Identifying the economic factors and drivers that govern the disposal and reduction / reuse / recycling of Construction and Demolition waste

Research Report No. 3

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SBEnrc P1.65 A National Economic Approach to Improved Management of Construction and Demolition Waste

Date: August 2019

ACKNOWLEDGEMENTS

This research has been developed with funding and support provided by Australia's Sustainable Built Environment National Research Centre (SBEnrc) and its partners.

Core Members of SBEnrc include Aurecon, BGC Australia, New South Wales Roads and Maritime Services, Curtin University, Griffith University, RMIT University, Queensland Government and Government of Western Australia.

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

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Citation: Maqsood, T., Shooshtarian, S., Wong, P., Khalfan M., Yang R., Ryley, T. (2019) Identifying the economic factors and drivers that govern the disposal and reduction / reuse / recycling of Construction and Demolition waste. SBEnrc 1.65 - A National Economic Approach to Improved Management of Construction and Demolition Waste. https://sbenrc.com.au/research-programs/1-65/

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EXECUTIVE SUMMARY

Economic factors play an important part in effective management of C&D waste management in Australia and elsewhere. With the introduction of a circular economy and recent calls for application of its principles to the C&D waste stream instead of a linear 'take-use-dispose' approach, the role of economic factors has been increasingly stressed in waste strategies and policies. Therefore, this review aims to understand the main economic factors that may prevent or accelerate a market for trading salvaged and recycled C&D waste materials. This review of economic factors mainly draws on the following sources:

- Waste legislative and non-legislative documents in Australia
- Previous research reports in Australia and elsewhere
- Research publications on the issues related to C&D waste management

The backbone of this review consists of the three components of effective waste management, namely enforcement, prevention, and encouragement. Reviewing the literature in these three areas, this study identified 24 factors that may influence circular economy of the C&D waste stream in Australia. A model is developed to framework these factors in a typical C&D waste flow in the Australian context. Following identifying these factors, key recommendations were formulated to guide reforms to the Australian waste and resource recovery industry as follows:

- Waive or reduce landfill levy rates imposed on recycling residuals, as is being practiced in New South Wales (NSW) for metal recovery, to boost waste recovery activities
- Provide waivers or discounted levy rates to recyclers for disposing of contaminants that enter the recycling stream
- Adjust levy rates to produce the best possible results
- Make EPR and similar schemes mandatory for a greater impact and compliance
- Invest in technologies and infrastructure to accommodate the growing quantity of C&D waste
- Impose a tax on raw materials extraction and import
- Consider a waiver on GHG emission schemes for recovery facilities through an emission trading scheme and carbon tax (if introduced)
- Invest in attitudinal change through R&D programs leading to raising C&D waste stakeholder's awareness
- Mandate Green Star (GS) and Infrastructure Sustainability (IS) principles with respect to waste minimisation or to award construction projects that support and fulfil the existing GS and IS requirements
- Give the Australian government the main responsibility for coordination of efforts to develop local C&D waste markets
- Support the development of an efficient and effective supply chain system
- Promote, appreciate or mandate sustainable procurements within the public sector
- Clarify when a waste ceases to be waste in the jurisdictional waste legislative framework so that consumers can take advantage of clean fills for levelling projects and avoid landfill levies
- Review existing waste regulations to consider further support for waste recyclers
- Promote a cradle to cradle approach in the design and manufacturing of construction materials
- Establish a marketplace that facilitates trade of salvaged and recycled C&D waste material
- Mandate developing and keeping as-built and as-renovated plans, including a bill of quantities. Having these registered in a permanent database would assist the task of application of EPR and similar schemes at later stages

1 INTRODUCTION

This section aims to address the third objective of this research project, which is to identify the economic barriers and enablers that govern C&D waste reuse and recovery in Australia and elsewhere. Several research studies have argued that market-based instruments should inform C&D waste management. These instruments, 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. Many past studies have demonstrated that an integrated and effective waste management system should consist of these three components. In Australia, much focus has been put on enforcement, except for in Tasmania (Tas) and the Australia Capital Territory (ACT), and the other two categories have not been well developed. Thus, this review attempts to provide examples, where available, of the development and practice of these two components in other countries. While these examples have been successful in some countries, the same practices have proved less successful in some other countries.

1.1 Enforcement

Currently, enforcement in Australia is imposed through three common practices: levies for landfilling, penalties on illegal dumping activities and the proximity principle. However, as discussed in Report No. 1[1], these three mechanisms are not consistently enforced across the states and territories of Australia. While the literature consistently confirms the positive impact of penalties on illegal dumping and stockpiling on market development for salvaged and recycled C&D waste, the effectiveness of landfill levies and the proximity principles seem to be more debatable. The following sections provide insight into the experience of Australia and other countries in enforcing landfill levy on C&D waste.

1.1.1 Landfill levies

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. In the literature, conflicting results are reported in response to the imposition of a landfill levy, both in domestic and international contexts. The mechanism and other characteristics of imposing a landfill levy in different Australian states and territories have been stated previously in Report No. 1[1]. In this section, the relevant literature is reviewed to understand the impact of this enforcement mechanism in Australia and elsewhere. In the first part of this section, worldwide evidence regarding the effectiveness of this mechanism is provided; the second part discusses the findings that show how landfill levies are perceived in Australia.

1.1.1.1 Part I: Effectiveness; worldwide experience

From 1987 to 1993, the waste levy enforced in *Denmark* resulted in a C&D waste reduction of 64%[2]. In the Netherlands, it was reported that, since the introduction of the landfill levy in 1995, until the time of the report (2003), the amount of landfilled waste decreased by almost three times[3]. In *the UK* it was found that, unlike in the case of municipal and C & I (1994-2000), the tax levy had a positive

[1] Discrepancies in regulations governing C&D waste and recommendations for reforms. https://sbenrc.com.au/research-programs/1-65/

[2] Andersen, M.S., 1998. Assessing the effectiveness of Denmark's waste tax. *Environment: Science and Policy for Sustainable Development*, 40(4), pp.10-15.

[3] Bartelings, H., van Beukering, P.J.H., Kuik, O.J., Linderhof, V.G.M., Oosterhuis, F.H., Brander, L.M. and Wagtendonk, A.J., 2005. Effectiveness of landfill taxation.

impact on C&D waste stream minimisation[4]. This status was later questioned through a study[5] in which the authors claim that the landfill levy and other fiscal measures are yet to have seriously reduced the amount of waste production. However, this claim was not confirmed by subsequent studies. For instance, in 2015 a study indicates that the landfill tax is a major driver for adopting waste management strategies among construction profiles. The same study also calls for the development of more viable options to the landfill levy that can cover the design stage. One of the participants in this study emphasised the positive role of the landfill levy and maintained that:

> *"With almost yearly increases in landfill tax, more people are finding alternative solutions. If the trend continues, waste landfilling could become something of the past, especially as money almost matters".* (p. 110).

This result refers to the fact that the construction industry is largely driven by financial gain. In *Hong Kong*, the results of a 3-year levy scheme (2006-2008) demonstrated that C&D-specific waste levy taxes can influence the construction industry's behaviours regarding C&D waste, resulting in a significant reduction in solid waste disposal[6]. It is reported that C&D waste reduced by 60% in landfills, and by about 23% and 65% in public fills and total waste respectively. Another study[7] reported that the tax levy is one of the most effective C&D waste policies in the reduction of waste disposal at landfills. Despite such evidence, a more recent study[8] in Hong Kong found that there is no consensus view among construction professionals on the effectiveness of the tax levy; 30% of respondents to this study agreed that the levy rate was not high enough to alert them about waste minimisation practices. From the literature above, it can be inferred that the evidence for the effectiveness of the levy outweighs those that underestimate its influence.

1.1.1.2 Part II: the Australian experience

In 2011, a C&D supply chain guide[9] prepared for the Commonwealth Government of Australia reported that many stakeholders had indicated that landfill costs (landfill operation and levies) are a significant driver for the use of salvaged and recycled C&D waste. In 2018, various respondents to the call for submissions to the Senate's Environment and Communicates References Committee expressed support for continuous imposing of landfill levies (Environment and Communications References Committee, 2018). The submissions highlighted that levy schemes can act as a disincentive for waste disposal. Further, they concluded that the ensuing revenue is an important source of funding for investment in waste and recycling management initiatives. The following table (Table 1) shows examples of support from different submitters:

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[4] Martin, A. and Scott, I., 2003. The effectiveness of the UK landfill tax. *Journal of Environmental Planning and Management*, 46(5), pp.673-689.

[5] Osmani, M., 2012. Construction waste minimization in the UK: current pressures for change and approaches. *Procedia-Social and Behavioral Sciences*, 40, pp.37-40.

[6] Hao, J.L., Hills, M.J. and Tam, V.W., 2008. The effectiveness of Hong Kong's construction waste disposal charging scheme. *Waste Management & Research*, 26(6), pp.553-558.

[7] Lu, W. and Tam, V.W., 2013. Construction waste management policies and their effectiveness in Hong Kong: A longitudinal review. *Renewable and Sustainable Energy Reviews*, 23, pp.214-223.

[8] Poon, C.S., Yu, A.T., Wong, A. and Yip, R., 2013. Quantifying the impact of construction waste charging scheme on construction waste management in Hong Kong. *Journal of Construction Engineering and Management*, 139(5), pp.466-479.

[9] Edge Environment. 2011. Construction and Demolition Waste Guide - Recycling and Re-Use Across the Supply Chain. The Commonwealth Government of Australia.

Table 1. The evidence of the effectiveness of landfill levies in Australia

Respondents	Indicative language
WA Government	There has been a notable diversion from landfill for two waste streams (i.e. C&D and C&I) since 2011 when levy rates were considerably increased.
Re.Group (http://www.re-group.com/)	NSW's relatively high recovery rate for two waste streams (i.e. C&D and household waste) has been driven by the landfill levy.
SA Government	Progressive increase of waste recovery (reduction in waste disposal) has been concurrent to the continuous increase in levy fees. The increase was more than 20% in 2015-2016 (81.6%) compared to 2003-2014 (60%).
The Western Australian Local Government Association	There is evidence that the landfill levy has been responsible for diverting inert material from landfill; however, it is not known where this waste is being diverted.
Envorinex (https://envorinex.com/)	Landfill levies should be priced high enough to encourage major business to send their waste to recyclers and not to landfill sites.

Source: Environment and Communications References Committee (2018)

In addition to support from the submissions to this committee[10], there are some concerns about the unintended consequences that emerge from the improper design of levy schemes. These concerns express that the jurisdictional legislation levy should not give rise to unintended outcomes such as interstate waste transfer because of cost disparity, discouraging private investors to invest in recycling infrastructure, high administrative costs corresponding to the application of complex schemes and stockpiling and illegal dumping.

In addition, some respondents provided evidence that shows that imposing a landfill levy did not achieve the intended goals (e.g. reduction in waste disposal or an increase in waste recovery activities)[10]. Indeed, this evidence demonstrates that there are limits to what can be achieved through the imposition of a landfill levy. Table 2 summarises these challenges associated with landfill levies.

Table 2. Unexpected results from the implementation of landfill levies in Australia

Submitter	Indicative language
The Law Council of Australia	Landfill levies can encourage stockpiling and illegal dumping.
GCS Consulting	During the period when the amount of the metropolitan New South Wales levy doubled, the NSW C&D industry was found to have reduced its recycling rate, which is contrary to expected market behaviour and the efficacy of the levy as a pricing mechanism that was achieved when the levy was at much lower levels.
Unspecified submitters	Little effect on waste generation, as ratepayers have no direct financial incentive to reduce waste destined to landfill.
Adelaide Hills Region Waste Management Authority	Waste disposal levies do 'not act as a direct driver for the community to reduce waste generation or increase recycling habits' because any increase in waste levies is 'covered by general rate revenue'.
The Australian Sustainable Business Group	Highlighted that there is evidence that an increase in the landfill levy results in incurring additional costs for the recycling industry.
National Waste and Recycling Industry Council	A levy on the disposal of recycling residuals reduces the competitiveness of materials sold into the international market.
Centre of International Economics	In NSW, the waste levy of $ AU 120 reduced the profit margin of metal recyclers in 2011.

[10] Environment and Communications References Committee (2018). Never waste a crisis: the Waste and recycling industry in Australia / The Senate. Canberra, ACT

Submitter	Indicative language
The Australian Council of Recycling	When recyclers are liable to pay the levy for the disposal of contaminants that have entered the recycling stream, they see it as a disincentive towards being involved in the recycling industry and instead it encourages shipping unprocessed waste overseas.
Re Group	The disposal of residuals generally represents a significant cost for recycling facilities, which can obviously create commercial incentives to seek lower disposal cost options. It also justifies transport waste to interstate locations with a lower disposal rate.
Visy, Owens-Illinois and SKM Recycling	Landfill levies penalise the recycling industry for the disposal of residual rubbish that enters the recycling stream.

Source: Environment and Communications References Committee (2018)

Aside from the views tabulated above and beyond the scope of this report, several respondents indicated that levies have little impact on domestic waste generation patterns in Australian cities[11]. It is found that, because councils charge households at a flat fee to recover the levy fees, which they pay on behalf of ratepayers, they have no motivation to reduce the amount of waste disposed. In other words, basically, the price signal is not passed on through the rates directly. There is a lesson in this causality that can be transferred to the context of C&D waste management; the levy should be accompanied with other financial incentives to effectively target waste generation at origin, for example, during the design and construction stages.

In response to the call made by the WA Department of Waste and Environmental Regulation for submission to a discussion paper on landfill levy several trends emerged. Some of the submissions presented different issues that were not considered in the relevant regulations and policies. The following are a selection of their responses to the latest levy regime in WA:

> *"A levy, by its nature, is a penalty/cost impost. In what way is the payment of a levy an incentive? Those paying the levy have less funds available to put into their own research and subsequent implementation of their own waste reform policies and systems"[12].*

> *"In addition, we are concerned that this appears to be revenue raising activity rather than a legitimate pursuit of better environmental outcomes for Western Australia"[13]*

- Levy should be articulated as the 'key environmental lever' not an 'economic policy lever'
- A rebate system has to be in place for those who are involved in landfill diversion
- Allow alternative methods of calculating waste volumes, rather than just utilisation of weigh stations

Another barrier to effective enforcement of landfill levies discussed previously (Research Report No.1) is to nationally harmonise gate fees. The support for harmonisation is abundant (Environment and Communications References Committee, 2018) and it is believed it can substantially minimise inter-jurisdictional waste transfer. However, it should be remembered that such an arrangement might not produce the best results. Simple harmonisation may overlook the existing contextual conditions in each jurisdiction. It may also interfere with the specific waste management system implemented in different states and territories. Hence, it is better to set up the levy fees in a way that ensures the negative impact on the effective management of C&D waste across Australia is minimised. For

[11] Ibid p. 51.
[12] Activa developments Pty ltd. 2017. Comments on waste reform project
[13] Alcoa of Australia Limited. 2017. Comments on waste reform project

instance, a rate disparity should be calculated to the extent that it does not prompt unnecessary long-distance waste transfer.

1.1.2 Illegal dumping penalty

Illegal dumping and stockpiling are seen as disincentives toward waste recovery. Multiple submitters to the Environment and Communications References Committee (2018) indicated that, in order to remove the unintended negative outcomes of a landfill levy, the government should do more to stop illegal waste disposal. The current regulatory environment for illegal dumping in the different states and territories of Australia is provided in the Research Report No.1.

1.1.3 Proximity principle

This principle requires waste generators to send their waste to a facility that is located in a certain perimeter of origin. Several submissions to the Environment and Communications References Committee (2018) argued that the proximity principle (PP) can assist in preventing movement of waste between jurisdictions for the purpose of avoiding and minimising levy liabilities. A criticised example of implementation of PP is happening in NSW where waste generators are only allowed to dispose of their waste within a 150km perimeter. The Waste Contractors and Recyclers Association of NSW instead suggested that a national proximity principle would be more effective. In this respect, the Law Council of Australia (LCA) suggests that implementation of a national PP should align with Section 92 of the Constitution, which stipulates that trade and commerce among the states are to be regarded as absolutely free.

The submission from the Waste Management Association of Australia indicates that its members need to stop the practice of long-distance transportation of waste. This association argues that, "*…we do not agree with long-distance transportation; we actually agree there has to be a proximity principle in place to stop the excessive and unnecessary movement of waste across distances, particularly if there is the infrastructure in place. You can't actually invest and develop infrastructure if you haven't got certainty about what's coming through the front gate. In Europe you do have a proximity principle, so we need to solve how we do that*" (p. 59).

The other argument in regard to PP is that authorities have to be alerted to the consequences of implementation of such a policy. It is argued that there are some environmental benefits that come with waste transport that could be diminished by imposition of PP. In the case of development of a domestic market for C&D waste, the trade of recovered/unrecovered waste materials between different locations is necessary to sustain industries and businesses involved in the market. China's National Sword Policy is another driver for the wise adoption of PP in Australia. This policy forces the Australian waste and resource recovery industry to commit to the development of a sustainable domestic market for trading waste materials across Australia. For waste energy recovery, the need for sustainable waste feedstock is found to be the main barrier to the development of Energy from Waste (EfW) facilities. It can be concluded that, until the full potential for waste management in proximity is fulfilled, reasonable distance transportation of recovered/unrecovered waste materials should be allowed.

1.2 Prevention

There are several economic-based strategies to prevent waste generation prior to, during and after construction. These strategies include 'extended producer responsibility' and similar schemes, 'cradle

to cradle approach' and 'tax on the use of raw materials'. If implemented fully, it is expected that these mechanisms can have a strong influence on C&D waste generation.

1.2.1 Extended producer responsibility

Extended Producer Responsibility (EPR) is found to be a successful market-based policy approach that has been applied to different waste types and streams[14] (Hanisch, 2000). Technically, EPR makes manufacturers responsible (financially and/or physically) for the entire lifecycle of their products during the supply chain of materials, including design, manufacture, recycling and final disposal (OECD, 2016). EPR provides an opportunity to divert additional waste away from landfills to reuse and recovery. EPR has been recognised as an incentive for producers to take into account environmental considerations when designing their products, resulting in preventing waste at the source through better product design (Environment and Communications References Committee, 2018). One submission to this committee inquiry stated that generally about 70-80% of the environmental impact of a product is locked in at the design phase (Environment and Communications References Committee, 2018).

These regulatory instruments enforce the price signal that ensures the entities that have the power to redesign their construction materials or to trade other materials play an active role in the management of waste produced. For this to be achieved, producers should use instruments such as design for recyclability, reduced material usage, product disassembly, reduced or eliminated the use of toxic materials, and re-manufacturability (Acree Guggemos and Horvath, 2003).

The idea of EPR originated in Germany in 1991 as a result of a landfill shortage. At the time, packaging made up 30% by weight and 50% by volume of Germany's total municipal waste stream[14]. To help slow down the filling of landfills, Germany created a law, the German Packaging Ordinance, that required manufacturers to be responsible for their own packaging waste through either (1) taking back their packaging from consumers and distributors; or (2) paying the national packaging waste management organisation to collect the packaging (Shea, 1992). The formal introduction of this terminology, however, was made by Thomas Lindhqvist in Sweden in 1990 (Lindhqvist and Lidgren, 1990) in a report to the Swedish Ministry of Environment. Other variations of EPR are Product Take Back (PTB), Product Stewardship (PS) and Polluter Pays Principle (PPP). Table 3 provides a summary of the description of various types of EPR schemes.

Table 3. Variations of Extended Producer Responsibility (EPR) programmes

Name	Description
Polluters pay principle	In this program, producers are recognised as responsible for the pollution that ensues from their products.
Product stewardship	This approach acknowledges that those involved in producing, selling, using and disposing of products have a shared responsibility to ensure that those products or materials are managed in a way that reduces their impact on the environment, human health and safety, throughout their lifecycle.
Product take-back	In this scheme, producers are required to take back products at the end of their useful life and reuse or recycle them.

The main distinction between PS and EPR is the focus of EPR being on preventing rising levels of waste and pollution, whereas shared PS initiatives primarily enforce that a producer covers a proportion of costs associated with management of waste at the end of a product's useful life. A common example of PS is container deposit laws whereby consumers are forced to pay extra when they buy beverages

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

in cans/bottles: the amount that can be redeemed upon returning cans/bottles. EPR is more comprehensive than PTB as it can take three forms: as re-use, buy back or recycling program.

Despite the differences mentioned above, the main three objectives of EPR and its variations include reduction in pollution prevention, a decline in the extraction of natural resources, and a drop in energy use for extracting and processing new materials (Fishbein, 2000, Acree Guggemos and Horvath, 2003). The implementation of EPR and similar schemes have been repeatedly mentioned as an effective policy approach in management of C&D waste in previous studies (Duan et al., 2019, Dubois et al., 2016, Acree Guggemos and Horvath, 2003, Zainu and Songip, 2017, Park and Tucker, 2017, Golev and Corder, 2016).

Until now, there is no universal and standard policy approach to implement and take advantage of EPR objectives for the C&D waste stream. Among different international organisations, the Organisation for Economic and Cooperation and Development (OECD), through its Working Party on Resources Productivity and Waste (WPRPW), has been heavily engaged in EPR activities for a long time. Furthermore, the PPP was first mentioned in the OECD's May 1972 recommendation and was reaffirmed in its November 1974 recommendation. Almost two decades later, it was laid down as Principle 16 of the UN Declaration on Environment and Development.

This literature review forms part of a larger research project (A National Economic Approach to Improved Management of Construction and Demolition Waste: https://sbenrc.com.au/research-programs/1-65/), which is being conducted at RMIT University and supported by Griffith University, through funding from Australia's Sustainable Built Environment National Research Centre (SBEnrc). This project endeavours to foster a holistic national approach to address C&D waste issues. Its objectives include the development of a consistent approach to define and measure C&D waste, the identification of influential economic factors that govern management of C&D waste, the conducting of a feasibility study on the creation of a marketplace for trading C&D waste, and the identification of opportunities to integrate a supply chains model in management of C&D waste.

EPR and similar schemes are new concepts for the management of C&D waste in Australia. The federal government, in collaboration with state governments, is working to develop a national EPR policy that can be applied throughout Australia. Therefore, this review study aims to provide necessary information about different aspects of EPR and similar initiatives that may inform policy development. In accordance with this aim, the objectives of this study are therefore outlined as follows:

- Review examples of EPR and similar policies application in relation to C&D waste
- Determine the position of Australia in developing EPR policies and other similar schemes legislation in Australia
- Explore the challenges in adoption of EPR and similar schemes in the Australian construction industry

1.2.1.1 Considerations in the development of EPR policies

The development of EPR and other similar policies is not straightforward, due to the complexities and wide range of stakeholders involved in product production, trade, delivery, consumption and waste management. Furthermore, the methods through which EPR policies are applied can vary. Several previous research studies have attempted to model these complex factors to boost the performance of EPR policies in practice. This section of results focuses on a few of these models. For instance,

Dubois et al. (2016) presented 5 criteria for the development and evaluation of product and its ensuing waste. Figure 1 depicts these five criteria.

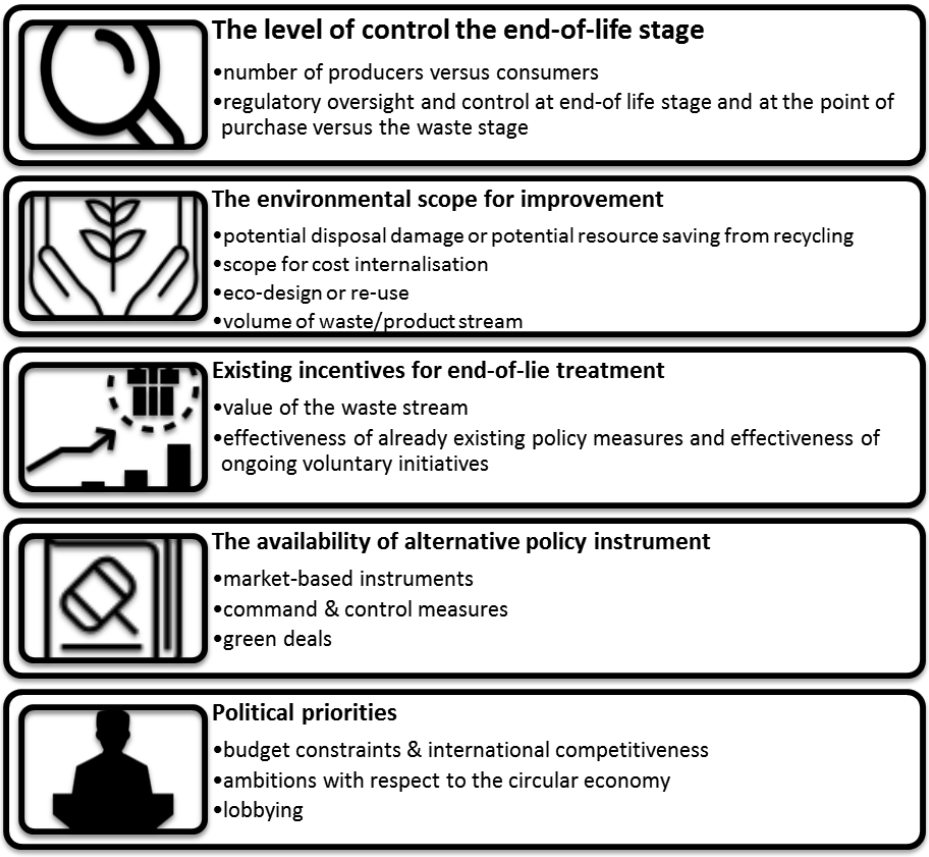

Figure 1. Five criteria that can be used for the development of EPR policy for a particular waste stream.

Source: materials adopted from Dubois et al. (2016)

Applying these criteria to the C&D waste stream in the Netherlands, the researchers indicated there is a motivation to implement EPR for only two criteria (e.g. environmental scope and political priorities). Acree Guggemos and Horvath (2003) put forward a policy framework to better achieve EPR goals for C&D waste management. This framework, which is based on Thorpe and Kruszewska (1999) model, consists of three types of policy instruments: regulatory, economic and information-based (Figure 2).

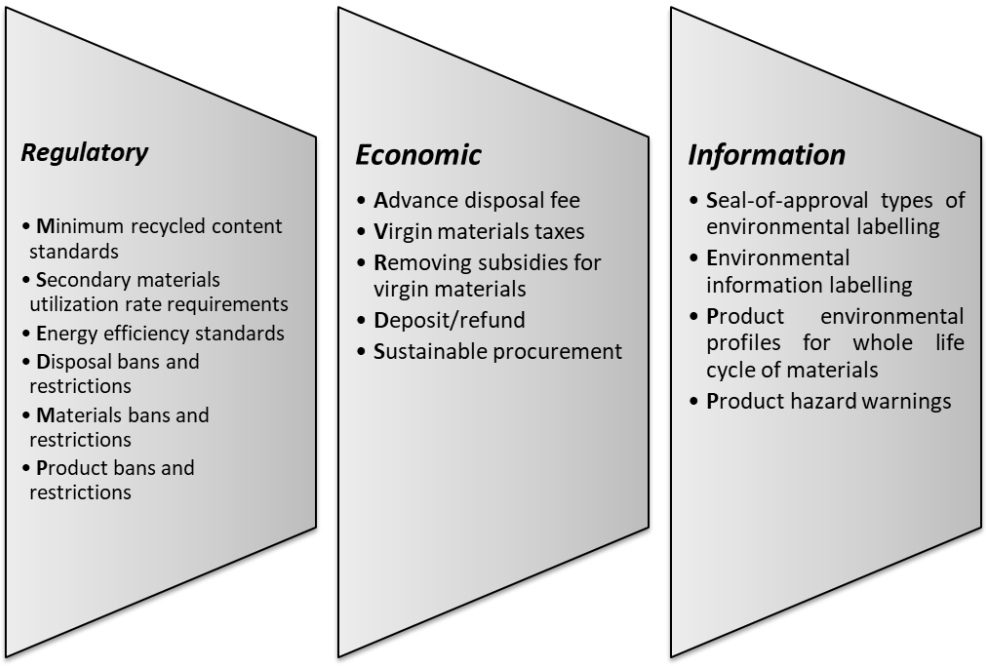

Figure 2. Three policy instruments that facilitate EPR achievement
Source: adapted from Acree Guggemos and Horvath (2003)

In addition to the models presented in Figures 1 and 2, there are other studies that have presented models with some similarities and differences (Forslind, 2005, Langrová, 2002, Nahman, 2010, Widmer et al., 2005, Lindhqvist, 2000). Furthermore, some studies investigating factors that impact EPR's performance provided useful information on how to maximise the adequacy of EPR and similar schemes for waste management. For instance, Gupt and Sahay (2015) conducted a comparative analysis on 26 case studies in developed and developing countries to identify the factors contributing to the success of EPR implementation and the main aspects of EPR development and implementation. The results revealed that the 'financial responsibility of the producers', 'separate collecting' and 'recycling agencies' significantly contribute to the success of EPR. The main aspects of EPR were also found to be 'regulatory provisions', take-back responsibility and 'financial flow'. In 2016, one study on the effectiveness of various policy approaches weighted and compared different policies in Maine, US (Isenhour et al., 2016). The results showed that EPR policies are regarded as highly effective but that their acceptability is uncertain.

1.2.1.2 Regulation of EPR and other similar schemes in Australia

There is no specific EPR driven legal instrument for the C&D waste stream in Australia; nor are there any nationally adopted EPR regulations. However, under the National Waste Policy (2018), Strategy 4: Product Stewardship, the Australian Government is responsible for leading a national approach to product stewardship. The federal government continues to work with state and territory governments and industry to consider possible product stewardship approaches for other products. Currently, there is one PS primary legislation, Product Stewardship (2011): the Act that is guided by the National Waste Policy. This act provides the framework to effectively manage the environmental, health and safety impacts of products, and in particular, those impacts associated with the disposal of products. The program has 26 signatories who have committed to improving areas such as manufacturing emissions, additives and end-of-life management (Edge Environment, 2012). The Act operates through three types of stewardship: voluntary, co-regulatory and mandatory.

- **Voluntary:** Industries with government oversight can voluntarily take action to reduce the impact their products have. These schemes, which are funded and led by industry, facilitate

sustainable management of products without the need for regulation. Industry based schemes that obtain the federal government accreditation are monitored to ensure they are achieving agreed outcomes.

- **Co-regulatory:** These schemes are the product of industry action and federal government regulation. Government sets the minimum outcomes and operational requirements, while industry has some discretion about how those requirements and outcomes are achieved.
- **Mandatory:** This imposes a legal obligation on stakeholders to take certain actions in relation to a product that leave little or no discretion on how the requirements are to be met. There are currently no fully mandatory product stewardship schemes in place under the Act.

In 2018, the Australian Environment and Communications References Committee provided some recommendations for the federal government with respect to the implementation of PS schemes:

- PS schemes under the Act should be mandatory and such an obligation should be applied to tyres, mattress, e-waste and photovoltaic panels.
- Extend producer responsibility under this Act through improved design.

The federal government supports PPP through the National Environment Protection Council Act 1994, under section 3.5.4 (improved valuation, pricing and incentive mechanisms Section). This Act maintains that:

> *"…polluter pays i.e. those who generate pollution and waste should bear the cost of containment, avoidance, or abatement the users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes" (National Environment Protection Council Act 1994 (Cth, p. 40))*

In relation to this Act, the PS schemes and regulations were developed for multiple products including e-waste (Product Stewardship (Televisions and Computers) Regulations 2011), batteries, tyres (Tyre Stewardship Australia), oil (Product Stewardship (Oil) Act 2000), used packaging (the Australian Packaging Covenant: co-regulatory scheme), agricultural chemicals and containers (Drum Muster: voluntary scheme) and paint (National Paint Product Stewardship Scheme). The latest product list, released in 2017-18, targets 'plastic microbeads and products that contain them', 'batteries', 'photovoltaic systems', 'electrical and electronic products' and 'plastic oil containers'.

At the jurisdictional level, except for in the Northern Territory (NT), relevant primary and secondary legislations have acknowledged the need for having EPR and similar schemes in place (Table 4). Only three jurisdictions, ACT, TAS and South Australia (SA), included the EPR definition and its principles in their relevant legislation. Among the jurisdictions, the most developed legislation occurred in Queensland (Qld), NSW and Western Australian (WA); these states allocated at least one section detailing the requirements and circumstances under which a product is regulated or managed a PR/EPR programs. In Qld, particularly, the Waste Reduction and Recycling Act 2011 provided the relevant conditions through which an industry can be accredited to launch a voluntary PS program; it also explains how regulations and monitoring of a PR scheme can take place.

Table 4. Regulatory framework supporting EPR and similar schemes in different states/territories

Regulation	State	Summary
Environment Protection Act 1997 Waste Management and Resource Recovery Act 2016	ACT	**Part 1 Preliminary** 3D-Principles applying to Act. The principles of EPR (only in EPA act 1997) and PP for the environment are enshrined in these acts.
Not relevant statements in legislation	NT	N/A
Waste Avoidance and Resource Recovery Act 2001	NSW	**Part 3- Objects of acts (e) to ensure that industry shares with the community the responsibility for reducing and dealing with waste** **Part 4– Responsibilities with respect to industry waste reduction** (15) Extended producer responsibility schemes (16) Regulations for implementation and operation of schemes (17) Circumstances in which schemes may be implemented (18) Priorities with respect to the implementation of schemes
Waste Reduction and Recycling Act 2011	QLD	The principles of PS are enshrined. **Chapter 4 Management of priority products and priority waste** **Part I –responsibility the purpose of this chapter is to (a)** to encourage, and in particular circumstances to require, persons who are involved in the life cycle of a product to share responsibility **Part 2– (objectives of act): (d)** to ensure a shared responsibility between government, business and industry and the community in waste management and resource recovery **Part 3– Product stewardship schemes** Division 1 Product stewardship schemes generally Division 2 Accreditation of voluntary product stewardship schemes Division 3 Product stewardship schemes by regulation Division 4 Monitoring of schemes
Environment Protection Act 1993	SA	**Part 2— Objects of Act/10-vi**: allocate the costs of environment protection and restoration equitably and in a manner that encourages responsible use of, and reduced harm to, the environment with polluters bearing an appropriate share of the costs that arise from their activities, products, substances and services.
Environmental Management and Pollution Control Act 1994	TAS	**Part 2—Objectives of the Act/ (d)** to allocate the costs of environmental protection and restoration equitably and in a manner that encourages responsible use of, and reduces harm to, the environment, with polluters bearing the appropriate share of the costs that arise from their activities.
Environment Protection Act 1970 Environment Protection (Resource Efficiency) Act 2002 Sustainability Victoria Act 2005	VIC	**The principles of EPR (1G) and PS (1H)** are enshrined in the act. **49AH-** The Authority may also require the person, in relation to the enterprise, process, products or service to assess alternative practices and product stewardship approaches to improve the use efficiency of specified resources or to reduce any ecological impacts identified by the Authority; **49AN-**The Authority may produce and publish guidelines concerning product stewardship approaches; **49AO-** Authority may conduct audits to provide an assessment of product stewardship approaches The functions of Sustainability Victoria are to (b) foster a stewardship ethos in relation to the use of resources

Regulation	State	Summary
Waste Avoidance and Resource Recovery Act 2007	WA	**Part 5 — Product stewardship** 45. Product stewardship plans 46. Extended producer responsibility schemes 47. Statements with regard to extended producer responsibility schemes Schedule 3 — Matters in respect of which regulations may be made Division 3 — Product stewardship

Currently, there are only two states that have a specific EPR policy in place. NSW was the first jurisdiction to establish an EPR policy (NSW Extended Producer Responsibility Priority Statement 2010) under the NSW Environmental Protection Authority Act (Waste Avoidance and Resources Recovery Act 2001, NSW). Under this Act, the EPA is required to publicly announce an EPR priority every year. The latest EPR priority statement was released in 2010 and 17 priority materials were identified. From these 17, only treated timber, packaging, and PVC are from the C&D waste stream. In 2008, the WA Municipal Waste Advisory Group prepared a Policy Statement on Extended Producer Responsibility 2008 for WA. According to the second outcome of this policy, EPR is linked with an improved valuation, pricing and incentive mechanism; it enables the market to better communicate the environmental and social costs of waste and makes waste minimisation an attractive action to producers and consumers; it eventually furthers the attractiveness of reusing and recycling materials.

In addition to these policies, there are various PS schemes across the Australian jurisdictions. For instance, in Victoria (Vic), Sustainability Victoria has led several schemes including ByteBack (Computers), BatteryBack (batteries), PaintBack (paint) and FlashBack (compact fluorescent lights).

1.2.1.3 Support for EPR application among different stakeholders in Australia

A review study in 2017[15] (Park and Tucker, 2017) suggested that EPR should be used to inform C&D waste management legislation in Australia. In 2013, the results of an interview with the public sector (Canberra Business Chamber, 2014) showed support from waste managers in 13 local governments of the Capital Region. The interviewees indicated that "*products stewardship program from industry' would assist a shift towards better management of C&D waste materials"* (p. 87).

There are several submissions to the Environment and Communications References Committee (2018) that are showing support for implementing EPR across the Australian waste and resource recovery industry. These submissions highlighted that rewarding more upstream material recovery efficiently leads to better economic, environmental and social outcomes for waste and resource recovery in Australia. The committee also reported that it received evidence of broad support for national PS schemes, and many submitters to this committee called for the expansion of current schemes. The following table (Table 5) presents the submissions in support of a national PS scheme.

[15] Park, J. and 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(3), pp.228-237.

Table 5. Summary of views of various stakeholders in waste and resource recovery industry in Australia on implementation of EPR

Commenter	Type	Indicative language
Australian Local Government Association˚	Government association	All future product stewardship schemes should be co-designed with local governments. There are existing schemes which now 'present a difficulty for local government' due to a lack of consultation.
Australian Local Government Association˚	Public association	Many product stewardship programs have been significantly underfunded; therefore, their reach and the way in which they operate is difficult'. Rural and regional jurisdictions are not always able to participate in PS programs as services and funding are not available.
Australian Local Government Association˚		More emphasis should be placed on EPR, with a clear focus on improving the design and manufacturing of products and packaging – including supply chain considerations and imports – so that unnecessary, problematic or hazardous materials are avoided, volumes are reduced and material content is more easily reprocessed into new products.
Equilibrium˚	Consulting company	In lieu of other national approaches to waste and recycling issues, the Product Stewardship Act 2011 provides an approach that is working and has been quite successful to date. There are a number of schemes that have got up under the auspices of the act—mostly voluntary schemes, not regulated. PS can be used to incentivise that greater supply chain thinking that it would be of value.
Green Industries SA˚	Environmental authority	SA Government is 'looking forward' to more stewardship schemes.
NSW Local Government˚	Government	It seems that the National Waste Policy 2009, promising PS (beyond just TVs and PCs), better packaging and sustainable procurement has gone silent and a national approach targeting producers has ceased.
The Hunter Joint Organisation of Councils˚	Organisation	There has been little or no action to address waste issues at a national level' since the National Television and Computer Recycling Scheme was established.
The National Waste and Recycling Industry Council*	Industry council	The council affirms its policy for EPR schemes to be applied uniformly across jurisdictions and be regulated, enforceable and enforced in order to operate effectively.
The Waste Management Association of Australia ¤		Australia can draw lessons from Germany because it is time for our Federal Government to take our extended producer responsibility laws and frameworks seriously if Australia is genuine about creating jobs and investment.
TIC Group˚	Consulting company	The Product Stewardship Act 2011, and the schemes established as a result, demonstrate that 'collaboration between industry, government and other stakeholders can provide cost-effective and efficient processes to recover and recycle more materials.
Transport Canberra and City Services Directorate˚	Environmental authority	ACT Government would 'like to work with the federal government' on the further expansion of product stewardships schemes.
Waste Management and Resource Recovery Association of Australia˚	Association	Before introducing a new product to the market, producers should be required to demonstrate an item's 'end-of-life home'. In SA, contractors are required to demonstrate end-of-life processes prior to undertaking large solar panel installations. The waste and recycling industry must be involved in discussions of product stewardship and that producers cannot be left to develop schemes alone.

Source: ˚Australian Environment and Communications References Committee 2018

* Waste Management Review. 2019. The NWRIC's visionary policy. http://wastemanagementreview.com.au/the-nwrics-visionary-policy/

∧ Waste Management Review. 2019. Towards a circular economy. http://wastemanagementreview.com.au/towards-circular-economy/

¤ Waste Management Review. 2018. WMAA's five policy priorities ahead of MEM. http://wastemanagementreview.com.au/mem-2018-wmaa/

1.2.1.4 Support from jurisdictional waste strategy documents in Australia

Most jurisdictions have a strategy document that guides government organisations and industries in improving waste management over the strategy period. In many cases, strategies set targets for resource recovery or other waste performance indicators. They also underpin waste management legislation in the respective jurisdiction. Among the states and territories, Vic does not have a current waste strategy document. In SA and WA, EPR is a long-term objective; EPR related schemes are supposed to be developed in the future. Table 6 presents a summary of support from different states and territories of Australia reflected in jurisdictional waste management strategy documents.

Table 6. Support for development and extension of EPR and similar schemes in Australian waste strategy documents

Document	State	Relevance to C&D waste
ACT Waste Management Strategy: Towards a sustainable Canberra 2011–2025	ACT	EPR is recognised among the areas of improvements for further waste management and resource recovery Strategy 1.4. Reducing packaging: waste a commitment to product stewardship by the supply chain and other signatories
Waste Management Strategy For the Northern Territory 2015–2022	NT	No mention of EPR and PTB NT will facilitate and promote product stewardship programs for recycling and treating nationally significant waste streams
NSW Waste Avoidance and Resource Recovery Strategy 2014–21	NSW	No mention of EPR and PTB NSW will continue to work with the Australian Government to introduce product stewardship initiatives at the national level under the Commonwealth Product Stewardship Act 2011
South Australia's waste strategy 2015-2020	SA	Long term objectives: Avoid and reduce wasteful use of resources in production processes and products, such as leaner production, design for the environment and EPR Promote the adoption of EPR, including State-based approaches where considered necessary, and encourage continuous improvement in existing producer responsibility and related schemes Encourage reuse of waste fill and intermediate level contaminated soils where appropriate as a priority and remediate low level and high-level contaminated soils for re-use Priorities for Action: Problematic and hazardous waste target: effective PS schemes in place by 2020
Queensland's Waste Reduction and Recycling Strategy 2010–2020	QLD	Strategy principles Making better use of finite resources (energy, water, materials) by encouraging waste avoidance and improving recovery through PS or PTB schemes Implement state-wide action such as PS schemes on priority waste Qld government aims to: encourage and support PS arrangements work with industry sectors to help build on achievements made through existing schemes and help promote PS activities work with other industry sectors to foster new PS arrangements
The Tasmanian Waste and Resource Management Strategy 2009	TAS	Strategic actions: Participate in and support the development of EPR and PS programs Tasmanians will have an increasing role and responsibility in environmental stewardship

Document	State	Relevance to C&D waste
Waste Strategy 2030: Western Australia's Waste Strategy	WA	We will support PS and EPR as part of our approach to shared responsibility.
National Waste Policy 2018: Less Waste, More Resources	Australia	Strategy 4 Product stewardship Develop and implement partnerships across government and business to ensure ownership and responsibility for action to minimise the negative impacts from products, ensure the minimisation of waste and maximise reuse, repair and recycling of products and materials throughout their life cycle

1.2.1.5 Application of EPR and similar schemes in the Australia context for C &D waste management purposes

There are limited examples of the application of EPR and similar schemes to the C&D waste stream in Australia. The few examples that exist cover particular C&D waste materials only. Below are some examples, documented in the Construction and Demolition Waste Guide - Recycling And Re-Use Across The Supply Chain (Edge Environment, 2012) are presented.

PVC- Since 2002, the Vinyl Council of Australia has voluntarily agreed to apply EPR principles and comply with the Product Stewardship Act 2011 requirements. Armstrong Australia, the world's largest manufacturer of resilient PVC flooring products collects the off-cuts and end-of-life flooring materials that would have otherwise been sent into landfill for recycling and processing into a new product.

Gypsum- CSR Gyprock™, through a gypsum board take-back scheme, collects offcuts and demolition materials. According to the instructions provided in this scheme, upon completion of gypsum board installation, the fixing contractor arranges collection with CSR Gyprock™'s recycling contractor who charges the builder a reasonable fee. It is claimed that such a scheme could reduce the cost of site clean-up and landfill fees, facilitate better on-site waste management, and save builders time and money.

Waffle pod- Expanded Polystyrene Australia and its Pod Group members, through a produce stewardship scheme (the Pod Scarp Bag program), target reduction of expanded polystyrene (EPS) waste from waffle pod offcuts on construction sites. Within this program, builders are supplied with scrap bags to separate EPS waste from other materials; the bags are then collected and transferred to the EPS manufacturer who claims to produce new EPS with 40% of recycled materials content.

Carpet- Since 1985, Ontera Modular Carpets, through Ontera's EarthPlus® environmental program, guarantees to take the product back at the end of its first life for re-use or recycling at no cost to the customer. This program operates without any destructive processes or measurable additional energy input. Ontera reported that this program has resulted in creating reputation and market stature, improved economic returns, reduced utility and landfill costs.

1.2.1.6 EPR related legislation in other countries

EPR and similar schemes have largely targeted hazardous materials; there are limited examples of their specific application to C&D waste. Australia is a member of OECD and can benefit from the experiences of those signatory countries that have successfully implemented EPR policies. The following table (Table 7) is extracted from the guideline issued by OECD, which showcases the application of EPR and similar schemes (OECD, 2016).

Table 7. Examples of implementation of EPR schemes

Country(ies)	Legislation	Materials
European Union	All member states have PTB (EPR) systems. The framework is established through EU but operational aspects are advised by states.	Four main types in all states: packaging, batteries, end-of-life vehicles, and Waste Electrical and Electronic Equipment. Some states also have different material lists
United States	There is no national EPR policy Individual states develop and implement their own policy. Today there are 89 EPR laws in 33 US states	A wide range of materials
Canada	Occurs at provinces/territories level Canada-wide Action Plan for (EPR). There are more than 30 federal and provincial producer stewardship programs in Canada	A wide range of materials
China	The new EPR policy was introduced in 2016-17 by China's State Council	Certain materials: electrical products, batteries and vehicles
Japan	Home Appliance Recycling Act	A wide range of materials including C&D waste
Korea	Resource Saving and Recycling Promotion Act 1992 Resource Circulation of Electrical and Electronic Equipment and Vehicles 2008	Household and industrial materials

In European countries, EPR principles first appeared in policy and law in the early 1990s (OECD, 2014). Several EU directives refer to EPR as a recommended policy instrument. Particularly, the Waste Framework Directive 2008/98/EC aims to effectively decouple economic growth from waste production (Mazzanti and Zoboli, 2008). At the European Union (EU) level, all Member States have implemented EPR schemes on the four waste streams: packaging, batteries, end-of-life vehicles, and electrical and electronic equipment.

In the US, between 1991 and 2015, states have developed and implemented 89 EPR policies that require manufacturers to execute EPR programmes (OECD, 2016, Isenhour et al., 2016). In addition to the mandatory programmes, voluntary programs are in place by manufacturers to collect and recover their product. **In Canada**, legislation regarding waste occurs at four tiers of government (federal, provincial, territorial and local governments). EPR is largely regulated at the provincial (territorial) level; however, in 2009, a national council has developed a Canada-wide Action Plan (CAP) for EPR to harmonise EPR approaches taken by different jurisdictions across the country (CCME, 2008b). This council also issued an EPR evaluation tool guideline (CCME, 2008a) that systematically allows the user to consider launching an EPR program for one or more candidate products by answering a series of questions (criteria).

In China, since 2012, PER regulations have made producers of some electrical products contribute to government recycling funds according to the quantity of production (Ministry of Finance, 2012). These funds are meant to provide subsidies to certified e-waste recyclers by the government. Critics have questioned the adequacy of this system as it provides little incentive for design change or take-back actions by the producers (Tong et al., 2018). However, the subsidies have created market niches that attract investment and entrepreneurship devoting to recycling. China's State Council introduced the first robots plan for China's EPR policy in 2017. In 2019, this council seeks to build a credit information collection system in order to extend the responsibility of producers; it is expected that by 2020 a framework for EPR policy will take shape and corresponding legislation will be finalised. **In Japan**, different EPR policies are applied to various items; there are variations in who is financially or physically responsible in these policies. For instance, for automobiles and home appliance, the target

stakeholders are manufacturers, and producers and retailers, respectively (Kojima, 2008). Japan and Europe have PTB policies in place for different products, including some C&D waste materials.

In Korea, through the Resource Saving and Recycling Promotion Act 1992, households are required to comply with volume-based garbage rate system requirements. Using the concept of polluter pays, this system urges each household to buy designated garbage bags at a supermarket and waste can only be discharged using the prepaid bags (Yang et al., 2015). The successful implementation of this act motivated the expansion of legislation to cover industrial waste, including C&D waste, and to make companies fully accountable for all the waste they produced (Waste Management Review, 2015).

1.2.1.7 C&D waste specific EPR programs

The general trend for the development of EPR policy for C&D waste largely targets particular construction materials (e.g. PVC, glass, asphalt, and packaging waste) rather than collective C&D waste. One example of specific C&D waste EPR legislation takes place in the Flanders region of France, where collaboration agreements with producers has been achieved to recycle C&D waste (Dubois et al., 2016). These agreements also require producers of several materials to set up logistic schemes or invest in infrastructure to collect used materials as input for new materials: gypsum, autoclaved aerated concrete, bituminous roofing, PVC and mineral wool.

Another successful implementation of C&D source EPR policy is the Netherland's float glass EPR scheme, which showcases how an EPR policy for C&D waste can work efficiently. This EPR scheme imposes an environmental fee of € 0.5/m2 for new double-glazed windows to financially support the management of float glass (i.e. collection and recycling of waste) (Dubois et al., 2016). In some countries, such as Malaysia, local C&D waste legislation exists that functions as an EPR policy with shared similar principles (Zainu and Songip, 2017).

1.2.1.8 Challenges in the application of EPR and similar schemes to C&D waste stream

There are several challenges identified that can act as a barrier to extensive adoption of EPR and similar schemes in the construction industry (Figure 3). As a result, not all EPR instruments shown in Figure 3 works equally well for C&D waste management. The following section explains the main challenges for effective development and implementation of an EPR policy in the construction industry.

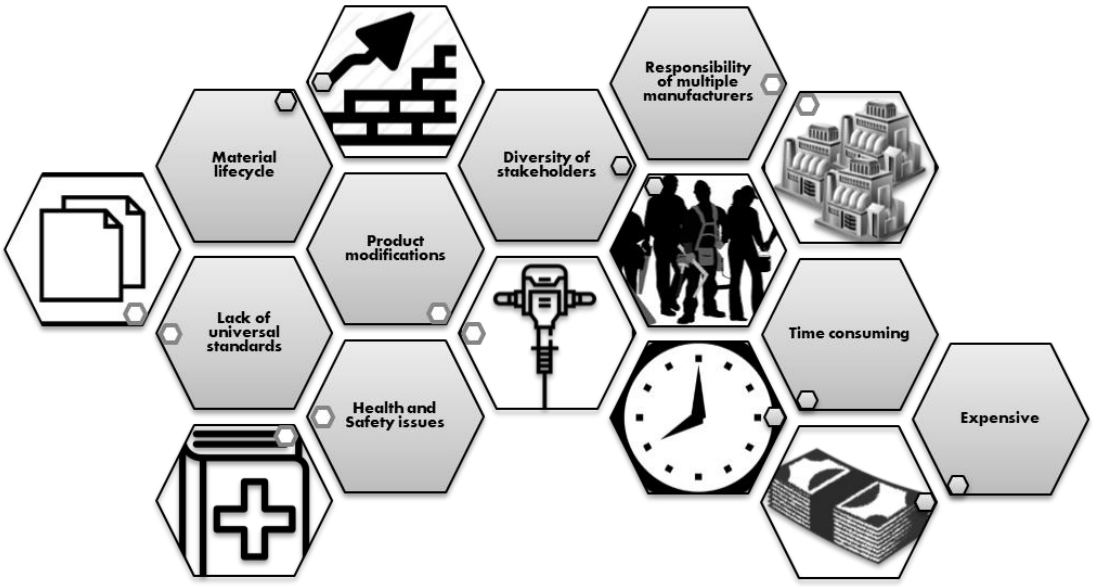

Figure 3. The main challenges toward the effective application of EPR to C&D waste stream

Time and cost- The costs associated with establishment and enforcement of EPR programs tend to be high (Shanoff, 1996); they also can be time-consuming for both domestic producers and a fortiori for importers (Acree Guggemos and Horvath, 2003).

Construction material lifecycle- The long product life of construction materials being designed to typically last for more than 10 years is another problem. This makes it difficult to apply TB and EPR principles to the waste that is produced as a result of ending the lifetime of these products. The longer lifecycle also impacts the reusability and recyclability of these materials. However, reducing the quantity of waste prior (i.e. at design, planning and procurement stages) and during construction activities remains the responsibility of those who are involved.

The longer life of construction materials also brings about a regulatory issue where EPR policies are based on the retroactive requirements that demand producers to abide by EPR principles for products that were produced before these policies are effective (Hunter, 1997). Indeed, the products that were previously created were not designed with EPR requirements in mind, nor did producers take into account the costs associated with management and recovery of waste from their products (Acree Guggemos and Horvath, 2003).

Diversity of stakeholders- The other instinctive barrier in construction is the diversity of players involved in construction activities relative to other industries. Traditionally, a producer is not responsible for product design in construction (Lu and Yuan, 2011); architects and engineers share responsibility of design and material selection, and a builder (contractor) builds the designed built environment. The disjointed practice of design and construction, therefore, makes it difficult to determine the responsibility for a product. These players also have their own concerns that impede consistent application of EPR. For instance, architects' designs focus on function and aesthetics; engineers aim to satisfy structural and safety requirements; clients pay attention to budget, quality and time; and builders are mostly concerned with time, cost and profit (Acree Guggemos and Horvath, 2003). One piece of research that studied two case studies in the US reported that designers have more control over the recyclability of a building (with control over 12 of the 15 areas (Srour et al., 2012).

Due to the complex nature of construction activities, it is a common practice that builders acting as the main contractor engage sub-contractors to complete different activities. As expected, it is a challenging task to keep track of the performance of tens of contractors involved in a construction project to make sure they are fully abiding by EPR principles.

Enforcement of EPR- Currently there is no universal standard for construction materials that can be implemented for different contexts (Acree Guggemos and Horvath, 2003). This can be even more complex in the Australian context where waste management legislation is formulated by different jurisdictions. EPR policies require manufacturers/importers to provide detailed reports that demonstrate compliance with the EPR requirements; if these vary across jurisdictions, they would be burdened with the task of complying with the EPR requirements in each country/jurisdiction where their product is to be sold. This also can undercut the financial performance of EPR-abiding manufacturers in markets without EPR implementation.

Responsibility of manufacturers- Project contractors generally sources numerous materials from different suppliers, plus the materials required differ from one project to another. As a result, it is not always easy to identify suppliers from the assessment of materials. Many materials do not have markings that show the manufacturers (Acree Guggemos and Horvath, 2003). Indeed, without knowing the producer, the responsibility for the material cannot be assigned and a fortiori at the end of material lifecycle.

Modification inbuilt facilities- Another problem with EPR application comes from modifications that can take place during maintenance or renovation of a built facility. Modifications are typically

performed every 10-15 years, which may end up in adding to, removing from or changes to the facility (Acree Guggemos and Horvath, 2003). These changes are unlikely to be made by the original architecture, engineer and contractors, adding to the already complex task. However, having well-documented as-built and as-renovated plans can assist the compliance officer to identify those responsible for the product.

Hygiene, health and safety issues- Contamination by other materials in C&D waste mix management is a common concern, particularly during demolition operations. Furthermore, the separation of C&D waste for collection on construction/demolitions sites bears safety risks (Shen et al., 2004). Therefore, a higher level of safety measures must be taken when offcuts or demolished materials are to be collected. These higher safety measures understandably have cost implications that impede effective implementation of EPR in construction projects.

1.2.1.9 Future direction for EPR policy development in Australia

From the review of the literature, it can be inferred that there is a general consensus among various stakeholders of waste and resource recovery in Australia on developing and implementation of EPR policies. However, there exist certain caveats that need full consideration in order to achieve EPR objectives. The following are some recommendations for better development of EPR policies.

Firstly, the approach recommended particularly at the December 07, 2018 meeting of Environment Ministers urges the federal government to take a lead in the development of consistent national EPR policies instead of varied jurisdictional legislation. EPR policy is usually most efficient when implemented nationally, as most companies affected by EPR operate at the national level (EPA Vic, 2014). To date, only a small number of schemes have been introduced nationally, but this has to change urgently. **Secondly,** as suggested by many waste and resource recovery stakeholders, the policy approach on EPR has to shift from voluntary to mandatory arrangements. **Thirdly,** any procedure taken towards development of EPR policies must ensure that input from different stakeholders is obtained prior to implementation. An extensively agreed EPR policy would guarantee its sustainable application and successful outcome. **Fourthly,** due to the complex and particular nature of C&D waste management, the EPR policy developed must be specific to the setting of this stream. Such a policy can specifically take into account the common issues in C&D waste management. Therefore, it is worth engaging research organisations such as universities to better determine the strategies required to overcome these precise issues. **Lastly,** there are successful examples of EPR application in the construction industry and other sectors in Australia and elsewhere for individual waste materials. Learning from these experiences and building on the policies governing them would enhance viability of potential EPR policies for C&D.

1.2.1.10 Recommendations for alleviating issues with EPR implantation

As identified in the review, there are challenges towards implementation of C&D sourced EPR policies. The following are some recommendations for minimising the impact of these challenges.

Efficient supply chain system- A reverse logistics system has to be developed to return the product from the individual consumer to the producer (Acree Guggemos and Horvath, 2003). This system has more complications than the original logistics wherein producers deliver a product to a local retailer and the consumer takes care of the final distribution leg from the store to home. Several studies have shown that the cost to run reverse logistic-based supply chain system runs several times higher than the usual supply chain (Nagel et al., 1999, Klausner and Hendrickson, 2000, Khor et al., 2016). Therefore, future efforts must target cost reductions for reverse logistics operations. There are successful examples of such operations for other waste materials in Australia that can inspire the C&D waste approach. For instance, the DHL Supply Chain Product Stewardship Program has efficiently delivered PS objectives in partnership with big Australian retailers (e.g. Target, Officeworks and Harvey Norman) under the National Television and Computer Product Stewardship Program. This program has

achieved all targets in the first 3 years of operation by establishing an effective collection network from 177 permanent drop zones.

Encouraging design for disassembly- Manufacturers need to be motivated to consider the requirements of design for disassembly. This design arrangement can go a long way in separation and collection of products at the end of their useful lifetime. Furthermore, designs can be made to facilitate the collection of offcuts during construction activities. Accordingly, designers can collect information on materials lifetime and recyclability in the region, reducing the number of materials used and component sizes, using two-stage building systems and recording changes during construction and operation (Srour et al., 2012).

The key to effectively encourage manufacturers to design with disassembly in mind is the development of a market for recycled C&D waste materials and the engagement of builders in EPR schemes and utilisation of recycled materials.

Determining responsibility for C&D waste- Currently in Australia there is no clear policy-making people responsible for waste coming from C&D waste activities. Upon determining responsibility, a policy can equate them to polluters that need to contribute to management of the end-of-life product. Therefore, communicating the responsibility of each of the stakeholders in a coordinated manner is crucial. Even if an EPR policy is designed to make multiple stakeholders responsible, cost affordability for each stakeholder to fulfil their obligation should be taken into consideration.

Health and safety risk management- Safe Work Australia, as the main regulatory authority, can take a proactive role in developing policies for safe and hygienic separation and collection of C&D waste in Australia. Policies such as How to Safely Remove Asbestos Code of Practice 2011 and Recycling Construction and Demolition Material 2007[16] would facilitate the successful implementation of EPR.

Product documentation- Developing and keeping as-built and as-renovated plans, including a bill of quantities, should be mandatory. Having these registered in a permanent database would assist the task of application of EPR and similar schemes at later stages.

Further studies are needed in a number of areas of EPR policy development and implementation. These studies should analyse which stakeholders might be affected by EPR and similar schemes, supply chain management, industry awareness, and readiness for EPR, domestic and foreign C&D recycled market. Australia has a long way to go to establish a successful national EPR policy for C&D waste materials. This is due to the complex nature of C&D waste management and the poor performance of the federal government in the development and imposition of relevant obligations. This study has sought to identify the position of Australia in application of EPR for waste management both in practice and regulations. The results show that Australia has good potential for taking a leading role worldwide in the application of C&D sourced EPR. Some strategies are outlined in this study that can assist in minimising the impact of barriers towards an effective and efficient EPR in Australia.

1.2.2 Cradle to Cradle approach

The new agenda of environmental sustainability promotes the application of the Cradle to cradle approach (C2C), instead of the traditional Cradle-to-grave (C2G) approach. This approach shares a similar underpinning philosophy with the circular economy and aims to motivate manufacturers that produce materials to ensure that, at their products' end of life stage, it can become the raw material for another industry. Then the material produced always remains a nutrient that can be reused or converted to useable new material[17]. Therefore, this concept is mainly underpinned by two specific

[16] Worksafe Victoria. 2007. Recycling construction and demolition material. Guidance on Complying with the Occupational Health and Safety (Asbestos) Regulations 2003.

[17] Mcdonough W, Braungart M. 2003. Towards a sustaining architecture for the 21st century: the promise of cradle-to-cradle design. UNEP Industry and Environment. 26:13-16.

design philosophies, namely 'design waste out' and 'design for disassembly'. One study in Australia revealed that the construction industry is still predominantly following C2G approaches despite the existence of C2C trends[18].

1.2.3 Virgin material taxes

Despite it being technically achievable to recycle most construction materials, the type and amount of material to be salvaged is often highly dependent on its value[19] (Tam & Tam, 2006; Tam, 2010; Lu & Yuan, 2011). The value of C&D waste-derived materials in most circumstance is a function of the price of new extracted or imported materials. In order to change the game in favour of C&D salvaged and recycled materials, a relatively new financial incentive has emerged that is intended to discourage consumers from using raw materials in their construction projects. This incentive can be applied in two forms: 'taxing on the use of virgin materials' or 'removing subsidies for virgin materials'. These two price mechanisms have proven to increase the competitiveness of salvaged and recycled C&D materials in several countries. For instance, since 2002, a regulation (Aggregates Levy[20]) has been imposed in the UK to make recycled C&D waste more competitive relative to the virgin aggregates. The levy is a tax (£2 per tonne) on the commercial exploitation of rock, sand, and gravel, and it aims to adjust the price of virgin aggregates to better reflect their intrinsic environmental costs. The tax is further expanded to target imported materials. A similar tax has also been implemented in some EU countries including France, Denmark, and Sweden[21].

In Australia, as discussed previously, some states have implemented a new policy to exclude clean fill from the definition of waste. This exclusion, together with lower prices, is expected to be conducive to making the construction industry more likely to use C&D waste instead of raw materials.

1.3 Encouragement

The new approach to the effective management of C&D waste has emphasised the role of incentive in the waste management system in contrast to command-and-control environmental regulations. There are a number of tested and trusted opportunities to motivate waste producers to not dispose of C&D waste at landfills. These opportunities include "emission trading scheme', 'green building rating' and 'development of the domestic market for C&D waste'.

1.3.1 Incentives for using recycled waste materials

Designing fiscal incentives for stakeholders that attempt to use salvaged and recycled C&D waste materials is necessary for the creation of suitable demand for these materials[22]. Owens-Illinois that has a recycling plant stated that *"companies who actively use recycled materials in their manufacturing process should be rewarded and provided with a benefit that recognises their contribution to recycling and waste minimisation"* (Environment and Communications References Committee, 2018, p. 55). The government is expected to play a more active role as it is not seen as a major player in this field. Currently, most of the government construction activities are tendered to private contractors, and there are no contractual obligations to use recycled content materials[23]. A review study[24] reported that the minimum barriers to reusing C&D waste in Australia are outside of the construction industry and

[18] Udawatta, N., Zuo, J., Chiveralls, K. and Zillante, G., 2015. Improving waste management in construction projects: An Australian study. *Resources, Conservation and Recycling*, 101, pp.73-83.

[19] Tam, V. and Lu, W., 2016. Construction waste management profiles, practices, and performance: a cross-jurisdictional analysis in four countries. *Sustainability*, 8(2), p.190.

[20] Aggregate Levy Manual.2014. https://www.gov.uk/hmrc-internal-manuals/aggregates-levy

[21] Hyder Consulting. 2012. Construction and demolition waste status report. p.43.

[22] Al-Sari MI., Al-Khatib IA, Avraamides M, Fatta-Kassinos D. 2012. A study on the attitudes and behavioural influence of construction waste management in occupied Palestinian territory. Waste Management Research. 30(2): 122-136.

[23] Hyder Consultation Company. 2011. Management of construction and demolition waste in Australia.

[24] Park, J and R. Tucker. 2017. Overcoming barriers to the reuse of construction waste material in Australia: a review of the literature. *International Journal of Construction Management*. 17 (3): 228-237.

include the lack of interest and demand from clients and 'attitudes towards reuse practices'. This study concludes that legislation should be better implemented to support reuse of C&D waste materials.

1.3.2 Deposit/refund

The deposit/refund approach is a systematically proven market-based instrument that motivates further waste recovery activities. One example of this approach is deposit/refund policies for a container deposit scheme which have shown to significantly increase the number of bottles recycled (Acree Guggemos and Horvath, 2003). This approach can be followed by manufacturers who signed up for the extended producer responsibility scheme. Deposit refund policy is currently being applied in Canada[25] and the US. In the US, contractors involved in demolition activities are required to pay a deposit to receive a building permit – the deposit is refunded upon demonstration that the C&D waste was sent to a certified recovery facility by the contractor[26].

1.3.3 Green Construction

1.3.3.1 *Green construction concept implantation in Australia*

The green construction concept, otherwise known as green building, sustainable building and high-performance building, refers to construction-related activities that are environmentally responsible and resource-efficient during a building's life cycle. This concept was introduced in Australia in two forms, the Green Star (GS) Program and the Sustainable Infrastructure (SI) rating system, by two authorities: the Green Building Council of Australia (GBCA) and the Australian Green Infrastructure Council (ISCA). Green building in the context of C&D waste is referred to as a notion that intends to employ low waste building technologies and promote utilisation of C&D waste or recycled materials. Since its establishment (2002) as the nation's authority (non-for profit) on sustainable buildings, communities, and cities, GBCA has developed sustainability programs to certify, educate and advocate green built environment projects in Australia. A year after the establishment of GBCA, it started providing the Green Star (GS) scheme, which is Australia's only national and voluntary rating system for buildings and communities. Currently there are four internationally recognised rating tools under GS Program, namely *Communities*, *Design & As Built*, *Interiors* and *Performance*. These voluntary tools promote the efficient use of management practices of construction and fit out materials and target C&D through 'Construction and Demolition Waste' credits. The C&D waste credit aims to encourage and reward management practices that minimise the quantity of C&D waste going to landfill from base building and/or interior fitout works. The credits operate to engage verified waste contractors and processing facilities that comply with minimum standards of GBCA reporting that were developed in 2013[27]. GBCA claims that green projects (buildings) recycled 96% of their C&D waste.

Generally, there are three areas of improvements in GS for C&D waste-related credits:

- Recycling of construction and demolition waste from the building
- Design of the storage for waste to encourage good recycling practices
- Use of recycled materials

According to the criteria, credit points are awarded when a project can prove that less than 4.5 kg/m^2 of fitout area have been sent to landfill. In particular, the following items can win credits for construction projects:

(1) **Reduction:** Reduction of C&D waste: 1 credit
(2) **Reuse:** Façade reuse (retained by 50%: 1 credit; retained by 80%: 2 credits), Structure reuse (retained by 30%: 1 credit, retained by 60%: 2 credits)

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[25] Construction and demolition recycling deposit refund procedure and form https://www.menlopark.org/DocumentCenter/View/130/ Recycle-Deposit-Refund-Procedures-and-Request-Form
[26] Houston-Galveston Area Council (2005) C&D Debris Regulations, Recycle C&D Debris Handbook.
[27] GBCA. 2013. Green Star Construction & Demolition Waste Reporting Criteria.

(3) **Aggregate:** Coarse aggregate is crushed slag aggregate or other alternative materials—at least 40% (0.5 credit), Fine aggregate is manufactured sand or other alternative materials—at least 25% by mass; in Australia both of these two categories are sourced from C&D waste[28]
(4) **Recycled content products:** 3% product (1 credit), 6% (2 credits), 9% (3 credits).

The following table (Table 8) presents the categories of GS rates and corresponding scores.

Table 8. Categories of Green Star (GS) rates

Score	Rating	Category
10-19	One Star	Minimum Practice
20-29	Two Star	Average Practice
30-44	Three Star	Good Practice
45-59	Four Star	Best Practice
60-56	Five Star	Australian Excellence
75+	Six Star	World Leadership

The evaluation of performance and effectiveness of GS in Australia has been the focus of several investigations in recent years. A study in Australia[29] has recommended that the GS's Construction and Demolition Waste credit to be mandatory; it also suggests that the additional costs that a client must incur to get a GS certificate should be reduced in future. A report[30] on the benefits of a decade application of GS in Australia revealed that GS certified buildings are recycling 96% of their C&D waste. This report found that, in total, 37,600 truckloads of C&D waste have been diverted from landfill due to good waste management practices. Another study in 2015[31] reported decisions in construction projects are constrained by financial gains unless a special requirement to comply with GS or any similar schemes is in force. One of the interviewees in this study indicated that designers do not tend to consider opportunities for waste minimisation unless they are required to fulfil building rating tools such as GS. Overall, the authors of this research concluded GBCA can improve its GS program to address the impacts of three main deterrents towards waste management practices: *lack of economic interest*, *professional roles* and *less accountability of construction stakeholders*. In addition to GS for buildings, the ISCA (a non-for-profit industry council) developed a voluntary rating system for assessment of infrastructures in terms of sustainability in 2007. This scheme seeks to foster resource efficiency and reduction of waste and associated costs in infrastructure projects.

1.3.3.2 *Experience from other countries*

There are about 40 similar green programs[32] being implemented across the world that share similar principles with the Australia green star program. GS is also adopted and modified by New Zealand (NZGB[33]) and South Australia. There are several research studies comparing the performance of different green programs. A study conducted in Australia revealed that, in comparison to Leadership

[28] Le, K.N., Tam, V.W., Tran, C.N., Wang, J. and Goggins, B., 2018. Life-Cycle Greenhouse Gas Emission Analyses for Green Star's Concrete Credits in Australia. *IEEE Transactions on Engineering Management*, 99:1-13.
[29] Park, J and R. Tucker. 2017. Overcoming barriers to the reuse of construction waste material in Australia: a review of the literature. *International Journal of Construction Management*.17 (3): 228-237.
[30] Green Building Council of Australia. 2014. Green Building Market Report Australia New Zealand 2014. P. 15. http:// www. bcimediagroup.com/wp-content/uploads/2014/12/BCI.Economics.Green_.Building.Market.Report.pdf
[31] Udawatta, N., Zuo, J., Chiveralls, K. and Zillante, G., 2015. Attitudinal and behavioural approaches to improving waste management on construction projects in Australia: benefits and limitations. *International Journal of Construction Management*, 15(2), pp.137-147.
[32] Thaickavil N.N and J. Thomas. Green Rating Credits for Waste Utilization in Construction. Green Buildings and Sustainable Engineering. Proceedings of GBSE 2018. pp.189-201.
[33] New Zealand Green Building Council.

in Energy and Environmental Design (LEED) and Assessment Standard for Green Buildings (ASGB), which is a performance-based rate, GS is more beneficial to the practice of designing in a green way[34]. Table 9 summarises the criteria used in the green rating systems for some of these green building programs.

Table 9. Green programs across the world.

Name of program	Criteria related to C&D waste
BREEAM: Building Research Establishment Environmental Assessment Method- developed by Building Research Establishment (BRE) in 1990 in the UK	**a.** Construction waste management (3 credits): waste reduction (2 credits) diversion from landfill (1 credit) **b.** 25% content from recycled or secondary aggregates (1 credit), **c.** Exemplary performance: construction waste management (1 credit), >50% content from recycled aggregate (1 credit)
LEED: Leadership in Energy and Environmental Design- developed by the US Green Building Council in 1998	**a.** Construction and demolition waste management (2 points): 50% diversion from landfill (1 point), 75% diversion from landfill (2 points) **b.** Recycled material based on the cost of total value of materials: 10% of building materials (1 point), 20% of building materials (2 points) **c.** Materials reuse: 5% (1 point), 10% (2 points) **d.** Building reuse: 50% of existing floors, walls, and roof (1 point), 75% of existing floors, walls, and roof (2 points), 95% of existing floors, walls, and roof (3 points) **e.** Reuse: 50% of non-structural elements
CASBEE: Comprehensive Assessment System for Built Environment Efficiency- developed in Japan in 2001	**a.** Reuse efficiency of materials used in a structure (3 points): Electric furnace steel in major structural elements (other than reinforcement bars) (1 point), Portland blast furnace cement concrete of major structural elements (1 point), Recycled aggregate used in concrete of major structural elements (1 point) **b.** Reuse efficiency of non-structural materials (3 points) **c.** Reusability of components and materials (3 points): the structure and finishing materials can be separated easily (1 point), Interior finishes and equipment are not entangled and each can easily be removed separately for demolition, refurbishment, and remodelling **d.** Reusable unit materials are used (1 point)
BEAM Plus: Building Environmental Assessment Method- developed by the Hong Kong Green Building Council Limited	**a.** Construction waste recycling (2 credits): at least 30% (1 credit), at least 60% (2 credits) **b.** Demolition waste recycling (2 credits): at least 30% (1 credit), at least 60% (2 credits) **c.** Recycled materials (3 credits): site exterior surfacing work, structures, and feature at least 10% (1 credit), façade and structure components at least 10% (1 credit), interior non-structural components at least 10% (1 credit) **d.** Reuse of existing sub-structure or shell (3 credits), > 30%: 1 credit, >60% (2 credits), >90% (1 credit, bonus).

1.3.3.3 *How main stakeholders may take advantage of GS scheme*

Increasingly, construction companies are attempting to be listed on sustainable and ethical indices; hence, there is a desire for green buildings and the associated reputational advantage. This desire paves the way for further recycling, reuse of C&D waste and use of products with recycled content. All this leads to the development of a sustainable domestic market. The GBCA provides services for assisting GS certified projects to market their product by showcasing their commitment to sustainability using their GS credentials. These services provide marketing strategies to broadcast green projects to the wider public, adding to the value of green buildings. Furthermore, currently, compliance with GS requirements is part of the tendering processes for large-scale construction sites[35]. Therefore, companies that are looking at getting a government contract need to improve their ability

[34] He, Y., Kvan, T., Liu, M. and Li, B., 2018. How green building rating systems affect designing green. *Building and Environment*, 133, pp.19-31.

[35] Hyder Consultation Company. 2011. Management of construction and demolition waste in Australia. p.46.

to meet GS requirements. Another study investigated and outlined multiple clusters of drivers for GS uptake in different countries[36]. Figure 4 depicts the GS specific drivers according to this study.

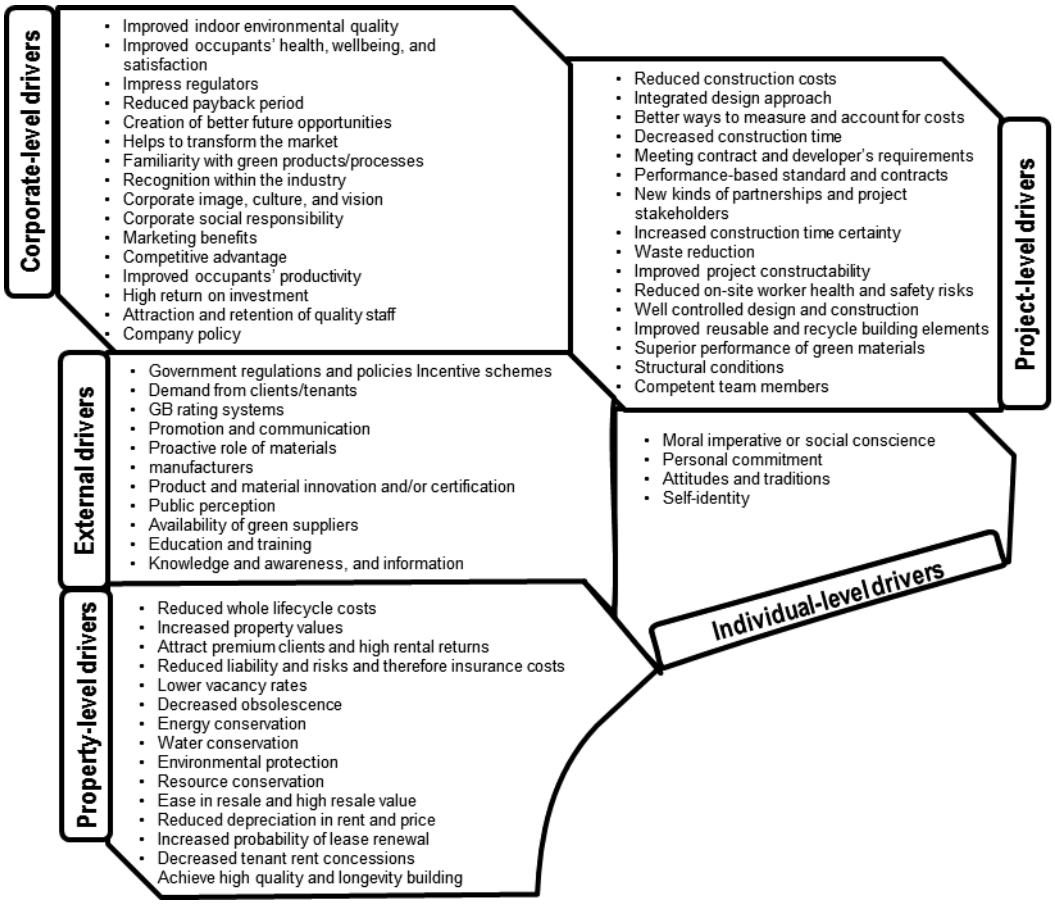

Figure 4. Factors influencing GS performance.
Source: adapted from Darko et al (2017).

Figure 5 shows examples of advertisements for green projects certified by GBCA in the Australian property market.

[36] Darko, A., Zhang, C. and Chan, A.P., 2017. Drivers for green building: A review of empirical studies. *Habitat International*, 60, pp.34-49.

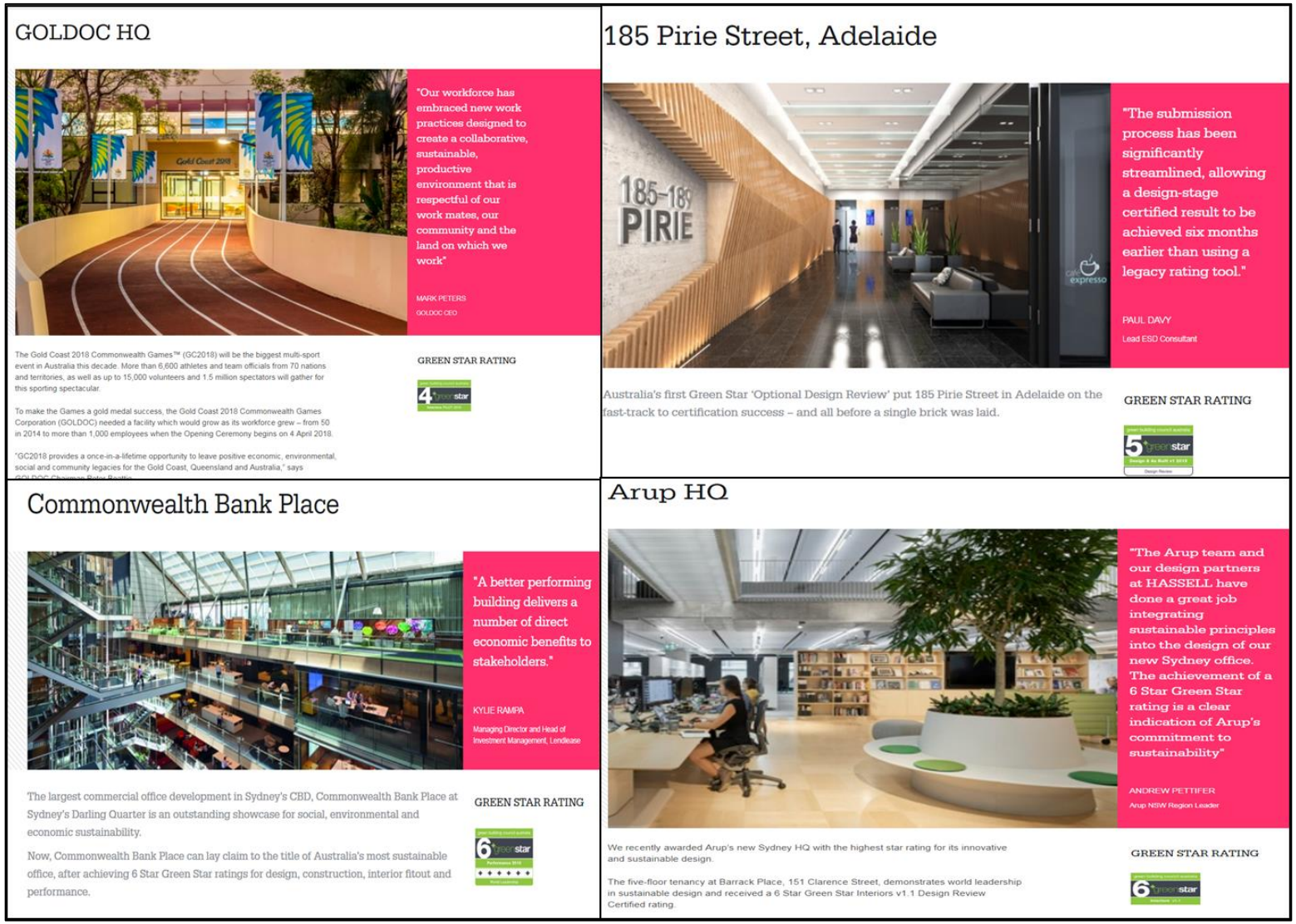

Figure 5. Examples of marketing green star rated projects in Australia. Source: Green Building Council of Australia Website

1.3.4 Emission trading scheme

The issue of carbon emission with regards to C&D waste management is complex. On the one hand, carbon emissions during recycling are inevitable; however, the measures for the substantial reduction in emissions are possible and very crucial. On the other hand, the options of landfill disposal and extraction of virgin materials have far more adverse environmental consequences[37].

There are two widely adopted approaches to addressing the issues with emissions: Command-Control (e.g. through regulations, direct and indirect taxes) and Trading Scheme. The first approach, Command-Control (CC) comes with some limitations, as the unit cost for removing additional quantities of pollution is unreasonably expensive in some countries. Another issue with CC is that it is stricter than the trading scheme approach, which is a more incentive-based system. In CC, the emission goal set for each polluter is fixed and, hence, shifting the burden of pollution reduction to the firms that can achieve it more cheaply is not possible. Thus, this approach is likely to be more costly in general[38] and, in most cases, the additional costs would be transferred to end-users[39]; hence, it is a less favoured technique in new waste management systems.

On the contrary, implementing an 'emission trading scheme', otherwise known as cap and trade, can contribute to reducing emissions from waste disposal and recovery facilities. Emission trading is a market-driven approach to managing pollution by providing economic incentives with the aim of reducing the emissions of pollutants[40]. In the general context, the idea is to mitigate the adverse effects of climate change and improve the environment. In the waste management context, this scheme can convince waste producers to consider the top layers of the waste hierarchy (e.g. reusing, recycling and recovery).

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[41]. Polluters (waste producers) need to own permits in an amount equal to their emissions. Polluters that wish to add to their emissions should purchase permits from others willing to sell them. An 'emission trading scheme (ETS) allows for emission goals to be met in the most cost-effective way by letting the market determine the lowest-cost pollution abatement opportunities. There are four main types of ETS: 'a cap-and-trade system', 'baseline-and-credit', 'project-based schemes' and 'hybrid schemes'. The European Union implemented a Cap-and-trade system[42] in 2005 under the Kyoto Protocol and aims to reduce greenhouse gas emissions in an economically effective manner.

ETS in Australia has been a point of disagreement between the major political parties because of its social and economic effects. Between 2003 and 2011, policies related to ETS were passed and overturned several times. The Parliament of Australia has provided a list of pros and cons of ETS in relation to varying factors[43]. The first ETS in Australia was established in NSW in 2003, based on a

[37] Damptey, E.O. 2011. Optimising the Use of Recycled C&D Waste Material in Civil Construction Projects. PhD thesis. Swinburne University. Australia.

[38] Rosen, Harvey S.; Gayer, Ted. 2008. Public Finance. New York: McGraw-Hill Irwin. pp. 90–94. ISBN 978-0-07-351128-3

[39] Yujie Lu; Xinyuan Zhu; Qingbin Cui .2012. "Effectiveness and equity implications of carbon policies in the United States construction industry". *Building and Environment*. 49: 259-269.

[40] Stavins, R.N. 2001. "Experience with Market-Based Environmental Policy Instruments" (PDF). Discussion Paper 01-58. Washington, D.C.: Resources for the Future. Retrieved 2010-05-20. Market-based instruments are regulations that encourage behaviour through market signals rather than through explicit directives regarding pollution control levels or method.

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

[42] EU Emissions Trading System (EU ETS).2005. https://ec.europa.eu/clima/policies/ets_en

[43] Carbon taxes. 2019. https://www.aph.gov.au/ AboutParliament/ParliamentaryDepartments/ ParliamentaryLibrary/BrowsebyTopic/ClimateChangeold/responses/economic/carbontax

baseline-and-credit scheme[44]; it only lasted for a decade and was terminated in 2012. A report[45] that reviewed this scheme's performance indicated a high level of commitment from different stakeholders during its lifetime. Nevertheless, there are still around 5 million certificates that remain available for voluntary surrender on this scheme registry. Later on in 2012, the Australian government initiated a carbon pricing scheme or "carbon tax" through the Clean Energy Act 2011. The purpose of this act was to make polluters pay a certain amount (AU $23) as tax per tonne of carbon that they released into the atmosphere. However, this act was repealed in 2014 and replaced with the Direct Action plan[46], which provides funding to companies to incentivise emission reduction activities. The government has spent AU $1.7 billion on 143 million tonnes of emissions, at an average cost of AU $12 a tonne. This fund is granted on a 'reverse auction' basis; awarding contracts to those who bid emissions abatement projects at the lowest cost.

The Australian Government has committed to a target of GGE abatement by 26-28% (from 2005 levels) before 2030. Some state waste strategy documents prioritise emissions reduction through increased waste recovery activities. SA is the first Australian jurisdiction to enact specific climate change legislation that sets a long-term ambitious emissions reduction target. SA, through the Climate Change and Greenhouse Emissions Reduction Act 2007, establishes a target to reduce SA's GGE by at least 60% (from 1990 levels) by 2050. In ACT, the Climate Change and Greenhouse Gas Reduction Act 2010 has provided a target of 40% emission by 2020 while the waste sector only accounts for 3% of total emissions. In Qld, an environmental strategy document[47] necessitates the implementation of ETS to reach a 60% target of reduction in national GGE by 2050.

There is some uncertainty about how a carbon tax, ETS or reverse auction may impact the waste sector in Australia. In a previous report[48], consultation with re-processors revealed that introduction of the carbon tax may result in more emphasis on the recovery of C&D waste as landfill operators should report on and pay a price for their activities produced emissions. Several studies have also compared the effectiveness of the two GHG managing mechanisms. One modelling study in 2014 showed that ETS can reduce GGE from waste by 75.9% (from 2015 levels) by 2030[49]; the study, however, stated that ETS is likely to reduce Australia's GDP by just over 1.1% in 2030 compared to a base case. In 2016, research findings[50] demonstrated that 'Direct Action' was not as effective as a carbon tax in enforcing companies to act urgently and manage emissions. The interviewees in this piece of research believed that the carbon tax motivated companies to act, as it raised their utilities costs, causing financial burden for some companies, and ruining their reputation as high emitting companies, in addition to these companies being liable under the tax. The study also indicated that, when the carbon tax was repealed, the focus on carbon emissions in these companies shifted. Another piece of research[51] compared three models of GGE reductions (i.e. ETS, Action Plan, and Carbon Tax) and found that ETS is the most viable option for both reductions in GGE and economic growth. This research predicts that the government will encounter much higher auction prices in the next rounds of auction compared

[44] The New South Wales Greenhouse Gas Reduction scheme. 2003. https://www.ipart.nsw.gov.au/Home/Industries/Energy/Energy-Savings-Scheme/Greenhouse-Gas-Reduction-Scheme

[45] NSW Greenhouse Gas Reduction Scheme - Strengths weaknesses and lessons learned - Final Report – 2013.

[46] Direct Action Plan. 2014. https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Direct_Action_Plan /Report/c05

[47] The Queensland Government. 2008. Toward 2 Tomorrow's Queensland.

[48] Construction and Demolition Waste Status Report. 2012. Hyder Consulting Pty.

[49] Adams, P.D., Parmenter, B.R. and G., Verikios. 2014. An emissions trading scheme for Australia: national and regional impacts. *Economic Record*, 90 (290), pp.316-344

[50] Direct Action not as motivating as carbon tax say some of Australia's biggest emitters.2016. *The Conversation*. https://theconversation.com/direct-action-not-as-motivating-as-carbon-tax-say-some-of-australias-biggest-emitters-64562

[51] Nong, D, and S. Mahinda. 2016.A Dynamic Evaluation of the Impacts of an Emissions Trading Scheme on the Australian Economy and Emissions Levels.

with those previous auctions; hence the current budget (AU $2.55 billion) may not be sufficient to purchase the required abatement by 2020, therefore making achievement of the 2030 target difficult.

Another study in Victoria[52] warned that it might also cause the industry to rethink recycling emissions levels and, therefore, negatively impact further recycling activities. In general, and to the interest of C&D waste and resource industry, it is advisable that legislation is modified to account for the fuel tax cuts.

1.3.5 China's new waste policy

One of the issues that has a mixed impact on Australia's waste and resource recovery system is the introduction of a new waste policy enforced by China in January 2018. The new policy, called the 'National Sword Policy', bans the import of certain foreign waste materials, with a strict level of contamination, to benefit the national policy environment. This seems to have similar objectives to another program called '*Operation Green Fence 2013*', which aims to restrict the import of contaminated recyclable materials.

China has long been the main end-market for recycling materials. It is claimed that China's economic boom is partially fuelled by the import of recyclables. In 2016 alone, China imported US $ 18bn of recyclables[53]. As a result, the new restrictions imposed by this policy have presented challenges for the waste industry, as the waste producers can no longer avoid landfill levies or recovery operation fees by shipping waste overseas. Although this policy only focuses on certain types of metals, textiles, plastic and not all C&D waste, the announced level of acceptable contamination is a real hurdle to the export of C&D waste from Australia. Some Australian organisations have claimed that the ban diminishes the ability of MRF operators to market sorted recyclables and consequently stockpiling and more landfilling will likely occur[54].

At the same time, this new policy comes with some advantages for the waste recovery industry in Australia. In a series of interviews with experts at Melbourne Law School, University of Melbourne, as described in a published MLS news article[55], it was stated that "*for too long we have looked elsewhere to deal with our waste problems*'. This article also included the views of another expert who contended, "*it's probably a little bit overplayed in some parts of the media, but I also think that it's a long-term issue that needs to be addressed*". One interim solution might be considering other overseas market such as Vietnam, Thailand, India, and Malaysia. In this regard, the Australian government has initiated a discussion with different departments and authorities to assess different markets for recycled materials.

However, effective mitigation of this issue through national and local solutions presents an opportunity to shift Australia's perspective from simply passing the issue of waste on through overseas waste recovery operators to consider internal improvements. From this new perspective a further analysis of waste recovery regulatory framework, investment in required infrastructure and development of the domestic market would be beneficial. Several submissions to the Environment and Communications References Committee (2018) inquiry stated that there has been a preference to ship unprocessed waste overseas rather than incurring waste recovery operation fees and landfill levies. Government has discussed this perspective with the National Waste and Recycling Industry Council policy officer[56], who suggested that there must be immediate, short, medium and long terms responses to this issue;

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[52] Damptey, E.O. 2011. Optimising the Use of Recycled C&D Waste Material in Civil Construction Projects. PhD thesis. Swinburne University. Australia.

[53] MRA Consulting Group. 2018. China's National Sword policy The impact on Australia's recycling.

[54] The Senate Environment and Communications References Committee. 2018. Never waste a crisis: the waste and recycling industry in Australia. p.80.

[55] Leggatt.J. 2018. China waste ban: crisis or catalyst?. Melbourne University School of Law News. May 2018. https://law.Unimelb .edu.au/alumni/mls-news/issue-19-may-2018/china-waste-ban-crisis-or-catalyst

[56] Waste Management Review. 2018. Harmonisation avoids 'perverse' outcomes. http://wastemanagementreview.com.au/harmonisation-avoids-perverse-outcomes/

in the immediate term, AU $ 47 million and AU $ 13 million packages were provided by NSW and Vic governments, respectively. Recently, SA also announced an AU $ 13 million package to alleviate the aftermath of China's new waste policy.

1.4 Domestic market

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 circular economy of waste has 5 principles, the third of which is to 'increase the use of recycled material and build demand and markets for recycled products', that is, market development. In the National Waste Policy (2018), Strategy 14 places emphasis on market development and research[57]. Estimations, based on the current solid waste generation rates in Australia, project that Australian recycling capacity must increase by 400% by 2040 to address the issue of solid waste in the future[58]. The influence of China's new waste policy urgently necessitates the development of domestic market capacity in Australia.

The submissions to the inquiry made by the Senate's Environmental and Communication Reference Committee offered diverse viewpoints about domestic market development. The following are the highlights from these submissions that cover various relevant issues.

> *"Several submitters highlighted the lack of local demand for recyclable materials. They explained that this has contributed to poor economic conditions in the recycling industry and resulted in unsustainable practices, such as stockpiling and export to overseas markets"*
>
> *"Markets for most recyclables in Australia are unable to absorb the quantity of material collected'. As a result, unstainable practices such as stockpiling and export to overseas markets are occurring"* - Maitland City Council
>
> *"The reliance on export to overseas markets, and in particular China, was raised in evidence. It was noted that China has in the past provided a stable market for Australian recyclable materials"*
>
> *"… the impact of commodity prices for imported materials (both virgin and recovered) relative to the prices for local recovered material on the domestic market for recycled product. … where imported products can be purchased more cheaply than products produced using locally recovered material, there is likely to be a detrimental impact on local businesses"* - South Australian Government
>
> *"the lack of genuine progress of the national waste strategy in the last eight years has hampered the creation of secondary markets and a circular economy in Australia. If this had occurred, Australia 'would not have the continued reliance we have, to an extent, on global trading markets, such as China, for our commodities"* - Waste Management Association of Australia
>
> *"Market volatility is also an issue… recyclables are sold into global commodity markets and as such, recovered steel and aluminium are affected by the price of virgin material…"* - The Australian Capital Territory Government

[57] National Waste Policy 2018. Less Waste. More Resources. p.16.

[58] The Senate Environment and Communications References Committee. 2018. Never waste a crisis: the waste and recycling industry in Australia. p.85.

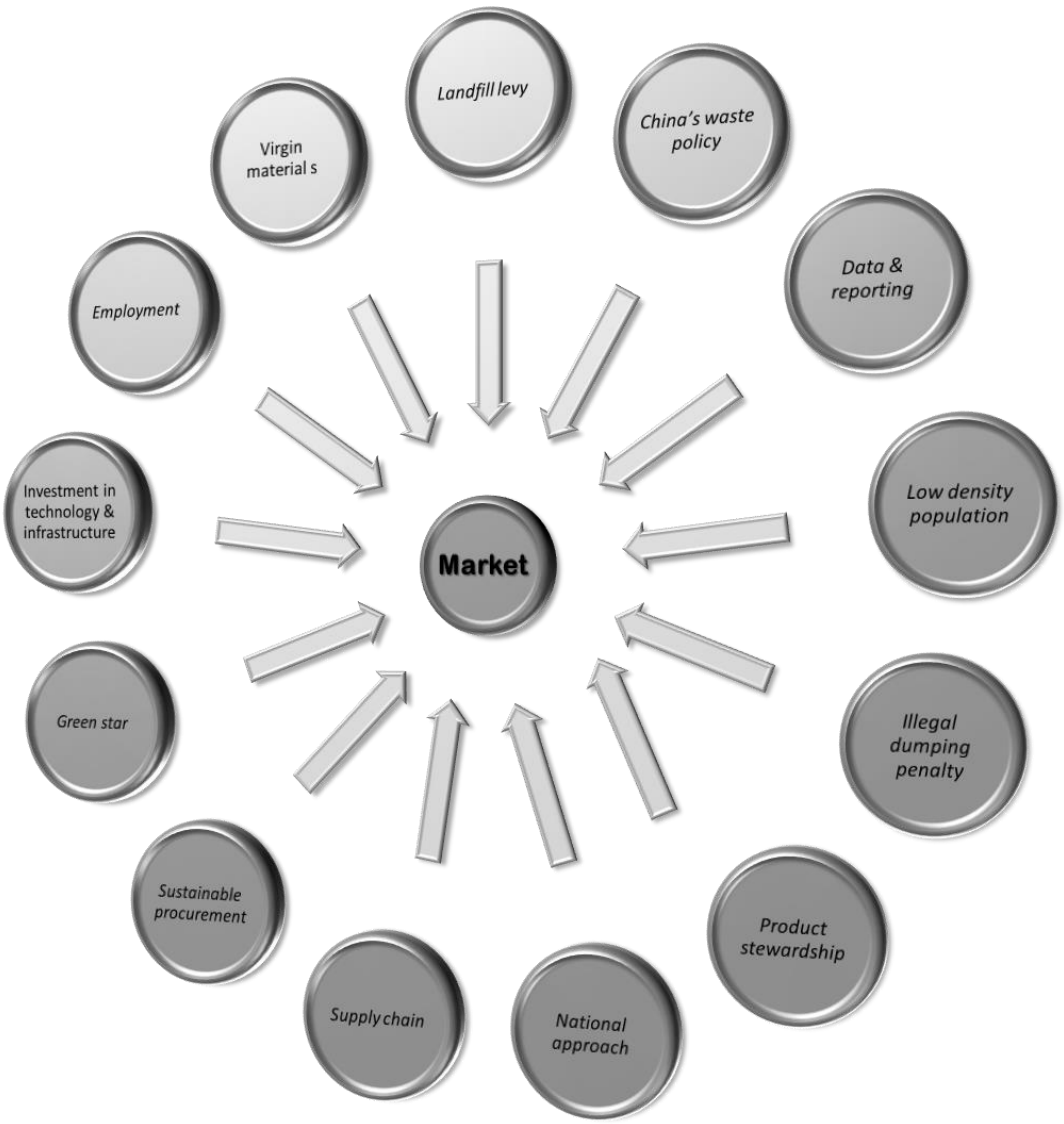

Figure 6. The main factors influencing the market for C&D waste materials (re-use/recycled)

However, the development of a domestic market for waste and recyclables is strongly influenced by several internal and external factors. In waste management language, some of these challenges induce push and pull effects. Resource recovery is greatly driven by a 'push' (supply of materials) to divert waste from landfill. In an ideal situation, this push should be matched by consumer and industry 'pull' (demand for products made from recovered resources). It is expected that, when these factors are systematically dealt with, this will pave the way for a circular economy and the subsequently closing of the loop of waste/resource flow in the Australian market. The most influential factors displayed in Figure 6 are described below.

National approach– There is an uncertainty about the extent of influence by various players in the waste and resource recovery market in Australia. On the one hand, the Australian federal government, Department of the Environment and Energy, opines that jurisdictions are in the best position to respond to market developments by providing recycling regulations[59] that align with the limited constitutional responsibilities of the federal government in the regulation of waste. On the other hand,

[59] The Senate Environment and Communications References Committee. 2018. Never waste a crisis: the waste and recycling industry in Australia. p.24.

the Australian government indicated that it would contribute when there are domestic market failures or absences of a market that require national policy or partnership programs[59].

At the jurisdictional level, Vic has a leading position in the development of a market for recovered and second-hand materials. In 2016, the Victorian Government released a strategy document on the development of a domestic market for recovered resources in 2016[60]. This document provides Victorian government plans to overcome challenges related to the imbalanced supply and demand for recovered materials in Victoria's domestic market. Four Victorian government interventions are advised to boost market development in the next 30 years (research and development, product specifications, product procurement and product stewardship). The following table (Table 10) presents some specifications of this strategy document, including challenges towards the market development:

Table 10. Victorian (Sustainability Victoria) Market Development Strategy Specifications

Item	Description
Barriers	(1) Product design not suitable for disassembly (2) The quality and quantity of recovered resources required to justify investment (3) Costs of the establishment of recovering facilities of low value material (4) Cost of transport of often low-value material (5) Low margin markets versus cheap virgin material or imports (6) Lack of regulatory support (7) Market price fluctuations (8) Lack of proper waste data management systems (9) Limited awareness about the effectiveness of products with recycled content
Strategies	(1) Improve the quality of recovered resources to support manufacturing (2) Improve consolidation and aggregation of recovered materials to contribute to growth in manufacturing (3) Improve the performance of products incorporating recovered resources (4) Increase the use of products incorporating recovered resources (5) Cross-government coordination within an integrated, statewide waste management framework (6) Adopt appropriate, evidence-based approaches to government intervention (7) Capitalise on policy and market signals supporting resource recovery
Priority material selection criteria	(1) Environmental impacts associated with the management of the waste material/ product (2) Amount of material generated (3) A functioning market existing for the material/product
Priority materials	Organics (including timber), rubber (tyres), e-waste, flexible plastics, glass fines, concrete and bricks.

Source: Victorian Market Development Strategy for Recovered Resources 2016

In consultation with different stakeholders, SV has contemplated waste/resource flow in a circular economy context. Figure 7 portrays different components of this circular flow. Other states and territories are also considering market development for various waste streams, including C&D waste.

[60] Sustainability Victoria.2016. Victorian Market Development Strategy for Recovered Resources.

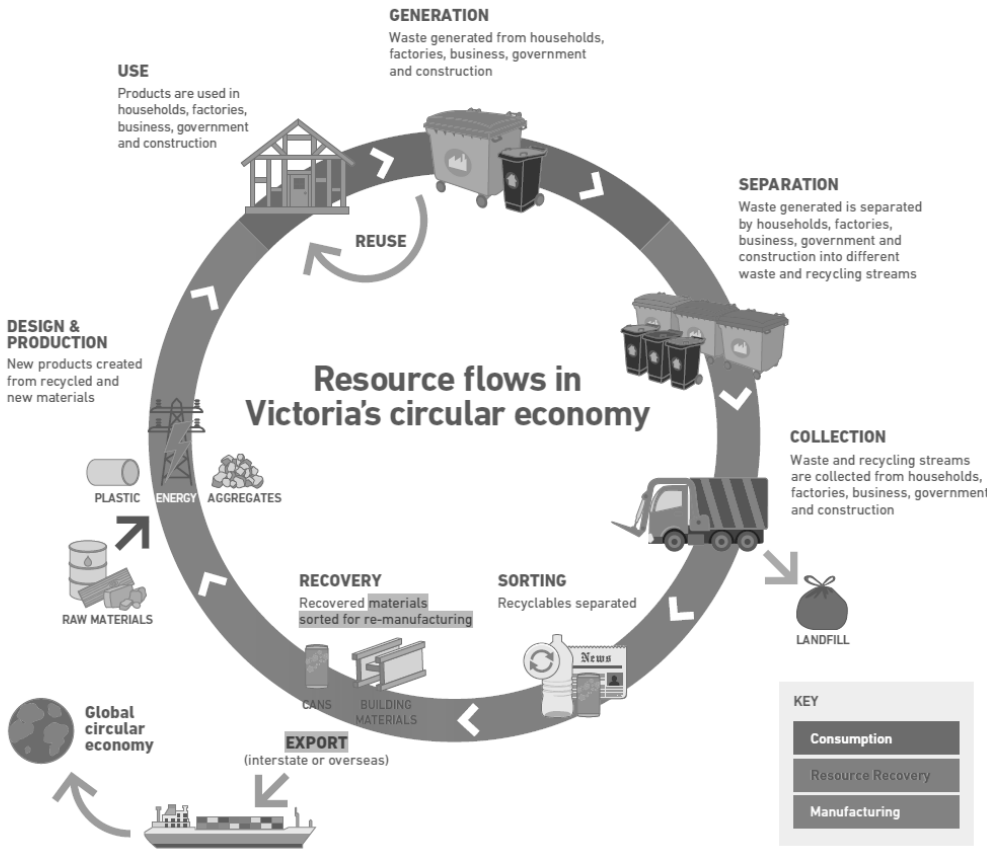

Figure 7.Resource flow in potential Victorian waste and resource market

Source: Sustainability Victoria (2015) [61]

Landfill levy– Unreasonable (both high and low price signal) priced landfill fees and their variation across Australia can negatively hinder C&D waste market development. For instance, GCS Consulting submitted that a continuous increase in the waste levy could diminish its efficacy as a pricing mechanism[62]. Other evidence also exists that confirms the negative consequences of landfill levies, including (a) increasing economic pressures on recyclers due to high levies; (b) poorer quality recyclable material entering the market and driving up the cost of treatment, and (c) changes to the market. A full discussion on the effectiveness of the landfill levy is presented before.

On the other hand, there are multiple other sources that necessitate having a landfill levy in place in regards to market development. For instance, several submissions[63] indicated that levy revenue could be used to invest in the development of a market for recycled materials through low-interest (subsidised business) loans or financial incentives and R & D. The National Waste and Recycling Industry Council firmly believes that market distortions take place due to variation in landfill levies across jurisdictions[64].

China's new policy– Australia exports recyclable material to over 100 countries, with 4.23 megatonnes of recycled materials exported in 2016–17[65]. As discussed previously, the introduction of China's new

[61] Sustainability Victoria. 2015. Statewide Waste and Resource Recovery Infrastructure Plan – Victoria -44, p.47, 2015.
[62] Submission to the Senate Environment and Communications References Committee. 2018. Never waste a crisis: the waste and recycling industry in Australia. p.50.
[63] Ibid pp.65-67.
[64] Ibid p.59.
[65] Blue Environment, 'Data on exports of recyclables from Australia to China. https://blueenvironment.com.au/wp-content/uploads/2018/03/ Data-on-exports-of-recyclablesfrom-Australia-to-China.pdf

policy (National Sword Policy) has a diverse impact on the performance of the market for C&D waste. While it motivates the development of a market, it will have some negative impact on C&D waste management since the local markets are not yet fully established. The latter may give rise to more landfilling, illegal dumping and stockpiling. One mid-term solution, in addition to domestic market development, could be seeking new overseas markets. In the long term, according to several submitters to the Senate Environment and Communications References Committee inquiry, the Australian waste and resource recovery industry need to shift away from the idea of exporting waste/resource and towards advocacy for reprocessing and reusing waste to make new products domestically[66].

Data and reporting– Accurate C&D waste data collection and reporting underpin the development of a local market for recyclables. Consistent and updated reporting can make it much easier to manage the C&D waste and resource market. According to 'Strategy 14' of National Waste Policy 2018 'Market Development and Research', '*all Australian governments and businesses generate and report information to support creating and maintaining markets for recycled materials, both domestically and internationally*" (National Waste Policy, 2018 p.16). Waste data is critical to well-targeted, evidence-based and planned waste projects and programs. Data on waste generation, landfill and resource recovery is also essential to the development and implementation of waste policies and programs. Up-to-date and consistent data is also required to understand the current state of waste and recycling. Historical data allows current performance to be plotted against prior performance and meaningful, achievable and realistic targets to be set. Historically, C&D waste data collection in Australia was found to be indicative rather than accurate and considered to be questionable in terms of transparency, comparability, accuracy, completeness, clarity, and timeliness[67].

Waste data collection methods vary by jurisdiction and material type. In the NT and Tas, no waste data is collected and establishing a platform to collect the data remains a priority. In the ACT, there is no established method to collect data and improved data gathering capability has been recommended to facilitate effective management of waste[68] in the territory. Since 2017, with the commencement of a new Act[69], however, the ACT has made it a requirement for waste businesses to report their activities quarterly. In four other jurisdictions (NSW, Qld, SA, and Vic), robust data systems serve to systematically collect and analyse waste data. The following table (Table 11) shows the waste data collection systems rolled out in these jurisdictions.

[66] Ibid p.84.
[67] Net Balance. 2009. National Waste Data System Requirements Study.
[68] ACT Government. 2018. Waste Feasibility Study Roadmap and Recommendations – Discussion Paper.
[69] Waste Management and Resource Recovery Act 2016 – ACT.

Table 11. Waste data systems in different jurisdictions

	Program	Function
NSW	Waste and Resource Reporting Portal (WARRP)	An online reporting tool designed to facilitate the submission of the Waste Contribution Monthly Report (WCMR). All licence holders of levy liable waste facilities) must submit the following reports to the NSW Environment Protection Authority (EPA): waste contribution monthly report, landfill facility information certificate (LFIC) and volumetric survey report. https://warrp.epa.nsw.gov.au/
QLD	The Queensland Waste Data System (QWDS)	A web-based system for operators to report on their waste data returns and the Annual Waste Survey. The system allows for the expanded capture of information about waste disposal and resource recovery. QWDS provides a streamlined reporting system for private and local government waste managers—replacing spread sheets and third-party online survey sites previously used to collect data. In addition, QWDS provides all the functionality required to transition to the system—which allows for more robust online data collection and reporting. (https://www.Qld.gov.au/environment/pollution/management/waste/recovery/data-reports/qwds)
SA	Zero Waste Environment User System (ZEUS)	A web-based system developed by Green Industries SA to facilitate the monitoring, analysis and reporting of waste reduction targets in SA. ZEUS collects information on: recycling activity; waste (tonnes) to landfill by waste stream (MSW, C &I and C & D); litter; economic and environmental costs and benefit; infrastructure needs; and areas needing regulatory underpinning.
VIC	Waste Data Portal (WDP)	Waste Data Portal developed by Sustainability Victoria's to collect and store waste and recycling data from a number of sources and regularly produces state-wide waste, recycling and litter data reports. The portal aims to strengthen and standardise existing waste and resource recovery data in Victoria, introduce new data as necessary and improve collection and sharing of data in Victoria between state and local governments and industry. https://www.sustainability.Vic.gov.au/Government/Victorian-Waste-data-portal

The systems tabulated above have definitely had a positive impact on achieving jurisdictional waste strategies. In 2016, EPA NSW provided a user guide[70] for their data management system (WARRP). This guide, through step-by-step navigational instructions, helps different stakeholders register and monitor data associated with waste management throughout the state. Particularly, landfill site owners and recycling facilities operators can use it for their obligatory waste data submissions. In Vic, one product of the WDP project is an interactive waste data map in which information is presented by year and material type for different regions of Victoria. The main data collection methods in Australia are an annual survey (NSW, Vic, and WA) and annual reporting (Qld and SA). The other discrepancy is the data collection mechanism that determines the obligatory or voluntary nature of data reporting. Local government waste data collection is voluntary in NSW, Vic and WA; it is obligatory in Qld and SA.

Despite the progress made in the field of waste data collection in some jurisdictions, the challenge of aggregation of individually collected waste continues to be the main concern at the national level. If properly merged, these systems will provide useful information that can lead to the development of a national approach in the management of general waste as well as C&D waste. It would also assist Australia to measure its performance against other countries. As previously mentioned, there have been some unsuccessful efforts to form a national waste database under the Australian Waste Database (AWD) projects in the 1990s. This is a challenging task, as it requires standardisations in collecting, processing and reporting data methods in various jurisdictions. The other main issues were found to be costliness and difficultness of data collection activities, followed by inconsistent classification systems, data source incomprehensiveness and inability to separate waste streams, etc.[71] However, in 2009, the Federal Department of Energy and Environment commenced the development of a national waste data system, which was later complemented with a 'method report' that describes what data would be collected and how it would be transformed. This work was furthered with a

[70]NSW Waste and Resource Reporting Portal (WARRP) User Guide. 2016.
[71] Blue Environment. 2018. National Waste Report 2018, p.5.

procedural document describing the whole process and a revised method was developed and agreed by all jurisdictions in 2015. The revised method included a Microsoft Excel tool that implements the agreed method. Despite these efforts, the national waste data system has not been launched, due to disapproval of the required budget; instead it was confined to the release of a biannual national waste data report.

Research and development– Any integrated waste management system greatly benefit from research and development. Almost every single strategy, policy, action plan and regulation on waste management in Australia has highlighted the role of R&D alongside with encouragement and enforcement for effective development and implementation of waste-related plans. In Australia, authorities have recently started taking advantage of R&D benefits and hence have engaged research and consultation entities to provide the information required for regulation of C&D waste streams. To date, the product of such collaboration has partially contributed to the decision making processes on an extended range of issues. Table 12 presents some seminal examples of these studies that are commissioned by public authorities and are published in the form of publicly available reports.

Table 12. Summary of research reports released to inform legislation, decision making or raising awareness

Report	Ordering authorities	Objective(s)
Construction and Demolition Waste Status Report (2011)- Hyder Consulting Pty Ltd	I. Department of Sustainability, Environment, Water, Population & Communities Queensland II. Department of Environment & Resource Management in accordance	Evaluation of the current conditions of C&D waste management in Australia & providing relevant reforms
Waste definitions and classifications, report on issues, opportunities and information gaps(2012)– Hyder Consulting Pty Ltd	Department of Sustainability, Environment, Water, Population & Communities	Review on (legal) definitions used for various waste streams in different jurisdictions
An Investigation into the Performance (Environmental and Health) of Waste to Energy Technologies Internationally (2017)-WSP Global Pty Ltd	Western Australia Department of Environment and Conservation	A review of legislative & regulatory frameworks, state of the art technologies and research on health and environmental impacts
A review of the scientific literature on potential health effects in local communities associated with air emissions from Waste to Energy facilities (2018)-Environmental Risk Sciences	EPA Victoria	Evaluation of potential issues associated with EfW technologies
Global Landfill Regulation & Waste Levy Review (2012)-SLR Consulting Australia Pty Ltd	I. Western Australian Department of Environment & Conservation II. Waste Authority	Review on landfill levy regulations in Australia and worldwide
Waste to energy consultation and case study for Melbourne's West (2017)- Reincarnate Pty Ltd	The Department of Environment, Land, Water & Planning	Investigation of the approved expansion of large residual waste landfills at Ravenhall & Werribee
Investigation into the Transport of Waste into Queensland (2017)- a research team from different entities	I. Environment & Heritage Protection II. National Parks & the Great Barrier Reef	To review and assess strategies to limit the transport of waste across Qld
Optimising the Use of Recycled C&D Waste Material in Civil Construction Projects (2011)-University of Swinburne (Ph.D. thesis)	University	To explore avenues for further uptake of recycled C&D waste in Australia
Construction & Demolition waste guide - recycling & re-use Across the supply chain (2012)- Edge Environment Pty	Department of Sustainability, Environment, Water, Population & Communities	To identify the issues of supply chain and review some case study of existing C&D waste supply chain

Note: the name of some of the authorities mentioned in this table may have now changed to other names.

The Australian legislation process is underpinned by consultations with the main stakeholders who are affected by developing regulations. Consultation drafts as a form of R&D call for submissions from industry, authorities, researchers and the public to ensure that any ensuing legislation provides a level playing field for all parties concerned.

Universities are important players in providing research services to decision-makers, regulatory authorities, industry, and wider communities. In a study in Spain[72], the role of universities, as a key new actor, in enhancement of C&D waste management through the creation of a 3R model (reduce, reuse and recycle) was stressed. The researchers of this study noted that "*Studies on C&D waste often forget to include a key player in waste management… Universities can advance the possibilities of solving technical problems and applying new methods of recycling and new market-oriented applications according to the current legislation*" (Calvo et al., p. 422). According to this study, other contributions from universities in this respect include:

- Availability of infrastructure and qualified academic staff to effectively develop R&D in this field so that the cost of concentrating research efforts can be reduced
- An ability to demonstrate recycling achievements to be applied in the recycled market-endorsing C&D recycled materials
- Training of professional staff for C&D waste and resource industry through postgraduate courses for construction

Another function of R&D is to raise public, industry and authorities' awareness. Indeed, several research studies demonstrated the positive role of evidenced-based awareness received through R&D activities. Then this awareness underpins management practices towards the development of a market for C&D waste materials. The following are exemplary statements from these studies:

> *"More high quality, site-specific and practical information about waste management strategies needs to be provided via training courses and awareness campaigns to keep operatives informed about waste management practices and techniques…More educational activities are needed to help raise operatives' consciousness of the longer term social and ethical implications of their activities on site"* (p. 749)[73]
>
> *"Improve major project stakeholders' awareness about resource saving and environmental protection' and 'improve operatives' construction skills through vocational training" were critical management measures in waste management* (p. 106)[74]
>
> *"Interviewees pointed out that enhancement of public awareness, by communicating the short-term and long-term benefits of waste management through social media and company newsletters, helps to improve waste management practices in construction projects"* (p. 78)[75]

[72] Calvo, N., Varela-Candamio, L. and Novo-Corti, I., 2014. A dynamic model for construction and demolition (C&D) waste management in Spain: Driving policies based on economic incentives and tax penalties. *Sustainability*, 6(1), pp.416-435.

[73] Teo, M.M.M. and Loosemore, M., 2001. A theory of waste behaviour in the construction industry. *Construction Management and Economics*, 19(7), pp.741-751.

[74] Yuan, H., 2013. Critical management measures contributing to construction waste management: Evidence from construction projects in China. *Project Management Journal*, 44(4), pp.101-112.

[75] Udawatta, N., Zuo, J., Chiveralls, K. and Zillante, G., 2015. Improving waste management in construction projects: An Australian study. *Resources, Conservation and Recycling*, 101, pp.73-83.

"…if attitude towards construction waste recycling needs to be enhanced then positive personal beliefs towards recycling must be cultivated through personal training and workshops" (p. 16)[76]

"In order to secure co-operation and engagement from the industry on implementing waste reduction and recycling practices, there needs to be a high level of awareness and knowledge of these issues among industry practitioners together with information and help to facilitate waste minimisation and recycling practices" (p. 47)[77]

R&D can also be employed to explore new opportunities for re/use of C&D waste materials. For instance, a study report[78] indicated that recycled brick and concrete could be used in the landscaping industry with competitive prices compared to alternatives. In the case of EfW, the research is needed to facilitate the use of energy produced in the local power grid.

Product stewardship– Product stewardship, extended producer responsibility, and take-back schemes are strong motivators for the establishment of a market. It is recommended that these schemes be regulated and implemented nationally because many of the potential participants work across Australian jurisdictions.

Regulatory support– It is vital that waste regulatory frameworks are set to be in favour of local market development and implementation of an effective circular economy. The issues that must be addressed in this regard are as follows:

1) Consistency in jurisdictional waste regulations throughout Australia
2) Clarification on when a waste becomes a source and is not liable for landfill levy
3) Illegal dumping and stockpiling activities are severely discouraged
4) Consistent reporting obligations

Geographical location and population density– Australia is a vast country with a relatively low population. The population is concentrated in capital cities which challenges market development. As a result, long distances between waste origins, waste facilities and the place that receives recycled and salvaged C&D waste is regarded as a barrier to the development of a domestic market.

Supply chain– Providing an efficient and effective supply chain to the waste and resource recovery industry is instrumental in developing a local market for C&D waste. The supply chain for this purpose needs to consider the principles of the circular economy and be driven by the industrial ecology (symbiosis) concept[79]. An effective supply chain system can assist in the implementation of EPR and similar schemes, provision of stockfeed for waste recovery facilities, and motivating compliance with GS and GI tools requirements. The World Economic Forum[80] acknowledges that the circular economy approach can be applied to supply chains functioning at a local level, as well as those supporting complex global multi-tier material flows. Creating a supply chain is not straightforward, as it involves numerous actors, each playing their part in the delivery of supply chain objectives.

In Australia, a decade's worth of effort towards the creation of an effective supply chain has resulted in some limited success. NSW is the leading state in building a supply chain system for domestic waste.

[76] Tam, V., Le, K., Wang, J. and Illankoon, I., 2018. Practitioners Recycling Attitude and Behaviour in the Australian Construction Industry. *Sustainability*, 10(4), p.1212.

[77] Canberra Business Chamber. 2014. Building and construction waste materials: Reduce, reuse and recycle - opportunities and strategies for the Capital region.

[78] Hyder Consultation Company. 2011. Management of construction and demolition waste in Australia. p.141.

[79] The wastes or by-products of one industry are used as inputs in another industry, thereby closing the material loop of industrial systems and minimising waste.

[80] World Economic Forum, Towards the Circular Economy: Accelerating the scale-up across global supply chains, January 2014.

In 2009, this state established an organisation called the Australian Industrial Ecology Network to promote the concept of industrial ecology and identify the opportunities to make connections between waste producers and waste consumers. In 2012, the Department of Energy and Environment (then known as the Department of Sustainability, Environment, Water, Population and Communications) released a guideline[81] on the supply chain of C&D waste materials. This document primarily aimed to promote industrial ecology in the C&D waste stream and secondarily to showcase successful examples of C&D waste trade in Australia. Some of these examples demonstrated effective development of a supply chain system, particularly with respect to product stewardship application.

The following are the key issues regarding building a supply chain system for C&D identified in different Australian based literature:

- Initial resistance from stakeholders to accommodate new safety requirements for C&D waste trade[82]
- The inaccuracy of reporting of C&D waste such as stockpiles[83]
- Decentralised purchasing systems are a challenge for most local governments[84]
- Involvement of various subcontractors that limits control of builder or construction company over supply chain management[85]
- Lack of strategic procurement and partnerships as key inhibitors towards a supply chain management framework[86]
- Poor organisational communication across units to facilitate change[5]
- The government's main concern was health issues of occupants, particularly with regard to the lack of quality control[87]

The bottom line is that any efforts to create a supply chain for the C&D waste market need to be informed by various stakeholders input so that the resultant product will be widely accepted and utilised. Recently, waste producers and consumers have appreciated the use of online platforms to trade valuable C&D waste. As depicted in Figure 8, currently the C&D waste is loosely being traded through online platforms such as the 'Gum Tree' website and 'Facebook' market place.

[81] Edge Environment.2011.Construction And Demolition Waste Guide - Recycling And Re-Use Across The Supply Chain.
[82] Ibid p.35.
[83] Harris, C.M.T. 2017.A supply chain analysis of Construction and Demolition waste streams in Perth, Western Australia. Murdoch University. BSc thesis.
[84] NetBalance (2009) Green Purchasing in Australia for EcoBuy.
[85] Hyder Consultation Company. 2011. Management of construction and demolition waste in Australia. p.47.
[86] London, K., Siva, J., and P. Zhang. 2013. A supply chain management self-assessment framework for waste minimisation for the residential sector.
[87] Chileshe, N., Rameezdeen, R., Hosseini, M.R., Lehmann, S. and Udeaja, C., 2016. Analysis of reverse logistics implementation practices by South Australian construction organisations. *International Journal of Operations & Production Management*, 36(3), pp.332-356.

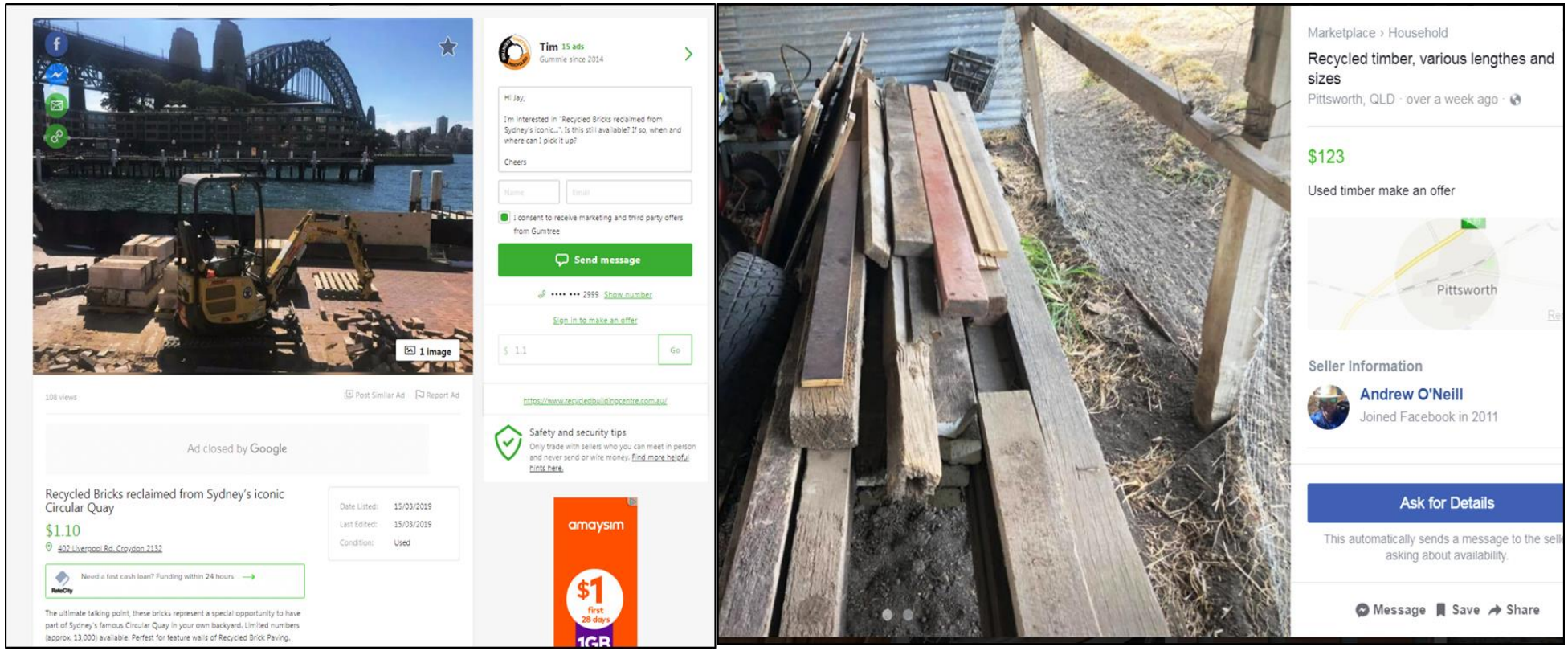

Figure 8. Some examples of trading of second hand C&D material on different platforms: Gumtree.com.au and facebook.com/marketplace

Sustainable procurement– Sustainable procurement can provide an incentive for further waste recovery. It is claimed that the implementation of SP has a spreadsheets impact on the flourishing of the C&D waste material market. In response to China's new waste policy, the Minister of Energy and Environment committed to supporting increased use of recycled materials in the goods procured by government, and to collaborate on creating new markets for recycled materials[88]**.**

In Australia, reuse of recycled materials is strongly encouraged under Ecologically Sustainable Development (ESD) and Sustainable Procurement (SP) programs. At the national level, NWP 2018 sets a target to reduce waste generation through prevention, reduction, recycling, and reuse. This policy has also emphasised the application of the principles of a circular economy to support better and repeated use of the nation's resources. Two strategies to promote sustainable procurement in Australia are at the forefront of this 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 NWP 2018 encourages the use of recycled C&D waste through sustainable procurement. The other strong motivation for using recycled materials is the adoption of sustainable procurement principles by government agencies, business, and individuals (Strategy 8 and 9- National Waste Policy 2018). The definition of Sustainable Procurement accepted by the UN, the UK government and the Australasian Procurement and Construction Council (APCC) is:

> *"A process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment"*[89]

The Environment and Communications References Committee suggests that local governments practice sustainable procurement policies to ensure strong domestic markets for recycled material[90].
The Australasian Procurement and Construction Council Australian and New Zealand Government Framework for Sustainable Procurement is implemented by the federal government to pursue three aims when procuring goods, services, works, and utilities. These aims involve the reduction of environmental impacts, social impact and economic impacts through the procurement process. This framework also shares some premises with the circular economy in considering alternatives to the 'take, make and dispose of' approach. According to this framework, the government has a decisive role in providing a market driver for increased use of recycled materials in the goods and works that it procures. Therefore, the federal government and some local government developed SP guidelines to coordinate their decisions and actions towards SP and the purchasing of recycled materials. In 2012, state government of SA was the first authority to release a Sustainable Procurement Guide[91]. One year later, in 2013, the federal government also released the first Australian guideline on SP[1]. This work was further complemented by state-specific guidelines to tailor sustainable procurement requirements in the ACT[92] (2015), NSW[93] (2017) and WA[94] (2017).

[88] Submission to the Senate Environment and Communications References Committee. 2018. Never waste a crisis: the waste and recycling industry in Australia. p.83.
[89] Commonwealth of Australia. 2013. Sustainable Procurement Guide, p.8.
[90] The Environment and Communications References Committee.2018. Less waste more recycling. P x
[91] SA Government. 2012. Sustainable Procurement Guideline.
[92] ACT Government. Sustainable Procurement Policy 2015.
[93] NSW Government. 2017. Sustainable Procurement Guide for Local Government in NSW.
[94] WA Government. 2017 WALGA Guide to Sustainable Procurement.

Green construction– Green construction has proven to hold a critical role in boosting C&D waste market worldwide, particularly when it is implemented obligatorily and is a requirement for large scale or government projects. In Australia, there are two voluntary industry-based rating systems, namely the 'green star program' and 'green infrastructure', which promote the concept of green construction.

Investments in technology and infrastructure– Advancements in waste recovery technology and infrastructure are advantageous to domestic market development. Building modern and efficient facilities not only addresses public social and environmental concerns but also provides better services to the waste and resource recovery industry through economies of scale. Government funding to improve waste and resource facilities together with effective law enforcement provides an impetus for further waste recovery activities and diminishes the reliance on waste export. An increase in the number of local infrastructures frees waste producers and collectors (waste responsible) from sending waste across the Australian states such that it would be easier to implement the proximity principle. Technically, a lot of waste minimisation practices and strategies, such as extended producer responsibility, depending on the availability of technologically advanced local infrastructures. Several waste management strategies in Australia have highlighted the need to keep pace with changes in technology for smarter and more efficient waste management. Many waste and resource recovery stakeholders in Australia believe that hypothecating landfill levies should be invested towards developing new technologies and infrastructure.

The use of new technologies, such as Building Information Modelling (BIM), Geographical Information Systems (GIS) and the online marketplace can solve several issues toward the successful establishment of a market for salvaged and recycled C&D waste material.

Employment– The potential for jobs to be created through a local market is attractive to decision-makers, politicians and different stakeholders. Basically, the extent to which waste recovery activities can give rise to employment can be assumed to be proportional to the level of support provided by politicians and major parties in Australia. A study on jobs associated with a circular economy in the UK proved that re-use and recycling jobs would be geographically dispersed across the country while remanufacturing jobs are likely to be more concentrated near existing manufacturing hubs[95]. Geographically dispersed job opportunities are particularly beneficial for Australian regional areas. The Local Government Association of Tasmania (LGAT) expressed that resource recovery operations employ more people and require greater investment in infrastructure per tonne of material compared to landfills. In WA, it is projected that an EfW facility can create 800 job opportunities during construction and 60 full-time jobs during operation. In 2017, Visy Australia, a company involved in resource recovery activities, announced its 10-year expansion plan that will create 5,000 manufacturing jobs and 15,000 indirect jobs[96].

1.5 European Union context in developing C&D waste market

Originating in European countries, the concept of a circular economy dates back to 1980s and 1990s[97]. However, it has only recently become prevalent at the highest level of European policies. In response to the rising prices of products, the European Commission (EC) introduced a *flagship* initiative on resource efficiency. This initiative first ran through *the roadmap for a resource efficient Europe*[98] and

[95] WRAP and Green Alliance (Julian Morgan and Peter Mitchell). 2015. Opportunities to tackle Britain's labour market challenges through growth in the circular economy

[96] Waste Management Review. 2017. Anthony Pratt announces 5000 Visy Australia manufacturing jobs. 2017. Waste Management Review. http://wastemanagementreview.com.au/anthony-pratt-announces-5000-visy-australia-manufacturing -jobs/

[97] Pearce, D. W. and R. K. Turner. 1990. Economics of natural resources and the environment. Baltimore, MD, USA: Johns Hopkins University Press.

[98] EC (European Commission). 2011. Roadmap to a resource efficient Europe. COM(2011) 571 final. Brussels: European Commission.

was then completed by a suite of policies gathered under *the Circular Economy Package*. In 2015, this package was replaced by the Closing the Loop—An Action Plan for the Circular Economy[99]. This action plan consists of multiple main areas[100]: production, consumption, waste management, boosting markets for secondary materials, priority areas, innovation investment and 'horizontal' measures, and monitoring progress. C&D waste is among the priority areas. Under the market section, the main strategy is to propose standards for various secondary materials to foster markets.

According to the latest report on achievements of this action plan, under this action plan, industry engagement has resulted in the adoption of the EU Construction and Demolition Waste Protocol[101]. This voluntary protocol has the final objective of increasing confidence in the waste management process and in the quality of recycled materials in the sector[102]. The following are the key findings from EU C&D waste-related achievements, lessons and best management practices:

- An increase in the costs associated with landfilling may induce the development of companies interested in C&D waste management
- By fostering the construction and demolition waste market, thousands of quality jobs could be created
- Progress has been made towards harmonised EU markets for C&D recycled materials
- A pre-demolition audit takes place to consider local markets for C&D waste and re-used and recycled materials, including the available capacity of recycling installations
- When starting C&D waste recycling, one typically starts with the easiest materials for which secondary markets already exist
- Decontamination is necessary so that hazardous particles will not contaminate the recyclable materials to prevent the reduction in markets' confidence in the recycled waste materials
- In order to create a market for high-value materials, proof of satisfying quality is required; usually, the contractor is one responsible for the quality confirmation
- Tracking and tracing procedures are needed to further develop the market for recycled C&D waste materials through building trust in these materials
- The end of waste criteria is the pre-condition for the development of a market
- To make use of the harmonised European standards that apply to primary materials to also apply to recycled materials for quality control purposes
- To develop a market for C&D recycled materials, a mix of landfill bans and high landfill taxes could provide the necessary incentives
- Authorities at all levels can provide incentives to promote the use of C&D recycled materials
- Market development is very sensitive to how the legal definitions of waste and recovery are interpreted in the Member States

1.6 Conclusion and recommendations

Management of C&D waste management is largely driven by economic factors. These economic factors may motivate or discourage waste management practices among the main stakeholders. This review has identified the influential economic factors and explored how these factors may impede or boost

[99] EC (European Commission). 2015a. Closing the loop: An action plan for the circular economy. Brussels: European Commission.

[100] McDowall, W., Geng, Y., Huang, B., Barteková, E., Bleischwitz, R., Türkeli, S., Kemp, R. and Doménech, T., 2017. Circular economy policies in China and Europe. *Journal of Industrial Ecology*, 21(3), pp.651-661.

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C&D waste and resource recovery industry in Australia. Furthermore, it provides some recommendations to enhance C&D waste management in Australia.

1.6.1 Economic factors

Review of economic factors demonstrated that there are a great number of issues that impact the economy of C&D waste management. This impact is even more evident when it is to be managed in a circular economy. These issues include economic factors (e.g. fiscal incentives and disincentives) and non-economic factors with economic results (e.g. best management practices and policy approaches). The combination of these is believed that forms the shape of C&D waste management in Australia. While some of these issues are currently being implemented and experienced, others are recommended for changing the C&D waste management landscape in Australia. Lastly, some of the issues identified can act in both ways (e.g. limiting and boosting C&D waste management practices) depending on settings; therefore, a separation between drivers and motivators is not possible at this stage and postponed to after survey with the main stakeholders. Table 13 lists and briefly describes these economic focused factors.

Table 13. List of economic focused factors and the associated description in Australia C&D waste management system.

No.	*Factor*	*Description*
1	Landfill levy	The imposition of a levy in most cases would provide motivation for further waste recovery. In certain circumstances it may inflict adverse consequences.
2	A new destination for C&D waste	Finding new replacements for China's waste market in short term is beneficial but in the long term can be a deterrent factor for domestic market development.
3	Levy waiver/subsidisation for waste recycling residual	It motivates further C&D waste recovery and subsequently market development
4	Levy waiver for waste recycling contaminants	It motivates further C&D waste recovery and subsequently market development
5	Penalty for illegal dumping and stockpiling	Enforcement through monetary penalty is an effective tool to enhance C&D waste recovery activities.
6	Government investment in technology	Technological advancement in various levels of C&D waste management produces positive results.
7	Government investment in the establishment of waste recovery facilities	Availability of waste recovery facilities would motivate further C&D waste recovery
8	Transport	Depending on the circumstance, the cost associated with waste transport is both a motivator (proximity principle) and a barrier.
9	Cost of separation at the construction site	A great barrier towards effective C&D waste recovery or reuse
10	China waste policy	It is a short term barrier and a long term motivator economic factor.
11	Levy waiver for clean fill	It encourages re-use of clean C&D waste in construction projects
12	Sustainable procurement	It motivates waste recovery and subsequently market development
13	Employment	Jobs created by developing the market and establishment of more waste recovery facilities is a significant economic factor
14	Deposit/refund scheme	Application of this economic-based policy can produce positive results for C&D waste stream
15	Green construction	Mandatory green rating systems would have a significant economic outcome for the construction industry
16	Development of the domestic market	It is a cornerstone of the circular economy for C&D waste

No.	Factor	Description
17	Extended producer responsibility	Effective policy approach with economic responsibility for C&D waste among various stakeholders
18	A low population and long distances	The low population of Australia and long distances are regarded as economic barriers
19	Product stewardship	Effective policy approach with economic responsibility for C&D waste among various stakeholders
20	Supply chain network	A fundamental economic factor that boosts domestic C&D market
21	Cradle to cradle approach	Through design out waste and design for disassembly can facilitate effective waste recovery, the cost for implementation of these might be perceived negatively by manufacturers and construction companies
22	Discounted 'emission trading scheme credits	Necessary to relieve economic burden on waste recovery facilitates
23	Government investment in R&D	Government funding (from
24	Proximity Principle	Is both a barrier and a motivator: it is a barrier when there is no local market for a C&D waste produced in a region. It is a motivator for developing market and establishment of local waste recovery facility
25	Virgin material tax	A noticeable economic factor that makes salvaged and recycled C&D waste economically competitive

Drawing on the factors listed in Table 13 the following model is developed. The model will be modified when the input from survey participants has been received. The red lines represent existing practices and policies and dotted green lines are denoting practices, policies and issues that are identified in this literature review (Figure 9). For better resolution and quality maximise the view.

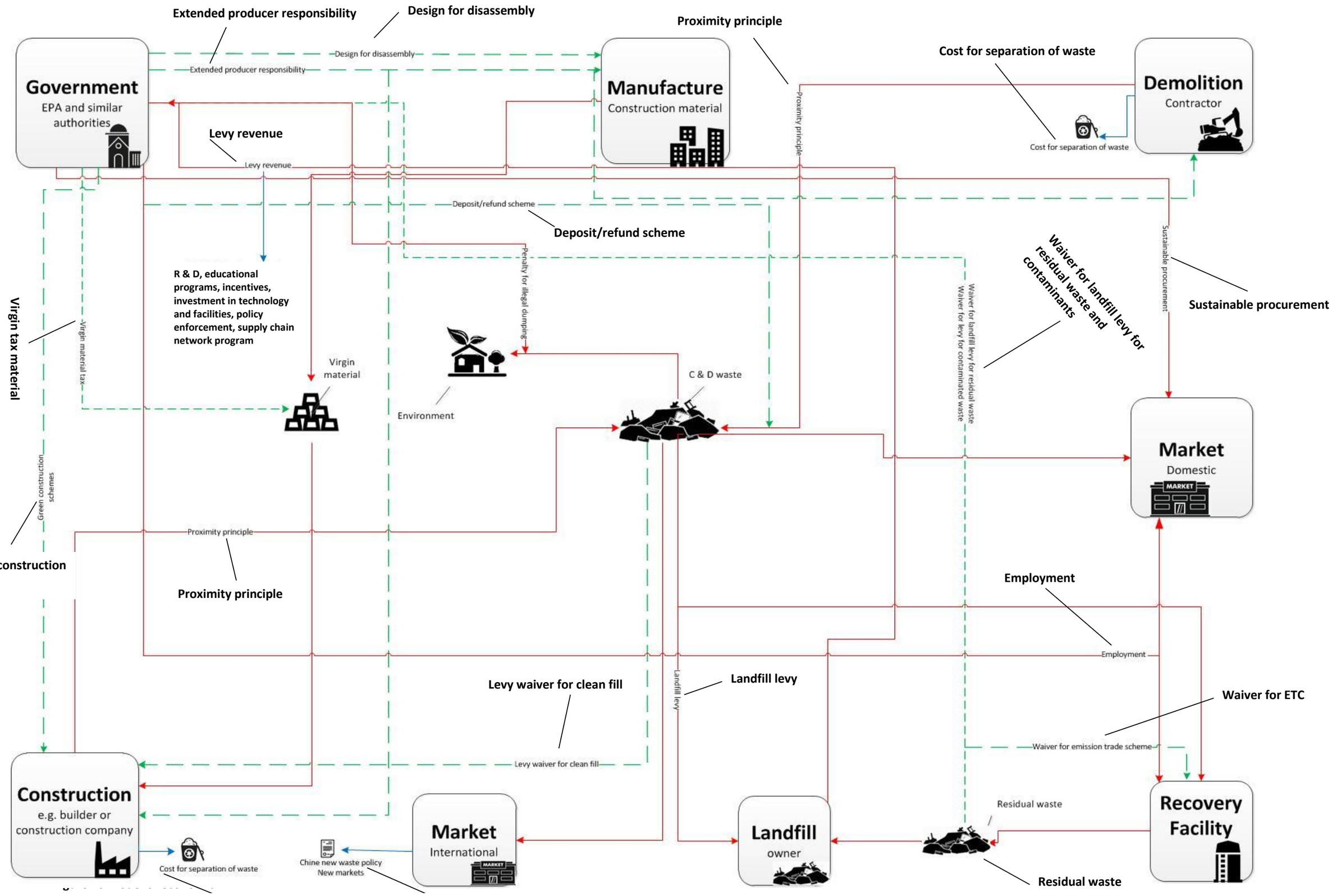

Figure 9. Model of economic factors for C&D waste flow

1.6.2 National level reforms

Following the identification and review of the economic factors involved in C&D waste management, some recommendations are provided. These recommendations, which are aligned with circular economy principles, aim to provide a platform for the development of a market wherein different stakeholders from material producers to waste generators and from waste recovery facility owners to end-users can smoothly trade salvaged and recycled C&D waste materials.

These recommendations primarily emerge from the following sources:

- Review of national jurisdictional legislation, waste policies and strategies
- Review of national and jurisdictional reports, consultation and review drafts, and submissions to the Senate's Environmental Reference Committee
- Review of peer-reviewed and valid research publications

In total 17 strategies were found to enhance C&D waste management across Australia. It is expected that these recommendations will be modified when the project has completed interviews with jurisdictional EPA and waste industry representatives, and the interviewees' views are gathered and analysed. Almost all of these recommendations can be incorporated in 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 directly and indirectly produce economic benefits for C&D waste management:

- Waive or reduce landfill levy rates imposed on recycling residuals, as is being practised in NSW for metal recovery, to boost waste recovery activities
- Provide waivers or discounted levy rates to recyclers for disposing of contaminants that enter the recycling stream
- Adjust levy rates to produce the best possible results
- Make EPR and similar schemes mandatory for a greater impact and compliance
- Invest in technologies and infrastructure to accommodate the growing quantity of C&D waste
- Impose a tax on raw materials extraction and import
- Consider a waiver on GHG emission schemes for recovery facilities through an emission trading scheme and carbon tax (if introduced)
- Invest in attitudinal change through R&D programs leading to raising C&D waste stakeholder's awareness
- Mandate GS and IS principles with respect to waste minimisation or to award construction projects that support and fulfil the existing GS and IS requirements
- Give the Australian government the main responsibility for coordination of efforts to develop local C&D waste markets
- Support the development of an efficient and effective supply chain system
- Promote, appreciate or mandate sustainable procurements within the public sector
- Clarify when waste ceases to be waste in the jurisdictional waste legislative framework so that consumers can take advantage of clean fills for levelling projects and avoid landfill levies
- Review existing waste regulations to consider further support for waste recyclers
- Promote a Cradle to cradle approach in the design and manufacturing of construction materials
- Establish a marketplace that facilitates the trade of salvaged and recycled C&D waste material
- Mandate developing and keeping as-built and as-renovated plans, including a bill of quantities. Having these registered in a permanent database would assist the task of application of EPR and similar schemes at later stages

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