

# Construction and Demolition Waste Management in Australia: Review of Differences in Jurisdictional Regulatory Frameworks

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## Abstract

Rapid growth in construction activities in Australia in recent years has led to increased generation of construction and demolition (C & D) waste. It is expected that C & D waste generation will continue to grow steadily in the coming years in the wake of population growth and migration. Failure in effective management of C & D waste will have unintended economic, social, political and environmental repercussions. The efficient management of C & D waste, however, is very much dependent on the associated legislation that governs C & D waste management activities. It is argued that inconsistencies that exist between jurisdictional C & D regulations impede effective management of C & D waste. Therefore, this paper is an attempt to review Australia's waste management legal framework and to identify the inconsistencies in C & D waste regulations and strategies that are currently implemented in the six states and two territories of Australia. This review study is a part of a larger research project funded by Australia's Sustainable Built Environment National Research Centre that aims to improve C & D waste management in Australia. The result of the review shows that there are substantial differences in the way that C & D waste management activities are regulated at the jurisdictional level. These differences are found to deter an efficient and consistent management of C & D waste across Australia. The results can inform efforts towards development of a holistic approach to improve regulation of C & D waste in Australia and other similar contexts.

**Keywords:** harmonisation, regulations, national waste policy, built environment, strategies

## 1. Introduction

Rapid growth in construction activities in Australia in recent years has led to increased generation of construction and demolition (C&D) waste. According to the latest statistics (NWR, 2018), about 20.4 Mt of C & D waste was generated across Australia during 2017- 2018. That is equal to 30.5% of the total waste generated, from which 33% is disposed of in landfill. With the existing rate of migration and population growth (ABS, 2018b), it is expected that C & D waste generation will continue to grow steadily in the coming years. Failure in effective management of C & D waste generated will have unintended economic, social, political and environmental repercussions (Park and Tucker, 2017). Therefore, it is of particular importance to properly manage this growing issue at the national level. The efficient management of C & D, however, is very much dependent on the associated legislation that governs C & D waste management (Lockrey et al., 2016). Legislative instruments are implemented to

develop and foster the regulatory environment for waste reduction (Yuan et al., 2012, Udawatta et al., 2018). They also help to achieve the objectives of waste management strategies that aim to adhere to the waste hierarchy (i.e. avoid and reduce, reuse, recycle, recover, treat and dispose) in the construction and waste recycling industries.

In the Australian context, C & D waste is regulated through three tiers of government: federal, state or territory, and local. However, the federal government is not directly involved in regulating C & D waste unless the regulations set by the other two tiers are in conflict with international treaties that Australia is a party to (e.g. Agenda 21, Basel Conventions, and Stockholm Conventions) or they impose threats to the environment that are of national concern. Technically, local governments and municipalities provide waste collection and recycling services, manage and operate or administrate landfill sites, deliver education and awareness programs, and provide and maintain recycling infrastructure (National Waste Policy, 2018). Therefore, the majority of legislation occurs at state and territorial government level. C & D waste management in each state/territory builds on the specific regulatory framework that prevails in that state. A particular issue with this regulatory approach is the emergence of inconsistencies between jurisdictional regulations. These inconsistencies give rise to barriers that impede effective C & D waste management activities (Hyder, 2011b, Laviano et al., 2017, Environment and Communications References Committee, 2018).

To provide context for the present study, a review of C & D waste governance in Australia is provided. The aim is to review Australia's legal framework and to identify the inconsistencies in C & D waste regulations and strategies that are currently implemented in different Australian jurisdictions. The review informs a larger research project entitled 'A National Economic Approach to Improved Management of Construction and Demolition Waste', which is being conducted at RMIT University and supported by the Australia Built Environment National Research Centre. This project endeavours to foster a holistic national approach to address C & D waste issues. Its objectives include development of a consistent approach to define and measure C & D waste, identification of influential economic factors that govern the disposal/reduction/reuse/recycling of C & D waste, conducting a feasibility study on the creation of a marketplace for trading C & D waste, and identification of opportunities to integrate supply chains model in management of C & D waste. These objectives relate to several strategies mapped out in the National Waste Policy 2018 and can provide a solution to the issues raised by recent changes in Chinese regulations that ban waste trade with other countries such as Australia .

## **2. Methodology**

### **2.1 Data collection, processing and analysis**

This review study is based on the secondary data that are publicly available. The document analysis technique was conducted to identify differences in jurisdictional regulatory frameworks and practices in Australia. The sources reviewed include acts, policies, regulations and strategies that are mostly administrated by the Australia Environmental Protection Authority (EPA) and other state-specific authorities (e.g. Sustainability Victoria in Victoria), reports and initiatives prepared for C & D waste management in Australia. In total, 62 documents were analysed that provided information about C & D waste legislation in Australia. It is worth bearing in mind that amendments to C & D waste regulations and acts occur periodically; therefore, information provided in this paper is considered valid at the time of writing. On this basis, the regulations that are not in force and/or have been repealed are excluded

from the review. Descriptive analysis is used to analyse and present the data collected. Quantitative results are mostly presented using analytical measures such as frequency and arithmetic average. Microsoft Excel V. 2016 is used to analyse the data and visualize results.

## 2.2 Context of study

Australia is a large country with a population of 25 million that is mostly settled in capital cities. Significant growth in migration and population in Australia generate demands for more construction activities. As a result, more infrastructure and new housing are needed to meet the requirements of this ever-increasing population (IBISWorld, 2019a). A more detailed overview of the construction industry is provided in the results section. The statistics have shown that such activities generate a large quantity of C & D waste (NWR, 2018). As such, the state governments attempt to regulate C & D waste management through enforcing relevant legislation.

As previously mentioned, C & D waste legislation mostly takes place at the state and territory level. Australia has 6 states: Victoria (VIC), New South Wales (NSW), Queensland (QLD), South Australia (SA), Western Australia (WA) and Tasmania (TAS); and 2 territories: Northern Territory (NT) and Australia Capital Territory (ACT). The main difference between state and territory government is that states have the power to pass laws in their own right whereas the federal government can modify or revoke laws in territories. The majority of regulations and policies that govern C & D waste are produced and administrated by state EPAs. The history of C & D waste legislation dates back to the 1970s, when the first EPA act (Environmental Protection Act 1970) came into effect in Victoria.

## 3. Results

### 3.1 Overview of the Australian Construction Industry

Construction in Australia comprises several activities; from general construction to the construction of pipelines, railroads and river works, it also involves irrigation projects, and the construction of water, gas, electricity and sewage infrastructure. According to Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006 (Revision 2), the Construction industry (Division E) involves three subdivisions: “Building Construction”, “Heavy and Civil Engineering Construction” and “Construction Services” (ABS, 2006). Each of these subdivisions is further divided into various “groups” and “classes” with certain activity definitions. Although there has been a slight negative annual growth in this industry from 2014 to 2019 in general, it is projected that the construction industry will enjoy a 2.4% annual growth between 2019-2024 (IBISWorld, 2019a).

Analysis of different construction subdivisions reveals a constant annual growth rate. For instance, the historic data from the Australian Bureau of Statistics (ABS) indicated that the value of work done in building construction activities has progressively increased by 33% from 2012 (22,099,416) to 2018 (29,428,494). During this period, the Australian population has grown by 11% (ABS, 2018b). These two trends clearly demonstrate the industry’s attempt to keep up with the growing population. In the residential sector, approximately 18,000 dwelling units were approved for construction monthly in 2017

(Martek et al., 2019). 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 benefit a 5.3% 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 VIC (up to 80%) and WA (39%).

### 3.2 Overview of C & D waste generation in Australia

The existing pace in construction activities in Australia is also indicative of the generation of more C & D waste. According to the National Waste Report (2018) prepared for the Australian Department of the Environment and Energy, in 2016-2017 Australia generated 831 Kg of C & D waste per capita (NWR, 2018), which has increased by 2% per capita over a 11 year period (2007-2017). The total waste generated has steadily increased by 1.9% from 2007 to 2017 (Table 1) and reached 20.4 Mt, which represents the largest source stream (43%) of all waste streams (i.e. C & D, Commercial and industrial (C & I) and Municipal Solid Waste (MSW). C & D waste is mostly recycled and then disposed of at landfills. Hence, activities associated with C & D waste management are important from economic and environment perspectives. C & D waste accounts for a significant proportion (26.9%) of the solid waste collection and recycling services industry in Australia; an industry that produces \$5.2 bn in revenue and enjoys 3% annual growth. This industry is influenced by two major factors: construction/demolition activities and population growth, both of which are projected to increase in the coming years (IBISWorld, 2019b). Another source, The Waste Management Association of Australia reported that the industry employs 50,000 individuals and contributes \$50 bn per annum to the Australian economy (Environment and Communications References Committee, 2018). Modelling by the Centre for International Economics (2017) indicates that a 5% rise in the recycling rate could add \$1 billion to Australia's gross domestic product. Other external factors that alter the industry's performance are number of households, level of urbanization and public concerns over environmental issues.

In terms of waste fate, statistics showed that, between 2016 and 2017, more than 6.7 Mt of C & D waste was transferred into landfills (NWR, 2018). Despite the growth in C & D waste generation, the annual average of waste disposal during the period of 2007 to 2017 remains largely unchanged. However, the waste disposal per capita rate shows a different trend, with a 1.6% annual drop (Table 1). Conversely, the quantity of waste recycled has significantly improved during this eleven-year period. Recycling of C & D waste has increased by 3.4 Mt or 34%.

*Table 1: C & D waste generation and management trends in Australia.*

| C & D waste                         | 2007 | 2009 | 2010 | 2011 | 2014 | 2015 | 2016 | 2017 | Average annual growth rate (%) |
|-------------------------------------|------|------|------|------|------|------|------|------|--------------------------------|
| <b>Generated - total (Mt)</b>       | 16.9 | 18.5 | 18.4 | 18.4 | 17.9 | 19.4 | 20.1 | 20.4 | 1.9                            |
| <b>Generated- per capita (t)</b>    | 0.82 | 0.86 | 0.84 | 0.83 | 0.77 | 0.82 | 0.84 | 0.84 | 0.2                            |
| <b>Disposed of (Mt)-total</b>       | 6.6  | 7.3  | 7.0  | 6.2  | 6.2  | 6.7  | 6.4  | 6.7  | 0                              |
| <b>Disposed of (Mt)- per capita</b> | 0.32 | 0.34 | 0.32 | 0.28 | 0.27 | 0.28 | 0.27 | 0.27 | -1.6                           |
| <b>Recycled (Mt)</b>                | 10.1 | 11.1 | 11.3 | 12.1 | 11.5 | 12.4 | 13.5 | 13.6 | 3                              |
| <b>Recycled- per capita (t)</b>     | 0.49 | 0.52 | 0.51 | 0.54 | 0.49 | 0.53 | 0.56 | 0.56 | 1.3                            |
| <b>Recovery rate (%)</b>            | 60   | 60   | 62   | 66%  | 65   | 65   | 68   | 67   | 1.1                            |

Source of data: National Waste Reporting 2018. This report acquired data from different EPAs across Australia.

Analysis of C & D waste data in different jurisdictions demonstrated unequal proportions of waste disposal to landfills (Table 2). In 2017, the largest quantity of waste disposed was registered in QLD

(2,312 Mt) followed by NSW (1,969 Mt) and VIC (1, 549 Mt). It seems that the quantity of waste disposed in each state does not correspond to population and some other factors such as levy rate and availability of proper recycling facilities are potentially involved. From Table 2 it can be noted that recovery rate within different jurisdictions differs significantly. The greatest recycling rate is in SA (91.1%), followed by in VIC (82%) and NSW (69%<sup>2013</sup>). Each of these three states has a better recycling performance than the national average (67%).

Table 2. & D waste generation and management in different jurisdictions in 2016-17.

| C & D waste                   | ACT | NSW                  | NT                  | QLD   | SA    | TAS | VIC   | WA    | AUS  |
|-------------------------------|-----|----------------------|---------------------|-------|-------|-----|-------|-------|------|
| Waste disposal (Kt)-total     | 180 | 132                  | 1,969               | 2,312 | 151   | 39  | 1,549 | 374   | 6.71 |
| Current recovery rate (%)*    | na  | 69 <sup>(2013)</sup> | 1 <sup>(2011)</sup> | 51    | 91.1  | 1   | 82    | 64    | 67   |
| Population (thousands: ' 000) | 406 | 7,798                | 245                 | 4,884 | 1,717 | 519 | 6,244 | 2,568 |      |

Source of data: National Waste Reporting 2018. This report acquired data from different EPAs across Australia.

\*Source of data: data is extracted from various reports produced by jurisdictional authorities.

### 3.3 Inconsistencies in legislative frameworks

As mentioned earlier, state governments have the main responsibility for management of C & D waste and, as a result, different regulations are being implemented across Australia. In this section, the inconsistencies found in the legislative frameworks of Australia's jurisdictions are presented.

#### Policy Makers and Authorities

The first difference in C & D waste management between jurisdictions is the variation in the number and type of agencies involved in making policy and authorising waste management practices. Historically, the main authority to regulate C & D waste in jurisdictions is the EPA (Figure 1). In 2009, however, Queensland's EPA ceased to regulate C & D waste independently and became a part of the Department of Environment and Resource Management. Gradually, EPAs have engaged other specialised agencies in the process of decision-making, policies and strategies development. The focus of these agencies is on the effective management of C & D waste, maximising waste recovery and raising awareness in the public and the construction industry to reduce waste generation. For instance, in WA, the Waste Authority, previously known as the Waste Management Board, has become the main authority that provides policy on waste avoidance and recovery. In VIC, Sustainability

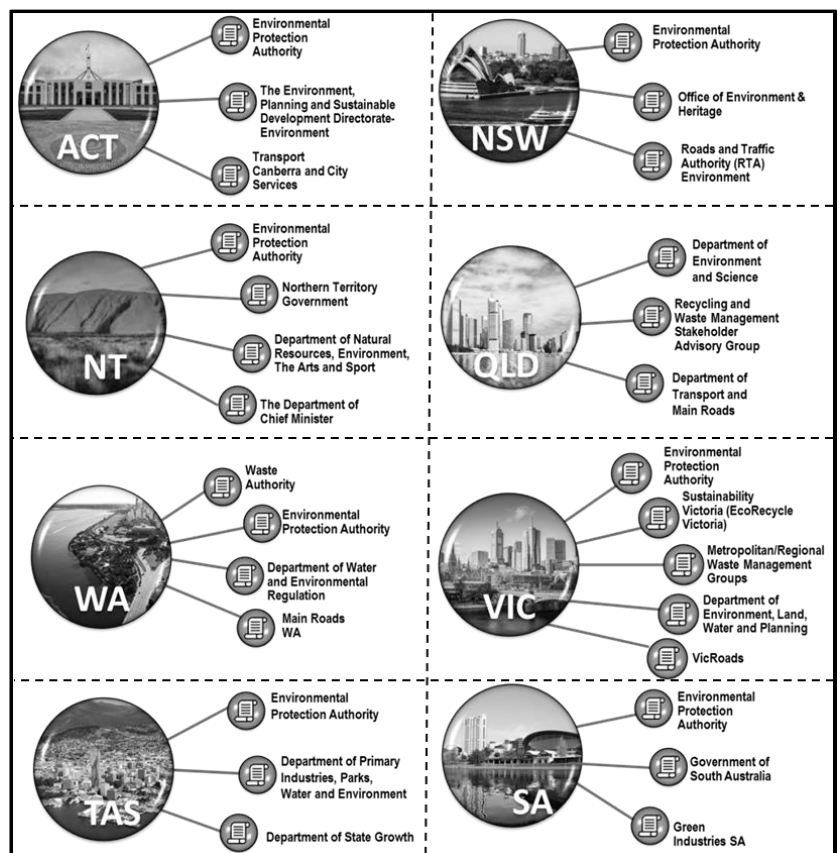


Figure 1: Agencies that contribute to C & D waste management legislation.

Victoria, previously known as EcoRecycle Victoria, has worked closely with EPA VIC and other partners to develop an industry standard on waste management. In SA, Green Industries SA, previously known as Zero Waste, has a statutory requirement (Zero waste Act 2004) to develop a waste strategy in SA. These agencies operate in close collaboration with local governments in developing C & D waste policies.

Technically, local governments provide waste collection and recycling services, manage and operate landfill sites, deliver education and awareness programs, and provide and maintain recycling infrastructure (National Waste Policy, 2018). From a more holistic perspective, as outlined by the Department of the Environment and Energy website, waste management and resource recovery are not just the responsibilities of governments but also a range of industries and businesses, as well as communities, and individuals that are involved. Figure 1 displays the various authorities that govern C & D waste in different jurisdictions.

At the national level, there is a greater variation of influencers. Fourteen authorities and associations are involved in the development of C & D waste management strategies and policy by submitting to the Department of Energy and Environment inquiry. The majority of these have contributed to development of National Waste Policy (NWP) 2018 (less waste, more resources). Among these, the Australian Local Government Association (ALGA) has a key role in developing NWP through facilitating assemblies in which state and territory environment ministers/officials, along with business and industry associations and non-government organizations, provide an input on priority issues.

## **Legislative instruments**

State and territory legislative frameworks governing waste and recycling are complex and involve multiple pieces of legislation and policy instruments. The primary pieces of legislation for C & D waste in each jurisdiction are the acts that are produced and administrated by EPAs (with the exception of QLD, where the overarching act is produced under the Department of Environment and Science). Most of these acts are updated regularly to meet current and changing industry and public demands and issues and achieve objectives recommended in state waste strategy documents. Among the jurisdictions, VIC and WA have the largest number of acts in place, followed by the ACT, NSW and SA with 3, and TAS and NT with only 1 act. In some jurisdictions, other authorities and departments have also produced acts that contribute to regulation of C & D waste or amend the primary EPAs acts. In ACT, in addition to EPA produced acts, Transport Canberra and the City Services Directorate enforced an act (Waste Management and Resource Recovery Act 2016) that informs C & D waste management. In SA, Green Industries SA has enacted the Green Industries SA Act 2004, which promotes innovation and business activity in the waste management, resource recovery and green industry sector in the State. In VIC, Sustainability Victoria developed an act (Sustainability Victoria Act 2005) to promote waste avoidance, waste reduction and recovery, reuse, recycling of resources and best practices in waste management. In WA, the Department of Water and Environment Regulation developed two acts (Waste Avoidance and Resource Recovery Act 2007/Waste Avoidance and Resource Recovery Levy Act) to regulate waste.

In each of the jurisdiction's subordinate regulations, policies and codes have been established to clarify and/or extend the scope and objectives of the overarching acts. WA has 3 subordinate regulations, followed by ACT, NSW, QLD, TAS and VIC, which enforce 2 regulations. Waste and resource management strategy are also published in jurisdictions to specify targets, strategies and priorities in management of C & D waste management. VIC is yet to develop a holistic waste strategy that facilitates implementation of C & D waste related regulations. At the national level, there are 2 pieces of legislation that are concerned with C & D waste management: the National Waste Policy and the National Environment Protection Council Act 1994. The former has outlined 14 strategies to manage waste in Australia; the latter, however, indicates the responsibility of polluters (i.e. waste producer) and the users of goods and services in relation to the cost associated with waste generation.

## Waste definition and classification System

Although the National Waste Policy 2010 set an objective to develop a 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. The practice of waste definition is excessively associated with classification of hazardous materials and determination on landfill levy liability. The legal definitions of waste, as written into regulations, have generally developed independently within each jurisdiction. Despite having general similarities between definitions of waste, each jurisdiction uses specific wording and practical applications. The definition of waste can decide when a material is a 'waste', a 'product' or a 'resource'. As such, this can have substantial regulatory, environmental and financial impacts for those who are involved in this industry (e.g. waste makers, recycling and disposal facility owners and transporters) (Hyder, 2012). In the case of C & D waste, it is simply defined in National Waste Policy (2018) as “*waste produced by demolition and building activities, including road and rail construction and maintenance, and land excavation associated with construction activities*” (p. 17). At jurisdictional level, C & D waste is not defined clearly in primary and subsidiary legislations; indeed, only two states (WA and NSW) have provided a definition for C & D waste. However, there are some other documents such as State Waste Strategy that serve this purpose. Again the range of definition of C & D varies greatly across the study jurisdictions. The main differences found include: exclusion/inclusion of clean fill (e.g. soil and rock), wording (e.g. construction (building) and demolition), and exclusion/inclusion of some materials (e.g. glass, plastic) and certain contaminations. In TAS and ACT, a clear definition for C & D waste is not provided at all. Overall, NSW has provided the most comprehensive definition comprising a broader range of construction and demolition activities and materials are specified.

Similarly to waste definition, the way that waste is classified has a significant impact on many aspects of waste management. The National Waste Policy and Draft National Solid Waste Classification System both advocate a classification that is based on three main streams: C & D, C & I and MSW. Yet this classification has not been used in waste related regulations in some of jurisdictions and other criteria (e.g. properties and the level of risk they may impose) are used to classify waste. The main functions of classification in jurisdiction are to manage hazardous waste and granting permit and licencing. In NSW, authorities took a risk-based approach and developed six categories with different levels of risk to subsequently consider waste's physical and chemical properties, with C & D waste falling within general solid waste (non-putrescible). In VIC, waste classification is primary based on source and properties and then risk level (municipal, industrial and prescribed waste), with C & D waste being classified under industrial waste. In QLD, the new classification system (which comes into effect in February 2019) will have a risk-based approach and C & D waste will fall under non-regulated waste (lowest risk). Similarly, in NT, C & D waste is classified as an “inert waste”, which is one of the three main categories of waste classification (i.e. putrescible waste, inert waste and listed waste). In the SA and TAS systems, there are five types of waste, with C & D waste being part of a separate category. The category of C&D in SA has two subcategories (i.e. inert and mixed). In ACT, waste classification is risk-based and has two main categories (liquid and non-liquid waste), with C & D lying under “inert” waste, which is one of the four subcategories of non-liquid waste (i.e. inert, solid, industrial and hazardous). In WA, the system is designed to serve landfill purposes and C & D falls within Class I (landfill inert). It worth noting the different classification systems that are currently established in each jurisdiction; these different systems are applied to cover various waste pathways including collection, transport, treatment, recovery and disposal. Moreover, different authorities may have different classification systems in place. For instance, in VIC, the classification system being used by Sustainability Victoria is somewhat different from that which is recommended by EPA VIC (Hyder, 2011a). It is notable that for reporting purposes most of the jurisdictions employ three main streams classification to report their waste management performance.

## Rate of landfill levy and penalty for illegal dumping activities

Authorities in Australia have encouraged the construction industry to minimise or further recycle C & D waste by imposing landfill disposal levies. The aim of these levies is to set a price on waste disposal that is higher than the cost of recycling, such that recycling becomes a more attractive end-point. Except for NT, each of Australia’s other jurisdictions have introduced a landfill levy; however, levies are imposed in different ways (Environment and Communications References Committee, 2018). The differences originate in the distinction between metropolitan areas versus regional areas, levy rate and whether they are obligatory versus voluntary. As displayed in Figure 2, some jurisdictions (ACT, QLD, TAS and WA) differentiate the levy rate between metropolitan and regional areas, offering a lower rate in regional areas. The voluntary levy in TAS is between 0 and \$7.5 per tonne. In the ACT, there is no C & D waste specific levy and the same fee that applies to commercial and industrial waste (C & I) is followed, which ranges from \$146.2 to \$199.2 (waste with less than 50% of recyclable materials).

Another interesting pattern is the link between the proportion of levy fee and the quantity of waste disposed of in QLD. Furthermore, a report found that lower levies in this state has facilitated interstate transport of waste to Queensland’s landfills (Queensland Government, 2017). On average, 60,000 tonnes of predominantly C&D waste is being transported from metropolitan Sydney to South East Queensland each month (Environment and Communications References Committee, 2018). In the wake of issues faced in QLD, the Queensland’s Environmental Protection Agency (EPA) has planned to introduce new levy rates in March 2019.

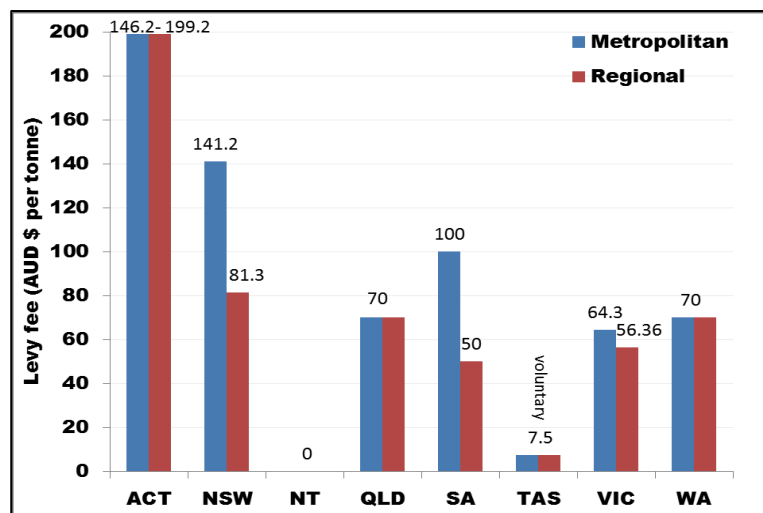


Figure 2: Levy fees for C & D waste disposal in different Australia’s jurisdictions. Source: EPA in each jurisdiction.

Legislators in Australia’s jurisdictions have set different penalty fees for illegal waste dumping. The most severe penalty is being applied in NSW, where offenders face up to 5 M and/or 7 year imprisonment. This is followed by the penalties in NT, TAS and ACT, which are 5 M (+/5 year imprisonment), 1.59 M (+/5 year imprisonment) and 1 M (+/7 year imprisonment), respectively. The next lowest penalty fees are charged in SA (up to 30 K), WA (up to 125 K), QLD (up to 217 K) and VIC (775 K).

### Future C & D Waste Management Targets

Several waste and resource strategies developed by jurisdictions use future targets to navigate efforts towards effective waste management. However, in the case of C & D waste, these targets are either non-existent or found to vary in the study jurisdictions. In terms of resource recovery and recycling, only five jurisdictions have a set target: ACT: 85% (2020), NSW: 75%-80% (2022), QLD: 80% (2024), SA: 90% (2020) and WA: 75% (2020). Other targets include increase in landfill waste diversion (NSW:



75%, QLD: 15%, SA: 90% and WA: 75%) and reduction in waste per capita (QLD: 5%, SA: 5%). To date, NT, VIC and TAS have set no specific target at all.

## **Reusing C & D waste**

In accordance with Principle 2 and 3 of the National Waste Policy 2018 (improve resource recovery and use of recycled materials), a number of regulations that are enforced in Australia’s state/territory governments are in favour of re-using (recycled) waste materials. In the case of C & D waste, state road authorities particularly support road pavement applications by providing guidelines that determine the requirements and specifications for recycled C & D waste. At the national level, Austroads—which is the association of Australian and New Zealand road transport and traffic authorities—introduced the first national guideline (Guide to Pavement Technology Part 4E: Recycled Materials) for using recycled materials in Australian roads in 2009. This guideline provides the specification, manufacture and application of a range of pavement products made from the recovery of C&D waste. In some states, recycled product specifications for recycled C&D waste have been developed. Various state authorities (in NSW, the Roads and Traffic Authority; in QLD, the Department of Transport and Main Roads; in SA, the Department of Planning, Transport and Infrastructure; in WA, WA Main Roads; and in VIC, VicRoads) have produced guidelines in which the requirements for recycled material usage in road pavement projects are outlined.

## **Waste Data Management System**

According to “Strategy 13 and 14” of the National Waste Policy 2018 “Data and Reporting” and “Market Development and Research”, all Australian governments and businesses must generate and report information to support the creation and maintenance of markets for recycled materials, both domestically and internationally (National Waste Policy, 2018 p.16). Waste data is critical to well-targeted and planned evidence-based waste projects and programs. Data on waste generation, landfill and resource recovery is critical to the development and implementation of waste policies and programs that align with international reporting requirements (SKM, 2012). Up-to-date and consistent data is essential to understanding the current state of waste and recycling. Historical data also allows current performance to be plotted against past performance. Waste policies and strategies have supported the development of waste data management systems. In some jurisdictions, reporting waste data is obligatory and more than one authority could be responsible for waste data collection. Among the jurisdictions, only four states (NSW, QLD, SA and VIC) have developed and operated a central data management system. In NSW, there is the Waste and Resource Reporting Portal (WARRP) through which waste facility owners are obliged to report some waste related information (e.g. waste contribution monthly report) to NSW EPA. In QLD, the Queensland Waste Data System (QWDS) is designed for the expanded capture of information about waste disposal and resource recovery. In SA, Green Industries SA has developed the Zero Waste Environment User System (ZEUS) to support monitoring, analysis and reporting on waste and recycling data across SA. In VIC, Sustainability Victoria operates the Waste Data Portal (WDP), which collects and stores waste and recycling data across VIC. In WA, the Waste Authority is responsible for conducting an annual census to collect waste data. These systems are being reviewed and upgraded to comply with the obligations needed for international waste data reporting.

## **4. Discussions and Conclusion**

This review study aimed to understand differences in management of C & D waste across Australia.

The results showed that there are fundamental differences in the way that C & D waste is regulated across jurisdictions. The differences include variation in regulatory and non-regulatory authorities that are responsible for enacting and enforcement of regulations, legislative instruments, definition and classification of waste, in force levy and penalty fees, C & D waste management targets, strategies to re-use recycled C & D material and waste data management systems. The lack of consistent C & D waste legislation implies that waste minimisation strategies are not uniformly employed between jurisdictions. This, in turn, can cause a wide range of consequential issues, including unreliable waste data collection, non-compliance with international reporting obligations and increases in illegal dumping and administration cost for waste management between jurisdictions. These issues also hinder efforts by the Australian recycling industry to respond to new bans placed by foreign governments on the import of C & D waste and to develop a domestic market that is attractive for investors. All of these issues can be addressed if a consistent (and thus more manageable) approach is developed at the national level and harmoniously adopted by jurisdictions. Any consistent approach has to be developed in consultation with state/territory and local governments, landfill and recycling facility owners, construction industry associations and other major stakeholders.

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## References

- ABS 2006. Australian and New Zealand Standard Industrial Classification *In*: STATISTICS, A. B. O. (ed.). ABS.
- ABS 2018a. 8762.0 - Engineering Construction Activity, Australia, Jun 2018. *In*: STATISTICS, A. B. O. (ed.).
- ABS 2018b. Australian Demographic Statistics. *In*: STATISTICS, A. B. O. (ed.).
- ENVIRONMENT AND COMMUNICATIONS REFERENCES COMMITTEE 2018. Never waste a crisis: the waste and recycling industry in Australia. *In*: SENATE, T. (ed.). Commonwealth of Australia 2018.
- HYDER 2011a. Australian Waste Classifications. *Roles in Decision Making*.
- HYDER 2011b. Construction and Demolition Waste Status Report: Management of Construction and Demolition Waste in Australia Australia Department of Energy and Environment (Department of Sustainability, Environment, Water, Population and Communities).
- HYDER 2012. Waste Definitions and Classifications: Report on Issues, Opportunities and Information gaps. Hyder Consulting Pty Ltd.
- IBISWORLD 2019a. Construction in Australia. IBISWorld.
- IBISWORLD 2019b. Solid Waste Collection Services in Australia. IBISWorld.
- LAVIANO, H., BARLOW, J., MONICA TON & DAWOOD, N. 2017. Waste and recycling industry in Australia: A Submission to the Senate Inquiry
- LOCKREY, S., NGUYEN, H., CROSSIN, E. & VERGHESE, K. 2016. Recycling the construction and demolition waste in Vietnam: opportunities and challenges in practice. *Journal of Cleaner Production*, 133, 757-766.
- MARTEK, I., HOSSEINI, M. R., SHRESTHA, A., EDWARDS, D. J. & DURDYEV, S. 2019. Barriers inhibiting the transition to sustainability within the Australian construction industry: An investigation of technical and social interactions. *Journal of Cleaner Production*, 211, 281-292.
- NATIONAL WASTE POLICY 2018. Less Waste. More Resources. *In*: GOVERNMENT, A. (ed.).
- NWR 2018. Australian National Waste Report 2018. Department of the Environment and Energy.
- PARK, J. & TUCKER, R. 2017. Overcoming barriers to the reuse of construction waste material in Australia: a review of the literature. *International Journal of Construction Management*, 17, 228-237.
- QUEENSLAND GOVERNMENT 2017. Investigation into the transport of waste into Queensland.
- SKM 2012. Review of Australia's international waste-related reporting obligations.

- UDAWATTA, N., ZUO, J., CHIVERALLS, K., YUAN, H., GEORGE, Z. & ELMUALIM, A. 2018. Major factors impeding the implementation of waste management in Australian construction projects. *Journal of Green Building*, 13, 101-121.
- YUAN, H., CHINI, A. R., LU, Y. & SHEN, L. 2012. A dynamic model for assessing the effects of management strategies on the reduction of construction and demolition waste. *Waste management*, 32, 521-531.