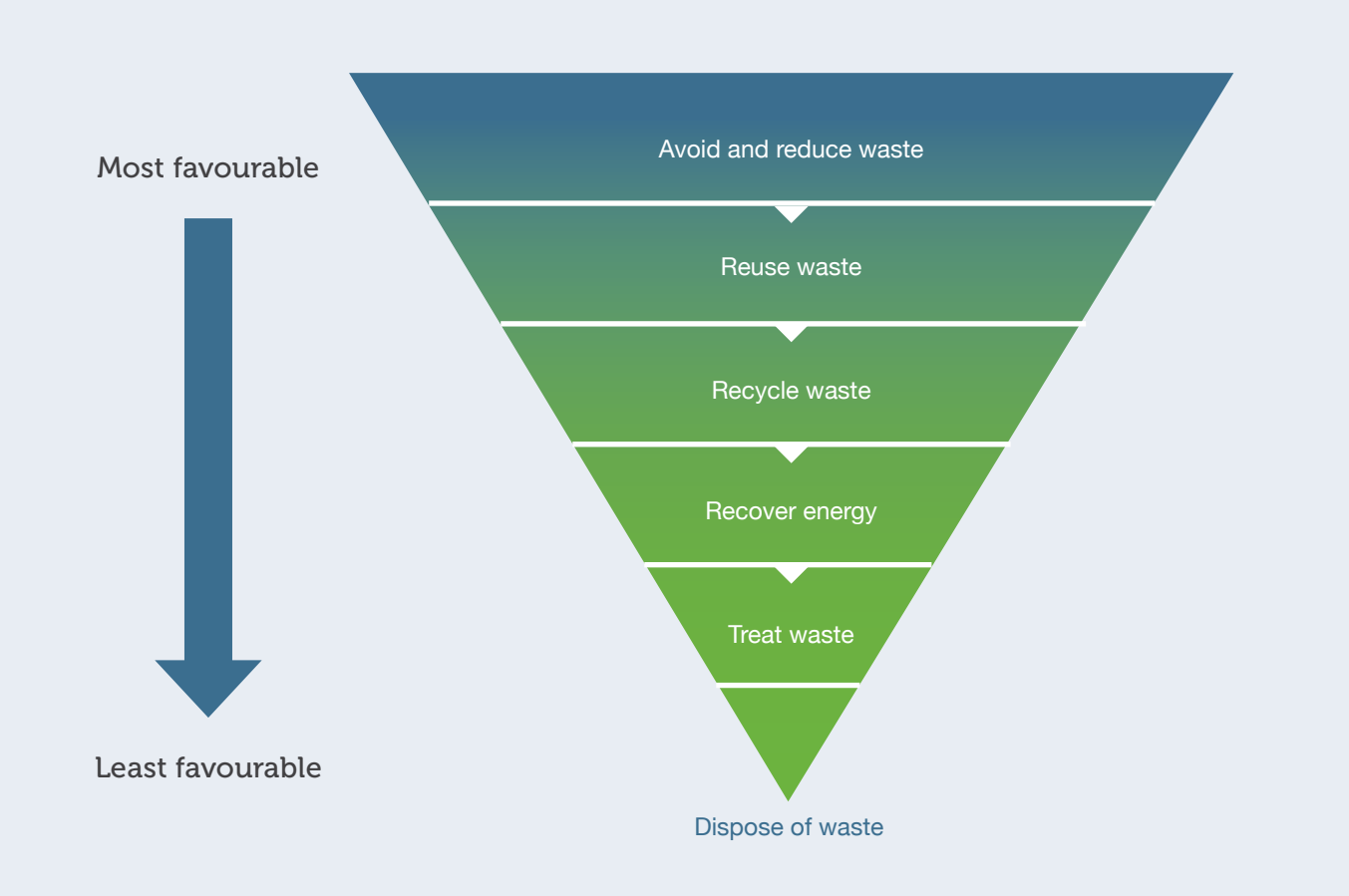


Figure 1. Waste hierarchy adopted by waste strategy documents across Australia

Figure 2. Organisations that contribute to C&D waste management in different Australian states and territories

The second discrepancy is the recycling target rate. The first step to moving towards less waste disposal is to set a target rate for recycling. Statistics indicate that the recycling rate has increased at a slow pace in Australia, with an annual growth rate of three per cent during the last decade. Among the jurisdictions, the Northern Territory (NT), Tasmania (Tas) and Victoria (Vic) have not specified any target for C&D waste recycling. The remaining jurisdictions have set a target — although, in some cases (for example, Queensland (Qld)) it seems too ambitious to be achieved (75 per cent). Currently, only South Australia (SA) has already achieved the target rate (90 per cent) that was set for 2020; this state has the highest C&D waste recycling rate (91.1 per cent), followed by Vic (82 per cent).

The results of the review of jurisdictional waste management systems and policies demonstrated inconsistencies in the management of landfills in Australia. The discrepancies were evident in variations in levy tax imposition, design of landfill sites, the complexity of waste disposal requirements, waste classification methods and standard waste treatment performed in each jurisdiction. These inconsistencies for regulating landfilling activities have impeded the productive and environmentally sensitive management of waste in Australia.

The other significant discrepancy is the imposition method of the landfill levy in various jurisdictions. Except for NT and Tas (voluntary levy scheme), all other Australian jurisdictions have introduced landfill levies (Figure 3); however, the taxes are imposed differently. The differences originate in the distinction between metropolitan areas and regional areas (except for Qld and WA) and levy rates being obligatory as opposed to voluntary and having or not having levy zones.

Legislators in Australia's jurisdictions have set different penalty fees for illegal waste dumping and stockpiling. The most severe penalty is being applied in New South Wales (NSW), where offenders can face up to $5 million and/or seven-years' imprisonment. This is followed by the penalties in NT, Tas and the Australian Capital Territory (ACT), which are $5 million (+/five-years' imprisonment), $1.59 million (+/five-years' imprisonment) and $1 million (+/seven-years' imprisonment), respectively. The next lowest penalty fees are charged in SA (up to $30,000), WA (up to $125,000), Qld (up to $217,000) and Vic ($775,000).

In Australia, there is no nationally prescribed method for distribution of levies revenue and each state government distributes according to its priorities and the objectives outlined in its waste strategy document. Hence, creating a national standard practice may enhance C&D waste management in Australia.

In Australia, re-use of recycled materials is strongly encouraged under ecologically sustainable development and sustainable procurement programs. In 2012, the SA Government was the first authority to release a Sustainable Procurement Guideline.[1] Some other states followed suit: ACT[2] (2015), NSW[3] (2017) and WA[4] (2017). Then in 2018, the federal government released the first Australian guideline.[5]

Another discrepancy exists relating to the development of a statewide resource recovery infrastructure plan. According to Principle 2 of the National Waste Policy (NWP) 2018[6] (improve resource recovery), for improvements in recycling and resource recovery, Australia relies on the right infrastructure, economically sustainable facilities and fair rules. However, among the jurisdictions (at the time of writing this report), only two states have developed such a plan: SA and Vic. The other jurisdictions are either in the process of developing such a plan or simply do not have one. Victoria is the first state in Australia to release a statewide infrastructure plan.

[1] SA Government. 2012. Sustainable Procurement Guideline.
[2] ACT Government. 2015. Sustainable Procurement Policy 2015.
[3] NSW Government. 2017. Sustainable Procurement Guide for Local Government in NSW.
[4] WA Government. 2017. 2017 WALGA Guide to Sustainable Procurement.
[5] Commonwealth of Australia 2018. Sustainable procurement guide
[6] National Waste Policy. 2010. Less Waste, More Resources, p. 14.

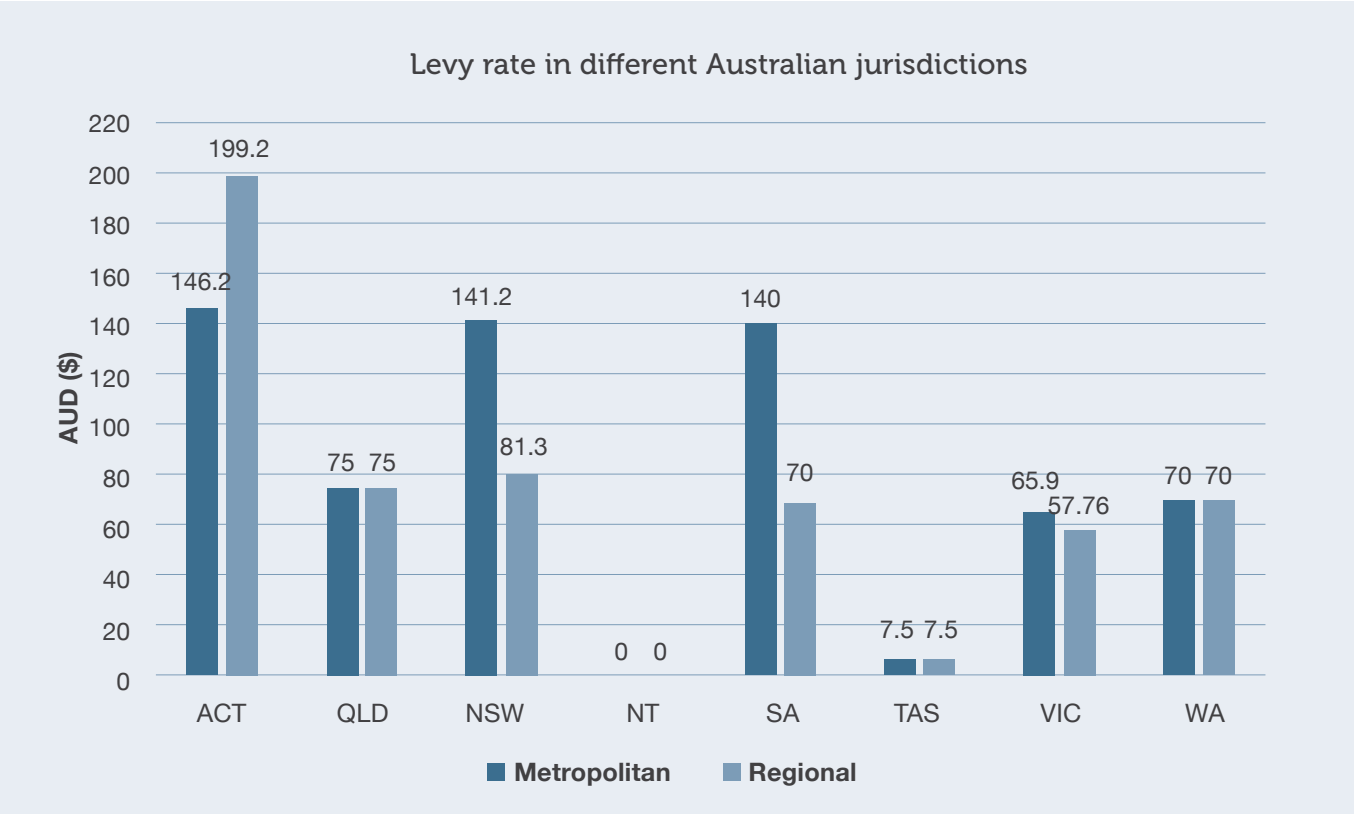


Figure 3. Levy fees for C&D waste disposal in different states and territories
Source: EPA in each of Australia's states and territories. July 2020.

Definition and Classification of C&D Waste

Definition of waste

Although the NWP 2010 set an objective to develop the national definition of waste under Strategy 4 (national classification system for waste), to date there is no consistent definition for general waste or C&D waste specifically. Defining waste is not an easy task, and there is no single domestic or international definition. The definition of waste can decide when a material is a 'waste', a 'product' or a 'resource'. In Australia, despite there being general similarities among definitions of C&D waste, each jurisdiction uses specific wording and practical applications. The definition of general waste is provided in the EPA-administrated legislation in different jurisdictions. The majority of definitions include some common elements, such as waste status (for example, unwanted, discharged, abandoned or emitted), waste substance (for example, gas, solid or liquid) and intended subsequent use (for example, re-use, recycle or recover). The differences include the source of waste (for example, commercial, demolition) and potential harm to the environment (alteration of the environment).

The definition of C&D waste in the various jurisdictions, however, is not straightforward. C&D waste is simply defined in the NWP 2018[7] as 'waste produced by demolition and building activities, including road and rail construction and maintenance, and land excavation associated with construction activities' (p. 17). Among the jurisdictions, only WA and NSW provide a specific definition for C&D waste in EPA-administrated Acts and regulations. Other jurisdictions refer to definitions that are loosely presented in other documents, such as state/territory waste strategy documents. In Tas there is no definition found for C&D waste in any of its waste-related publications. NSW has provided a comprehensive definition in which a broad range of construction and demolition activities and materials specifications are covered, as well as their potential environmental impact. The WA definition provides a concise statement that only includes three types of construction activities.

Definition of clean fill

The other inconsistency found among jurisdictions is the definition of clean fill. Generally, clean (waste) fill comprises uncontaminated (reprocessed) soil, sand or rock produced during excavation and used to level off construction sites prior to construction. In Qld, this material is not deemed waste. Therefore, its re-use would not be recognised as waste disposal, and there is no liability for landfill levy. However, in other jurisdictions, this material is regarded as waste.

Some jurisdictions have not established a clear definition for clean fill (ACT, NT and Vic). Moreover, among those that have, the definitions differ. There is a need to harmonise this definition should other jurisdictions decide to exclude it from the definition for waste. Clean fill is termed as 'waste fill' in SA, 'clean earth' or 'clean earthen material' in Qld, and 'virgin excavated natural material' in NSW.

Waste classification

One of the differences in the operation of landfill facilities is the method by which the incoming waste is classified, accepted or treated. Jurisdictional Acts and regulations determine the waste classification. Similar to the definition for waste, the way that waste is classified has a significant impact on many aspects of waste management. Currently, national level policies advocate a classification that is based on three main streams: C&D, commercial and industrial (C&I) and municipal solid waste. Yet this classification has not been used in waste-related regulations in some jurisdictions, with other criteria (for example, properties and the level of risk they may impose) used to classify waste instead.

Also, there are different classification systems established in each of the jurisdictions. These different systems are carefully applied to cover various waste pathways including collection, transport, treatment, recovery and disposal. Moreover, different authorities may have different classification systems in place. Even in one state, two

[7] National Waste Policy. 2018. Less Waste. More Resources. In: Government, A. (ed.).

organisations contributing to waste management can follow varying waste classification systems, which creates confusion and hinders effective implementation of waste strategies. For instance, in Vic, Sustainability Victoria (SV) follows the NWP 2010 classification, which is different from the three categories proposed by EPA Victoria.[8] EPA Victoria has published a guideline (Industrial Waste Resource Guidelines Waste Categorisation) in which the categorisation system in Vic is detailed.

When a waste ceases to become waste

In the NWP 2018, the concept of 'a waste is not always waste' is promoted in the 'Waste as a Resource – the Circular Economy' section (p. 11). The results of the review of strategies and regulations show that – aside from Qld, NSW and SA – other jurisdictions have largely not adopted the NPW 2018 notion (waste as a resource). In Qld, under the Waste Reduction and Recycling Act 2011 (Chapter 8), the End of Waste[9] framework is proposed to promote resource recovery opportunities and aims to shift the common perception from 'waste is always waste' to it being valued as a resource.

Waste recycling residuals

Currently, under all jurisdictional regulations, the residuals of waste recycling facilities are considered as waste, and thus facility owners are liable for a landfill levy. However, there are requests from the construction and waste recovery industries to change the fact that these residuals are still considered as waste in relevant regulations. Many waste management and resource recovery professionals state that a levy on the disposal of recycling residuals reduces the competitiveness of materials sold into the international market.

Reforms

Due to their complex nature, these suggestions can only be implemented through coordinated decision-making processes supported by all states and territories. To achieve this, environment ministers at all levels of government should meet regularly and reach an agreement that:

a) aligns the waste-related classifications used for reporting purposes and landfilling activities to remove inconsistencies

b) provides consistency in resource exemptions and separation between 'resource' and 'waste', to remove confusion in the definition of general waste and C&D waste as provided by NWP 2018

c) establishes a robust and consistent national waste data management system that facilitates the assessment of the application of waste-related strategies, policies, laws and business transactions in different jurisdictions

d) provides consistent guidelines for waste auditing that are applicable throughout Australia.

[8] Hyder. 2012. Waste Definitions and Classifications: Report on Issues, Opportunities and Infromation gaps. Hyder Consulting Pty Ltd.

[9] Waste Reduction and Recycling Act 2011.

Economic Barriers and Drivers of Effective Waste Management

Several research studies have argued that market-based strategies should inform C&D waste management. These strategies, which include incentives and penalties, help companies, organisations and individuals to change their behaviour in dealing with waste. The economic factors in this review are clustered within three main categories: prevention, enforcement and encouragement.

Prevention

There are several economic-based strategies to prevent waste generation before, during and after construction. These strategies include an appropriately developed 'extended producer responsibility' (EPR) scheme, cradle-to-cradle approach and 'design out waste'. If implemented fully, it is expected that these mechanisms can have a strong influence on C&D waste generation.

An appropriately developed EPR is found to be a successful market-based policy approach that has been applied to different waste types and streams.[10] Technically, EPR makes manufacturers responsible (financially and/or physically) for the entire life cycle of their products during the supply chain of materials including design, manufacture, recycling and final disposal.

Enforcement

Enforcement is imposed through three standard practices: levies for landfilling, penalties for illegal dumping activities, and the proximity principle (the latter only practised in NSW). However, these three mechanisms are not consistently in place across the jurisdictions. The approach to taking advantage of a landfill levy is not straightforward due to the role of varying factors in the effective management of waste. While in some circumstances a landfill levy is the best economic driver, it can act as a disincentive in other circumstances (for example, the likelihood of illegal dumping or reduced recycling activities, with a large volume of residuals). Indeed, a jurisdictional legislation levy should not give rise to unintended outcomes such as interstate waste transfer because of cost disparity; discouraging private investors from investing in recycling infrastructure; high administrative costs corresponding to the application of complex schemes; and resource stockpiling and illegal dumping.

Illegal dumping and resource stockpiling discourage sustainable waste management and recovery activities. To remove the unintended negative outcomes of a landfill levy, the state and territory governments should do more to stop illegal waste disposal. Due to data unavailability and poor data management practices, it is difficult to understand the overall extent of illegal dumping activities across Australia. Using an approximate estimate, it is safe to assume that, in 2016-17, Australia spent about $70 million to manage and control illegal dumping activities.[11]

The proximity principle is a universally accepted philosophy that requires waste generators to send their waste to a facility that is located in a certain perimeter of origin. It can assist in preventing movement of waste between jurisdictions to avoid and minimise levy liabilities.

[10] Hanisch, C. 2000. Is extended producer responsibility effective? Environmental Science & Technology, 34, 170A-175A.

[11] Laviano, H., Barlow, J., Ton, M., and Dawood, N. 2017. Waste and recycling industry in Australia – An Inquiry into the Waste and Recycling Industry in Australia: a submission to the Senate Inquiry

Encouragement

The new generation of policymakers advocate waste management approaches that prioritise incentives over more command-and-control environmental regulations. There are several tested and trusted opportunities to motivate waste producers to not dispose of C&D waste at landfills including sustainable procurement, emission trading schemes, green building ratings and development of the domestic market for C&D waste.

Sustainable procurement can provide an incentive for further waste recovery. It is claimed that the implementation of sustainable procurement has a positive impact on the flourishing of the C&D waste material market. Two strategies to promote sustainable procurement in Australia are at the forefront of the NWP 2018 policy: Strategy 8 (Sustainable Procurement by Governments) and Strategy 9 (Sustainable Procurement by Business and Individuals). These two strategies urge the public and private sectors to promote demand for recycled materials and products containing recycled content. The federal government or state governments should determine and announce the targets and minimum specifications for the application of recycled materials in public projects or projects of certain values in sustainable procurement policies and guidelines.

In emission trading, the main authority allocates a limited number of permits to dispose of a certain amount of a specific pollutant during the time period stipulated.[12] Polluters (waste producers) need to own permits in an amount equal to their emissions. The Australian Government has committed to a target of Greenhouse Gas Emission abatement by 26 to 28 per cent (from 2005 levels) before 2030. Some state waste strategy documents prioritise emissions reduction through increased waste recovery activities.

The green construction concept refers to construction-related activities that are environmentally responsible and resource-efficient during a built environment's life cycle. This concept was introduced in Australia in two forms: the Green Star (GS) Program and the Infrastructure Sustainability (IS) rating scheme, by two authorities – the Green Building Council of Australia (GBCA) and the Infrastructure Sustainability Council of Australia (ISCA). A green building in the context of C&D waste aims to employ low-waste building technologies and promote utilisation of recycled C&D waste materials. In the GS rating system, generally, C&D waste credits require improvements in three areas:

1. Recycling of C&D waste from the building.
2. Design of the storage for waste to encourage good recycling practices.
3. Use of recycled materials.

The GBCA awards C&D waste credits to encourage management practices that minimise the quantity of C&D waste going to landfill from base building and/or interior fit-out works. The ISCA (a not-for-profit industry council) developed a voluntary rating system for assessment of infrastructure in terms of sustainability, in 2007. This scheme seeks to foster resource efficiency and reduction of waste and associated costs in infrastructure projects.

[12] Cap and Trade: Key Terms Glossary. Climate Change 101. Centre for Climate and Energy Solutions.

Figure 4. **Economic barriers and enablers of market development**

Along with efforts to reduce the volume of waste generated, the development of a market for salvaged and recycled waste materials (including C&D waste) has been frequently emphasised in different policies, strategies, waste management principles and concepts in Australia. The development of a domestic market for waste and recyclables is strongly influenced by several internal and external factors (Figure 4).

It is expected that, when these factors are systematically dealt with, this will pave the way for a circular economy and a subsequent closing of the waste/resource flow loop in the Australian market.

Conclusions and recommendations

The research provides several high-level C&D waste management recommendations that are applicable across Australia. Almost all of these recommendations can be incorporated into jurisdictional legislation, and their benefits can be achieved when they are supported in primary legislation and subordinate regulations. These strategies are either economic-driven practices or policies, or indirectly produce economic benefits. The recommendations are to:

1. Develop appropriate EPR and similar schemes for greater impact and compliance.
2. Support and promote design out waste practices through funding and education.
3. Invest in technologies and infrastructure to accommodate the growing quantity of C&D waste.
4. Provide a GST subsidy for building materials with recycled content.
5. Invest in attitudinal change through R&D programs, leading to raising C&D waste stakeholders' awareness.
6. Mandate GS and IS principles with respect to waste minimisation, or award construction projects that support and fulfil the existing GS and IS requirements.
7. Support the development of an efficient and effective supply chain system.
8. Mandate sustainable procurements within the public sector.
9. Review existing waste regulations, policies and strategies to provide further support for the waste management and resource recovery industries.
10. Promote a cradle-to-cradle approach in the design and manufacture of construction materials.
11. Establish a marketplace that facilitates the trade of salvaged and recycled C&D waste material.
12. Mandate developing and keeping as-built and as-renovated plans, including a bill of quantities.

Having these recommendations registered in a permanent database would assist the task of applying EPR and similar schemes at later stages.

Economic Evaluation of C&D Waste Management: a Case Study

This section of the report aims to compare various C&D waste management methods. The comparison will help provide economic information to conduct a feasibility analysis for developing a marketplace to trade C&D waste. A hypothetical case study in a Melbourne inner-city suburb was considered to compare: 1) landfilling in metropolitan areas; 2) landfilling in regional areas; and 3) recycling. Waste disposal to a landfill is used as the base of comparison.

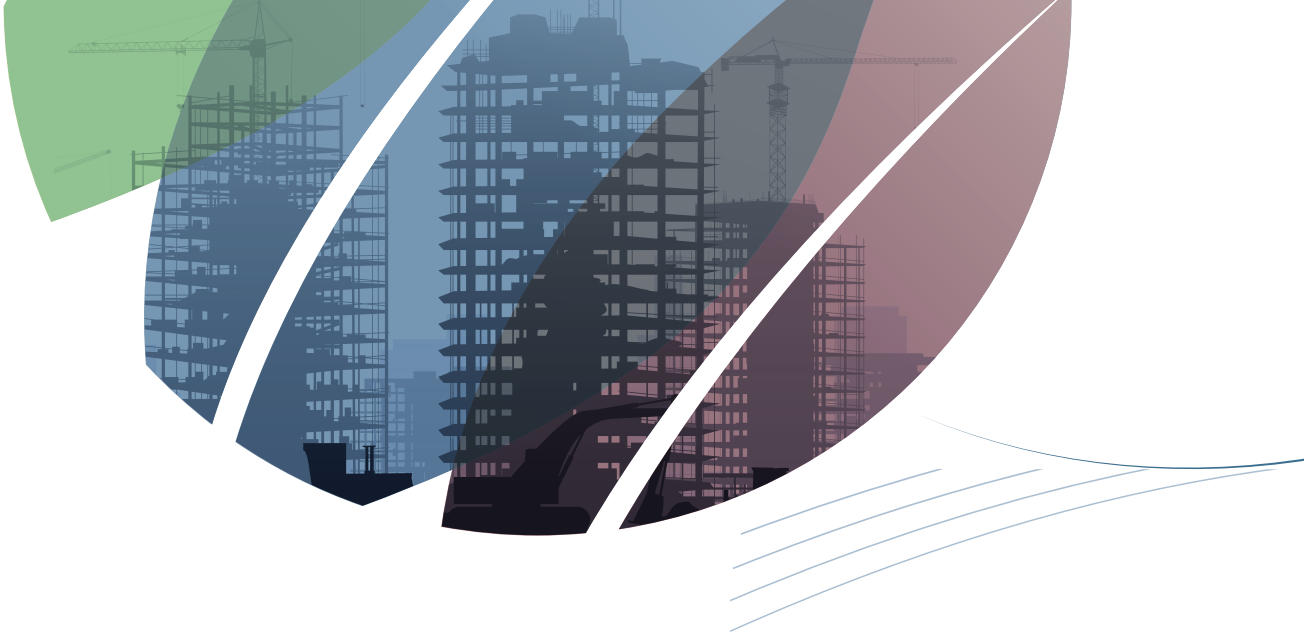
It should be noted that, in real-world conditions, there are often many interacting factors that affect the economy and economic activities. In this case, these factors include but are not limited to fluctuations in economic cycles, location and size of the construction and waste generated, state and national waste management regulations, market conditions such as the strength of supply and demand balance, and the performance of the waste management and recovery industry. Hence, the case study analysed below – and the associated estimation—is not indicative of standard practice in the industry. Indeed, several factors determine a C&D firm's decision as to how to manage their C&D waste. Therefore, the interpretation of results should be made with this caveat in mind.

Landfilling

Landfilling is the worst option for the management of C&D waste. The scenario of the construction of a high-rise residential building in the inner city of Melbourne (suburb: South Yarra) was analysed to evaluate the economic aspects of this management option. The potential composition of C&D waste materials that were generated in the pre-construction and construction phases is tabulated in Table 1.

Table 1. Waste generated during demolition and construction

Material	Quantity
Pre-construction/demolition	
Asbestos contaminated debris/waste	205,000 kg
Brick	3,000 kg
Clean fill	20,000 kg
Concrete rubble	2,000,000 kg
Tile	350 kg
Non-ferrous metal	6,000 kg
Steel	120,000 kg
Construction	
GIB plasterboard sheet	45,000 kg
Timber	224,000 kg
Plaster	1,500 kg
Brick	1,000 kg
Tile	900 kg
Steel	2,710 kg
Cardboard	1,130 kg
Hardfill (mix of a few masonry materials)	20,000 kg
General	100,000 kg
Total weight	**2,499,460 kg ~ 2,500 tonnes**



Several assumptions about the conditions of the case study are made. These assumptions are based on expert consultations, previous literature and include the following:

1. The costs of traffic control management are not considered.
2. The levy charged for each volume of the waste is based on the state-announced levy rate ($65.90/tonne in July 2020).
3. The levy is only imposed on 70 per cent of waste materials, the rest is recycled
4. The skip bins only contain C&D waste at 50 per cent of bins' nominal capacity.
5 Google Maps is used to estimate distances from the waste generation origin and construction site to various waste landfill and recycling centres.
6. Landfilling requires energy at two stages: carting waste away and processing the waste at landfill, with the energy unit cost calculated at $33.75/tonne.
7. The price of recycled material is $50 on average.
8. Only 65 per cent of waste received at the recovery facility can be recycled.

1. Landfilling in metropolitan areas

In this scenario, the waste generated in the project is sent to the nearest landfill that accepts C&D waste materials – Altona North Landfill.

According to the calculations above, the total cost of C&D waste generated in this case scenario is $238,450, consisting of $38,750 (cost of waste collection), $115,325 (cost of waste landfilling) and $84,375 (cost of energy used). Refer to the main report for the full calculations.

2. Landfilling in regional areas

To understand the impact of distance/location on the economic performance of C&D waste management, the waste disposal in regional areas of Victoria is modelled. The waste generated in South Yarra (Melbourne) is dumped in a waste landfill facility located in the City of Ballarat to take advantage of a lower levy rate for regional areas. The landfill facility is 137 km away from the waste origin, and the waste transfer takes about two hours to complete.

The mathematical modelling estimations show that the final cost for this management method is $501,705, which consists of cost for waste collection ($316,250), cost of waste landfilling ($101,080) and cost of energy used for landfilling and waste transportation ($84,375). This cost is likely to be a major deterrent to landfilling in regional Victoria despite having lower levy rates.

3. Recycling

Recycling is a preferred method over landfilling and is generally one of the more common practices in C&D waste management systems in Australia. However, due to several reasons, this is not the case for all waste materials, areas and construction industry subdivisions. Mathematical modelling is conducted to understand the economic performance of this option as follows.

The total cost of this method of waste management is $474,563, which comprises $122,500 (cost of waste segregation), $38,750 (cost of waste collection), $243,750 (cost of waste recycling), $57,663 (cost of landfilling of unrecyclable waste) and $93,150 (cost of energy used) minus $81,250 (the revenue obtained from selling recycled materials). The recycling costs in comparison with landfilling in metropolitan areas were about 99 per cent more expensive, whereas they were 5.4 per cent less expensive compared with waste disposal in regional Victoria.

Conclusions

Comparison among the three scenarios in the case study reveals important information about the major implicit and implied factors that can influence decision-making processes in the construction industry. Findings regarding these major factors include:

1. Landfilling the waste, if it is not too far away, is still a more economically viable option compared with waste recycling; this case study showed that landfilling is 76.6 per cent cheaper than recycling.
2. Transportation costs are an instrumental factor in the selection of the method to manage C&D waste; they can diminish other benefits such as lower levy rates that would have been obtained in the absence of high transportation costs.
3. A higher landfill levy is a strong disincentive tool to encourage recycling activities.
4. Without a healthy and sustainable market, the minimum benefits that are currently attainable will be diminished, which further deteriorates the imbalance between recycling and landfilling in favour of landfilling.
5. A consistent method for valuation of intangible costs such as achievement of a reputation for further recycling needs to be offered by the federal government.

Circularity of C&D Waste

Circularity of C&D Waste

Circular economy principles are increasingly being adopted by policymakers to make sound and sustainable policies to solve urban issues. In the context of C&D waste, circularity refers to the substantial value in waste materials. One primary strategy to apply circularity to the C&D waste space is the development of a marketplace. To inform the development of a market for C&D waste, this study analysed the entire supply chain of five common C&D waste materials (brick, concrete, timber, glass and steel). This analysis identified opportunities for reducing the quantity of waste disposal.

For the purpose of analysing the entire life cycle of study materials, a conceptual model was developed. This model is called the Less of Waste and More of Resources (LoWMoR) model. The development of this model was informed by the concept of circularity, the 3R model (reduce, re-use and recycle), C&D waste literature and other relevant conceptual frameworks. This model outlines several opportunities where stakeholders can minimise waste landfilling (Figure 5).

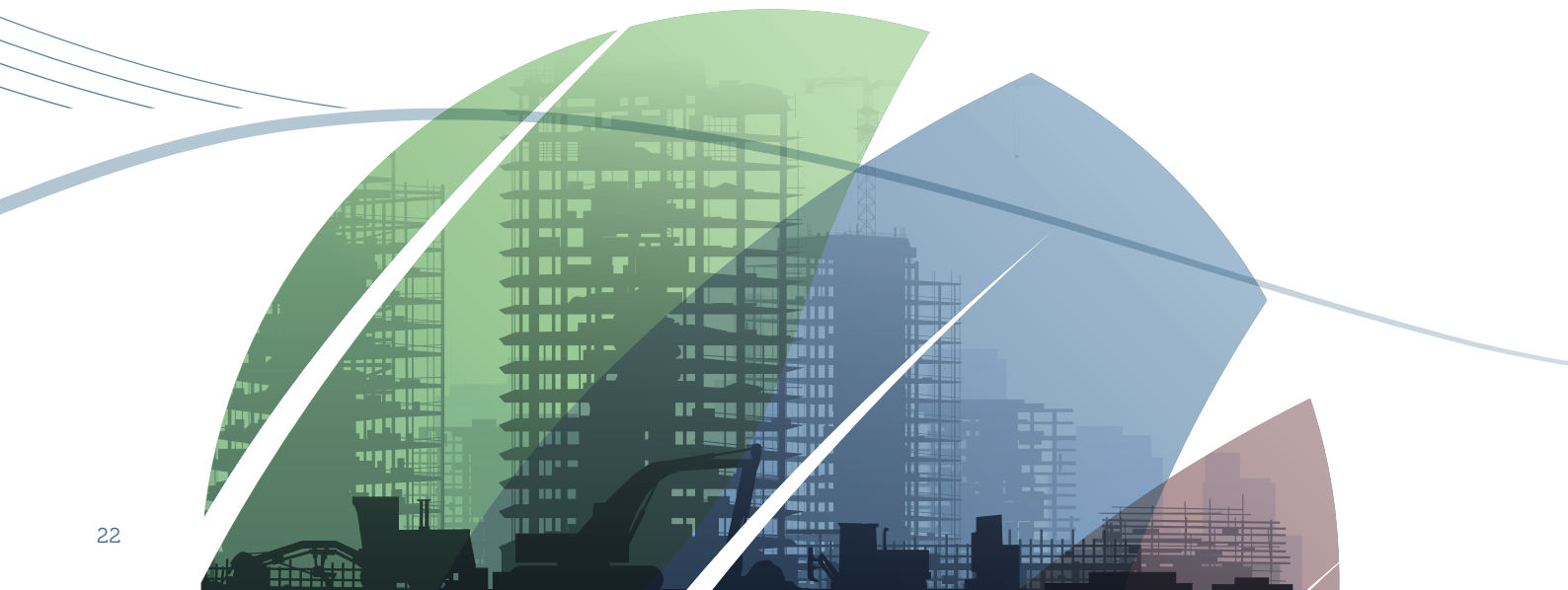
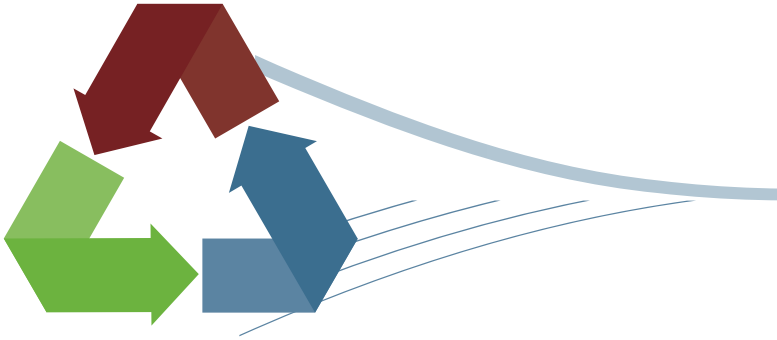


Figure 5. **LoWMoR model components**



Brick

Bricks are produced in several ways in terms of type, size and the material used; the variation is largely associated with the origin and time of the brick's production. Brick has different applications in construction elements, notably walls and pavements. In Australia, in 2011, between 85 and 90 per cent of new dwellings were built with external brick walls and concrete flooring. In 2018-19, the three main clay brick products in Australia were face bricks (65.5 per cent), common bricks (22.11 per cent) and clay pavers (12.4 per cent). It is estimated that brick waste accounts for 50 to 70 per cent of the construction waste produced by urban redevelopment and 30 to 50 per cent by building operations. Analysis of the clay brick life cycle shows that there are several opportunities for minimising and redirecting brick waste from landfill. These opportunities present themselves at brick manufacture, design, planning and contract, procurement, transportation and delivery, construction, demolition, re-use and waste recovery (recycling and upcycling).

The following is a selection of the recommendations that can facilitate waste circularity in brick material, according to the Brick-LoWMoR model (Figure 6):

1. Consider building standardisation to improve buildability and reduce the number of offcuts.
2. Design appropriate landfill levy schemes to discourage brick waste landfilling.
3. Strengthen controls over licensed landfill sites.
4. Ensure the bottom layers of bricks remain useable by preventing soil contamination.
5. Store bricks in a stable flat area to avoid breakages from fall-overs.
6. Determine a means for cutting bricks into half more accurately so that both halves can be used, and breakages avoided.
7. Supplier to provide more flexible 'last pack' sizes (i.e. a 'fractional' pallet instead of a full pallet).
8. Use the 'supply and lay' model to eliminate brick leftovers.
9. Take unwanted bricks back to brickyard for crushing and re-use in brick production – this can be complemented with offering the customer leftover (full) bricks.
10. Include a clean-up payment in the scope of the bricklayer's subcontract to assist recycling and to discourage wasteful site practices.
11. Develop an agreement where a contractor 'sells back' the recycled waste from the original material supplier.
12. Take brick leftovers away to use as aggregate or landscaping cover.

Figure 6. **Brick-LoWMoR model**

Concrete

Concrete is one of the more widely used building materials, with a global consumption rate approaching 25 gigatons per year. The key economic drivers for concrete product manufacturing in Australia include demand from residential building construction, demand from heavy industry and other non-building construction, demand from commercial building construction, actual capital expenditure on mining, capital expenditure by the public sector and demand from road and bridge construction. The residential and commercial building markets represent the principal source of demand for concrete products. The prime building contractors or project developers, including individual homeowners or property developers, generally fund the procurement of concrete products for building projects. Concrete makes up the greatest proportion of masonry material recycled in Australia, at around 60 per cent of all masonry material recycled. The latest data for concrete waste recovery indicates that Australia recycled 6,007,156 tonnes of concrete waste, of which 71 per cent was generated in the construction industry.

The Concrete-LoWMoR model presents a few opportunities through which concrete waste can be efficiently managed. Figure 7 depicts these opportunities and the relationships between them. The following is a selection of the recommendations that can facilitate waste circularity in concrete:

1. Recognise that recycled concrete aggregate (RCA), when produced to conform to the standard specification criteria, is a technically viable alternative that can be utilised in non-structural and structural concrete elements.
2. Conduct a life cycle analysis to quantify potential savings from increased durability on RCA.
3. Introduce RCA through pre-cast panels as a quality that can be closely monitored.
4. Change construction industry attitudes towards sustainability-conscious material choices, as inertia towards traditional practices in construction is prevalent.
5. Improve separation onsite to sort concrete waste material from other C&D waste.
6. Utilise advanced density separation techniques to grade crushed concrete fines to increase homogeneity and reduce the presence of foreign inclusions.
7. Incentivise end-markets for RCA, such as minimum recycled content specifications in projects, additional Green Star/ISCA rating points.
8. Standardise the technical specification of applications across Australian jurisdictions so that one state does not have higher standards than another state.
9. Direct some landfill levy revenue to industry R&D activities to test RCA products into practice (link manufacturers with engineers and procurement).

Figure 7. Concrete-LoWMoR model

Timber

Due to its flexibility, durability and appealing visual aesthetic, timber has multiple applications in the construction industry. The amount of wood waste generated from C&D is influenced by the life span of the building materials. In Australia, timber waste is classified into three major categories: untreated timber (Type A), engineered timber products (Type B) and treated timber (Type C). In 2016-17, Australia generated 2,369,680 tonnes of timber waste. The share of the C&D sector, as the second-largest timber waste generator, was almost 612 kilotons (25.8 per cent), behind C&I with almost 1,524 kilotons (64.3 per cent). Among the jurisdictions, NSW, Vic and Qld had the largest amount of timber waste material in total and in the C&D waste stream. The findings of this research identified opportunities for reducing waste throughout the timber waste material supply chain.

These opportunities are conceptualised through the Timber-LoWMoR model (Figure 8), which recommends to:

1. Use non-disposable metal formwork instead of timber formwork in construction projects.
2. Redefine and harmonising timber waste in national and jurisdictional regulations and policies.
3. Exclude timber waste recovered from construction activities from generic timber waste.
4. Improve existing, and employ new varieties of, machinery, instead of using old and obsolete tools, to help reduce timber waste.
5. Fund the development of waste energy recovery infrastructure, particularly for those that are able to recover energy from chemically treated timber waste.
6. Consider pre-cast timber frames in the design stage.

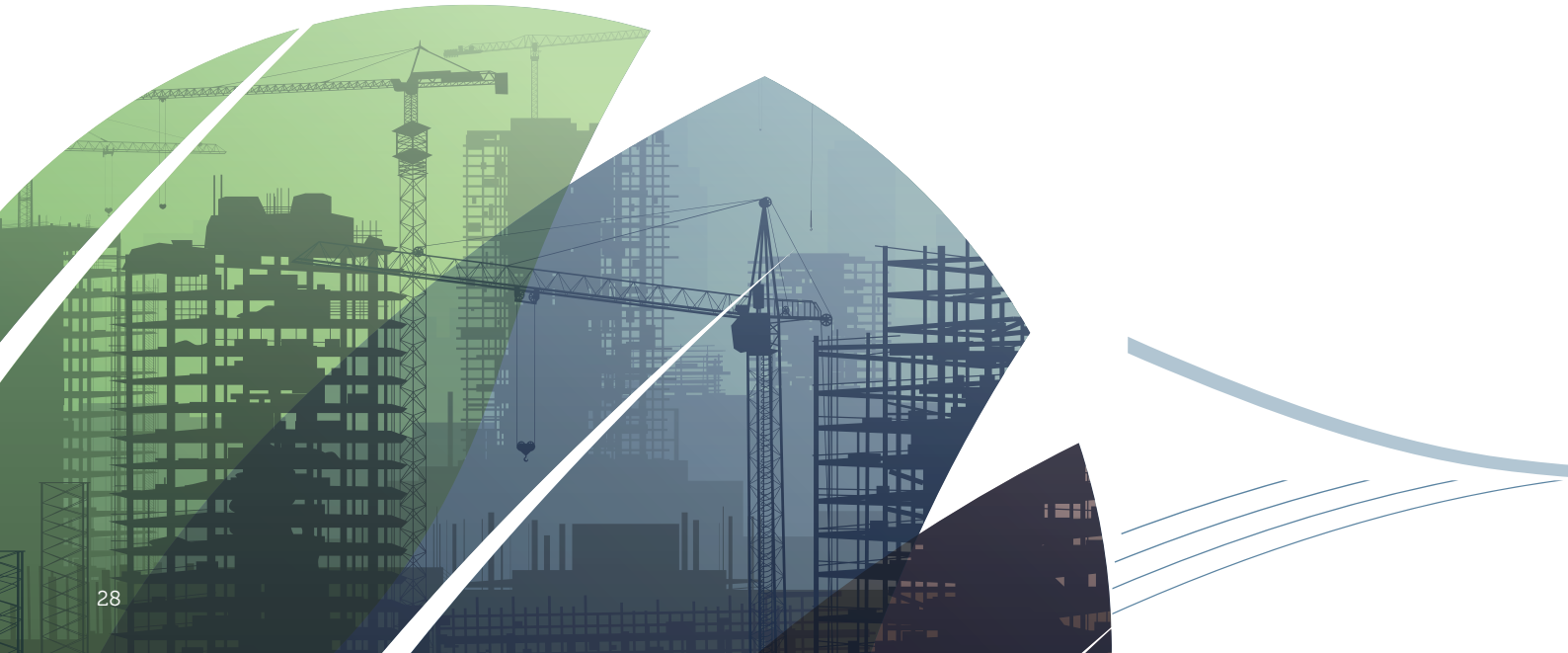


Figure 8. Timber-LoWMoR model.

Glass

Glass is a hard substance that may be transparent or translucent and is brittle in nature. The use of glass in the building sector has a long history; however, with new technological advances its application has become very broad. Glass is now used in the building industry as an insulation material, a structural component and an external glazing and cladding material. In infrastructural projects, the application of glass includes but is not limited to sound barriers and tunnels and as ingredients for road surfaces such as asphalt and insulators. Australia generated 1,078,83 tonnes of waste glass in all waste streams in the period 2016-17. However, the construction industry is not a significant contributor to glass waste generation: from the total glass waste, only 0.62 per cent came from the C&D waste stream. Despite a higher level of glass waste recycling relative to landfilling in all waste streams, landfilling is prominent in the C&D waste stream. The average landfilling rate of glass waste in the C&D stream is 82.3 per cent.

While there is an established market for some applications of glass waste material, there are other applications that require further investigation. The glass waste market is currently not efficient due to several reasons, including a high level of waste material contamination, the undesirable marketability of recycled glass and low-cost overseas outsourcing of glass materials. Economic analysis of using recycled glass, factoring in these issues, suggests that an economic incentive for recyclers as well as manufacturers in Australia is not currently present. The main reason is the low-cost overseas outsourcing of glass materials. However, with promising results from new national and jurisdictional initiatives, it is most likely that the current trends in the market will change for the better.

Drawing on the Glass-LoWMoR model (Figure 9), the following are the recommendations targeting glass waste reduction in various stages of the glass waste supply chain:

1. Promote the use of glass aggregate in road constructions.
2. Change jurisdictional landfill levy regulations in favour of glass recycling.
3. Design a partial levy exemption for residual waste in the recycling industry.
4. Conduct more research projects to establish new applications for glass waste such as used in the landscape industry.
5. Grow consumer awareness and desire to buy ‘green’ products – such activity may win more work.
6. Establish legislation for public and social housing that requires the contracts for window replacement to include recycling of all removed materials in closed-loop schemes so that the significant opportunities and quantities of potential materials are not overlooked in this sector.
7. Improve the purity of cullet and prevent colour contamination to enhance the value and recyclability of cullet.

Figure 9. Glass-LoWMoR model

Steel

Steel is one of the more common materials used in the construction industry, which is one of the most important steel-using industries, accounting for more than 50 per cent of world steel demand. The structural steel fabrication industry has derived solid demand from the key building markets over the past five years (2015-2019), although declining demand from the non-building and mining infrastructure markets has negatively affected the industry's performance. The constant threat of competition from low-priced imports has also limited industry revenue growth over the period.

According to the available data, in 2016-17, 3,822,990 tonnes of steel waste was generated in Australia. Among the states and territories, the largest volume was generated in NSW (1,345,349 t), Vic (925,563 t) and Qld (703,502 t). Except for SA, with 3,155 tonnes of landfilled steel waste, other states and territories did not report their disposal rate.

In the Steel-LoWMoR model, there are 11 points wherein steel waste material can be efficiently managed. Figure 10 depicts these opportunities and the relationships between them. In Australia, the majority of steel waste is sent back to steel fabrication manufacturers to be used for the production of new steel products.

Some recommendations to facilitate the cradle-to-cradle approach in steel scrap are to:

1. Provide landfill levy exemption for residual waste derived from steel recycling.
2. Adjust specifications in favour of steel waste-based materials in new construction projects.
3. Stabilise market volatility to ensure sustainable usage of steel waste in steel manufacturing.
4. Introduce government-imposed freight subsidises to enable the delivery of recyclables to processing facilities.

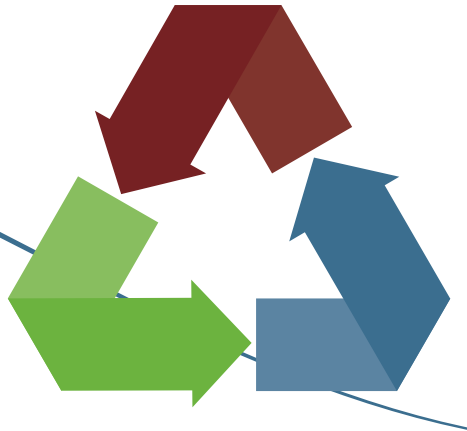


Figure 10. Steel-LoWMoR model

Survey Results: Perceptions of Stakeholders

Survey Results: Perceptions of Stakeholders

A questionnaire survey was conducted with the aim of capturing the perception of key stakeholders in the C&D waste management industry, government and public sector to complement the first phase of research. In total, 132 participants took part in this online survey.

More than 50 per cent of the participants belonged to three industries: waste recovery (20 per cent), construction (16 per cent) and landfilling (15 per cent). In terms of the length of experience working, about 44 per cent of participants had less than six years' experience and less than 30 per cent of them had worked in an industry related to C&D waste management for more than 15 years at the time of the survey. More than 60 per cent of participants were based in two large states: Vic and NSW. The following discussion presents the main findings extracted from the participants' responses. Most of the respondents were in favour of market incentives (that is, to remove regulatory barriers; foster minimum recycled content in products; invest in technologies to recycle and facilitate trade such as trading platforms), with more than a 92 per cent level of agreement (Figure 11).

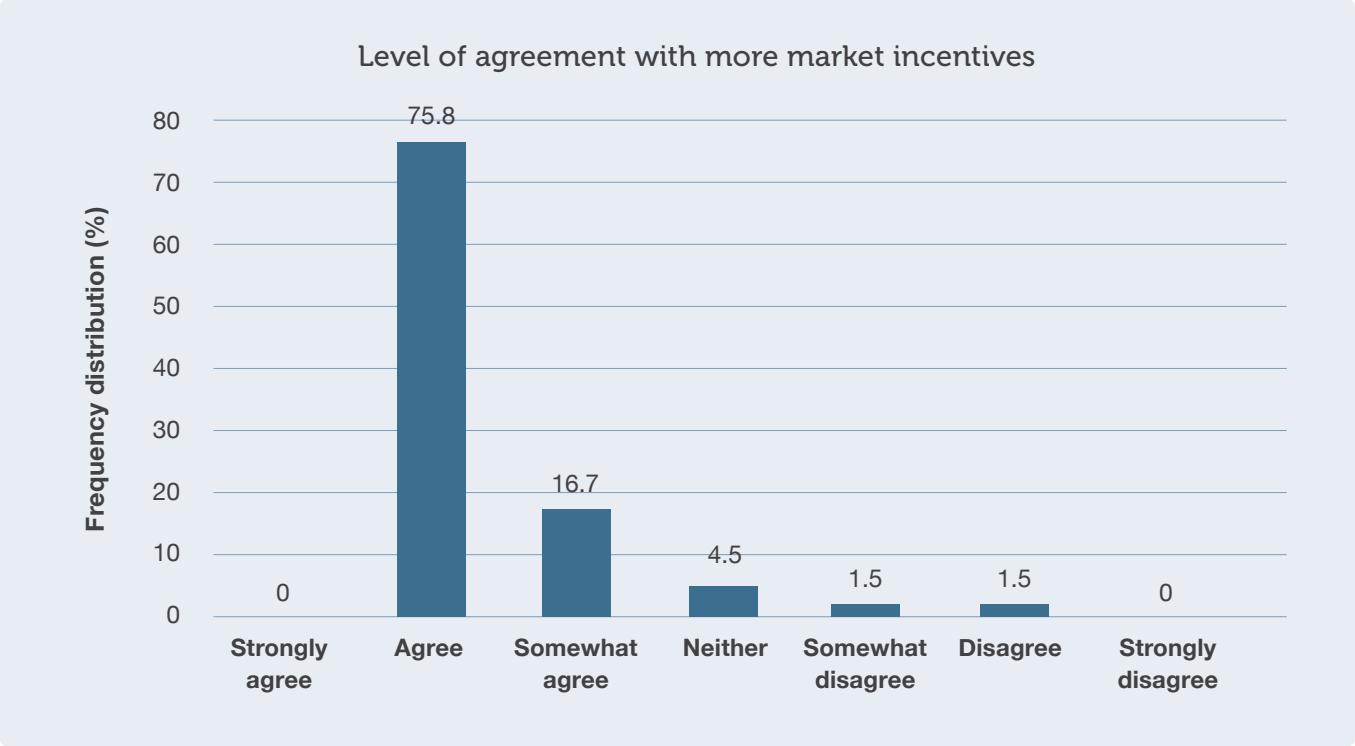


Figure 11. Frequency distribution of agreement level with the increased implementation of market incentives in C&D waste stream

A more pecuniary approach (landfill levy increases; taxes on producers; more regulations, monitoring and enforcement) also received significant but comparatively lower support; the results showing that about 70 per cent of respondents had a level of agreement with this approach (Figure 12). Furthermore, 90 per cent of those respondents who agreed to more pecuniary imposts also endorsed the effectiveness of landfill levies in reducing waste disposal (Figure 13). About 44 per cent of respondents indicated that consistency in levy rates is needed, as the differential may cause unintended consequences and unnecessarily complicates waste management. However, about 30 per cent of respondents expressed that differences in levy rates between metropolitan and regional areas are necessary, and further discounts and waivers are required in regional areas.

The participants were asked to indicate if the current legislation supports or discourages C&D waste reduction, re-use and recycling in their jurisdiction. More than 45 per cent of the respondents indicated that current regulations are not encouraging recycling and waste minimisation activities. In the context of policy development, responses suggested that the main three priorities are to:

1. Provide a guideline that determines the accepted level of contamination for re-using C&D waste.
2. Prepare guidelines on the requirements of using recycled C&D materials in different industries.
3. Set a target for reduction, re-use and recycling of C&D waste.

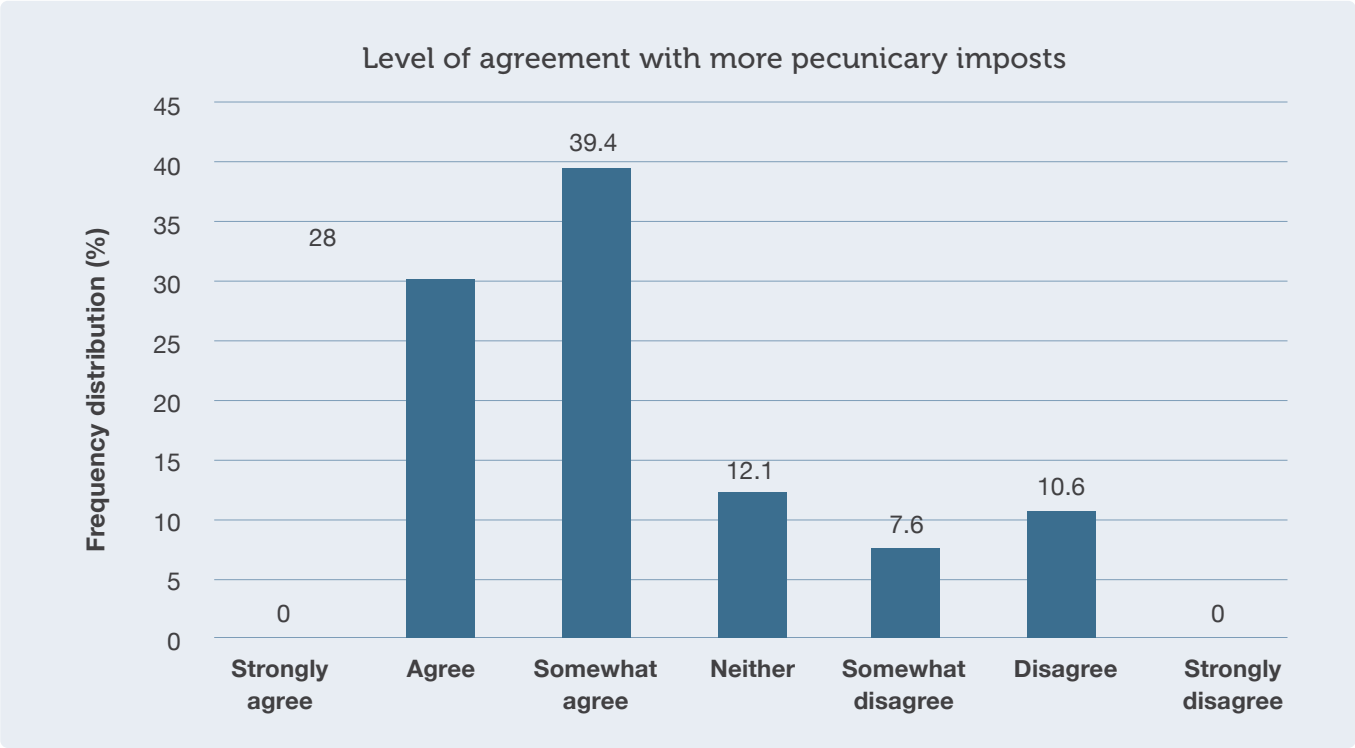


Figure 12. Frequency distribution of agreement level with increased implementation of pecuniary imposts in C&D waste stream

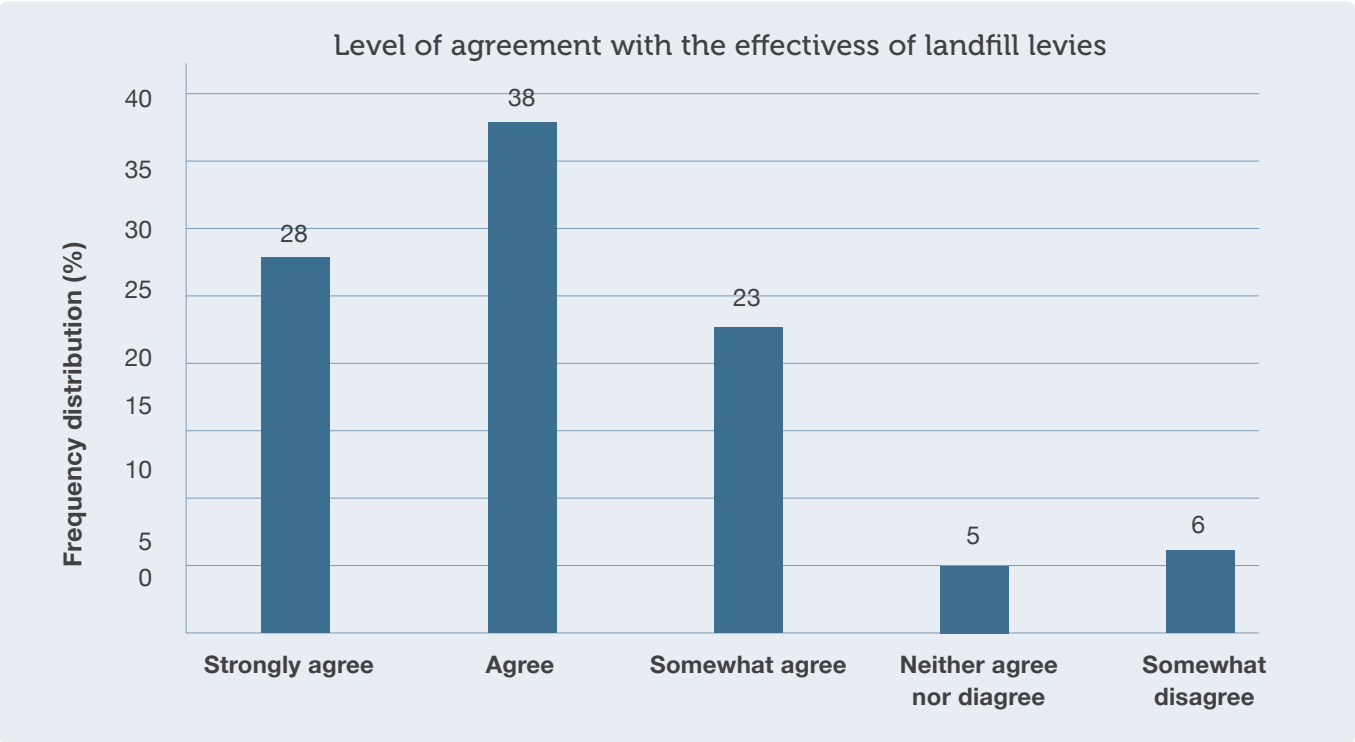


Figure 13. **Frequency distribution of agreement level with the effectiveness of landfill levies**

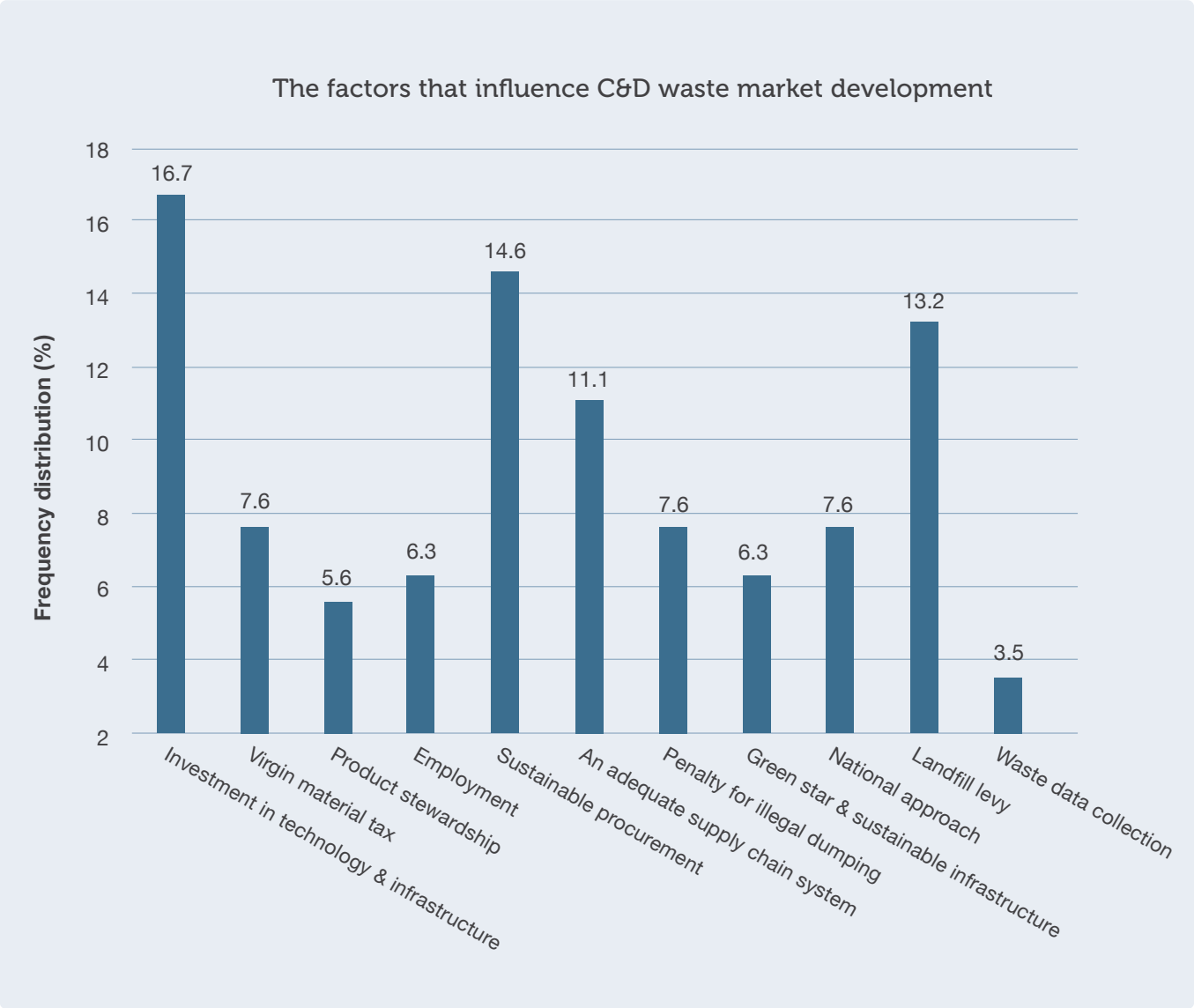


Figure 14. Frequency distribution of the factors that influence C&D waste market development

Respondents also highlighted that the 'manufacturer's shared responsibility of waste generation', the 'proximity principle' and 'IS rating scheme' are the most effective management schemes for the C&D waste stream in Australia. Furthermore, they reported that investment in technology and infrastructure and sustainable procurement are two influential factors that have a significant impact on market development (Figure 14).

In response to identifying the main barriers towards effective management of C&D waste, participants reported 'over-regulation, tough recycled materials criteria and increased testing' (13.41 per cent), 'lack of local market' (9.76 per cent) and 'culture, education and attitude' (8.54 per cent) as the major barriers. Once they were provided with a wider range of choices, the main three issues were found to be: 'EPR', 'definition of waste as opposed to resource' and 'waste data management and reporting'.

The role of the federal government in mitigating the C&D waste issues was also investigated and the results suggest that the government can create positive impact through 'building confidence in C&D salvaged and recycled materials in the market', 'providing national leadership and coordination of C&D waste efforts' and 'developing nationally applicable regulations' as the main priorities.

This research would not have been possible without the ongoing support of our core industry, government and research partners:

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