Circular Economy Policies for Optimal Use of Recycled Content in the Built Environment

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Version Control 2

EXECUTIVE SUMMARY

The Australian waste management and resource recovery industry has achieved a satisfactory recovery rate within the construction and demolition (C&D) waste stream. Although initiatives are ongoing to reduce waste generation in the building and construction sector, growing construction activities underscore the need for enhanced resource efficiency. Aligned with circular economy (CE) principles, the **adoption of products with recycled content (PwRC) serves as an effective approach to help the sector meet its sustainability goals.** Given the current satisfactory waste recovery rates, the next critical challenge is maximising the use of PwRC in construction projects. CE policies are essential in promoting and guiding the optimal integration of these resources within the sector.

This report presents the key findings of research aimed **at understanding the perceptions of key stakeholders in the Australian building and construction sector concerning CE policies that influence the optimal use of PwRC** within the industry.

The findings indicate that 17 policies may directly or indirectly impact the uptake of PwRC in the sector. **These policies were examined further through a semi-structured survey with 62 participants** possessing CE knowledge and expertise within the sector. While nearly two-thirds of respondents reported a moderate to extensive understanding of these policies, further analysis revealed a significant lack of awareness regarding certain policies. Furthermore, **only 35% agreed that the policies effectively drive optimal PwRC uptake.** Almost all participants supported the idea of implementing some or all of these policies on a national level. The **top four policies** identified for **their strong positive impacts were sustainable procurement, financial incentives, recycled product certification and product stewardship.** Additional findings highlight the effectiveness, impact mechanisms, challenges and implementation measures associated with each policy reviewed in the study.

The findings of this research offer valuable insights that can **support policy development efforts** aimed at accelerating the transition of the building and construction sector towards a CE. This research can inform government regulatory bodies in developing regulations and standards that drive sustainable practices across the sector. Additionally, these findings serve as a strategic resource for private organisations striving to reduce their carbon footprints. **Companies can leverage the insights to align their operational practices with CE principles,** optimise resource efficiency and make informed decisions regarding the adoption of recycled materials. Together, these contributions can help both public and private stakeholders achieve their sustainability objectives, advancing industry-wide commitments to environmental resilience and reduced waste.

This report is structured in five sections as follows:

1

Introduction

This section outlines the background of construction and demolition (C&D) waste management in Australia, focusing on the integration of products with recycled content (PwRC). It further highlights the critical role of circular economy (CE) policies in promoting the efficient and sustainable use of these resources within the building and construction sector.

2

Research approach

This section begins by outlining the research aim and objectives. It then details the approach used to identify relevant CE policies and to capture the knowledge and perspectives of key Australian stakeholders on these policies. Finally, it presents profiles of the research participants, including their demographic information.

3

Stakeholders' perspective on circular economy policies

This section presents 17 CE policies that directly or indirectly impact the optimal utilisation of PwRC in the building and construction sector. It then examines participants' insights into these policies, covering their effectiveness, impact mechanisms, challenges and implementation strategies within the Australian context.

4

Collective responses

This section presents the results of comparative analyses among the study policies, offering insights into their scale of application, impacts and mechanisms for the optimal use of PwRC in construction projects. It also summarises participants' feedback on additional policies beyond this report and implementation of circular policies in the Australian context.

5

Concluding remarks

The final section of this report delivers concluding remarks on the study's implications, highlighting how the findings can inform the policy development landscape in Australia to advance a more CE within the sector.

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Abbreviation	Extended form	Abbreviation	Extended form
ACT	Australian Capital Territory	**LCBA**	Life Cycle Benefit Assessment
APC	Australian Packaging Covenant	**LEED**	Leadership in Energy and Environmental Design
APCC	Australasian Procurement and Construction Council	**LGA**	Local Government Area
CDS	Container Deposit Scheme	**Mt**	Million tonnes
CE	Circular Economy	**NCC**	National Construction Code
CSR	Corporate Social Responsibility	**NSW**	New South Wales
C&D	Construction and Demolition	**NT**	Northern Territory
C&I	Commercial and Industrial	**NTCRS**	National Television and Computer Recycling Scheme
DfD	Design for Deconstruction	**PEFC**	Programme for the Endorsement of Forest Certification
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen	**PP**	Proximity Principle
EfW	Energy from Waste	**PVC**	Polyvinyl Chloride
EPA	Environmental Protection Authority	**PwRC**	Product with Recycled Content
EPR	Extended Producer Responsibility	**Qld**	Queensland
ESG	Environmental, Social, Governance	**RCA**	Recycled Concrete Aggregate
ETS	Emission Trading System	**RPC**	Recycled Product Certification
FSC	Forest Stewardship Council	**RtR**	Roads to Reuse
GBCA	Green Building Council of Australia	**R&D**	Research and Development
GBI	Green Building Index	**SA**	South Australia
GDP	Gross Domestic Product	**SME**	Small and Medium Enterprise
GECA	Good Environmental Choice Australia	**t**	Tonne (metric)
GGT	Global GreenTag	**Tas**	Tasmania
GGE	Greenhouse Gas Emissions	**UAE**	United Arab Emirates
GHG	Greenhouse Gas	**UDIA**	Urban Development Institute of Australia
ILFI	International Living Future Institute	**USGBC**	US Green Building Council
IPWEA	Institute of Public Works Engineering Australasia	**VENM**	Virgin Excavated Natural Material
ISC	Infrastructure Sustainability Council	**Vic**	Victoria
ISO	International Organisation for Standardisation	**WA**	Western Australia
KPI	Key Performance Indicator	**WMRR**	Waste Management Association of Australia
LCA	Life Cycle Analysis		

INTRODUCTION

Construction and demolition waste in Australia

Over the past few decades, there has been considerable growth in the construction and demolition (C&D) waste stream because of significant urbanisation driven by a rising population, movement and migration. In the absence of a standardised definition for C&D waste, this waste stream is typically defined as materials taken from demolition and construction sites that are unwanted or discarded. The National Waste Report 20221 states that, in 2020-21, Australia generated 29 million tonnes of C&D waste, an increase of 73% since 2006-2007. Comprising 45% of the total waste, this waste source remains the main generator of Australian waste. The report also indicates that the recovery rate for this waste stream has reached 80%. However, significant limitations persist in the use of recycled materials within the building and construction sector. Addressing this challenge calls for Australia to embrace a circular economy (CE), promoting a sustainable built environment.

Circular economy and the use of recycled materials

To date, numerous definitions of 'circular economy' have been proposed[2,3]. The Ellen MacArthur Foundation explains the CE as "an industrial economy that is restorative or regenerative by intention", a defination widely acknowledged and adopted by government officials, practitioners, as well as academics[4]. The European Parliament offers a simpler definition, describing CE as a model of production and consumption founded on "sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as possible", which lengthens the life cycles of products and materials[5]. Within the building and construction sector, a CE is an economic system that replaces the standard 'end-of-life' philosophy; the emphasis is on minimising, inventively repurposing, recycling and reclaiming materials from distribution or manufacturing and consumption activities to make use of those materials as long as possible in the cycle, thereby minimising the misuse of natural resources.

Hence, adoption of products with recycled content (PwRC), in alignment with CE objectives, offers a pathway to reduce the environmental and economic costs of waste, including landfill maintenance, virgin material extraction, landfill levies, transportation expenses and illegal dumping[6].

Given the current satisfactory waste recovery rates in Australia, the next critical challenge is maximising the use of PwRC in construction projects. The uptake of these resources is reported to be influenced by three key factors: education, enforcement and encouragement—all of which can be effectively promoted through the development and enforcement of appropriate CE based policies. Hence, CE policies are essential in promoting and guiding the optimal integration of these resources within the sector.

Policy instrument in circular economy

Moving from a linear economy to a CE warrants substantial changes to current production and consumption systems[7]. One of the major barriers to implementing CE objectives is the lack of a supportive policy framework[6]. Hence, one critical area for a society wishing to achieve a CE is to develop supportive policies that inspire circularity across the materials supply chains. Three types of policy instruments assist the sector in applying economy principles to the sector's projects: administrative, economic and informative.

[1] Blue Environment (2023) 'National Waste Report' Department of Climate Change, Energy the Environment and Water, https://bit.ly/3UA1djJ

[2] Guerra BC and Leite F (2021) 'Circular economy in the construction industry: An overview of United States stakeholders' awareness, major challenges, and enablers', Resources, Conservation and Recycling, 170:105617

[3] Kirchherr J, Reike D and Hekkert M (2017) 'Conceptualizing the circular economy: An analysis of 114 definitions', Resources, Conservation and Recycling, 127:221-232

[4] Anastasiades K, Blom J, Buyle M and Audenaert A (2020) 'Translating the circular economy to bridge construction: Lessons learnt from a critical literature review', Renewable and Sustainable Energy Reviews, 117:109522

[5] European Parliament (2022) Circular economy: definition, importance and benefits, https://rb.gy/m0495

[6] Shooshtarian, S., Maqsood, T., Wong, P. S., Yang, R. J. and Khalfan, M. (2020) Market development for construction and demolition waste stream in Australia, Journal of Construction Engineering, Management & Innovation, 3(3), 220-231.

[7] Peck, P., Peck, Richter, J., L., Richter, and Delaney, K. (2020) Circular economy – Sustainable materials management: A compendium by the international institute for industrial environmental economics (iiiee) at Lund University, The International Institute for Industrial Environmental Economics (IIIEE), Lund, Sweden.

Licenses, bans, benchmarks and voluntary agreements between industry and government are examples of administrative or regulatory instruments, while economic instruments include fees, subsidies, taxes and other charges. Informative instruments comprise labelling, reporting obligations, certification initiatives and awareness-raising campaigns[7].

Although some CE policies exist within the Australian context, there remains limited insight into their effectiveness in stimulating demand for PwRC[8]. Gaining a deeper understanding of these policies' performance is essential for informing the development of new policies and refining the current policy framework. This knowledge can help ensure that policies are not only present but are also impactful in fostering a robust CE.

RESEARCH APPROACH

Aim and objectives

The research aimed to understand the perceptions of key stakeholders in the Australian building and construction sector regarding CE policies that impact the optimal use of PwRC within the industry. To achieve this aim, the following objectives were addressed:

- To identify the key CE policies impacting the use of PwRC in construction
- To explore stakeholders' familiarity with these policies within the sector
- To evaluate the effectiveness and impact of these policies on the optimal uptake of PwRC in the sector
- To assess the challenges and implementation strategies associated with these policies.

Research design

The research utilised a mixed-methods approach to identify key CE policies and assess their impact on the adoption PwRC in the building and construction sector. To achieve Objective 1, qualitative data was gathered through a systematic literature review. Quantitative data, addressing Objectives 2 through 4, was collected via a semi-structured survey. Surveys are an appropriate data collection method to obtain both quantitative and qualitative information using well-planned questionnaires and are widely used by researchers within the construction management domain. In this study, an online questionnaire was used as the most appropriate delivery method because this tool is efficient and flexible and ensures participant confidentiality. In addition, conducting questionnaires online is the most common delivery method, so participants are familiar with the approach and are more likely to respond.

Sample and data collection

A cross-sectional survey of a purposive sample of stakeholders of C&D waste management operating in different jurisdictions of Australia was conducted from January to September 2024. A purposive sampling strategy was the most time-effective sampling approach available. It was employed to recruit a wide range of participants across the C&D waste supply chain. Recruitment was executed according to the Australian National Statement on Ethical Conduct in Human Research and RMIT University Human Ethics Committee instructions and requirements. Several key industry peak bodies and public organisations assisted in recruiting participants for the survey.

Since the study required experts in the field, one of the main selection criteria was adequate experience in dealing with the management of C&D waste and CE in Australia. Participants were recruited through email communication, LinkedIn posts and direct messaging. An email or LinkedIn message containing the online survey link and the project information sheet was sent to a list of participants compiled by the research team in a single round. A reminder email/message was also sent to those who did not respond in the first round. Survey participation was voluntary, and a completed survey implied informed consent. The investigators maintained the privacy and confidentiality of all survey information as per the human ethics requirements.

[8] Iyer-Raniga U, Gajanayake A and Ho, O. T.-K. (2023) 'The transition to a circular built environment in Australia: An Analysis of the Jurisdictional Policy Framework'. Environmental Policy and Law, 53(4): 233-246

Survey design

The survey was development based on review of the literature, regulations, policy statements, other international guidelines and expert opinions regarding the main issues of PwRC uptake and implementation of CE policies. The questionnaire was designed using Qualtrics. The first draft of the questionnaire was reviewed by three experts to establish content validity and tested for online accessibility and comprehension by a group of construction professionals and experienced researchers. The content, clarity and length of the survey were modified accordingly. The questionnaire included multiple questions addressing various aspects of the 17 identified policies. The survey design consisted of a range of question types: multiple-choice questions, 5- and 7-point Likert scales (1 = 'strongly agree' to 7 = 'strongly disagree'), and single and multiple text entry(ies).

Research participants' profiles

The administration of the survey resulted in 92 responses, of which 62 were complete and therefore were included in the data analysis. Figure 1 presents a summary of the survey participants' profiles. The majority of respondents were in the age groups of 35-44 and 45-54 (61%); and almost half of this population had been engaged in promoting material circularity within the sector for between 1 and 5 years (54%). Their main locations of operation were in four major Australian states, with Victoria having the greatest number of respondents.

The main employer sectors among the survey participants were 'Government' (25.8%) followed by 'Consultation', 'Construction' and 'Academia' (14.5%). Participants from academia were those recently engaged in research on C&D waste management and the implementation of CE principles within the built environment. The sub-sectors of the government category included general, infrastructure delivery, policy making and

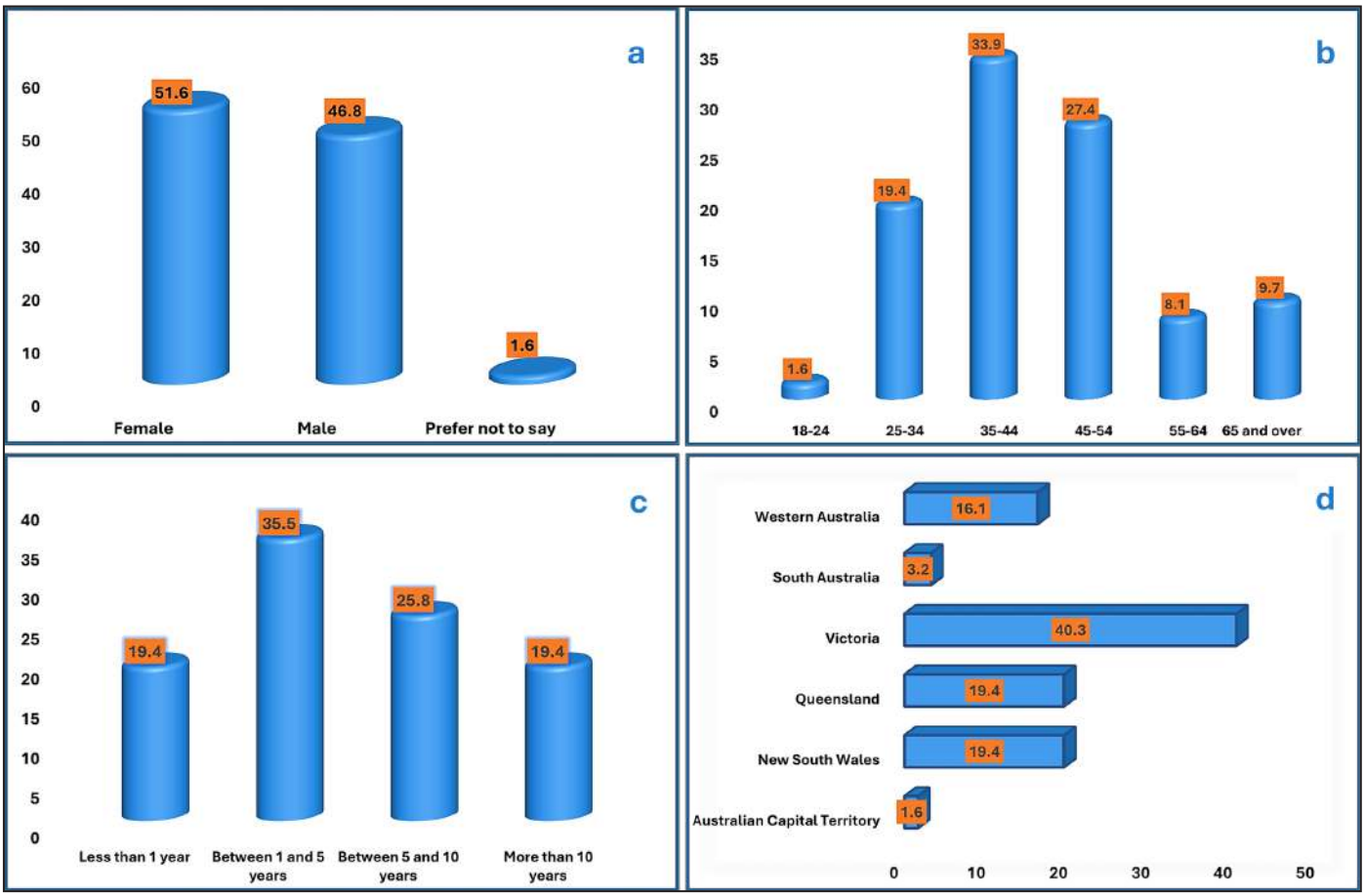

Figure 1. Participants profile (frequency distribution %). Gender (a), age groups (b), work experience (c) and location of operation (d)

enforcement. Figure 2 presents the participants' employment sector. The category of 'Material supply' refers to those who are engaged in material engineering, manufacturing and supplying.

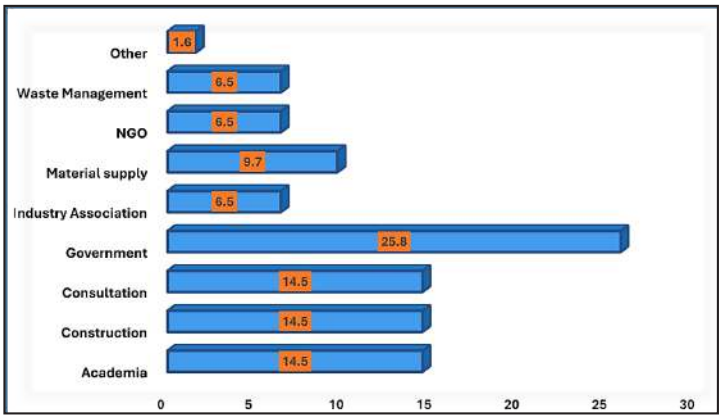

Figure 2. Employment sector of participants (frequency distribution %).

OVERVIEW OF STUDY POLICIES

In this section of the report, 17 policy interventions that are currently imposed or proposed to be implemented in the Australian context are visually presented (Figure 3). These policies are divided into two categories: policies with direct impact on the use of PwRC in construction projects and those that have indirect impacts. The subsequent sections provide an in-depth analysis of each policy, followed by a presentation of the research participants' perspectives on these policies. Table 1 presents a summary description of each policy.

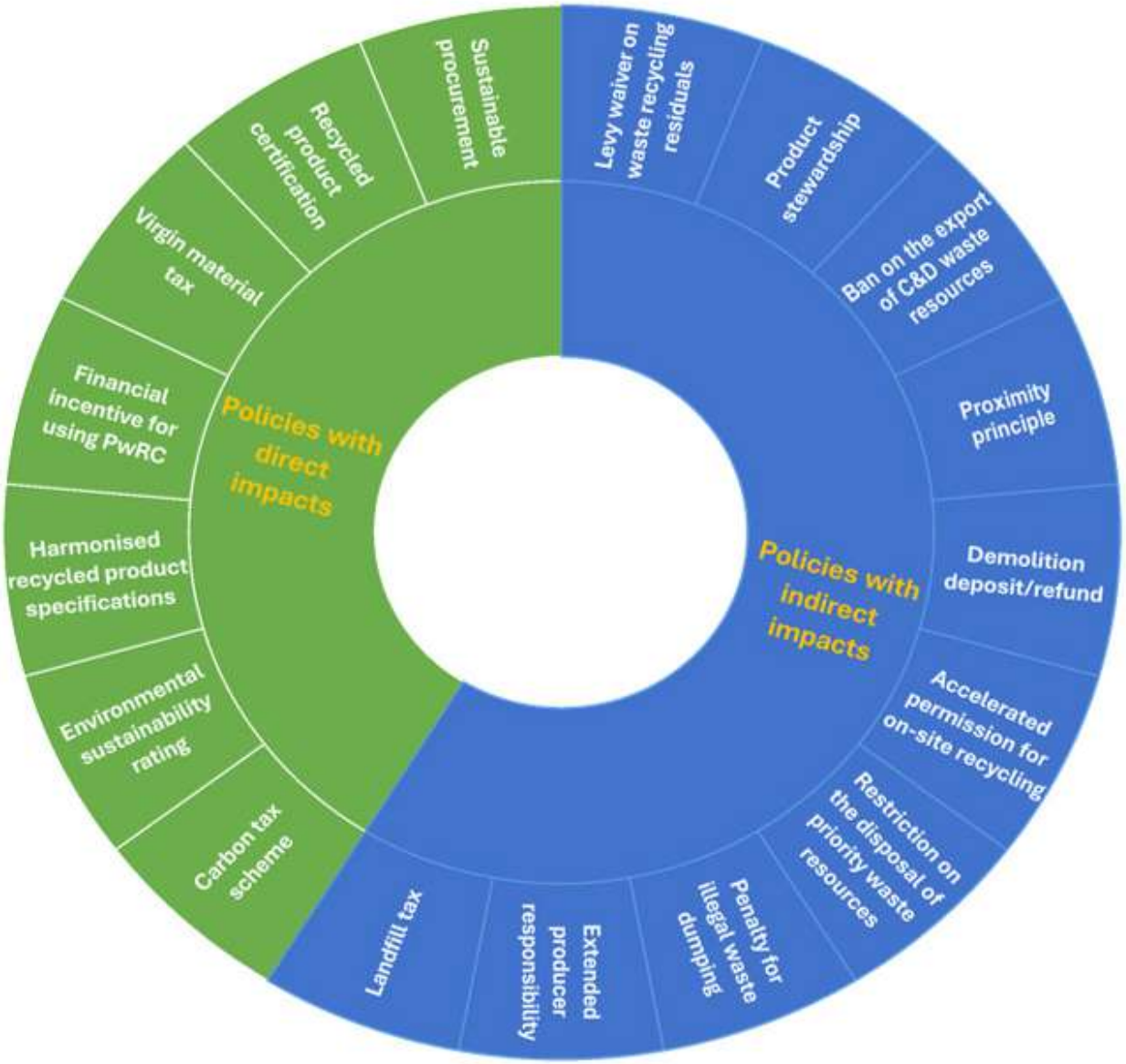

Figure 3. Circular economy polices (with direct and indirect impacts on the use of PwRC) investigated in this report

Table 1. Summary of the study CE policies

Policy	Description	Policy	Description
Sustainable Procurement	Sourcing and purchasing recycled products while considering their environmental, social and economic implications	**Penalty on Illegal Waste Dumping**	A financial or legal consequence imposed on individuals, businesses or entities that engage in the improper disposal of waste materials in an unauthorised or environmentally harmful manner
Recycled Product Certification	A CE-based strategy that is designed to assure the quality, performance, environmental friendliness and safety of recycled products	**Restriction on the Disposal of Priority Waste Resources**	Regulatory measures and policies implemented by governments or authorities to limit or prohibit the disposal of specific types of waste materials that are deemed valuable, scarce, hazardous or environmentally damaging
Virgin Materials Tax	A financial mechanism that aims to discourage or penalise the use of virgin materials and encourage the use of recycled products	**Accelerated Permission for Onsite Recycling**	A a regulatory or administrative process designed to expedite or fast-track the approval and permitting of recycling facilities or practices that are conducted onsite
Financial Incentive for Using Recycled Materials	A monetary or economic benefit provided to individuals, businesses or organisations to encourage the use of recycled products	**Demolition Deposit/Refund**	A financial security or collateral mandated on eligible construction and/or demolition projects, with the primary objective of guaranteeing the appropriate recycling and disposal of C&D waste materials
Harmonised Recycled Product Specifications	Specifications designed to establish common guidelines and requirements that define the quality, composition and performance standards of products with recycled content	**Proximity Principle**	A waste management concept that emphasises the importance of handling waste as close to its source of generation as possible. It encourages minimising the transportation of waste over long distances and promoting the management of waste near its point of origin
Environmental Sustainability Rating (Recognition)	A systematic framework used to assess, measure and rate the environmental sustainability of various entities, such as buildings, products, services and organisations. Examples include Green Star, LEED, IS Rating	**Product Stewardship**	A comprehensive and proactive approach to managing the environmental and social impacts of a product throughout its entire life cycle, from design and production to use and disposal
Extended Producer Responsibility	It is a policy approach that places the responsibility for the entire life cycle of a product on the manufacturer or producer, including the collection, recycling and proper disposal of the product once it becomes waste	**Ban on the Export of C&D Waste Resources**	A regulatory policy or legal measure implemented by a government or authority to prohibit or restrict the export of C&D waste materials to other countries
Landfill Levy (Tax)	A landfill levy is a financial charge or fee imposed by a government or regulatory bodies on the disposal of waste materials in landfills	**Recycling Residual Waste Levy Waiver**	A waiver that allows a specific entity to be excused from certain requirements or obligations related to the disposal of residual waste materials when they can demonstrate a significant commitment to recycling practices

GENERAL KNOWLEDGE OF CIRCULAR ECONOMY POLICIES: SURVEY FINDINGS

Prior to presenting participants with the policies outlined in Table 1, they were asked to self-assess their knowledge of Australian CE policies that influence the use of PwRC in the construction sector. Nearly two-thirds indicated a moderate to extensive understanding of these policies (Figure 4a). When asked whether existing Australian policies actively support the optimal use of PwRC, only 35% of participants agreed that these policies effectively serve this purpose. This suggests that the majority view current policy frameworks as insufficiently aligned with promoting the use of recycled content in construction (Figure 4b).

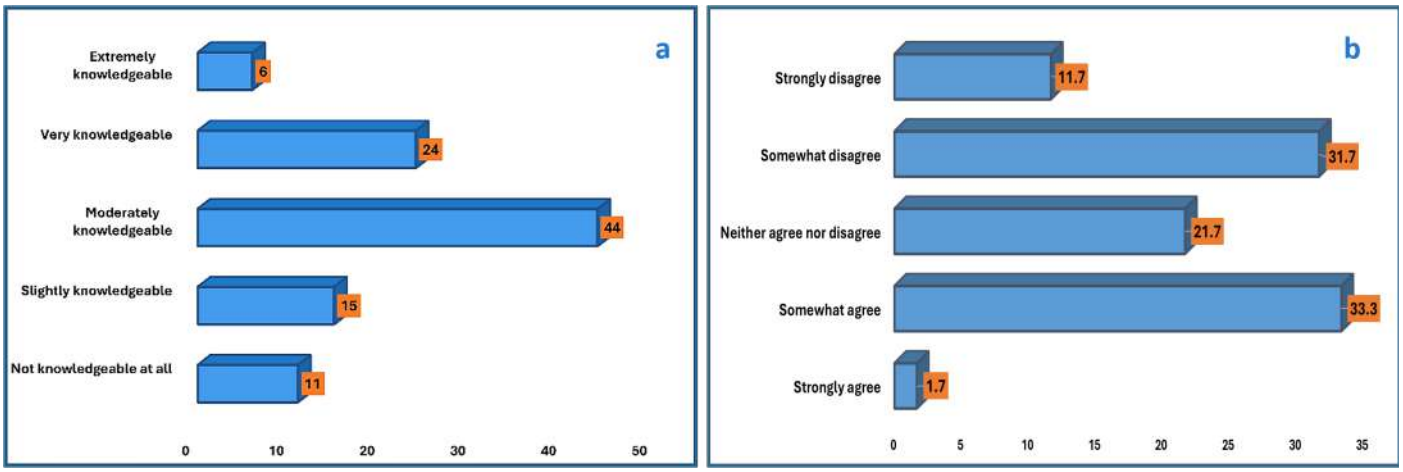

Figure 4. Frequency distribution (%) of participants' responses on (a) their level of general knowledge of CE policies and (b) perceptions on whether existing Australian policies support the use of PwRC in construction

POLICIES WITH DIRECT IMPACTS

This section of report explores seven policies that have direct impacts on procurement of PwRC in the building and construction sector. Four of these policies are implemented in Australia, with varying degrees of application across states and territories.

Sustainable procurement

Among current policies, sustainable procurement has the most potential to significantly improve C&D waste management systems. This policy approach will also help enhance circularity in resources in the building and construction sector. Various organisations define sustainable procurement for different scenarios and usages. The United Nations, the UK government and the Australasian Procurement and Construction Council (APCC) accept the following definition: "*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*"[9]. Sustainable procurement can also be referred to using terms such as 'green public procurement', 'sustainable public procurement'[10], 'environmental purchasing', 'circular procurement' and 'environmentally preferable procurement'.

the principles of sustainable development, such as ensuring a strong, healthy and just society, living within environmental limits and promoting good governance'[11]. The existing research outlines many of the advantages of sustainable procurement application. For example, Pick (2017)[12] lists advantages including energising the market at a local level, adding to the 'Zero Waste' movement and various goals relating to environmentalism and decreasing the costs faced by local governments using long-lasting and reusable materials.

In the building and construction sector, implementing sustainable procurement provides multiple environmental benefits. By way of example, it could lead to greenhouse gas emissions (GGE) reduction by curtailing energy use. This is important since estimations suggest that, of the energy needed to build a structure for a built environment, 80% is directed towards the production and transportation of materials for construction[13]. Furthermore, sustainable procurement helps

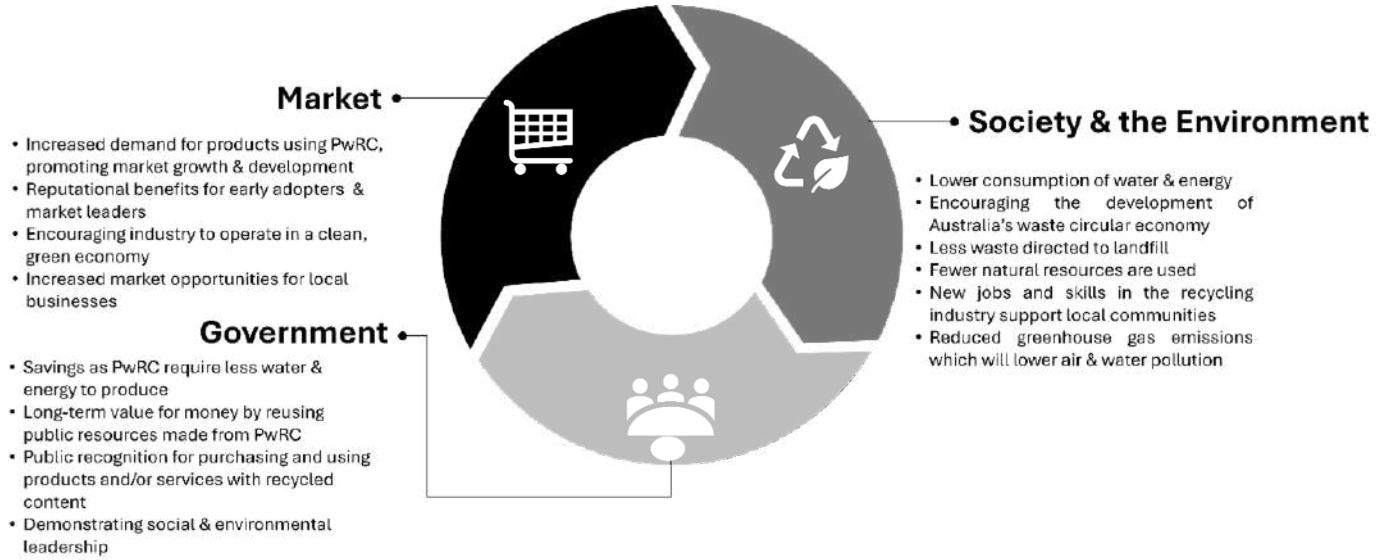

Figure 5. Advantages of sustainable procurement by society, government, market and environment.
Source: adapted from two resources[18,27]

Sustainable procurement adds onto the concepts of CE and the cradle-to-cradle approach evaluated through various measures, including to evaluate product lifecycle. This approach is consistent with increase waste recovery and generates a demand for PwRC with a minimum environmental impact.

[9] Commonwealth of Australia (2013) Sustainable Procurement Guide

[10] Alhola K, Ryding S-O, Salmenperä H and Busch NJ (2019) 'Exploiting the potential of public procurement: opportunities for circular economy', Journal of Industrial Ecology, 23(1):96-109

[11] Brammer S and Walker H (2011) 'Sustainable procurement in the public sector: an international comparative study', International Journal of Operations & Production Management, 31(4):452-476

[12] Pick, F (2017) Waste as a resource: tools for construction and demolition waste management, Metro Vancouver in conjunction with the National Zero Waste Council.

[13] Craighill A and Powell JC 1999, A lifecycle assessment and evaluation of construction and demolition waste.

A research study revealed that, among 25 study countries, mandating suppliers to commit to waste reduction goals is one of the five central functions of sustainable procurement policies[10]. A study in the Netherlands[14] reported that sustainable procurement is the primary approach to stimulating concrete recycling. Sustainable procurement was also the most promising option for establishing the long-term mechanism of using PwRC in the building and construction sector[15].

Sustainable procurement principles and benefits in the Australian context

To enhance the market demand for PwRC, government agencies need to become more involved in the wider implementation of sustainable procurement practices via the creation of specifications, quality assurance, accreditation and awareness raising regarding the outcomes (financial, social, environmental and ethical) of the PwRC and services[16]. The findings of a survey study[6] indicated that this policy approach, landfill levies and investment in technology and infrastructure are three major influential elements that significantly affect PwRC market development. In one study, research participants suggest that sustainable procurement is a vital solution for organisational waste management but only if it is a workable alternative or the client agrees to pay more[17].

In another study, Ershadi et al. (2021)[30] explored the role of the project management office (PMO) in implementing sustainable procurement for construction projects. The study identified eight primary areas through which the benefits of this approach can be fulfilled. These include task assignment, strategic analysis, goal setting,

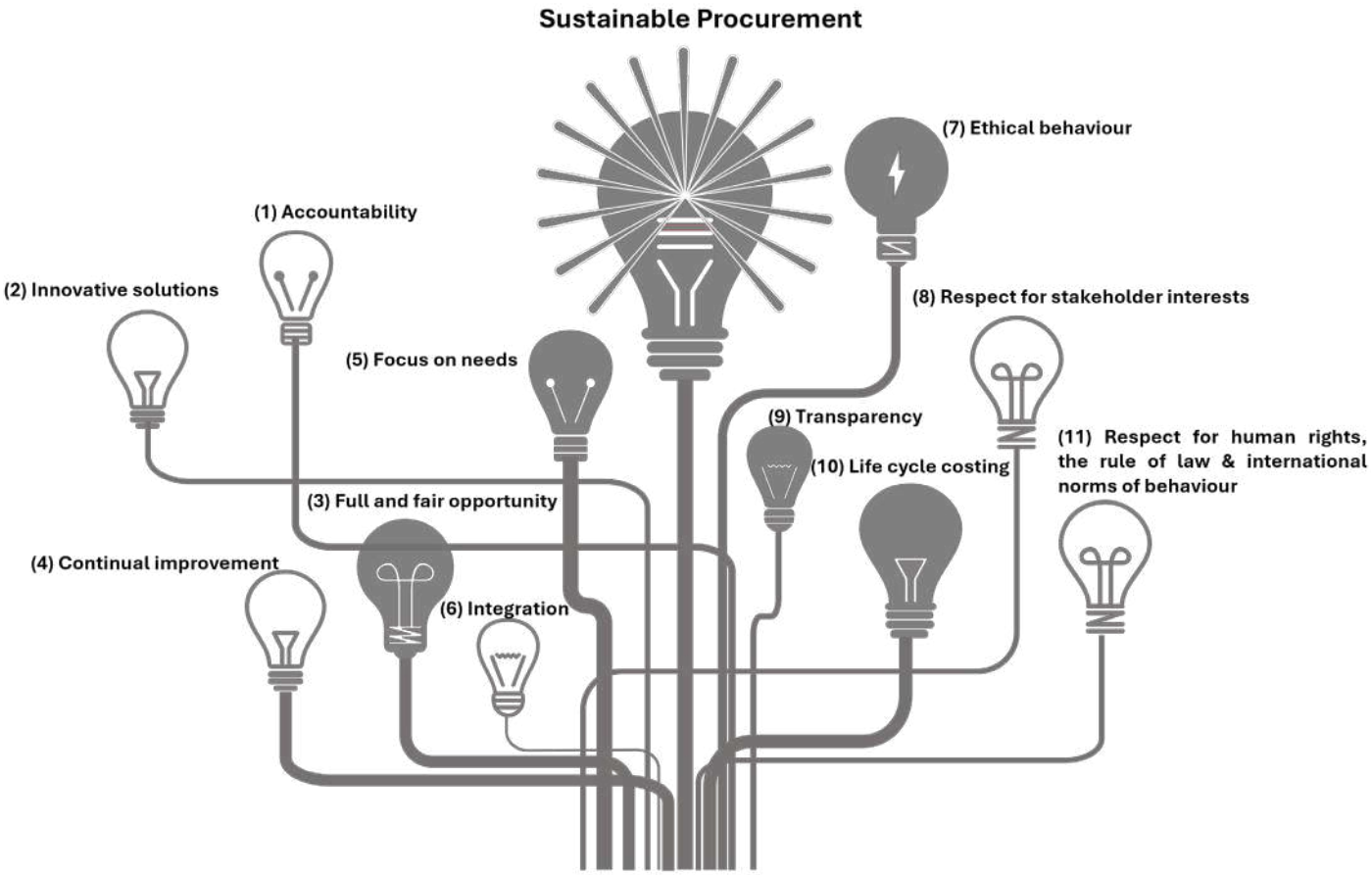

Figure 6. Primary principles of sustainable procurement
Source: Adapted from Local Government NSW (2021)[20]

[14] Zhang C, Hu M, Yang X, Miranda-Xicotencatl B, Sprecher B, Di Maio F, Zhong X and Tukker A (2020) 'Upgrading construction and demolition waste management from downcycling to recycling in the Netherlands', Journal of Cleaner Production, 266:121718.

[15] He Q, Shi S and Hu M (2014) 'Exploring a long-term mechanism of construction and demolition waste recycling: A case of Chongqing', Springer Berlin Heidelberg,

[16] Hyder Consulting Pty Ltd (2011) Construction and demolition waste status report: Management of construction and demolition waste in Australia Department of Energy and Environment (Department of Sustainability, Environment, Water, Population and Communities).

[17] Davis, P., Simon, L., Sher, W., Tang, P. and Newaz, M. T. (2019) Key Solutions for Construction and Demolition (C&D) Waste Management in NSW, Australia, 43rd AUBEA Conference: Built to Thrive: Creating Buildings and Cities That Support Individual Well-Being and Community Prosperity., Noosa, Australia, 612-628

tendering support, planning support, operation support, maintaining consistency and post-review.

In the wake of the Australian government's 2010 Sustainable Procurement Guideline, a revised guide was released in 2020[18]. This document outlines a framework for the Australian government to continue efforts to enhance sustainability outcomes and popularise sustainability principles in future procurement. This document offers a list of benefits to purchaser (government), market, and society and the environment that are fulfilled by the purchase of PwRC. Figure 5[19,27] integrates this list with the model proposed by Australian ISO 20400 Committee.

Sustainable procurement principles are informed by 11 factors. As shown in Figure 6[20], these items refer to a range of facets of sustainable procurement and can guide public and private organisations on how to devise specific sustainable procurement policies. Table 2 summarises the definition of these principles and proposes an action (the last column) that translates the principle into sustainable procurement of PwRC.

Table 2. Sustainable procurement principles, functionality and relevance to PwRC procurement

No	Principle	Description	Action relevant to PwRC procurement
1	**Accountability**	Be accountable for its impacts on society, the economy and the environment, including the impacts of the organisation's supply chain	To increase the cost of utilisation of virgin materials for end-users to be accountable for their procurement policies and practices
2	**Innovative solutions**	Seek solutions to address its sustainability objectives and encourage innovative procurement practices to promote more sustainable outcomes throughout the entire supply chain	To develop policies that promote innovation in the procurement of PwRC furthering PwRC uptake
3	**Full and fair opportunity**	Avoid bias and prejudice in all procurement decision making	To ensure that PwRC are not compared to virgin materials
4	**Continual improvement**	Work towards continually improving its sustainability practices and outcomes, and encouraging its supply chains to do the same	To optimise the supply chain in the building and construction sector to embed in PwRC in procurement planning and practices
5	**Focus on needs**	Review demand, buy only what is needed and seek more sustainable alternatives first	To prioritise PwRC when specifying materials for low-value applications
6	**Integration**	Ensure that sustainability is integrated into all existing procurement practices to maximise sustainable outcomes	To motivate the building and construction sector to build capacity for the application of sustainable procurement
7	**Ethical behaviour**	Behave ethically and promote ethical behaviour throughout its supply chains	To monitor waste handling and processing activities to minimise the risk of procurement of PwRC.
8	**Respect for stakeholder interests**	Respect, consider and respond to the interests of stakeholders impacted by its procurement activities	To provide a level playing field for all stakeholders involved in the use of PwRC
9	**Transparency**	Be transparent about its procurement processes and how its decisions and activities impact the environment, society and the economy	To ensure transparency in handling, processing and procurement of PwRC
10	**Life cycle costing**	Consider the cost incurred, the value for money achieved and also the costs and benefits on society, the environment and the economy resulting from its procurement activities	To consider the social and environmental benefits of procuring PwRC
11	**Respect for human rights, the rule of law and international norms of behaviour**	Be aware of any violations throughout its supply chains and actively encourage its suppliers to do the same	To reduce the need for virgin materials through procurement of PwRC

Source: Local Government NSW (2021)[20]

[18] Australian Government (Department of Agriculture WatE) (2020) Sustainable procurement guide: A practical guide for commonwealth entities

[19] Australian ISO 20400 Committee (2018) Building the business case for sustainable procurement in Australia – guidance,

[20] Local Government NSW (2021) Sustainable Procurement Guide: for local government in NSW

Barriers to applying sustainable procurement

Barriers play a significant part in shaping sustainable procurement practices and determining the success or otherwise of sustainable procurement outcomes. The literature uncovers various elements that hamper the publicity and implementation of sustainable procurement practices. Table 3 outlines studies that explore sustainable procurement barriers in developed and developing nations and presents 30 barriers reported in the literature. The two key barriers are revealed to be 'the lack of supportive organisational culture' and 'uncertainty about the PwRC quality'.

Table 3. Summary of barriers to applying sustainable procurement in the building and construction sector
Source: Authors

Reference	Study context	1 lack of long-term planning	2 higher costs of PwRC	3 lack of methods to measure sustainability	4 lack of knowledge about sustainable products	5 obligation to procure from local suppliers to lower costs and keep the quality	6 unavailability of certain PwRC	7 lack of government support	8 misconception about PwRC production cost & time	9 lack of motivation	10 lack of supportive organisational culture	11 lack of inclusion of PwRC in construction specification documents	12 lack of mandatory imposition	13 uncertainty about PwRC quality	14 lack of operations	15 lack of an organisational policy	16 struggle to procurement behavioural change	17 lack of market & market barriers	18 traditional procurement procedures	19 oversupply of PwRC	20 lack of sustainable suppliers	21 time pressure to complete projects, minimising the possibility of sustainable procurement	22 difficulty in assessing the non-environmental impact	23 the complexity of cost-benefit analysis for PwRC	24 lack of training and education for suppliers	25 involvement of various stakeholders	26 shortage of relevant resources	27 suppliers focus on price than quality	28 desire to diversify contractors	29 economic uncertainty	30 lack of aptitude for sustainable procurement by top management
21	Brazil	●	●		●	●		●			●																					
22	Brazil									●	●				●			●												●		
11	Canada											●		●						●			●				●		●	●		
23	France									●	●			●	●																	
24	Malaysia	●			●			●																				●				
25	Saudi Arabia										●																					●
26	South Korea					●	●							●																		
27	UN		●										●			●		●	●													
28	Global								●								●				●			●	●							

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Enablers to apply sustainable procurement

Procurement experts contend that sustainable procurement planning must be founded on the realisation of several mostly context-specific conditions. Previous studies have identified a range of enablers that would enable the effective implementation of sustainable procurement, mainly in the public sector in developing (i.e., Australia, New Zealand, Canada and France) and developed (i.e., South Africa, Saudia Arabia and Nigeria) nations (Table 4). From the 20 enablers identified in the literature analysis, the two key enablers were revealed to be 'developing clear & supportive regulations' and 'maintaining transparency & good governance'.

Table 4. Summary of enablers to apply sustainable procurement in the building and construction sector
Source: Authors

Reference	Study context	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		developing clear & supportive regulations	project owners' commitment to sustainability	project team capability	strategic partnership	customer expectation/ pressure	providing incentives and rewards	strong technical expertise	quality assurance to maintain the consistency	corporate reputation	proper planning & anticipating the arrangement	improving sustainability knowledge through education	setting a measurable target for using PwRC	maintaining transparency & good governance	mandatory application of sustainable procurement	conducting a cost-benefit analysis to educate project leaders & investors	potential to export locally manufactured goods	screening out suppliers with a lack of commitment to sustainability during the tendering stage	knowledge sharing among project stakeholders	effective coordination to address challenges and conflicts	procurement post-review
29	Australia								•		•		•	•		•		•		•	•
30	Australia																				
11	Canada		•											•							
31	China	•				•	•														
32	France												•								
33	Malaysia	•	•		•		•					•			•				•		
34	New Zealand					•				•											
35	Nigeria	•										•		•							
36	South Africa	•			•			•													

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Overview of Key Findings

- Approximately **70%** of participants reported being very to moderately **familiar** with this policy **(Figure 7a)**
- 58% participants indicated that **'Sustainable Procurement'** can be very to moderately effective in optimal use of PwRC in construction **(Figure 7b)**
- Only **42%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 7c)**
- About **34%** of participants indicated that the policy's application has some negative consequences **(Figure 7d)**
- Participants identified 12 potential negative impacts of this policy **(Table 5)**
- The three primary ways this policy can boost PwRC use include '**creation of sustainable supply chains for using PwRC', 'creation of demand for PwRC'** and **'improvements in the general environmental sustainability in the construction sector' (Figure 7e)**
- They proposed **19 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects (**Table 6**)
- **80%** participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **90%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Sustainable Procurement'

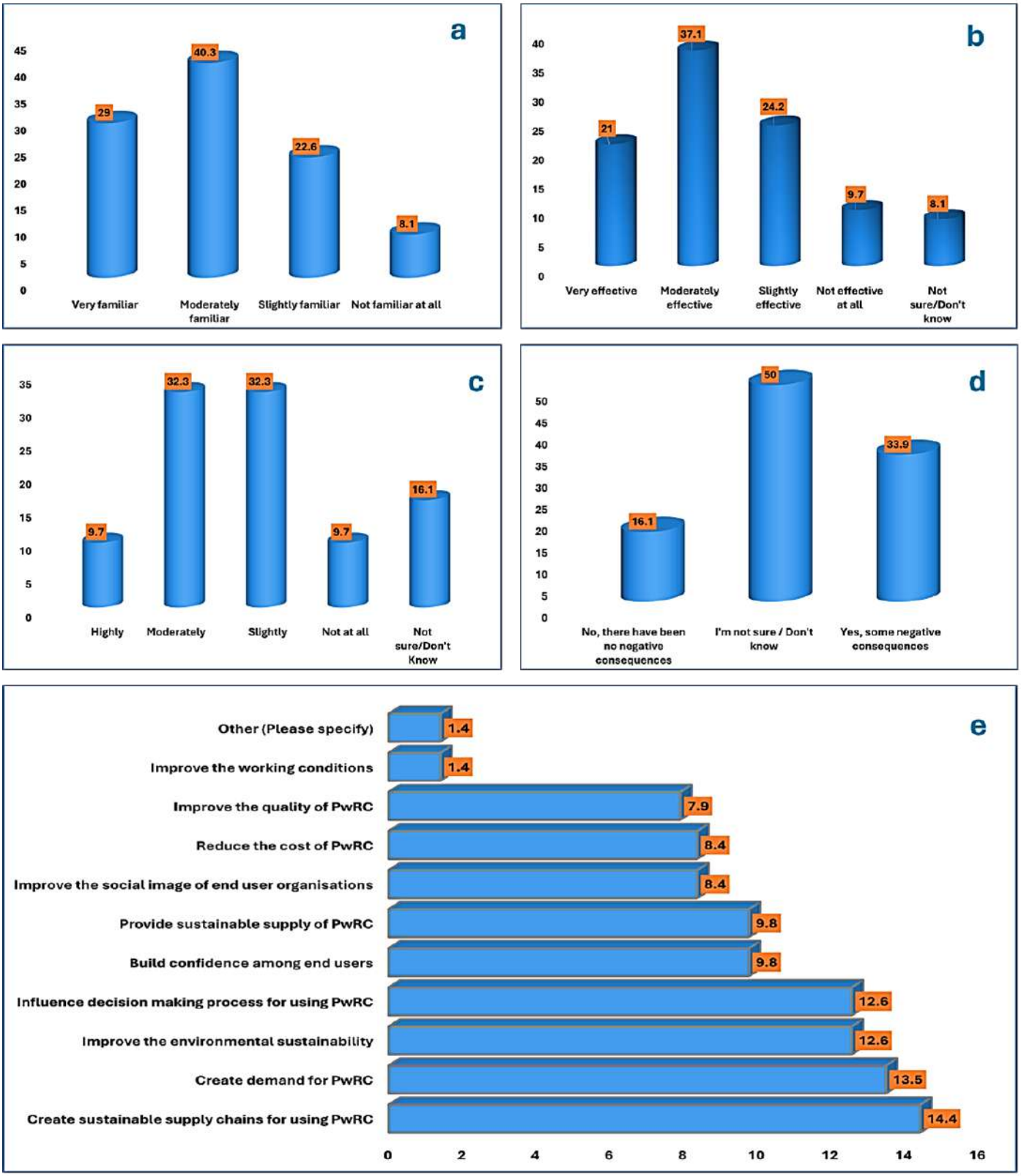

Figure 7. Participants' responses (frequency distribution %), sustainable procurement. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 5. Key issues and impacts of implementing sustainable procurement policy

No	Issue	Description
1	**Incorrect application**	Incorrect and/or inadequate application of the policy for its intended purpose
2	**Time for adoption**	I don't think that there will be some negative consequences. However, it may take some time to adopt this policy and receive the positive consequences
3	**Lack of standards**	Until Australian standards address PwRC application in construction and where in the design in the buildings, it can have some adverse effects such as lack of durability and unfavourable mechanical properties
4	**Greenwashing**	Gives the impression that government is doing more than it actually is. A form of greenwashing
5	**Material rejection**	Lack of materials testing has led to some materials being rejected for use
6	**Low quality and contamination**	• Materials are low quality and may be contaminated • Early concerns about contamination of product, particularly with asbestos • Ongoing concerns around performance of some products compared to virgin materials as well as concerns around additional cost • Potential for people to push poor quality PwRC or materials from a sustainability viewpoint • Potential for people to push poor quality PwRC or materials from a sustainability viewpoint
7	**Supplier limitations**	It limits the number of suppliers as not all of them source PwRC
8	**Cost and time**	Time-consuming, expensive, with more reliance on imports
9	**No further actions**	No other actions will take place
10	**Lack of long-term studies**	There are no studies to ensure that there are no long-term structural or environmental issues in using these materials
11	**Inconsistent outcomes**	Limited certifications and reporting standards can lead to inconsistent outcomes
12	**Slow improvement**	Setting expectations that are too long reduces the rate of improvement
Positive impact		
Additional demand for PwRC		Increases sustainable supply and drives demand for PwRC verification, traceability and improved metrics beyond current LCA capabilities
Job creation		Supports job creation through increased use and demand for PwRC

Table 6. Key measures to enhance sustainable procurement effectiveness

No	Measures	Description	No	Measures	Description
1	**PwRC application targets**	•The policy should set clear priority material targets to improve local waste management and align industry efforts with policy intent •Specific local-level targets for PwRC adoption should be established to drive consistent progress	11	**A wider industry engagement**	Greater engagement with the construction sector beyond road projects should be prioritised in Western Australia
2	**Application of PwRC certification**	Prioritise PwRC that have been certified by recognized sustainability standards, such as the Forest Stewardship Council (FSC) or LEED. This ensures transparency and credibility in the sourcing process	12	**Life cycle benefit analysis**	Life Cycle Benefit Analysis (LCBA) should be conducted to compare environmental impacts of PwRC and virgin materials
3	**Increase awareness and educational programs**	•Industry awareness campaigns should promote the use of PwRC in construction projects •Educational programs should highlight the economic and environmental benefits of using PwRC •Awareness campaigns should inform construction companies and the public about PwRC benefits	13	**Procurement requirements**	PwRC content requirements should be included in tenders, and procurement rules should be standardised across states
4	**Financial incentives**	•Financial incentives such as tax credits should be provided to encourage PwRC adoption in construction •Financial incentives and subsidies should be provided to companies that aim to transition to supply and use PwRC	14	**Collaboration and coordination**	Stakeholder collaboration should be improved to enhance resource recovery and circular waste management
5	**Regulatory support**	Supportive regulations should be implemented to promote the use of PwRC in the construction industry	15	**Risk and contamination concerns**	Contamination standards should be established to build confidence in PwRC materials
6	**Industry leadership**	Organisations should adopt PwRC to lead by example and stay competitive within industry standards	16	**Life cycle and Client involvement**	Clients should play a leadership role in waste reduction and promote the use of PwRC in building projects
7	**Local government role**	Local governments should prioritise PwRC in procurement tenders and support local suppliers	17	**Supplier engagement**	PwRC material suppliers should be engaged to ensure a reliable and consistent supply chain
8	**Cost of externalities**	Policies should account for external costs like carbon footprint when comparing virgin materials and PwRC	18	**Monitoring and reporting**	Mechanisms for monitoring and reporting PwRC usage and sustainability progress should be implemented
9	**Standardisation**	Standards should be developed to make PwRC a default choice rather than an optional one	19	**Addressing industry hesitance**	Research and cost analysis should address industry hesitance and demonstrate the value of PwRC in construction
10	**Voluntary to mandatory policy**	PwRC policies should transition from voluntary to mandatory to ensure industry-wide compliance			

Recycled product certification

Recycled product certification (RPC) offers verifiable data on a PwRC's quality, safety, performance and environmental performance. A PwRC awarded an RPC after stringent evaluations and quality control can be perceived more positively, potentially attaining higher market value, uptake and buyer's confidence. As shown in Figure 8, key stakeholders in the building and construction sector benefit from the application of RPC. Recycling companies in the construction materials supply chain can gain advantages by using RPC to showcase product features required by potential buyers[37]. For builders, RPC serves as an efficient information management method to streamline workload in tenders requiring PwRC. Utilising RPC will allow builders to manage any risk that may arise from the usage of PwRC. In this circumstance, clients and contractors will bear the risk equally. Such schemes also enable sustainable procurement policies in private and public sectors domestically and develop the overseas market for states that recognise certain certificates. For clients, it offers an option for those who are willing to work towards sustainable development[38]. For suppliers and clients, RPC schemes will serve as a marketing tool to demonstrate the sustainability of their products and projects, respectively.

It is highlighted that classification of PwRC and aggregates into easily comprehensible categories, together with correct certification, facilitates future client purchases[39], as they will be able to acquire a product suited to its intended use (e.g., structural concrete may use a recycled aggregate of class A, whereas recycled aggregate of class D may be used in road construction for subgrade). PwRC currently enter the market in two forms: non-certified and certified. Most recycling plants produce non-certified PwRC. However, in recent years certification has become essential as consumers increasingly demand PwRC with specified and assured quality. It is important to understand that product standards and eco-labels are distinct. Eco-labels are supposed to tell consumers about the environmental impact of their purchases. Most eco-labels do not give consumers real information about the product, but rather they suggest that it is among the top 10-20% of its product category from an environmental standpoint[37].

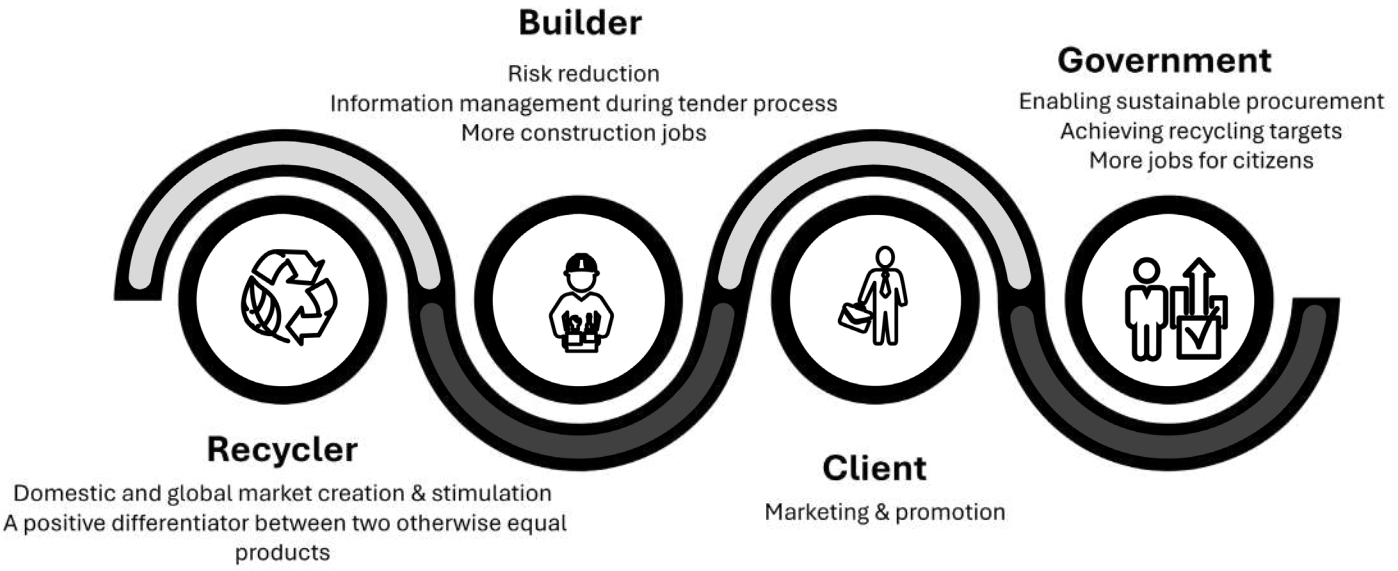

Figure 8. The advantages of RPC for recycled products supply chain participants

Source: Authors

[37] Shooshtarian S and T. Maqsood 2021) 'How does product certification help construction and demolition waste resource recovery? ', The Fifth Estate

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Main barriers to the application of product certification

Despite the long history of product certifications[37], their full application in the building and construction sector is rather recent. Few studies detail the challenges associated with their practical use. The existing literature suggests that the implementation of PRC for is hindered by several challenges. Figure 9 shows that these challenges include high costs, currently unjustified expenses, reliance on self-certification, misalignment between RPC and sustainability rating systems, and the presence of unreliable certifiers.

of the material and may negate any cost savings from reusing it. Self-certification is commonly used to establish PwRC quality, with recyclers and PwRC suppliers often performing it themselves. While more cost-effective, this approach lacks the assurance that end-users can safely rely on when procuring PwRC.

Main enablers of application of product certification

Six categories of RPC enablers are identified following a comprehensive literature review. These enablers are illustrated in Figure 10. Effective quality

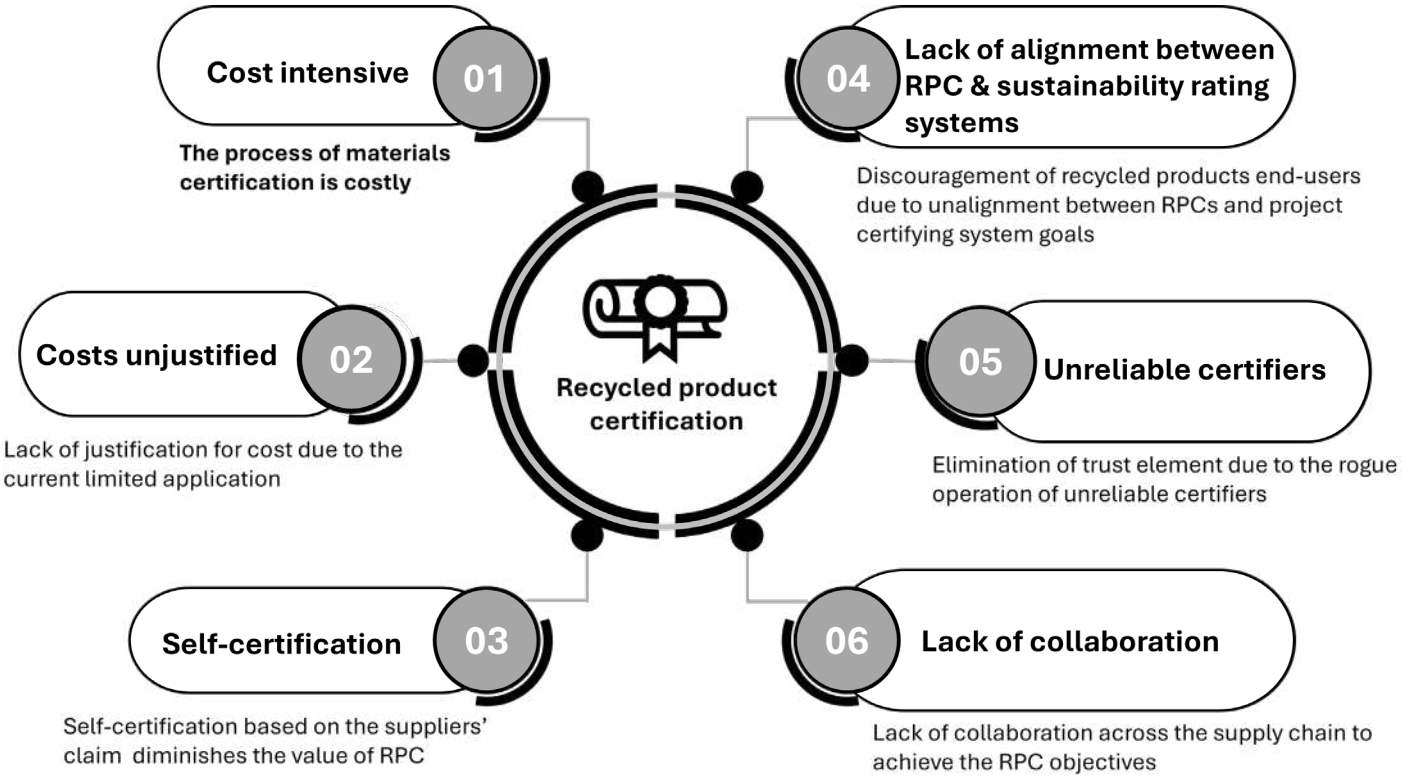

Figure 9. Main barriers to the application of product certification for PwRC
Source: Authors

A report by Equilibrium (2019)[40] indicated that in Australia, testing of PwRC for quality, performance and safety is inadequate, resulting in these products lacking independent validation. Further, the scarce opportunities to use these products are inadequately advertised, making it hard for stakeholders to justify the expense of certifying such products. Ghaffar (2019)[41] indicated that mandatory RPC expenses in the EU add to the price

monitoring and certification of PwRC by suppliers are required to instil and maintain stakeholder trust in these products. However, this must be accompanied by more vigorous government action in the form of legislation and standardisation[38]. The government has a part to play in changing the general public's perceptions towards PwRC via promotional activities through the media. Ongoing training offered by the government could contribute to shifting the attitudes of industry stakeholders[42].

[40] Equilibrium (2019) Review of standards and specifications for recycled content products, The Australian Department of Agriculture, Water and Environment Melbourne, Australia, 20.

[41] Ghaffar, S. (2019) How we can recycle more buildings, The Conversation. Accessed via https://bit.ly/4hA0oBa

[42] Bao, Z. and Lu, W. (2020) Developing efficient circularity for construction and demolition waste management in fast emerging economies: Lessons learned from Shenzhen, China, Science of The Total Environment, 724, 138264.

Furthermore, contractual obligation or other client requirement to use certified PwRC is another enabler for the implementation of RPC[37]. Currently, in the EU, it is illegal to use recycled content in construction materials that are not certified[40], which has resulted in more frequent uptake of these programs in construction projects across the European territory. According to a report by WSP Environmental and TRL Ltd (2005)[37], the benefits of mandatory RPC include the elimination of poor actors, improved stakeholder perception of data reliability, reduced opportunities for manipulation and enhanced credibility, all of which strengthen the value of RPC.

The fifth category of enablers refers to the availability of qualified material engineers at reasonable prices. According to anecdotal evidence, these professionals are scarce and expensive to employ. By educating more individuals to become trained materials inspectors, not only will jobs be created, but audit costs will also be reduced. The final category addresses the simplicity of certification methods for PwRC. The waste recovery industry's interest in RPC will be piqued by certification processes that are simple yet effective and require a reasonable amount of administrative work[37].

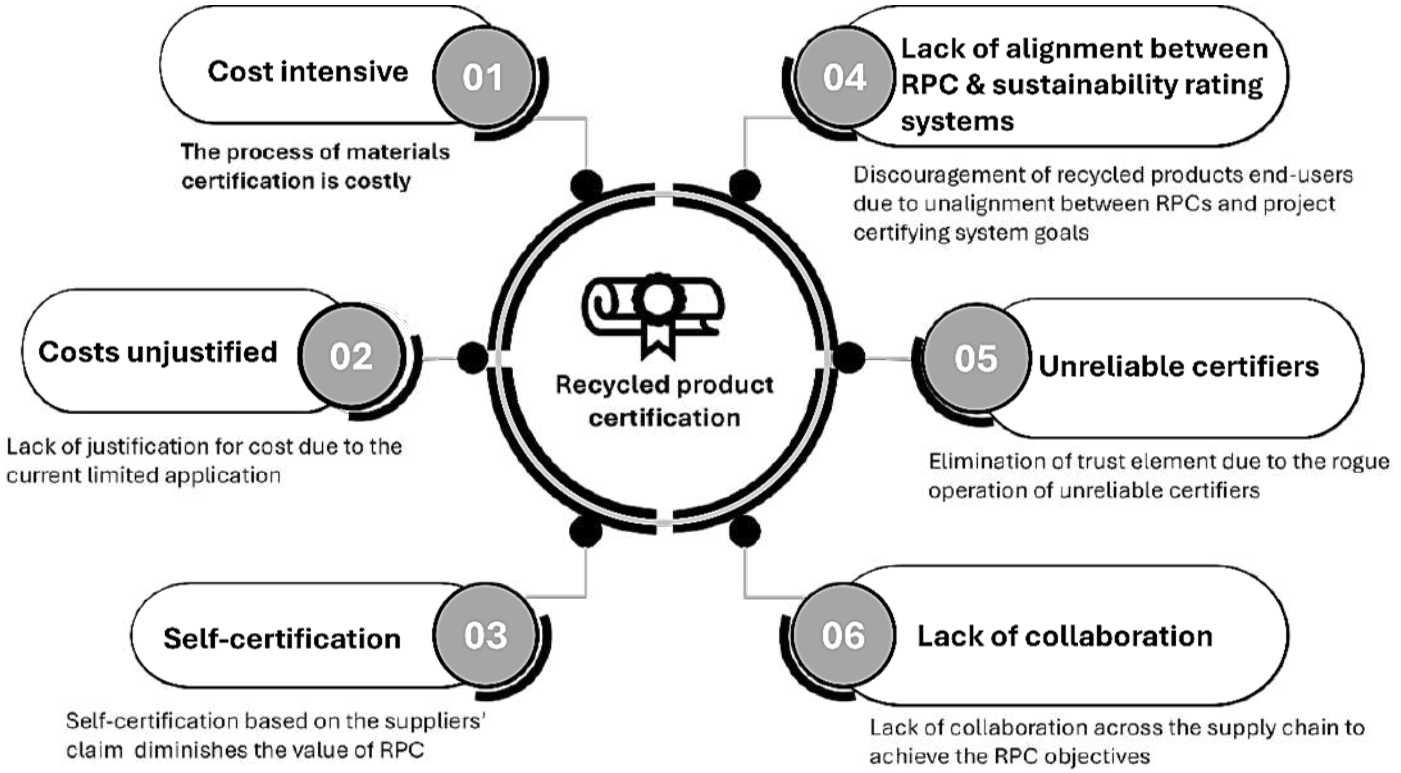

Figure 10. Main enablers of the application of product certification for PwRC
Source: Authors

Overview of Key Findings

- Approximately **52%** of participants reported being very to moderately **familiar** with this policy **(Figure 11a)**
- **51%** participants indicated that '**Recycled Product Certification**' can be very to moderately effective in optimal use of PwRC in construction **(Figure 11b)**
- Only **52%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 11c)**
- Only **16%** of participants indicated that the policy's application has some **negative consequences (Figure 11d)**
- Participants identified **six** potential negative impacts of this policy **(Table 7)**
- The three primary ways this policy can boost PwRC use include '**building confidence among end-users', 'improving the environmental sustainability of construction industry'** and **'improve the social image of end-user organisations' (Figure 11e)**
- They proposed **44 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 8)**
- **~71%** participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **~82%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Recycled Product Certification'

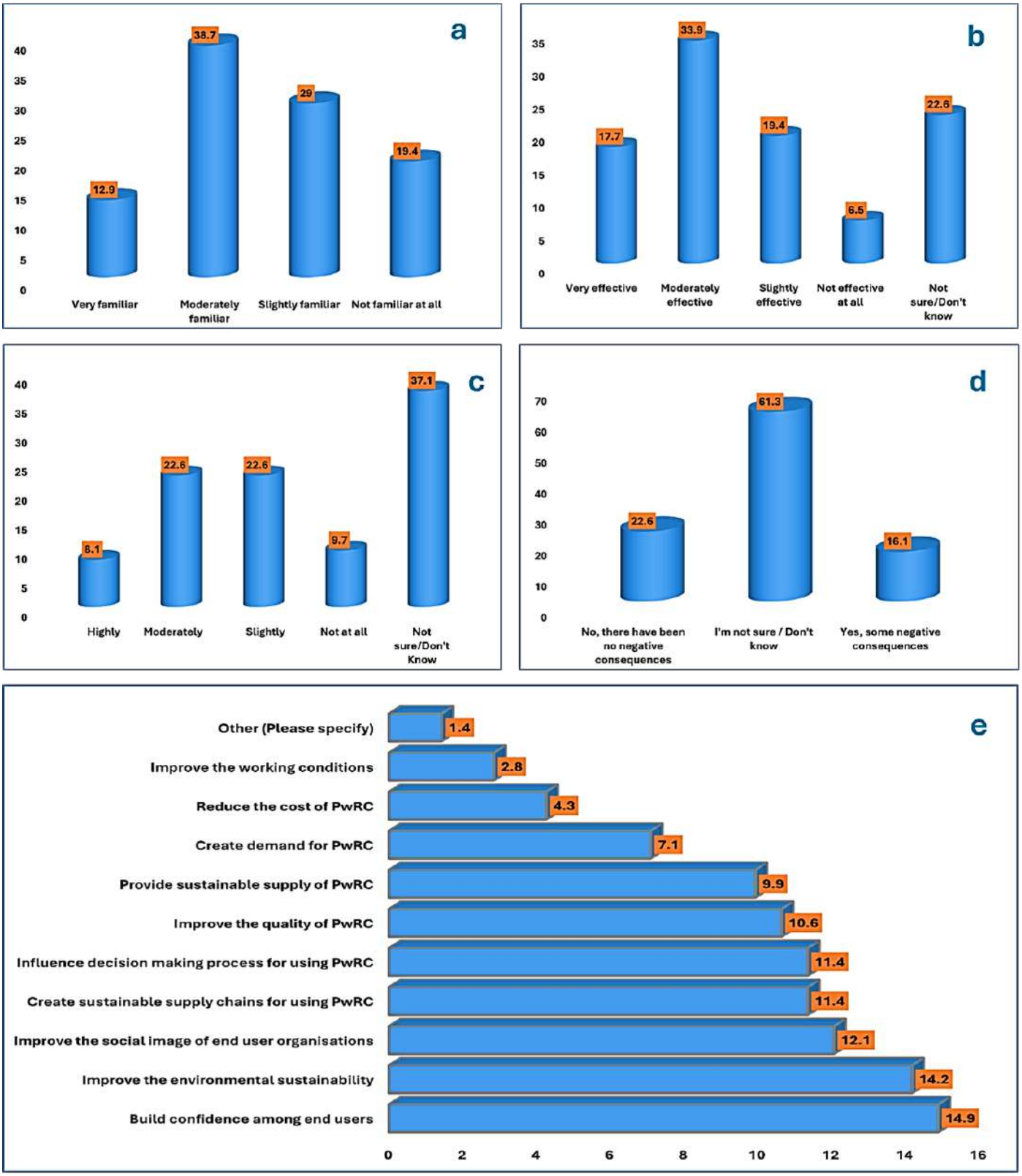

Figure 11. Participants' responses (frequency distribution %), recycled product certification. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 7. Key issues and impacts of implementing recycled product certification policy

No	Issue	Description
1	**Increased costs**	Additional expenses on builders already facing financial pressure
2	**Increased bureaucracy**	More administrative processes, potentially slowing down project timelines
3	**Certification body effectiveness**	Mixed opinions on the reliability of certifying bodies, potentially diminishing credibility (e.g., Green Tag)
4	**Supplier deterrence**	Certification requirements may discourage suppliers due to time and cost burdens
5	**Economic policy limitations**	Hinders the development of more economically supportive policies
6	**Inconsistent outcomes**	Creates a new hurdle for new entrants in the sustainable materials market
Positive impact		
Traceability of materials		Ensures traceability of materials within the supply chain
Enhanced transparency		Potential to improve transparency and standards for PwRC

Table 8. Key measures to enhance recycled product certification effectiveness

No	Measures	Description	No	Measures	Description
1	**Policy implementation**	Policies should enhance transparency and establish standards for PwRC	15	**Research and innovation support**	Support R&D to improve PwRC quality and environmental performance
2	**Market confidence**	Efforts should boost market confidence in PwRC, ensuring better access and acceptance	16	**Stakeholder collaboration**	Strengthen partnerships between government, industry and certification bodies
3	**Certification in WA**	Increase availability of certified products in Western Australia	17	**Australian testing standards**	Develop Australian testing standards for PwRC similar to conventional materials
4	**Awareness of the benefits of RPC schemes**	•Industry awareness campaigns should highlight the benefits of certification programs •Focus education on increasing the industry's understanding of PwRC certifications •Conduct campaigns to educate end-users about the benefits of certified PwRC	18	**Imported PwRC concern**	•Prevent reliance on cheaper imported PwRC over local PwRC •Ensure certifications don't incentivise cheaper imports over local recycled products
5	**Case studies on PwRC**	Develop case studies to showcase certified PwRC success in projects	19	**Testing requirements**	Align testing requirements for PwRC with Australian standards
6	**Compliance requirements**	Set thresholds for the use of certified PwRC, e.g., 25% GreenTag products in projects	20	**Alignment with existing standards**	Certification programmes should align with existing regulatory and green building standards
7	**Certification confidence**	Certifications should provide consumer confidence and competitive differentiation	21	**Avoiding negative impacts**	Ensure PwRC certifications account for potential environmental risks
8	**Global certification expansion**	Expand programmes like GGT globally for better access to certified PwRC	22	**Digital passports and traceability**	Implement digital passports to enhance traceability of recycled content
9	**Legitimacy of PwRC**	Establish RPC as a credible and recognised standard	23	**Broader certification criteria**	Expand certification to include more building materials and establish clear performance standards
10	**Certification incentives**	•Provide financial incentives to encourage certification adoption •Introduce financial incentives like tax reductions to promote certified PwRC adoption •Provide government funding or low-interest loans to help businesses obtain certifications •Provide subsidies to help SMEs achieve certifications	24	**Standardised certification**	•Certification criteria should be standardised across suppliers and policymaking entities •Certification criteria should be harmonised across regions for ease of adoption •Align different certification schemes (e.g., GGT, GECA and C2C) for easier market adoption
11	**Integration with green standards**	Integrate RPC into existing green standards like LEED	25	**Policy requirement for certification**	• Policies should mandate certification and traceability for PwRC to improve reliability • Mandate certifications to ensure PwRC market adoption
12	**Procurement specifications**	•Public/private procurement policies should mandate certified PwRC •Mandate certification for public projects to ensure quality and sustainability	26	**Government/scientific endorsement**	Certifications should be backed by government or scientific bodies for ensuring credibility of PwRC
13	**Capacity building**	Train manufacturers on certification processes	27	**RPC scheme coverage issues**	Address inconsistencies in RPC schemes implementation across Australia
14	**Transparency and traceability**	•Develop mechanisms to ensure certified PwRC legitimacy in the supply chain •Enforce chain-of-custody to verify recycled content claims	28	**Mitigating greenwashing**	• Use certifications to reduce greenwashing risks and increase product transparency • Use third-party certifications to enhance product credibility and reduce greenwashing

Tax on using virgin materials

Although most construction materials are technically recyclable, the intention to recycle them and the extent to which recycling occurs often depend on their value. In most circumstances, this is compared to the price of a material when newly extracted or imported. To shift perceptions towards sustainably procuring PwRC, certain pricing mechanisms can be implemented to discourage buyers from selecting virgin materials for construction projects[43]. This enticement takes two forms— 'removing subsidies for virgin materials' and 'taxing on the use of virgin materials'. The application of such mechanisms in several countries has demonstrated improved competitiveness of PwRC in the construction materials market. For example, since 2002, the UK has implemented a regulation to strengthen the position of PwRC relative to new materials. This regulation takes the form of a levy (£2 per tonne) applied to the use of gravel, sand and rock for commercial purposes. The purpose is to adjust the cost of new materials to reflect their underlying environmental impact. Sweden, Denmark and France, among other EU countries, have applied a similar tax[15].

In the Australian context, waste definitions that exclude clean fill have been adopted by a few states. Coupled with reduced costs, this approach is anticipated to encourage the building and construction sector to adopt PwRC rather than raw materials. Survey findings in Australia[44] , suggest that key stakeholders perceive cheaper virgin materials as one of the five top barriers towards effective C&D waste management. Recently in the European Union, a tax on using virgin plastic in packaging is in the process of being implemented to "reduce packaging waste and stimulate Europe's transition towards a circular economy"[45] . It is estimated that upon implementation, this initiative will generate €7 billion annually in revenue. A recent study by the Institute of Australia[46], suggests that adopting a similar approach in Australia could yield $1.5 billion in revenue.

[43] Bruvoll A (1998). Taxing virgin materials: an approach to waste problems. Recourses, Conservation and Recycling. 22(1998): 15-29.

[44] Shooshtarian, S., Caldera, S., Maqsood, T., Ryley, T. and Khalfan, M. (2021) An investigation into challenges and opportunities in the Australian construction and demolition waste management system, Engineering, Construction and Architectural Management. 29(10):4313-4330.

[45] European Commission (2018) Proposal for a Council decision on the system of own resources of the European. European Union. Available from https://shorturl.at/xDQ28

[46] Anderson L and N Gbor (2024) Plastic waste in Australia and the recycling greenwash. The Institute of Australia. Available from https://shorturl.at/chFO9

Overview of Key Findings

- Approximately **29%** of participants reported being very to moderately familiar with this policy **(Figure 12a)**
- **63%** participants indicated that ***'Tax on Using Virgin Materials'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 12b)**
- Only **27.4%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 12c)**
- About **26%** of participants indicated that the policy's application might have some negative consequences **(Figure 12d)**
- Participants identified **nine** potential negative impacts of this policy (Table 9)
- The three primary ways this policy can boost PwRC use include **'creation of demand for PwRC', 'creation of sustainable supply chains for using PwRC'** and **'reduction of PwRC cost' (Figure 12e)**
- They proposed **26 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 10)**
- **~43%** participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **47%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Tax on Using Virgin Materials'

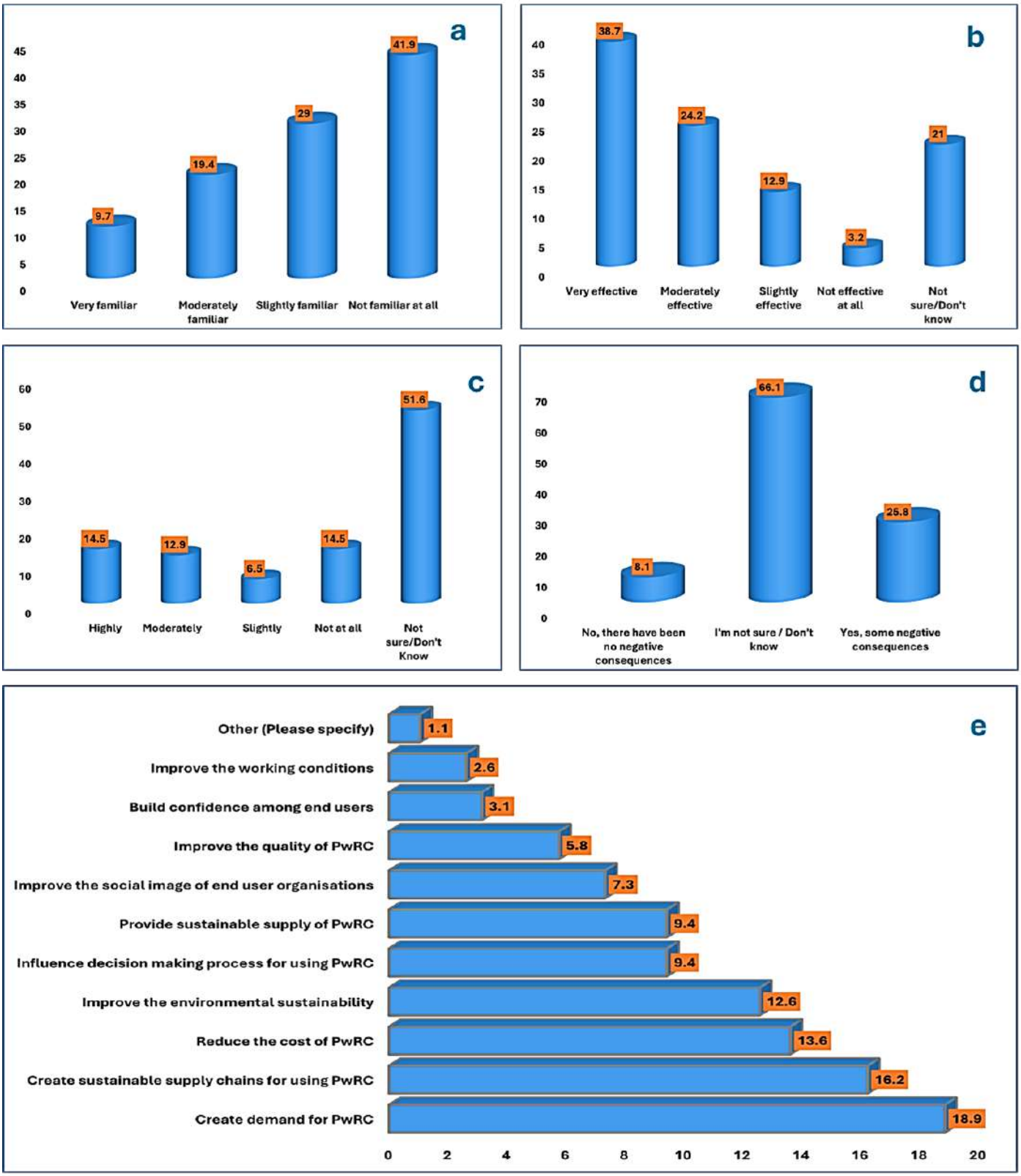

Figure 12. Participants' responses (frequency distribution %), tax on using virgin materials. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 9. Key issues of implementing tax on using virgin materials policy

No	Issue	Description
1	**Limited replacement potential**	Not all PwRC are suitable replacements for virgin materials in certain applications
2	**High construction cost**	Rising costs in construction can strain budgets and make recycled options less attractive
3	**Supply of PwRC**	Effective implementation of the policy requires an adequate PwRC supply; otherwise, a tax could be unfair
4	**Financial burden on citizens**	Policies may indirectly place additional financial pressures on citizens
5	**Inappropriate material use**	Incentivising PwRC could lead some builders to misuse them in critical areas, risking structural integrity
6	**Supplier incentive imbalance**	Incentivising PwRC suppliers may drive others to exploit loopholes to continue supplying non- PwRC
7	**Penalisation of suppliers**	Penalising suppliers without a constructive approach may not effectively support the policy's goals
8	**Cost of inaction vs. Action**	In the UK, businesses often find paying a tax more affordable than adapting to PwRC use, reducing policy impact
9	**Insufficient tax impact**	Businesses tend to absorb or pass on tax costs if the tax rate isn't substantial enough to incentivise sustainable practices

Table 10. Key measures to enhance tax on virgin materials effectiveness

No	Measures	Description	No	Measures	Description
1	**Managing cost implication**	•Implementation should avoid adding excessive costs to the economy •Balance the cost between PwRC and non-PwRC supply chains to encourage adoption •Adjust tax rates to create financial incentives for PwRC over virgin materials •Apply Virgin Tax to reduce reliance on virgin plastic and boost PwRC demand	14	**Increase Australian product use**	•Use Virgin Tax to favour Australian PwRC over cheaper imports •Avoid making Australian virgin materials more expensive, which could encourage imports with higher carbon footprints
2	**Price signal for RCA**	Establish price signals favouring Recycled Concrete Aggregate (RCA) over quarried aggregates	15	**Market-based instruments**	Use tools like tradable permits or carbon pricing to internalise the environmental costs of virgin materials
3	**Awareness of reporting requirements**	Increase awareness of reporting, weight calculation and claiming reliefs	16	**Education and awareness**	Launch campaigns to educate industry on PwRC benefits and Virgin Tax implications
4	**Virgin materials tax application**	•Impose heavy taxes on natural materials to reduce PwRC costs and counter perceptions of high PwRC prices •Apply Virgin Tax to specific materials to drive PwRC supply chains	17	**Industry collaboration**	Collaborate with industry to set standards and best practices for PwRC use
5	**Tax definition clarity**	Use “raw virgin materials tax” to distinguish from excavated materials, encouraging virgin excavated natural material (VENM) reuse	18	**Certification and verification**	Implement certification to ensure PwRC quality and build market trust
6	**Environmental protection**	•Use taxation to prevent environmental destruction •Ensure taxes consider environmental footprints, regulatory environments and transport impacts	19	**Research and development**	Fund R&D for recycling innovations, improving PwRC performance and cost-effectiveness
7	**International agreements**	Verify international material supply chains for consistency and accountability	20	**Standards for PwRC**	Develop standards to define PwRC applications in construction
8	**Graduated tax rates**	Set graduated tax rates based on recycled content; taxing virgin materials higher	21	**Public procurement policies**	Require public projects to prioritise PwRC and demonstrate compliance
9	**Tax revenue allocation**	•Allocate Virgin Tax revenue to support the recycling industry and PwRC development •Allocate tax revenue to promote PwRC development and market visibility •Use Virgin Tax revenue to fund R&D for new technologies and applications •Ensure Virgin Tax revenue supports CE processes and nature-based solutions •Use tax revenue to cover transport costs and support waste processors	22	**Tax incentives for PwRC use**	•Provide tax incentives or exemptions for projects using PwRC •Offset costs to incentivise PwRC adoption and support businesses investing in sustainable materials •Offer tax credits or rebates to incentivise PwRC investment
10	**Shift from virgin sources**	Shift reliance from virgin materials to PwRC as the default option	23	**Budget constraints and greenwashing**	Address low-budget project challenges and minimise risks of greenwashing with minimal recycled content
11	**Controlled quality supply**	Maintain quality control to ensure PwRC can effectively replace virgin materials	24	**Performance and longevity**	Consider cases where virgin materials offer better durability and sustainability before taxing
12	**Regulation and black-market risks**	Address potential black-market risks and regulatory feasibility	25	**Recycled asphalt and cementitious materials**	Encourage recycled asphalt and cementitious materials through Virgin Tax
13	**Underpriced virgin materials**	Highlight how under-pricing virgin materials distorts market comparisons, making PwRC seem expensive	26	**Tax rate sufficiency**	Ensure Virgin Tax rates are high enough to incentivise PwRC use over virgin materials

Financial incentives for procurement of PwRC

This policy refers to a monetary or economic benefit provided to individuals, businesses or organisations to encourage the use of PwRC. One of the major sources for financial incentives can be the hypothecated revenue that emerges from imposing tax on waste disposal activities[47]. In research conducted in Australia[48], the results of a survey responded to by key stakeholders in the building and construction sector revealed that financial incentives are among top ten factors that enables CE in that sector. Recently, in Western Australia (WA), the government issued a policy[49] that supports the local governments to source PwRC from accredited suppliers and use them in construction projects through providing a payment of $5 per tonne of PwRC. The previous research indicates that financial incentives are particularly effective in developing markets for PwRC[50,51] .

However, there is evidence from previous research that argues that financial incentives are not a necessarily a major factor in encouraging key stakeholders to use more PwRC in construction projects. For instance, the findings from a recent research study[52] showed that this policy is barely a motive for using PwRC in construction projects. Instead, the participants in this research indicated that the environmental benefits, ensuring a competitive advantage and future proofing resulting from PwRC application play a more important role. Similarly, Calvo et al. (2014)[53] indicated that Spain's C&D waste recovery targets could be achieved in ten years using landfill levies, which was estimated to be faster compared to 12 years using financial incentives. In research conducted in 2020[43], participants were asked to identify the key initiatives they believed the Australian federal government should prioritise to establish effective C&D waste management; the findings revealed that the GST subsidy for PwRC was perceived as the least important factor, with over 43% of participants expressing some level of disagreement with the idea of the government pursuing this strategy. This perception could be linked to the perceived risks associated with the application of these resources in construction projects.

[47] Shooshtarian S, Maqsood T, Khalfan M, Yang R.J and Wong P (2020) 'Landfill levy imposition on construction and demolition waste: Australian stakeholders' perceptions'. Sustainability. 2020, 12, 4496. https://doi.org/10.3390/su12114496

[48] Shooshtarian S, Hosseini MR, Kocaturk T, Arnel T and Nicole T. Garofano (2023) Circular economy in the Australian AEC industry: investigation of barriers and enablers, Building Research & Information, 51:1, 56-68.

[49] WA Department of Local Government, Sport and Cultural Industries. 2022. Local governments rewarded for using recycled construction and demolition waste. Available from https://shorturl.at/anrIJ

50 Hu, Q.; Peng, Y.; Guo, C.; Cai, D.; Su, P. (2019) Dynamic incentive mechanism design for recycling construction and Demolition waste under dual information asymmetry. Sustainability 2019, 11, 2943

[51] Shooshtarian S, Caldera S, Maqsood T, Ryley T, Wong PSP and Zaman A (2022) 'Analysis of factors influencing the creation and stimulation of the Australian market for recycled construction and demolition waste products'. Sustainable Production and Consumption. 34(2022): 163-176.

[52] Shooshtarian S, Maqsood T, Wong PSP, Caldera S, Ryley T, Zaman A and Caceres Ruiz AAM (2024) 'Circular economy in action: The application of products with recycled content in construction projects: A case study approach'. Smart and Sustainable Built Environment. 13(2): 370-394.

[53] Calvo, N.; Varela-Candamio, L.; 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 2014, 6, 416–435.

Overview of Key Findings

- Approximately **43%** of participants reported being very to moderately familiar with this policy **(Figure 13a)**
- **64%** participants indicated that ***'Financial Incentive for Procurement of PwRC'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 13b)**
- Only **~35%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 13c)**
- About **20%** of participants indicated that the policy's application might have some negative consequences **(Figure 13d)**
- Participants identified **eight** potential **negative impacts** of this policy **(Table 11)**
- The three primary ways this policy can boost PwRC use include **'creation of demand for PwRC', 'creation of sustainable supply chains for using PwRC'** and **'reduction of the PwRC cost' (Figure 13e)**
- They proposed **35 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 12)**
- **~66%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **~82%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Financial Incentive for Procurement of PwRC'

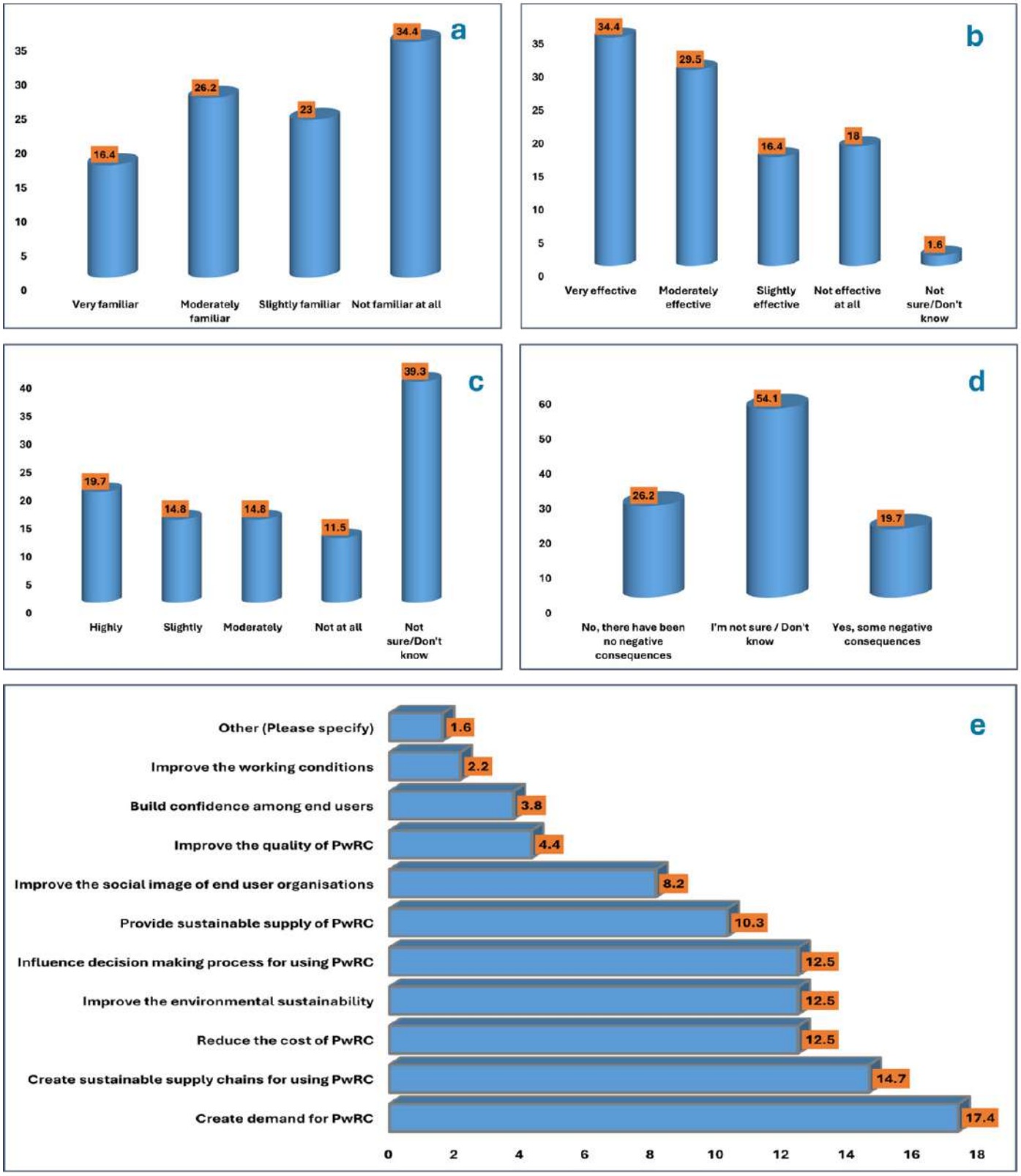

Figure 13. Participants' responses (frequency distribution %), financial incentive. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 11. Key issues and impacts of implementing financial incentive for PwRC procurement

No	Issue	Description
1	**Assurance of authentic recycled material**	Ensuring that genuine PwRC are used, preventing the misuse of “fake” PwRC
2	**Lack of quality**	Concerns over the quality and durability of some PwRC compared to virgin materials
3	**Policy exploitation**	Risk of improper policy application by stakeholders aiming for financial gains without achieving true sustainability
4	**Inappropriate use by builders**	Builders may misuse PwRC in unsuitable applications, potentially compromising safety
5	**Cost balance between material types**	Need to maintain a balance between the costs of virgin, PwRC and associated taxes
6	**Lack of long-term studies**	Absence of research confirming that PwRC use does not result in chemical leaching or creation of harmful by-products over time
7	**Subsidy allocation issues**	Subsidies provided to producers may not incentivise actual material use unless extended to builders or developers with compliance checks
8	**Favouritism towards heavy materials**	Current policies may inadvertently favour heavier materials, potentially unbalancing sustainable material choices
Positive impact		
Investment in innovation		Increased investment in innovation to support PwRC development

Table 12. Key measures to enhance financial incentive policy effectiveness

No	Measures	Description	No	Measures	Description
1	**Traceability system**	Implement a traceability system to ensure transparency and reliability in PwRC use	19	**Industry standards and collaboration**	Industry collaboration on PwRC standards ensures quality and consistency
2	**Price incentive clarification**	Clarify specific price incentive policies; ensure they address key sectors like road infrastructure	20	**Guidelines for PwRC use**	Develop construction guidelines for safe and effective PwRC applications
3	**Encouraging new users**	•Design policies to encourage first-time users to try PwRC •Provide funding for initial infrastructure costs related to PwRC adoption	21	**Crumb rubber in roads**	Support trials and adoption of higher crumb rubber content in road projects
4	**Targeted financial incentives**	Provide tailored financial incentives for sectors managing municipal, C&D and general waste	22	**Prioritisation for high-quality PwRC**	Ensure incentives are tied to high-quality PwRC to build confidence
5	**Market efficiency and new markets**	Improve market efficiency and foster new markets for PwRC through policy frameworks	23	**Life-cycle incentives**	Apply financial incentives throughout the project lifecycle to increase PwRC usage
6	**Central database**	Develop a centralised database for PwRC procurement to improve transparency and accessibility	24	**Awareness through value proposition**	Position PwRC as a cost-saving and socially beneficial value-add to drive adoption
7	**Client involvement in sustainability**	•Increase client involvement and leadership in promoting PwRC and sustainable construction •Project clients increasingly demand recycled content in materials	25	**Reduced processing costs**	•Lower processing and logistics costs to further encourage PwRC use •Provide monetary incentives to mitigate high processing costs and stimulate PwRC supply chains
8	**National adoption**	Extend PwRC policies and incentives nationwide to standardise impact	26	**Contamination control**	Verify contamination levels in PwRC to enhance confidence in incentivised materials
9	**Local content priority**	Prioritise locally produced recycled content to support local supply chains	27	**Long-term viability**	Ensure PwRC remains cost-effective in production for sustainable long-term adoption
10	**Incentives for green materials**	Expand financial incentives to include all green materials and methods	28	**Targeting underutilised materials**	Focus on underutilised materials to bolster supply chain sustainability
11	**Increased financial benefits**	•Develop incentive schemes that provide meaningful value to stakeholders •Boost subsidies, tax breaks and grants for PwRC projects	29	**Complement virgin tax**	• Pair financial incentives with virgin material bans for effective circularity • Combine incentives with a Virgin Tax to drive sector-wide change
12	**Mandatory recycled content**	Mandate minimum recycled content in construction materials to drive PwRC usage	30	**Risk of subsidy dependency**	Address risks of subsidy dependency and potential budget issues post-withdrawal
13	**Public awareness campaigns**	Launch campaigns to educate stakeholders about the benefits of PwRC	31	**Differentiated pricing approach**	Implement pricing mechanisms to prevent favouring heavy materials over lighter ones like insulation
14	**Alternative incentives**	Explore alternative incentives beyond monetary rewards to ensure long-term sustainability	32	**Encouraging private sector engagement**	Extend incentives to encourage private sector participation in PwRC adoption
15	**Streamlined certification**	Simplify PwRC certification to lower adoption barriers	33	**Budget constraints and greenwashing**	Manage low-budget project impacts and greenwashing risks by ensuring meaningful recycled content
16	**Supplier collaboration**	Collaborate with PwRC suppliers for a reliable and consistent supply chain	34	**Independent scientific studies**	Support peer-reviewed studies on PwRC to build public trust and legitimacy and avoid conflicts of interest
17	**R&D funding**	Investing in recycling innovation and new PwRC technologies broadens the range of materials available for construction	35	**Case studies and benchmarking**	Sharing case studies and promoting benchmarking of best practices can support PwRC uptake
18	**Government procurement policies**	Mandate PwRC prioritisation in government projects to increase demand			

Harmonised recycled product specifications

In Australia, the use of PwRC in infrastructure construction projects is subject to compliance with requirements stipulated in recycled product specifications. These specifications are sometimes individually developed and administrated in states and territories. A recycled product specification is a document that outlines specific material types, qualities and dimensions required for PwRC. For instance, in New South Wales (NSW), there are several specifications[54] available for utilising particular PwRC in the construction of infrastructure and products. Figure 14 shows the public agencies involved in developing PwRC specifications[55] across eight states and territories in Australia.

Figure 14. Public agencies that are responsible for developing PwRC specifications
Source: Authors

The fact that these documents are not primarily nationally developed or imposed is considered to be a major hurdle for those organisations that operate interstate where required. This approach can add complexity and cost to the operation and

[54] IPWEA (2010). Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage 2010. Institute of the Public Works Engineering Australia (NSW)

[55] Equilibrium (2019) Appendix. Available from https://shorturl.at/AOYZ8

manufacturing of PwRC and limit the markets for these products as they need to be prepared according to various state-based specifications. In the presence of various recycled product specifications, following different testing criteria is necessary, which is both complex and costly. In research published in 2022[44], it was argued that the state-developed regulations in Australia are not consistent for PwRC, and perhaps the first step towards improvements is to harmonise the specifications documents. Any inconsistencies in these documents can significantly impact national efforts towards developing a market for PwRC in a negative way (p. 4326).

Hence, having harmony in these specifications can improve the PwRC application usability and competitiveness in the Australian market. Such harmonised recycled product specifications policies should allow a wide range of PwRC applications in civil works and infrastructure projects. In a report published by Equilibrium in 2019[40], the Australian industry's reaction to the potential development and implementation of new standards and specifications was extremely positive. Furthermore, national specifications were viewed as highly desirable outcomes, signalling a strong endorsement from the industry. However, due to the number and diversity of organisations involved in the process, it is not a straightforward task. The federal government has a leadership role in coordinating efforts to make sure consistent criteria for PwRC are applied across Australia.

Overview of Key Findings

- Approximately **41%** of participants reported being very to moderately familiar with this policy **(Figure 15a)**
- **~62%** participants indicated that ***'Harmonised Recycled Product Specifications'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 15b)**
- Only **41%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 15c)**
- About **13%** of participants indicated that the policy's application might have some negative consequences **(Figure 15d)**
- Participants identified **four** potential negative impacts of this policy **(Table 13)**
- The three primary ways this policy can boost PwRC use include **'building confidence among end-users', 'improving the environmental sustainability'** and **'improving the quality of PwRC' (Figure 15e)**
- They proposed **29 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 14)**
- **~40%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **60%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Harmonised Recycled Product Specifications'

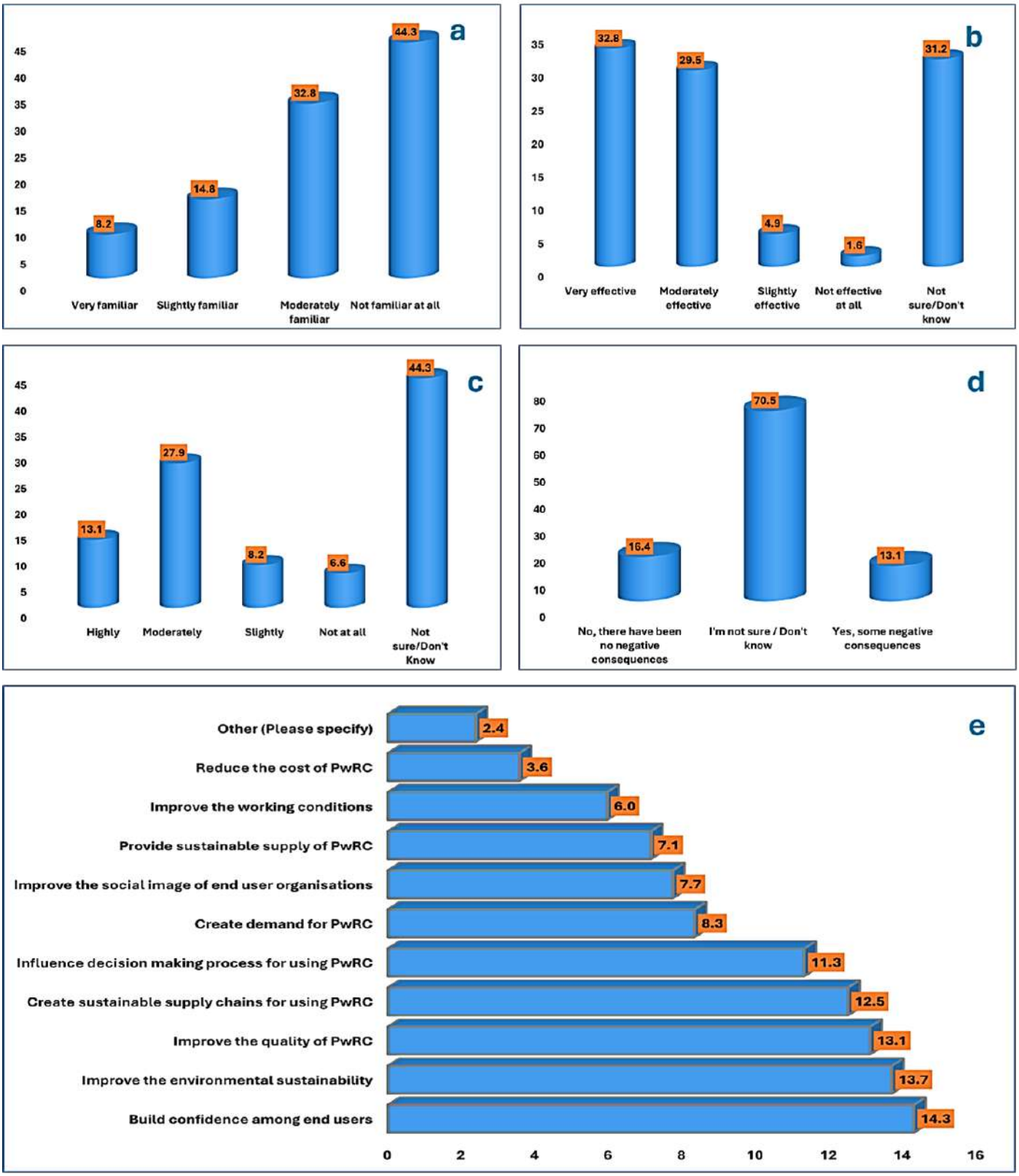

Figure 15. Participants' responses (frequency distribution %), harmonised PwRC specifications. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 13. Key issues and impacts of implementing harmonised PwRC specifications

No	Issue	Description
1	**Limitations on innovative use**	Policies may inadvertently limit creative applications of PwRC, restricting innovation
2	**Varied legislative frameworks**	Different states have unique legislative approaches and perceptions, complicating unified policy implementation
3	**Entry barriers for new players**	High standards and regulations may deter new entrants from participating, limiting diversity in the market
4	**Long-term impact of red tape**	Excessive bureaucracy and regulatory requirements could stifle innovation over time
Positive impact		
Uncertainty in engineering confidence		Provides greater confidence within the engineering and process engineering professions

Table 14. Key measures to enhance the effectiveness of harmonised PwRC specifications

No	Measures	Description	No	Measures	Description
1	**Cross-jurisdictional use**	Policy relevance increases when PwRC can be used across multiple jurisdictions	16	**Communication with stakeholders**	Standards must be clearly communicated to ensure stakeholder understanding and compliance
2	**Performance-based standards**	Performance-based standards should allow flexibility in PwRC use while meeting functional requirements	17	**Support for suppliers**	Provide funding support for suppliers and manufacturers to overcome adoption barriers
3	**User confidence through awareness**	Raising awareness of standards boosts user confidence in PwRC	18	**Avoiding lowest standard default**	Avoid standardisation defaults that reduce existing PwRC use
4	**Circular economy integration**	Embed CE principles to encourage design for disassembly, reuse and recyclability	19	**R&D investment**	Fund R&D to improve the quality, performance and cost-effectiveness of PwRC
5	**Minimum standards**	Set minimum standards for PwRC to improve industry quality outcomes	20	**Capacity building and training**	Provide training for construction professionals on PwRC use and compliance
6	**Life cycle assessment**	Integrate LCA to ensure PwRC provides environmental benefits	21	**Harmonised legislation**	Harmonise waste legislation and introduce smart waste models
7	**Showcasing for adoption**	Early adoption can showcase policy success and encourage broader adoption across Australia	22	**Monitoring and evaluation**	Establish monitoring and evaluation to refine PwRC specifications
8	**Standardisation and certification**	•Standardise testing and certification to build confidence among construction professionals •Promote certification and benchmarking to ensure PwRC quality and compliance	23	**Expansion to other materials**	•Harmonised specifications should cover a broad range of materials without stifling innovation •Develop specifications for a wider range of construction materials that can use PwRC, e.g., concrete, steel, glass
9	**PwRC performance standards**	Demonstrate that PwRC performance matches or exceeds non-PwRC materials through demonstration projects	24	**Focus on ease of business**	Consistent standards simplify business and facilitate PwRC adoption
10	**Market development**	Stimulate PwRC market through procurement policies, incentives and awareness campaigns	25	**Focus on ease of business**	Consistent specifications should simplify business and facilitate PwRC adoption
11	**Government leadership and action**	•Early government adoption can lead to broader industry uptake of PwRC •WA's Roads to Reuse shows the benefits of high-quality, contamination-free PwRC	26	**National consistent information-sharing**	National standards and consistent information-sharing are essential for effective implementation
12	**PwRC standards development**	Developing standards that reduce risks and encourage end-users to apply PwRC	27	**Legislative approval for mixed content**	Legislate for mixed recycled materials in traditional materials to boost adoption
13	**Encouraging innovation**	Specifications should foster innovation and material development	28	**Alignment with existing standards**	Align policies with current certification and manufacturing standards
14	**Cross-jurisdictional cooperation**	Industry collaboration is needed to harmonise specifications across states	29	**Supply chain consistency**	Ensure strong and consistent supply chains to support PwRC adoption across regions
15	**Expert confidence**	Specifications should increase confidence among engineering professionals, encouraging PwRC adoption			

Environmental sustainability rating

This policy is based on a systematic framework to assess, measure and rate the environmental sustainability of buildings, products, services and organisations in the building and construction sector. In Australia there are a number of organisations that provide such ratings for construction projects. The most important national rating schemes include Green Star provided by Green Building Council of Australia (GBCA) and NABERS by NSW Government for building projects, IS rating[56] by Infrastructure Sustainability Council (ISC) for infrastructure projects and EnviroDevelopment[57] by the Urban Development Institute of Australia for development projects.

Table 15. Some sustainability rating schemes from around the world

Name	Organisation	Description
BREEAM	UK Building Research Establishment	BREEAM assesses the environmental performance of buildings. It encourages the use of PwRC and awards credits for their incorporation
CASBEE (Comprehensive Assessment System for Built Environment Efficiency)	Japan Sustainable Building Consortium	CASBEE evaluates and rates the environmental performance of buildings and promotes the use of PwRC
DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen)	German Sustainable Building Council	It offers a certification system for sustainable buildings. It includes criteria for the use of PwRC
Estidama	UAE Department of Urban Planning and Municipalities	Estidama promotes sustainable development through its Pearl Rating System. It encourages the use of PwRC and considers them in its assessment criteria
FSC	Forest Stewardship Council	Offers three labels including FSC Recycled that indicates that a produce is made from 100% recycled material
Green Star	Australia GBCA	It includes credits for the use of PwRC in construction
Green Building Index (GBI)	Malaysian Institute of Architects (PAM) and the Association of Consulting Engineers Malaysia (ACEM)	GBI encourages the use of PwRC as part of its assessment criteria
IS (Infrastructure Sustainability)	Australia Infrastructure Sustainability Council	It evaluates the sustainability performance of infrastructure projects and considers factors such as resource efficiency, environmental impact and innovation, including the use of recycled materials
LEED	US Green Building Council (USGBC)	It provides a framework for green building design, construction, operation and maintenance. It awards points for the use of PwRC in construction
Living Building Challenge®	International Living Future Institute	Petal Certification System it awards the use of PwRC in building projects
UDIA	Urban Development Institute of Australia	It advocates for sustainable development practices, which may include the use of PwRC in urban development projects

Source: Authors

[56] ISC (2022). IS Rating Scheme. Available from https://shorturl.at/hwBLR

[57] UDIA (2023). EnviroDevelopment: Developments for environmentally conscious home buyers. Available from https://udiavic.com.au/envirodevelopment/

Furthermore, there are several international rating schemes that are also used in Australia. These include Living Building Challenge® by International Living Future Institute[58], BREEM by Building Research Establishment (UK) and LEED by US Green Building Council. Table 15 summarises some global sustainability rating schemes in the building and construction sector.

These rating schemes are based on credit systems that technically promote the efficient use of construction materials. For instance, under Green Star scheme, construction projects can obtain credit points for waste-related practices, which include: the use of PwRC, waste storage that promotes reusing and recycling of C&D waste from the project.

Previous research called for a reasonable set-up for specifying, testing and auditing the use of PwRC in construction projects through these rating schemes in Australia[59]. Australian governments have a key role in the wide adoption of this policy within the building and construction sector through enforcement or encouragement. For instance, from May 2024, achieving an energy efficiency rating of 7 has become mandatory for new housing in Australia[60], as stipulated in National Construction Code (NCC) volume two[61]. In 2023, Sustainability Victoria, launched a program called 7 Star Homes to build capacity within the residential building market in preparedness for an increase to this new minimum energy efficiency standards[62]. This program offers a range of capability building opportunities such as rebates, as-built verification assessment, training in design and implementing effective marketing strategies.

[58] International Living Future Institute (2024) Living Building Challenge. Available from https://living-future.org/lbc/

[59] Shooshtarian S, Maqsood T, Wong PSP and Bettini L (2022) 'Application of sustainable procurement policy to improve the circularity of construction and demolition waste resources in Australia'. Materials Circular Economy. 4(27): 1-22.

[60] NCC (2022) Building for 7 Stars: top tips and guidance. Available from https://shorturl.at/pR346

[61] National Construction Code (2023). Volume 2. Available from https://shorturl.at/uyBK6

[62] Sustainability Victoria (2024) 7 Star Homes Program: Guidelines. Available from https://shorturl.at/forY5

Overview of Key Findings

- Approximately **89%** of participants reported being very to moderately familiar with this policy **(Figure 16a)**
- 77% participants indicated that '***Environmental Sustainability Rating'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 16b)**
- About **66%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 16c)**
- About **33%** of participants indicated that the policy's application might have some negative consequences **(Figure 16d)**
- Participants identified **14** potential negative impacts of this policy **(Table 16)**
- The three primary ways this policy can boost PwRC use include **'improving the quality of PwRC', 'influencing decision making process for using PwRC'** and **'improving the social image of end-user organisations' (Figure 16e)**
- They proposed **29 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 17)**
- **~57%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **68%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Environmental Sustainability Rating'

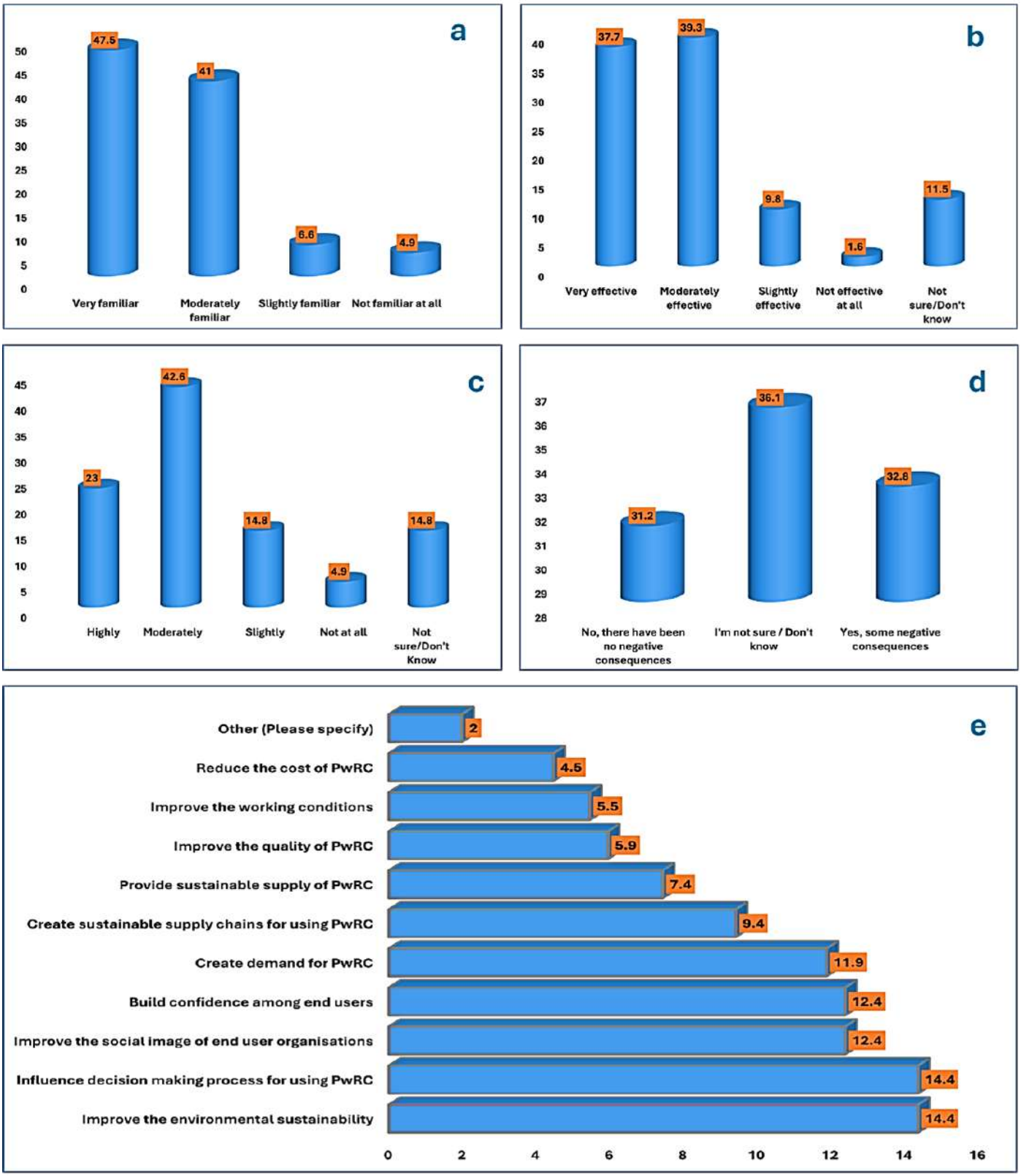

Figure 16. Participants' responses (frequency distribution %), environmental sustainability rating Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 16. Key issues and impacts of implementing environmental sustainability rating

No	Issue	Description
1	**Incorrect policy application**	Misalignment of policy application, focusing on construction/design instead of operational performance
2	**Cost of high star ratings**	Additional expenses incurred to achieve higher star ratings, impacting project budgets
3	**Training costs**	Significant costs associated with training personnel in green star qualifications and maintaining certifications
4	**Greenwashing**	Practices that create an impression of supporting PwRC without substantial impact
5	**Increased construction costs**	Policies contributing to higher overall construction costs
6	**High standards restricting material use**	Strict standards may prevent the use of innovative PwRC in construction, necessitating subsidies to offset costs for compliance
7	**Loopholes and enforcement challenges**	Lack of adequate enforcement and the presence of loopholes reduce policy effectiveness
8	**Increased effort for recycled material use**	More work is required to incorporate PwRC, adding complexity to construction processes
9	**Early recycling product failures**	Initial failures in recycled polymer products highlighted the need for thorough testing and adaptation, now leading to successful application in suitable use cases
10	**Rating vs. Real outcomes**	Rating systems may prioritise ratings over actual environmental impact, potentially diminishing genuine sustainability efforts
11	**Barrier to new entrants**	High standards and complex processes can deter new entrants, limiting competition and innovation in the market
12	**Complacency in standards**	High standards may foster complacency, as stakeholders view compliance as sufficient without pursuing broader sustainability goals
13	**Limited market impact**	High standards often serve higher-end markets only, potentially excluding more accessible, widespread sustainability solutions
14	**Perverse incentives with certifications**	PwRC lacking certification may not earn points, and rating tools may fail to incentivise PwRC use, reducing the overall policy impact

Table 17. Key measures to enhance the effectiveness of environmental sustainability rating

No	Measures	Description	No	Measures	Description
1	**Rating scheme encouragement**	Use rating schemes and tools to drive wider PwRC use, especially with specific material targets	16	**Monitoring and feedback mechanisms**	Establish feedback systems to continuously refine PwRC promotion strategies in construction
2	**Demand for standards**	Create demand for IS, Green Star and LEED standards to motivate organisations to meet benchmarks	17	**Focus on Australian PwRC**	Emphasise Australian PwRC in rating tools, excluding imported materials from credits
3	**Other rating systems**	Develop alternative rating systems to further environmental sustainability	18	**Public awareness and case studies**	Promote case studies showcasing high-standard projects to raise industry awareness to aim for higher
4	**Whole-of-life approach**	•Increase focus on life-cycle impacts, including building operations to enhance sustainability outcomes •Adopt life-cycle thinking that supports PwRC but also encourage reuse or refurbishment over new production	19	**Addressing multiple rating tools complexity**	•Simplify multiple rating tools to avoid consumer confusion and improve effectiveness •Simplify administrative requirements to encourage companies to exceed minimum standards
5	**PwRC specific criteria within ratings**	•Add specific PwRC criteria to rating systems, rewarding PwRC use with extra points or credits •Increase PwRC integration within IS tool and expand its relevance in Green Star ratings •Encourage specific PwRC criteria in rating systems to incentivise use •Address PwRC's minor role in current environmental rating schemes to drive its expansion	20	**Managing the risk of added costs**	•Mitigate risks of additional PwRC sustainability rating costs that could increase project expenses •Provide subsidies to make rating certifications accessible to smaller organisations •Develop cos-effective rating options that enable all developers follow sustainability goals
6	**Increasing ratings requirements and targets**	•Spur product innovation by increasing sustainability ratings and targets •Set objectives beyond minimum rating targets to encourage PwRC adoption	21	**Mandatory application of rating tools through contracts**	•Enforce sustainability rating compliance in significant projects or high-value contracts through legislation •Contracts requiring specific rating level requirements that make the use of PwRC a standard practice
7	**Educational outreach for PwRC**	Provide resources to guide professionals in sourcing PwRC aligned with rating systems	22	**Innovation and research promotion**	Reward innovation in PwRC materials and technologies through rating system incentives
8	**Market access for alternative products**	Expand market access for alternative products, offering sustainable more construction options	23	**Limited products for rating schemes**	Address limited availability and high costs of rated products, which hinder smaller manufacturers
9	**LCA expansion**	Incorporate LCA principles into rating systems to evaluate environmental impacts from extraction to disposal	24	**Addressing point-chasing risks**	Prevent point-chasing in rating systems to ensure substantive sustainable practices
10	**Prioritising high-recycled content materials**	Encourage builders to prioritise high-recycled-content materials in projects	25	**Rating schemes' cost as a quality filter**	High certification and sustainability rating costs often reflect genuine commitment to sustainability
11	**Transparency and reporting**	Require transparency and reporting on PwRC use as part of rating process to promote accountability	26	**Project-specific implementation**	Align rating scheme use with organisational and policy goals for consistent impact
12	**Corporate social responsibility recognition**	Leverage Corporate Social Responsibility (CSR) recognition in ratings to boost PwRC adoption across the built environment	27	**Voluntary and process-driven ratings**	Address limitations of voluntary process-driven ratings- which may limit circular or regenerative benefits- by focusing on outcomes
13	**Supplier engagement**	Motivate suppliers to certify PwRC and validate its environmental attributes	28	**Generating market demand**	Use ratings to create market demand for PwRC by highlighting sustainability benefits
14	**Rewarding sustainable projects**	•Reward projects incorporating new PwRC technologies, fostering recycling advancements •Offer financial incentives for projects achieving high sustainability ratings through PwRC use	29	**Policy alignment**	•Align rating systems with government policies to support PwRC adoption •Align policies with Green Star, IS and LEED to ensure rating system adoption without relying solely on voluntary adoption
15	**Expanded scope for building ratings**	Expand building ratings scope to cover more types, increasing PwRC use			

Carbon Tax Scheme

A carbon tax scheme is an economic mechanism implemented by governments or regulatory bodies to incentivise and promote the use of PwRC in construction projects while simultaneously imposing a tax or fee based on the carbon emissions associated with using virgin materials. There is no mandatory carbon tax scheme currently being applied in Australia. The issue of carbon emission with regards to the production of PwRC is complex. On the one hand, carbon emissions during recycling are inevitable; however, the measures for substantial emissions are possible and crucial. On the other hand, the options of landfill disposal and extraction of virgin materials have far more adverse environmental consequences[63].

There are two widely adopted approaches to addressing the issues with emissions: Command-Control (for example, through regulations, direct and indirect taxes) and a carbon tax scheme. The first approach comes with some limitations, as the unit cost for removing additional quantities of pollution is unreasonably expensive in some scenarios. Another issue with the Command-Control approach, is that it is stricter than the carbon tax scheme approach which is a more incentive-based system. In Command-Control, the emission goal set for each polluter is fixed; hence, shifting the burden of pollution reduction to an organisation that can achieve it more cheaply is not possible. Thus, this approach is likely to be more costly in general[64] and, in most cases, the additional costs would be transferred to end-users[65]; therefore, it is a less favoured method in circular-based systems.

On the contrary, implementing a carbon tax scheme, can reduce emissions from waste disposal and recovery facilities. This is a market-driven approach to managing pollution by providing economic incentives to reduce the emission of pollutants[66]. In the general context, the idea is to mitigate the adverse effects of climate change and improve the environmental protection. In the CE context, this scheme can convince waste producers to consider the top layers of the waste hierarchy (re-use, recycle and recover).

A version of the carbon tax scheme is an emission trading system (ETS). Through this scheme, the relevant authority allocates a limited number of permits to dispose of a certain amount of a specific pollutant during the period stipulated[67]. Polluters (waste producers) need to own permits in an amount equal to their emissions. Polluters who wish to add to their emissions should purchase permits from others willing to sell them. An ETS allows for emission goals to be met most cost-effectively by letting the market determine the lowest-cost pollution abatement opportunities. There are four main types of ETS: 'cap-and-trade system', 'baseline-and-credit schemes', 'project-based schemes' and 'hybrid schemes'. The EU implemented a cap-and-trade system in 2005[68] under the Kyoto Protocol and aims to reduce GGE in an economically effective manner.

The ETS in Australia has been a source of disagreement between the major political parties because of its social and economic effects. Between 2003 and 2011, policies related to the ETS were passed and overturned several times. The Australian Parliament has provided a list of the pros and cons of the ETS concerning varying factors[69]. The first ETS in Australia was established in NSW in 2003, based on a baseline-and-credit scheme[70]; it only lasted for a decade and was terminated in 2012. A report[71] that reviewed this scheme's

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

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

[65] 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.

[66] 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.

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

[68] EU Emissions Trading System (EU ETS) (2005). https://bit.ly/3tBcsca

[69] Carbon taxes. (2019). Available from https://shorturl.at/kvJN4

[70] The New South Wales Greenhouse Gas Reduction scheme (2003) https://bit.ly/3sBf7B6

[71] NSW Greenhouse Gas Reduction Scheme - Strength's weaknesses and lessons learned - Final Report – 2013.

performance indicated a high level of commitment from different stakeholders during its lifetime.

Nevertheless, around five million certificates remain available for voluntary surrender on this scheme's registry.

Later 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 ($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, which provides funding to companies to incentivise emission reduction activities. The government has spent $1.7 billion on 143 million tonnes of emissions, at an average cost of $12 per 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. South Australia (SA) is the first Australian jurisdiction to enact specific climate change legislation that sets an ambitious long-term emissions reduction target. Through the *Climate Change and Greenhouse Emissions Reduction Act* 2007, SA establishes a target to reduce its GGE by at least 60% (from 1990 levels), by 2050. In the Australian Capital Territory (ACT), the *Climate Change and Greenhouse Gas Reduction Act* 2010 has provided a target of 40% emissions by 2020, while the waste sector only accounts for 3% of total emissions. In Queensland (Qld), an environmental strategy document necessitates implementing an 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 recovery sector in Australia. In a previous report[72], consultation with waste recyclers revealed that introducing 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 an ETS can reduce GGE from waste by 75.9% (from 2015 levels) by 2030[73] ; the study, however, stated that an ETS is likely to reduce Australia's gross domestic product (GDP) by just over 1.1% in 2030 compared to a base case.

In 2016, findings of a study[74] demonstrated that 'direct auction' was not as effective as a carbon tax in forcing companies to act urgently and manage emissions. The interviewees in this piece of research stated 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 the focus on carbon emissions in these companies shifted when the carbon tax was repealed. Another piece of research[75] compared three models of GGE reductions (ETS, auction plan and carbon tax) and found that an ETS is the most viable option for reductions in GGE and economic growth. This research predicts that the government will encounter much higher prices in the next rounds of auction than previous auctions. Hence, the current budget ($2.55 billion) may not be sufficient to purchase the required abatement by 2020, making achieving the 2030 target difficult.

Another study in Victoria[63] warned that an ETS might also cause the industry to rethink recycling emissions levels and this would negatively impact further recycling activities. In general, and in the interest of CE and resource recovery industry, legislation should be modified to account for the fuel tax cuts.

[72] Construction and Demolition Waste Status Report (2012). Hyder Consulting Pty.

[73] 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

[74] Kumarasiri J, Jubb C and KA Houghton (2016) Direct Action not as motivating as carbon tax say some of Australia's biggest emitters. The Conversation. https://bit.ly/3svAP9H

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

Overview of Key Findings

- Approximately **57%** of participants reported being very to moderately familiar with this policy **(Figure 17a)**
- 59% participants indicated that ***'Carbon Tax Scheme'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 17b)**
- About **20%** of participants indicated that the policy's application might have some negative consequences **(Figure 17d)**
- Participants identified **three** potential negative impacts of this policy **(Table 18)**
- The three primary ways this policy can boost PwRC use include 'improving the environmental sustainability, **'creation of demand for PwRC' and 'influencing decision making process for using PwRC' (Figure 17e)**
- They proposed **28 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 19)**
- **~63%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **~57%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Carbon Tax Scheme'

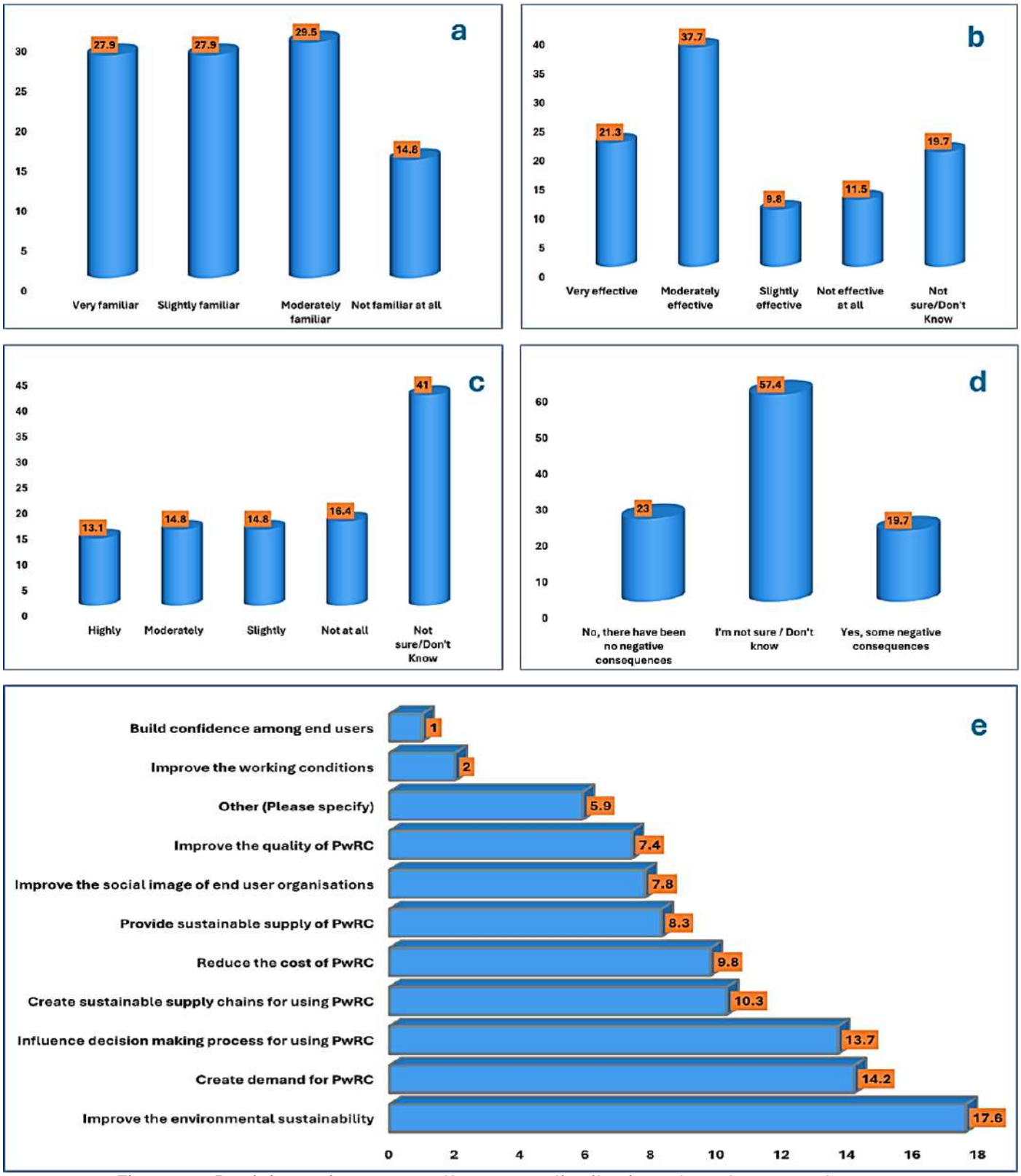

Figure 17. Participants' responses (frequency distribution %), carbon tax scheme Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 18. Key issues and impacts of implementing carbon tax scheme

No	Issue	Description
1	**Higher GHG emissions from PwRC products**	Traditional LCA often shows higher GGE for PwRC compared to virgin materials, potentially disadvantaging some PwRC
2	**Promotion of less durable materials**	Emphasis on carbon-neutral materials may lead to the use of less sturdy materials unable to withstand extreme conditions
3	**Greenwashing and ineffective solutions**	Risk of greenwashing and reliance on ineffective methods, like carbon offsetting, rather than true sustainable practices
Positive impact		
Financial benefits		Financial benefits for government and listed companies
Bogus offset schemes		Implementation of bogus offset schemes

Table 19. Key measures to enhance the effectiveness of carbon tax policy

No	Measures	Description	No	Measures	Description
1	**Supplier availability**	Ensure the availability of suppliers offering PwRC with lower embodied carbon	15	**Target application areas for low carbon materials**	Focus policies on areas where low-carbon materials are viable, excluding critical applications where PwRC are less suitable
2	**Carbon pricing scheme awareness**	•Increase understanding of carbon tax or credit schemes to incentivise PwRC use by reflecting emissions costs •Educates stakeholders about the carbon benefits of PwRC and carbon pricing schemes to build support	16	**Co-investment in innovation and recovery infrastructure**	•Advocate for government co-investment to foster innovation in recycling processes and material development •Invest in recycling infrastructure to improve PwRC supply
3	**Tax incentives and financial support**	•Monetise PwRC to encourage its adoption in the building and construction sector •Offer tax rebates or incentives for companies using PwRC to offset higher sourcing costs •Provide financial assistance to offset initial PwRC adoption costs in construction	17	**Lifecycle carbon pricing**	•Cover all lifecycle emissions in carbon pricing to ensure comprehensive environmental impact accounting and recycling benefits are not limited •Advocates for lifecycle impact assessments rather than carbon-only metrics to avoid unintended consequences •Full lifecycle carbon pricing is most effective, accounting for impacts from vegetation loss for virgin material extraction •Recognise that PwRC manufacturing may have higher carbon due to additional processes, making lifecycle assessments critical •Implement full lifecycle carbon pricing, including impacts from vegetation loss for virgin material extraction
4	**Commercial advantage**	•Highlight competitive advantages for companies specifying and procuring PwRC •Emphasise competitive advantage and future-proofing as key motivators, beyond financial gain	18	**Carbon accounting standardisation**	•Standardise carbon accounting for recycled and virgin materials through industry collaboration •Address complexities in assigning embodied carbon responsibility (developers vs. asset owners)
5	**Tool limitations**	Address concerns about carbon credits through developing quantitative tools	19	**Local governments' carbon pricing schemes**	Encourage local governments to apply their own carbon costs, promoting sustainable choices as seen in Dutch Local Government Areas (LGAs)
6	**Market creation through awareness**	Raise awareness of PwRC and best practices to help establish a market	20	**Addressing risk of using substandard materials**	Mitigate risks of promoting low-quality recycled options by ensuring accurate lifecycle carbon calculations
7	**Minimal difference for aggregates**	Highlight that limited carbon differences between recycled and virgin aggregates increase PwRC appeal	21	**External cost integration**	Integrate external costs of virgin materials into pricing to reflect true costs and encourage PwRC use
8	**Differentiated carbon pricing**	Introduce carbon pricing based on emissions from virgin vs PwRC to incentivise PwRC use	22	**Certification and verification**	Certification systems should be utilised to ensure the quality and authenticity of PwRC
9	**Carbon credit incentives**	Offer carbon credits for PwRC use, rewarding lower-carbon projects	23	**End carbon offsetting**	Advocate for ending carbon offsets in favour of direct legislation promoting PwRC
10	**Transparent carbon footprint reporting**	Provide transparent reporting on carbon footprints for construction materials to empower informed choices	24	**EU and global carbon pricing models**	Learn from global carbon pricing models to ensure effective implementation in Australia and avoid unwanted consequences
11	**R&D funding for PwRC**	Allocate R&D funding to reduce PwRC's carbon footprint, increasing competitiveness against virgin materials	25	**Price of carbon determinant**	Set an effective carbon pricing rate to drive meaningful changes; Australia's current rate is ~$75/tonne
12	**Market-based carbon instruments**	Consider market-based tools (e.g., carbon trading) to reward emissions reductions from using PwRC	26	**Carbon pricing and clean technology**	Pair carbon pricing with mandatory climate reporting to drive innovation and clean technology development
13	**Public procurement for PwRC**	Use public procurement policies to prioritise PwRC and set an example for the private sector	27	**Long-term policy stability**	Ensure policy consistency to encourage sustainable investment and reliable PwRC supply chains
14	**Carbon tax reception**	Address negative perceptions of carbon tax by providing viable alternatives, a 'tax' can cause negative perceptions	28	**Carbon tax revenue redistribution**	•Hypothecate carbon tax revenue to promote market development and sustainability •Carbon tax reinvested in innovation and recycling

POLICIES WITH INDIRECT IMPACTS

Landfill tax

The building and construction sector's current preferred method for dealing with C&D waste is landfilling. This is because of its convenience and cheap cost (via low landfill levies) compared with alternative waste management methods, as well as its accessible hours of operation[76,3]. Udawatta et al. (2015)[77] contend that poor financial returns and lack of incentives inhibit subcontractors' interest in waste minimisation. Newaz et al. (2020)[78] also point this out, arguing that construction projects' variety makes consideration of waste management difficult during the design phase. Analysis of numerous fit-outs case studies in NSW indicates that 78% of waste produced on-site goes to landfill[76]. Recycling facility fees applied to waste materials processing compared to those at landfill sites are greater[79]. Ratnasabapathy et al. (2019)[80] demonstrate in a recent study that a minor reduction in Australian C&D waste disposal highlights the necessity of devising ways to limit landfilling. The researchers predict that, if the trajectory continues, this will result in a 78% diversion rate from landfill by 2025.

Most of the existing studies on this topic emphasise the need for landfill levies. For example, studies suggest that the recovery of waste can be driven by landfill levy fees that are high. Shooshtarian et al. (2020)[53] state that, of participants in one survey, 90% recommended landfill levies as generally effective. Landfill levy rates in Australia are decided on by state and territory governments[27]. This means there is variation between states, depending on how the rates are formulated. A study of states' recent waste strategies found that these documents recommend the revision of current levy practices to dissuade the industry from waste disposal as their second-highest suggestion[81]. The jurisdictions of ACT, SA, Qld, Tasmania (Tas) and WA all suggested this way forward.

Research has been conducted into landfill levies' standards in Australia as well as their suitability[78,82]. Stakeholders are concerned about the effective design of such scheme to better mirror practical considerations plus expand its influence[83]. Shooshtarian et al. (2020)[47] contend that while landfill levies may be the preferred market approach in certain scenarios, they can also inadvertently discourage best waste management practices. For example, these levies may lead to increased illegal dumping, shifting of waste to other regions and a reduction in overall recycling efforts. Rameezdeen et al. (2016)[84] show that illegal dumpling can be an unintended consequence of a higher landfill levy rate. In WA, a government document as cited in Zhao et al. (2021)[83] echoes this finding.

A Qld study showed that how the state government decisions regarding the establishment and rescinding of landfill levies can impact the C&D waste recycling rate across the state[85] . A study by Wu et al. (2020)[86] showed that there are some levels of waste transfer between a number of Australian states e.g. NSW and ACT, NSW and Qld and SA and Victoria. The researchers indicated that the recycling/landfilling site availability and inconsistent levy rates are the main reasons for

[76] Fini, A. A. F. and Forsythe, P. (2020) Barriers to reusing and recycling office fit-out: An exploratory analysis of demolition processes and product features, Construction Economics and Building, 20(4), 42-62.

[77] 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), 137-147.

[78] Newaz, M. T., Davis, P., Sher, W. and Simon, L. (2020) Factors affecting construction waste management streams in Australia, International Journal of Construction Management. 22 (13): 2625-2633.

[79] Tam, V. W., Kotrayothar, D. and Loo, Y.-C. (2009) On the prevailing construction waste recycling practices: a South East Queensland study, Waste Management & Research, 27(2), 167-174.

[80] Ratnasabapathy S, Perera S, Alashwal AM and Lord O (2019), Assessment of waste generation and diversion rates in residential construction projects in Australia, The Hong Kong Polytechnic University, Hong Kong, China, 17 – 21 June

[81] Shooshtarian, S., Maqsood, T., Wong, S. P., Yang, J. R. and Khalfan, M. (2020) Review of waste strategy documents in Australia: Analysis of strategies for construction and demolition waste, International Journal of Environmental Technology and Management, 23(1), 1-21.

[82] Jayasinghe RS, Rameezdeen and Chileshe N (2018) 'Waste management practices in Australia: Comparison of strategies' 22nd International Conference on Advancement of Construction Management and Real Estate, Melbourne, Australia

[83] Zhao, X., Webber, R., Kalutara, P., Browne, W. and Pienaar, J. (2021) Construction and demolition waste management in Australia: A mini-review, Waste Management & Research, 0734242X211029446.

[84] Rameezdeen, R., Chileshe, N., Hosseini, M. and Lehmann, S. (2016) A qualitative examination of major barriers in implementation of reverse logistics within the South Australian construction sector, International Journal of Construction Management, 16(3), 185-196.

[85] Forghani, R., Sher, W., Kanjanabootra, S. and Totoev, Y. (2017) Consequence of waste levy revocation: case study Queensland, Australia, 23rd Annual Pacific Rim Real Estate Society Conference on The Built Environment and Health, Infrastructure and System Resilience Planning, Sydney, Australia 15th-18th January.

[86] Wu, H., Zuo, J., Yuan, H., Zillante, G. and Wang, J. (2020) Cross-regional mobility of construction and demolition waste in Australia: An exploratory study, Resources, Conservation and Recycling, 156, 104710

these inter-state waste transports. This issue that can be minimised by implementing policies such as the proximity principle[99], in which waste transfer is restricted over long distances. Newaz et al. (2020)[78] report specialists' opinions that NSW's levy on waste is ineffective in terms of minimising waste landfilling, due to their being few practical results from levies and the fact that the state permits waste transfer to Qld, which has comparatively lower landfill levies. In Shooshtarian et al. (2020)[47], participants report that the current landfill levy schemes used in Australia could be more efficient and require changes to fulfill waste diversion goals.

Generally, landfill levies are determined based on the location of landfills, levy exceptions for particular materials, how waste is composed and levy zones. For this reason, they rise regularly[82,87]. Jayasinghe et al. (2018)[82] argue that levies should be decided depending on the waste classification, demographics, financial impact analysis and levy rebates for waste recovery. Landfill levy revenues are in part spent on bolstering enforcement and compliance, devising good policies, and funding initiatives and activities that foster waste minimisation. However, Australia lacks a national approach to the spending of levies on the aforementioned purposes, with each state government doing so as guided by its specific concerns and preferences[47].

Several studies propose strategies targeting waste landfilling and landfill levies. Shooshtarian et al. (2020)[47] contend that strategies to enhance landfill levy effectiveness include consideration of fees on transport and possible price repercussions for the building and construction sector when deciding the levy fees; standardisation of levies for landfill; supplementing levies with technology-driven compliance and enforcement systems; improving local infrastructures; directing revenue from landfill levies into resource recovery via initiatives such as offering monetary incentives or low-interest loans; and funding R&D activities. A good strategy for better resource circularity in landfills is to increase the use of energy recovered (mainly methane gas) from combustible C&D waste materials that would otherwise end up in landfills[88].

Tam et al. (2009)[79] suggest that landfill operators should use differential applications of a levy to encourage C&D waste source separation. Additionally, competent waste data and reporting systems that enumerate the precise quantity of landfilled waste would enhance planning and regulation for greater waste minimisation via landfilling or otherwise[89]. Effective waste landfilling is complemented by locating engineered landfills close to transfer stations and reprocessing centres for optimal transportation[82]. A combination of properly designed landfill levies, the proximity principle and locating landfill sites at further distances, could encourage recycling instead of landfilling.

[87] Chileshe, N., Jayasinghe, R. S. and Rameezdeen, R. (2019) Information flow-centric approach for reverse logistics supply chains, Automation in Construction, 106, 102858.

[88] Shooshtarian S, Maqsood T, Wong P, Khalfan M and Yang R (2019) 'Review of energy recovery from construction and demolition waste in Australia', Journal of Construction Engineering, Management & Innovation, 2(3):112-130

[89] Ratnasabapathy S, Perera S and Alashwal A (2019) 'A review of construction waste data and reporting systems used in Australia' 43rd AUBEA: Built to thrive: Creating buildings and cities that support individual well-being and community prosperity, Noosa, Australia

Overview of Key Findings

- Approximately **82%** of participants reported being very to moderately familiar with this policy **(Figure 18a)**
- Approximately **73%** participants indicated that ***'Landfill Tax'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 18b)**
- About **46%** of participants indicated that the policy's application might have some negative consequences **(Figure 18d)**
- About **66%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 18c)**
- Participants identified **nine** potential negative impacts of this policy **(Table 20)**
- The three primary ways this policy can boost PwRC use include ***'improving the environmental sustainability'***, ***'creation of sustainable supply chains for using PwRC'*** and ***'influencing decision making process for using PwRC'*** **(Figure 18e)**
- They proposed **31 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 21)**
- **~51%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **~63%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Landfill Tax'

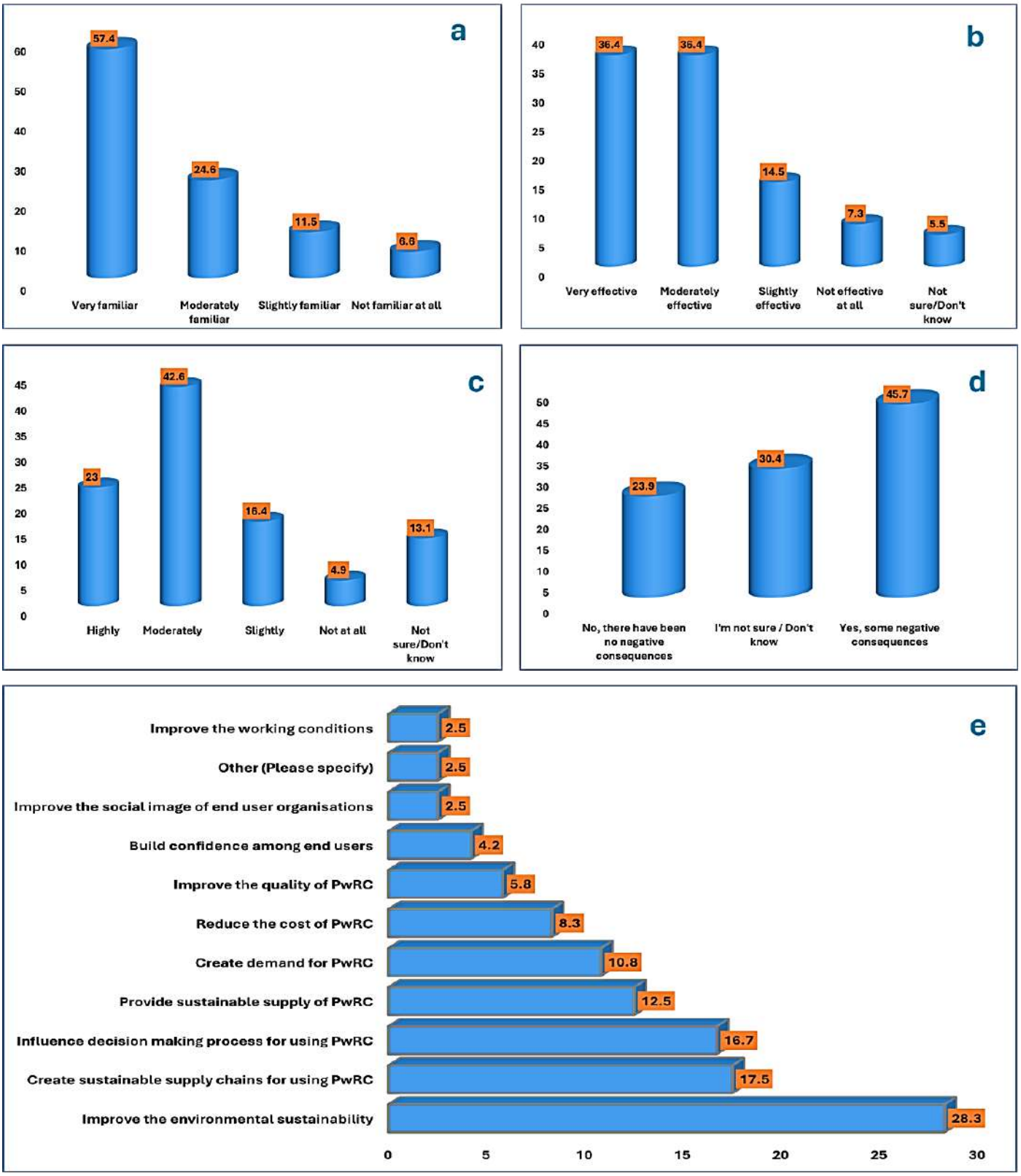

Figure 18. Participants' responses (frequency distribution %), landfill tax. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 20. Key issues and impacts of implementing landfill tax policy

No	Issue	Description
1	**Regional levy discrepancies**	Non-uniform levies may lead to waste being transported to low-levy areas, avoiding proper waste management in high-levy regions
2	**Illegal dumping and disposal**	Higher landfill levies incentivise illegal dumping and disposal, increasing environmental risks
3	**Misclassification of waste**	Incorrect categorisation, such as labelling contaminated materials as "Clean," can lead to cross-contamination and hidden hazardous materials (e.g., asbestos)
4	**Stockpiling of waste**	Landfill levies encourage stockpiling, particularly of C&D waste in regions like WA, where demand and supply chains are insufficiently developed
5	**Dumping in local government areas**	Local governments may see an increase in illegal dumping due to levy avoidance tactics
6	**Incentivised illegal export**	Higher levies might also encourage the illegal export of waste materials
7	**Use of non-beneficial recycled materials**	Encouraging PwRC use without careful consideration may lead to the use of less beneficial or unsuitable PwRC
8	**Cost of action vs. Inaction**	The balance of costs (levy vs. incorporating recycled content) impacts compliance, with higher landfill taxes increasing the motivation for illegal disposal
9	**Landfilling lightweight materials**	Levy structures inadvertently push certain lightweight materials, like textiles, towards landfilling due to lack of recycling incentives
Positive impact		
Part of building price scheme		Seen as a part of the building price scheme now

Table 21. Key measures to enhance the effectiveness of landfill tax policy

No	Measures	Description	No	Measures	Description
1	**Uniform levy application**	Inconsistencies in levy application undermine effectiveness; uniform application is crucial	17	**Land subsidies for recycling industry**	Subsidise for land and operations can stabilise the recycling industry and supply chains
2	**State-by-state levy variation**	Inconsistent levies across states reduce overall effectiveness compared to uniform application	18	**Avoid high costs without recycling options**	Raising levies without increasing recycling options can lead to continued landfill use at a higher cost
3	**Increased illegal dumping risk**	•Higher levies can lead to illegal dumping, requiring monitoring and regulation •Higher levies should be paired with increased recycling options to reduce incentives for illegal dumping	19	**Paired with circular economy investment**	•Pair levies with CE opportunities reduces risks of illegal dumping and supports sustainable practices •Levy funds should support recycling infrastructure and innovation to drive CE development
4	**Justifying policy intent**	Clearly outline policy purpose aids responsible industry decision-making	20	**Effective globally for recycling**	•Landfill levies are globally proven tools for recycling and circularity •Landfill levies are critical for driving recycling and CE adoption
5	**Higher disposal costs**	Increased costs for disposing of C&D waste can create more recycling opportunities	21	**Target downstream supply chain**	Landfill levies influence downstream supply, potentially increasing PwRC supply
6	**Waste diversion and job creation**	Diverting waste from landfill creates sub-industries, job opportunities in upcycling and supply chain development	22	**Surcharge for non-PwRC**	Establish a landfill surcharge for waste that could have been recycled but was disposed of instead
7	**Recycling infrastructure investment**	Investments in recycling infrastructure are needed to support PwRC markets	23	**Levy review for disincentivising landfill**	Levy should be regularly reviewed to ensure it effectively discourages landfill disposal
8	**Levy revenue for waste recovery infrastructure**	•Allocates levy revenue to recycling infrastructure, supporting PwRC processing •Levy revenue should support recycling facility expansion and PwRC market development	24	**Avoid passing levies to consumers**	•Levies should be borne by waste producers, not consumers, to drive industry change •Ensures levy costs aren't transferred to consumers, promoting EPR to hold waste producers accountable
9	**Stockpiled recycled aggregate**	Large quantities of unused recycled aggregate highlight the need for increased market demand	25	**Policy linkage to holistic framework**	Landfill levies should be part of broader waste and recycling policy frameworks to prevent unintended behaviours
10	**Tax incentives for PwRC use**	Provides tax rebates to incentivise PwRC use, reducing raw material demand and landfill	26	**Addressing lightweight material challenges**	Levy should consider material weight; lightweight materials often easier to landfill reducing recycling incentives
11	**Preference for incentives over taxes**	•Incentives are more effective than landfill taxes in encouraging recycling •Avoid excessive levies and taxes; incentives are preferred	27	**Clear rebate structure**	Levy rebates should incentivise waste reduction and recycling
12	**R&D grants for PwRC**	Grants for PwRC R&D can improve quality, durability and foster innovation	28	**Levy avoidance and stockpiling**	Concerns about levy avoidance and stockpiling; pairing with sustainable procurement can build PwRC markets
13	**Mandatory PwRC requirements**	Set minimum PwRC usage standards would create demand and drive recycling innovation	29	**Encourage source segregation**	A surcharge on landfill deliveries containing recyclables incentivises pre-sorting and recycling efforts
14	**Collaboration with industry**	Engage stakeholders to promote PwRC benefits through knowledge-sharing, training and showcase projects	30	**Enforcement of compliance**	Effective compliance monitoring is essential to prevent levy avoidance and ensure funds support recycling
15	**LCA certification**	Certification for lifecycle impact of PwRC helps builders prioritise environmentally friendly options	31	**Local supply chains support**	Develop local recycling supply chains to support sustainable material use and reudce landfill demand
16	**Sustainable procurement**	Public procurement prioritising PwRC increases demand and sets an example for private sector adoption			

Extended producer responsibility

Extended producer responsibility (EPR), also called the "polluter pays" or "take-back" principle, is a policy approach designed to encourage manufacturers, suppliers and importers of construction materials to take active responsibility for waste minimisation. EPR makes the material's manufacturer or its supplier accountable—physically and/or monetarily—for the entire lifecycle of their materials, including the waste generated from the application of a product[90].

Criteria used to develop EPR policies

Previous studies have sought to develop models that address the intricate factors influencing EPR to improve its practical application and outcomes[91]. For instance, Dubois et al. (2016)[92] offered five measures of the capability of EPR for C&D waste management development and assessment, as shown in **Figure 19a**. The authors argued that the EPR application in the study context is primarily driven by two key factors: environmental scope and political priorities. Furthermore, Acree Guggemos and Horvath (2003)[93] put forward a policy framework to optimise achievement of EPR goals for C&D waste management. This framework which is based on Thorpe and Kruszewska's (1999)[94] model, comprises three forms of EPR

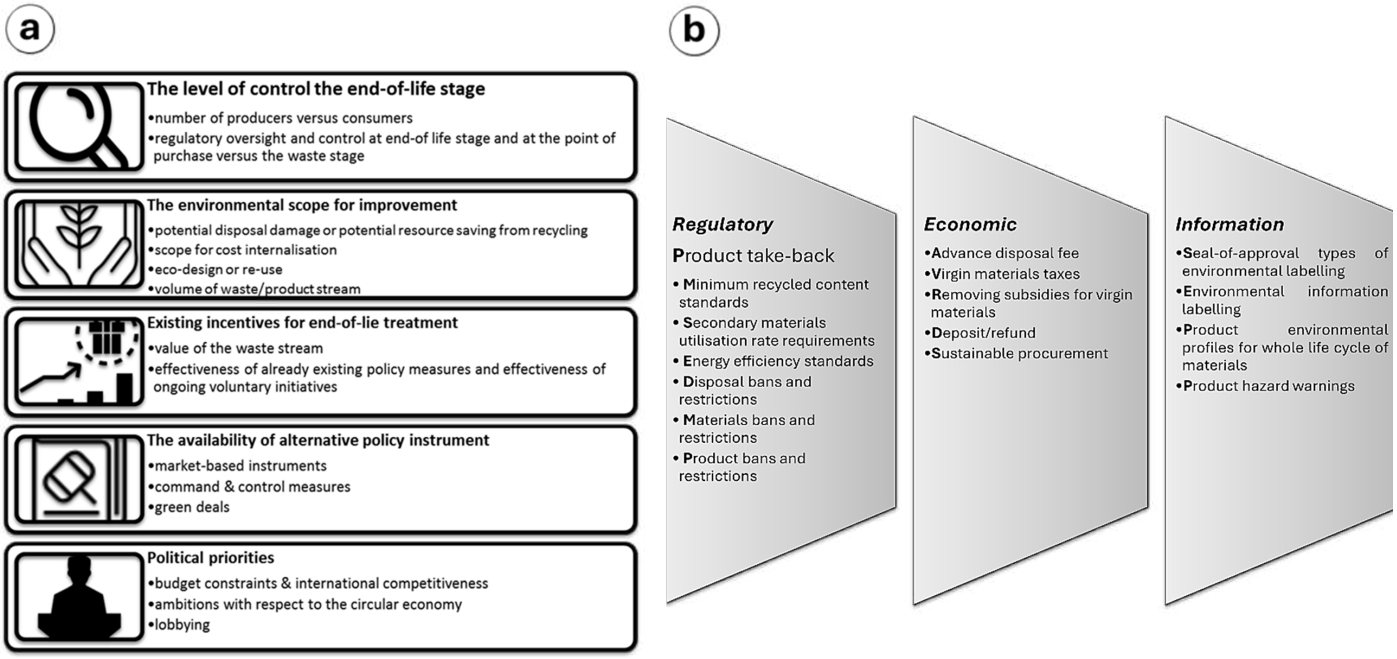

Figure 19. Five criteria suggested for the development of EPR policy

(a) Source: Adapted from Dubois et al. (2016)[91] Right: Three policy instruments that facilitate EPR implementation (b) Adapted from Acree Guggemos and Horvath (2003)[92]

When effectively implemented, EPR can motivate producers to proactively address the environmental impacts of their products. This approach encourages waste prevention at the source by promoting sustainable product design, technological advancements and the adoption of eco-friendly designs. Additionally, EPR fosters efficient waste management strategies within large-scale production planning, creating a ripple effect that contributes to minimising waste generation across the entire production lifecycle.

[90] Tam VW-Y and Lu W (2016) 'Construction waste management profiles, practices, and performance: a cross-jurisdictional analysis in four countries', Sustainability, 8(2):190.

[91] Xu J, Ye M, Lu W, Bao Z and Webster C (2021) 'A four-quadrant conceptual framework for analyzing extended producer responsibility in offshore prefabrication construction', Journal of Cleaner Production, 282:124540

[92] Dubois, M., de Graaf, D. and Thieren, J. (2016) Exploration of the role of extended producer responsibility for the circular economy in the Netherlands, EY: London, UK.

[93] Acree Guggemos, A. and Horvath, A. (2003) Strategies of extended producer responsibility for buildings, Journal of Infrastructure Systems, 9(2), 65-74.

[94] Thorpe B and Kruszewska I 1999, Strategies to Promote Clean Production: Extended Producer Responsibility. Clean Production Action, Institute for Sustainable Futures, UTS Appendix A,

policy instrument: regulatory, economic and information-based **(Figure 19)**.

Other studies have also suggested alternatives that involve a few overlaps and divergences compared to the models presented in **Figure 19**[95,96,97,98,99]. Furthermore, some studies present valuable insights into optimising EPR policies by examining factors influencing their outcomes. For instance, Gupt and Sahay (2015)[100] conducted a comparative analysis of 26 case studies to find the elements that are linked with successful EPR application and the key aspects of EPR expansion and execution. They found that 'recycling agencies' and 'source segregation' as well as 'financial responsibility of the producers' strongly support positive EPR outcomes. A 2016 study[101] on the effectiveness of various environmental policies revealed that EPR policies are considered to be highly effective but that there is uncertainty about their acceptability. The following section provides insights into challenges of EPR policy development and application.

Main challenges to adopting EPR in the building and construction sector

The building and construction sector's widespread embrace of EPR policies is held back by a number of obstacles. These challenges are outlined in **Figure 20**[93,102,103]. Obstacles to establishing EPR policies include cost and time implications; complexity

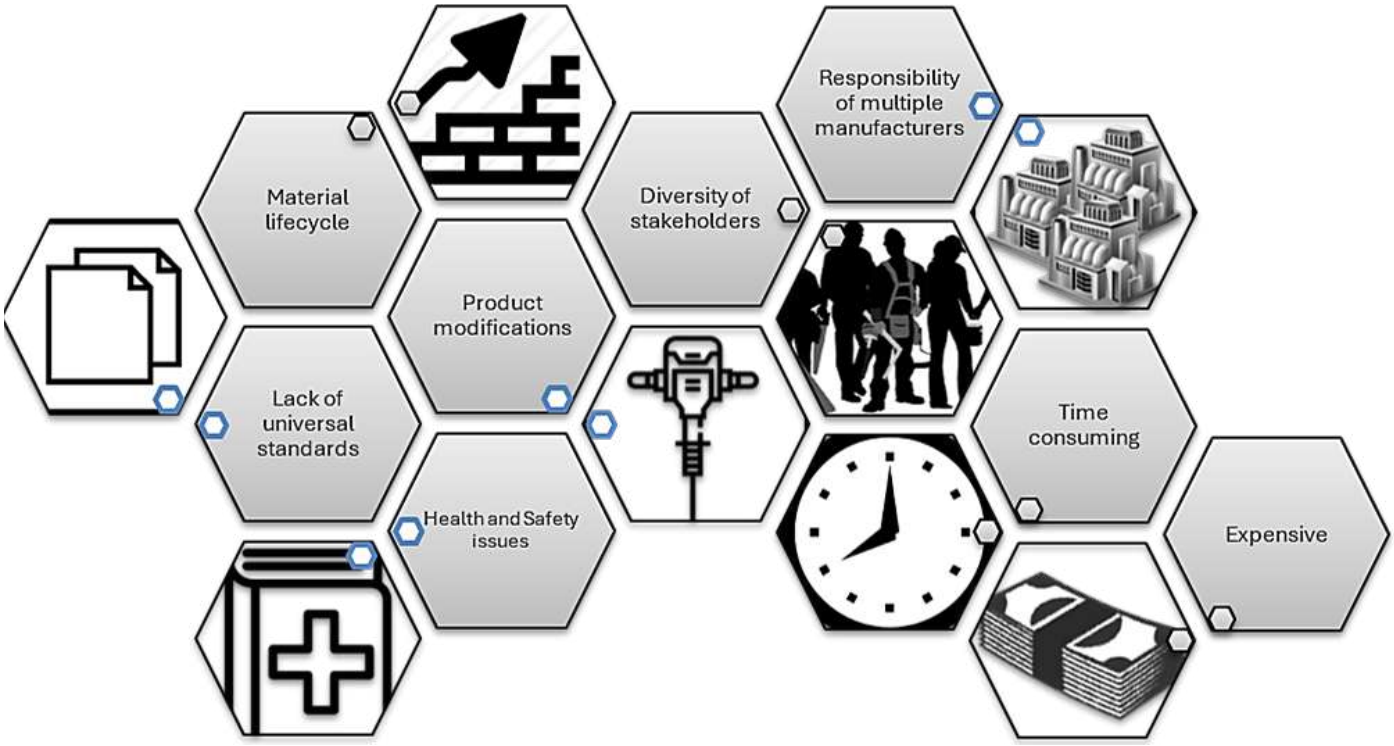

Figure 20. The key obstacles limiting the successful implementation of EPR for the C&D industry.
Source: Shooshtarian et al. (2021)[103]

[95] Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M. and Böni, H. (2005) Global perspectives on e-waste, Environmental Impact Assessment Review, 25(5), 436-458.

[96] Nahman, A. (2010) Extended producer responsibility for packaging waste in South Africa: Current approaches and lessons learned, Resources, Conservation and Recycling, 54(3), 155-162.

[97] Forslind K (2005) 'Implementing extended producer responsibility: the case of Sweden's car scrapping scheme', Journal of Cleaner Production, 13(6):619-629

[98] Langrová V (2002) 'Comparative analysis of EPR programmes for small consumer batteries: case study of the Netherlands, Switzerland and Sweden'. Lund University

[99] Lindhqvist T (2000) Extended producer responsibility in cleaner production: Policy principle to promote environmental improvements of product systems, Lund University.

[100] Gupt Y and Sahay S (2015) 'Review of extended producer responsibility: A case study approach', Waste Management & Research, 33(7):595-611.

[101] Isenhour C, Blackmer T, Wagner T, Silka L and Peckenham J (2016) 'Moving up the waste hierarchy in maine: Learning from "best practice" state-level policy for waste reduction and recovery', Maine Policy Review, 25(1):15

[102] Srour, I., Chong, W. K. and Zhang, F. (2012) Sustainable recycling approach: an understanding of designers' and contractors' recycling responsibilities throughout the life cycle of buildings in two US cities, Sustainable Development, 20(5), 350-360.

[103] Shanoff B (1996) 'Proposed recycling rules create obstacles', World Wastes, 39(6):14-17

of policy establishment and enforcement; responsibility of manufacturers; the range of stakeholders involved in the process; the lifecycle of materials in construction; and OH&S to address these issues, suggestions include the establishment of an effective supply chain system; encouraging Design for Deconstruction (DfD); product documentation; waste responsibility assignment; and enhanced health and safety risk management.

Implementation of EPR in the Australian building and construction sector

Implementing EPR in Australia's building and construction sector presents significant challenges due to the diverse range of stakeholders involved in the lifecycle of construction materials. These stakeholders include manufacturers, suppliers, contractors and waste management entities, with each play a role in the production, distribution, use and disposal of construction products. The absence of a unified and comprehensive EPR strategy in this sector is largely attributed to the complexity of coordinating these varied participants. This complexity is further compounded by the need to align differing interests, regulatory frameworks and operational practices across the sector. Consequently, developing and implementing a harmonised EPR approach requires extensive collaboration and integration among all parties to effectively minimise waste and promote sustainability within the sector[104].

There is no mandatory EPR policy legislated in Australia at present for construction material manufacturing. NSW and WA, however, do have voluntary EPR policies[104]. Two studies in Australia[105,106] point to the lack of a mandatory EPR policy as an obstacle to the reuse of waste materials and the creation of C&D waste trading markets in Australia. Shooshtarian et al. (2021)[104] studied the implementation of EPR in Australia and found that there is significant agreement between various stakeholders about the need for EPR.

[104] Shooshtarian, S, Maqsood T, Wong PS, Khalfan M and Yang RJ (2021) 'Extended producer responsibility in the Australian construction industry', Sustainability, 13(2):620

[105] Park J and R Tucker (2019) 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.

[106] Ratnasabapathy S, Alashwal A and Perera S (2021) 'Exploring the barriers for implementing waste trading practices in the construction industry in Australia', Built Environment Project and Asset Management, 11(4):559-576.

Overview of Key Findings

- Approximately **78%** of participants reported being very to moderately familiar with this policy **(Figure 21a)**
- Approximately **63%** participants indicated that ***'Extended Producer Responsibility'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 21b)**
- About **53%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 21c)**
- About **45%** of participants indicated that the policy's application might have some negative consequences **(Figure 21d)**
- Participants identified **11** potential negative impacts of this policy **(Table 22)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'building confidence among end-users'** and **'providing sustainable supply of PwRC' (Figure 21e)**
- They proposed **25 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 23)**
- 60% of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- 65% of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Extended Producer Responsibility'

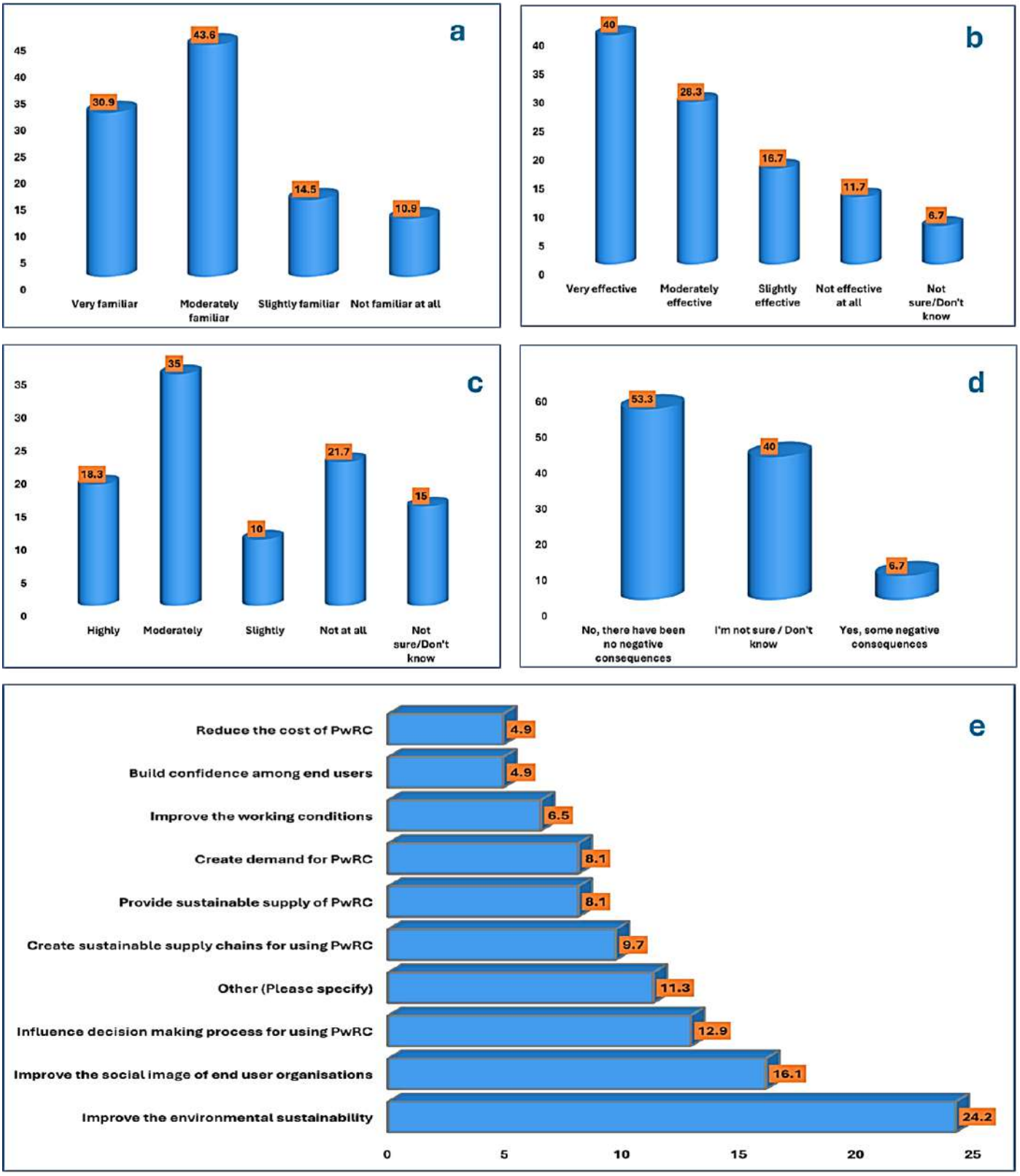

Figure 21. Participants' responses (frequency distribution %), EPR Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 22. Key issues and impacts of implementing EPR policy

No	Issue	Description
1	**Increased construction cost**	Policies may result in higher overall construction costs, impacting budgets and project viability
2	**Greenwashing potential**	Risk of greenwashing, with schemes possibly altering reported volumes of PwRC to appear more effective
3	**Poorly designed EPR**	Inadequate EPR schemes can lead to cost shifting to non-responsible parties and create 'free-rider' problems with unregulated operators
4	**Global supply and labour skills issues**	Challenges with accessing global spare parts and shortages of skilled labour may hinder effective implementation
5	**Full life-cycle responsibility challenges**	Placing full life-cycle responsibility on manufacturers is complex and may not be easily achievable
6	**Long-term responsibility lapses**	Due to the long lifespan of construction materials (10-20 years), it can be easy to neglect responsibilities over time
7	**Limited effectiveness of EPR in construction**	Many EPR schemes in construction are theoretical only, with limited practical application, as post-use recycling often isn't feasible due to contamination issues
8	**Voluntary and limited EPR schemes**	In Australia, many EPR schemes are voluntary, apply only to select products, and thus have limited impact
9	**Misperception of waste solution**	These policies can create a false perception that the waste problem is solved, while also shifting landfill and recovery costs from councils back to manufacturers
10	**Unequal impact on producers**	The policy affects producers differently depending on their products, leading to an imbalance and potentially unfair competition
11	**Business pressure**	Puts pressure on businesses; potentially challenging to implement across industries
	Positive impact	
Implications for product design		Implications for the design and preparation of products to enable second and third life cycles
Reducing free riders		Reduces free riders, improves social and environmental conditions, increases economic development, supports local jobs
Manufacturer accountability		Forces suppliers and manufacturers to take responsibility for their products' end-of-life impact
Life cycle accuracy		Creates an accurate life cycle of the products

Table 23. Key measures to enhance the effectiveness of EPR policy

No	Measures	Description	No	Measures	Description
1	**Stakeholder inclusion**	•Ensure all stakeholders share responsibilities based on contributions, avoiding imbalanced costs •Responsibility should be distributed among all lifecycle stakeholders, not just manufacturers •Recognise suppliers' significant influence on material selection sharing responsibility	14	**Policy applicability in construction**	•Acknowledge EPR's conceptual effectiveness but note its limited practical application and low recovery rates •Highlight EPR challenges in construction due to long product lifecycles but note its value in other industries •Address challenges in tracking responsibilities over long lifecycles (10-50 years) in the building and construction sector
2	**Supply-side focus**	Further policies are needed to influence on demand rather than supply	15	**Mandated EPRs for building sector**	Mandate EPR in construction to support segregated waste streams and recycling
3	**Consumer awareness of EPR**	Increase consumer awareness about producers' roles in product lifecycle, recycling and disposal	16	**Recycled content targets**	Set specific PwRC targets within EPR requirements to encourage usage
4	**Case studies and best practices**	•Share case studies and best practices to highlight successful product stewardship and EPR •Learn and adopt best practices from Europe in product stewardship and EPR	17	**Enforce supplier compliance**	•Introduce penalties to ensure procurers take policies seriously •Force suppliers and manufacturers to take responsibility for end-of-life impacts of their products
5	**Lifecycle impact responsibility**	Encourage companies to assess lifecycle impacts and take end-of-life responsibility	18	**Focus on longer product lifespans**	•EPR policies should encourage manufacturers to create materials with extended lifespans and multiple use cycles •Incentivise durable, reusable and improved supply chains by requiring suppliers to take back products
6	**Cultural shift needed**	Counter the "out of sight, out of mind" mentality prevalent in affluent countries	20	**Demand creation for PwRC through product stewardship**	Increase demand for PwRC by including them in product stewardship targets
7	**Extending EPR scope**	Extend EPR scope beyond packaging to cover other products	21	**Segmentation of EPR in construction**	•Segment EPR in construction to address unique handling of different building materials at end-of-life
8	**Business pressure**	Acknowledge that EPR may put pressure on businesses, posing potential implementation challenges	22	**Importer and free-rider prevention**	Mandatory EPR should include measures to prevent freeloading by imports and ensure all suppliers share responsibility
9	**Accessibility and cost of logistics**	Address logistics and cost that are key barriers to effective EPR implementation	23	**Robust tracking platforms**	Implement rigorous tracking platforms for effective EPR scheme management
10	**Scheme governance**	•Ensure EPR schemes are well-governed and support real recycling costs while actively creating markets for PwRC •Improve governance by inclusion of academic, community and governmental oversight for transparency and accountability	24	**Encouraging circular economy principles**	Embed CE principles throughout the product lifecycle
11	**Container deposit scheme model**	Implement a CDS-style refund model for a broader range of products	25	**Whole lifecycle design**	•Identify opportunities for sustainable materials and product reuse through whole-of-life design •Emphasises product design for reuse/recycling, including reverse logistics •Encourage manufacturers to implement take-back systems and design products for recycling •Encourage take-back systems and designs for recycling
12	**Limited impact on material selection**	Address how future recyclability focus may not influence initial material choices			
13	**Reporting and auditing**	Require regular reporting and external audits to maintain compliance and trust in EPR systems			

Penalties for illegal waste dumping

In the Australian C&D waste management environment, illegal dumping and long-term stockpiling pose significant challenges. While the National Waste Report[1] suggests that only 1% of C&D waste is from illegal dumping, anecdotal evidence suggests a larger percentage, especially in Northern Territory (NT) and WA. The existing literature finds a range of motives for illegal dumping and stockpiling. For instance, a study by Shooshtarian et al. (2020)[6] suggests that the presence of varying jurisdictional regulatory frameworks across Australia contributes to illegal dumping and long-term stockpiling. Two other studies[84,47] find that higher landfill levy rates can cause illegal dumping. Shooshtarian et al. (2020)[107] acknowledge the limited return of levy revenue to the C&D waste management sector as a barrier to effectively preventing illegal waste practices.

Australian states and territories address illegal dumping with substantial fines enforced by specialised task forces, coupled with ambitious targets aimed at reducing these practices[108]. However, penalties for illegal waste dumping vary across Australia's jurisdictions, with the highest being imposed in NSW, where offenders face up to $5M and/or seven year imprisonment (for wilful offences). In NT, Tas and ACT, the penalty is $5M (+/five years imprisonment), $1.59M (+/ five year imprisonment) and $1M (+/seven year imprisonment), respectively. This is followed by SA (up to $30K), WA (up to $125K), Qld (up to $217K) and Vic ($775K).

The state governments use waste strategy documents to guide efforts to reduce illegal dumping[81]. The overarching structure to guide these efforts include education (awareness-raising, stakeholder engagement); enforcement (evaluation and monitoring, regulations); and encouragement (infrastructure development, capacity building and networking).

The specific strategies to reduce illegal dumping and stockpiling include enhanced supervision by demolition companies to deter improper disposal[109], implementing standardised regulations with uniform levy fees[17,110] and allocating funds for educational programs[17]. Furthermore, adopting advanced technologies such as image processing, remote sensing and GIS[111,112] can provide effective oversight, enabling authorities to monitor and control illegal waste activities more efficiently. Lastly, for prevention of long-term stockpiling an upfront levy obligation can be implemented[81]. This approach applies a fee to waste upon arrival at disposal depots, incentivising quicker processing and reducing the likelihood of prolonged stockpiling. This method is currently practiced in NSW.

[107] Shooshtarian, S., Maqsood, T., Barrett, C., Wong, S. P., Yang, J. R. and Khalfan, M. (2020b) Opportunities to reduce brick waste disposal Imaginable Futures: Design Thinking, and the Scientific Method. 54th International Conference of the Architectural Science Association 2020, edited by e. a. Ali Ghaffarianhoseini, Virtual Conference: Auckland, New Zealand, 25-28 November.

[108] Zuo J and Zhao Z-Y (2014) 'Green building research–current status and future agenda: A review', Renewable and Sustainable Energy Reviews, 30:271-281

[109] Kabirifar, K., Mojtahedi, M. and Wang, C. C. (2021) A systematic review of construction and demolition waste management in Australia: Current practices and challenges, Recycling, 6(2), 34.

[110] Laviano, H., Jordan, B., Monica, T. and Noor, D. (2017) Waste and recycling industry in Australia: A Submission to the Senate Inquiry

[111] Glanville, K. and Chang, H.-C. (2015) Mapping illegal domestic waste disposal potential to support waste management efforts in Queensland, Australia, International Journal of Geographical Information Science, 29(6), 1042-1058.

[112] Ratnasabapathy S, Perera S and Alashwal A 2019b, A review of smart technology usage in construction and demolition waste management, Colombo, Sri Lanka, 8-10 November

Overview of Key Findings

- Approximately **75%** of participants reported being very to moderately familiar with this policy **(Figure 22a)**
- Approximately **68%** participants indicated that ***'Penalties for illegal waste dumping'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 22b)**
- About **53%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 22c)**
- Only **7%** of participants indicated that the policy's application might have some negative consequences **(Figure 22d)**
- Participants identified **two** potential negative impacts of this policy **(Table 24)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'improving the social image of end-user organisations'** and **'influencing decision making process for using PwRC' (Figure 22e)**
- They proposed **17 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 25)**

'Penalties for illegal waste dumping'

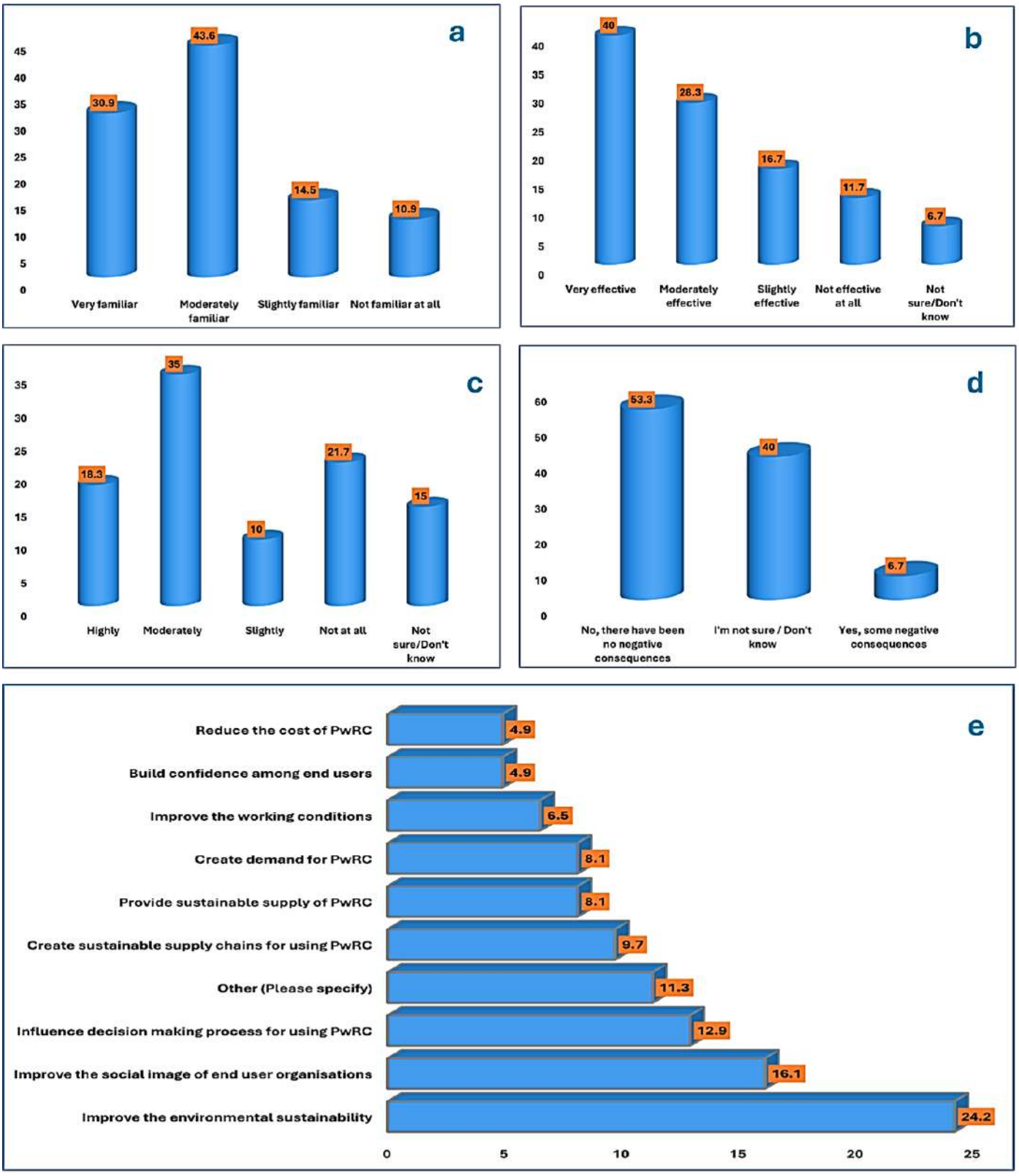

Figure 22. Participants' responses (frequency distribution %), penalties for illegal waste dumping. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 24. Key issues and impacts of implementing penalties for illegal waste dumping

No	Issue	Description
1	**Persistent illegal dumping**	Illegal dumping and disposal practices continue despite regulatory efforts, undermining waste management initiatives
2	**Creation of hidden illegal dump sites**	The policy inadvertently encourages the establishment of concealed dumping locations to avoid detection and regulatory fees
Positive impact		
Limiting harmful waste		Aims to limit harmful waste products in the environment, e.g., asbestos dumping
Penalty enforcement		Penalises wrong-doers, but only if they are caught

Table 25. Key measures to enhance the effectiveness of penalties for illegal waste dumping

No	Measures	Description	No	Measures	Description
1	**Awareness raising**	•Raise awareness among all stakeholders to prevent improper waste disposal •Launch public awareness campaigns to educate the construction sector on illegal dumping consequences and promote best practices •Fund campaigns educating stakeholders about PwRC benefits and proper waste disposal practices	10	**Enforcement and penalty increase**	•Increase penalties for illegal waste disposal to encourage responsible management and divert waste to recycling •Strengthen enforcement through increased monitoring, inspections and punitive measures to curb illegal dumping •Strengthen penalties, including higher fines and licence suspensions to deter repeat offenders •Use substantial penalties to deter offenders, avoiding the risk of penalties becoming just a business cost
2	**Responsibility**	Hold stakeholders accountable for waste disposal to ensure responsible practices	11	**Monitoring and inspection**	Implement systematic waste monitoring from collection to final destination, with regular inspections for effective implementation
3	**EPA and licensing**	•Advocate for EPA monitoring and licensing to strengthen regulatory frameworks •Significant regulatory enforcement is needed to address persistent illegal dumping issues	12	**Improved enforcement in non-levy and regional areas**	•Strengthen enforcement in regional and non-levy areas with improved waste transport and infrastructure •Address illegal dumping issues in regions, focusing on small companies and tradespeople
4	**Reward system for reporting**	Introduce a reward system to encourage reporting of illegal dumping incidents	13	**Recycling and safety**	Emphasise that a balance between recycling and safety is essential to prevent illegal dumping and promote recycling
5	**Industry collaboration**	Collaborate with industry associations to promote compliance and responsible waste management	14	**Illegal dumping linked to levy increases**	Illegal dumping rises with increased waste levies when recycling options are limited, highlighting the need for broader support
6	**Technology solutions for surveillance**	Invest in technology like surveillance cameras and drones can improve monitoring and catch offenders in real-time	15	**Supply chain support for recycling**	Develop recycling supply chains to encourage waste generators to choose recycling over landfilling
7	**Balance penalties with PwRC encouragement**	Find an appropriate balance between penalties and PwRC incentives to generate improved compliance and PwRC use	16	**"Name and shame" as deterrent**	Publicly identify offenders to deter illegal dumping and promote accountability
8	**Incentives for proper waste disposal**	Offer tax breaks to construction companies practising responsible waste disposal	17	**Support for LGAs**	•Support LGAs with collection efforts, especially for hazardous or difficult-to-manage waste •Provide adequate funding to local governments for better enforcement and waste management policy regulation
9	**Public-private partnerships**	Foster collaborations between government, law enforcement and private stakeholders to combat illegal dumping			

Restriction on the disposal of priority waste resources

Restricting the disposal of priority waste resources can incentivise the waste recovery sector by guaranteeing a consistent and sustainable supply of feedstock for facilities processing C&D waste. This approach not only supports the viability of recycling operations but also promotes the efficient use of waste materials that would otherwise end up in landfills.

In the Australian waste regulatory environment, priority waste resources are those with high disposal impacts (such as toxicity or greenhouse gas emissions), social impacts (such as community concern or amenity) or whose recovery would present resource savings or business opportunities[113]. However, not many C&D waste materials are classified as priority waste in Australian state and territory waste regulatory frameworks. For instance, in SA, from 21 waste materials banned from disposal at landfilling, only Polyvinyl Chloride (PVC) and aggregated metals fall under the C&D waste stream. In Vic, WA and Qld e-waste are banned from landfilling. In NSW, there is currently only one program aimed at banning household organics from landfill, which is scheduled to be implemented in 2030.

The disposal ban approach falls under three broad definitions of waste by source, by type and by property. In Europe, there have been a number of bans on, for example, unsorted waste, untreated waste, treated and/or untreated organic wastes (with specific properties) and combustible waste. The bans are defined by a mixture of all three waste categories[114].

[113] Queensland Government (2014) Waste–Everyone's responsibility. Available from https://shorturl.at/nyH04

[114] Dawkins E and P Allan (2010) Landfill ban investigation. Australian Government. Available from https://shorturl.at/DGJNR

Overview of Key Findings

- Approximately **45%** of participants reported being very to moderately familiar with this policy **(Figure 23a)**
- Approximately **61%** participants indicated that ***'Restriction on the Disposal of Priority Waste Resources'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 23b)**
- About **45%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 23c)**
- About **15%** of participants indicated that the policy's application might have some negative consequences **(Figure 23d)**
- Participants identified **five** potential negative impacts of this policy **(Table 26)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'providing sustainable supply of PwRC'** and **'influencing decision making process for using PwRC' (Figure 23e)**
- They proposed **16 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 27)**
- **~37%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **55%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Restriction on the Disposal of Priority Waste Resources'

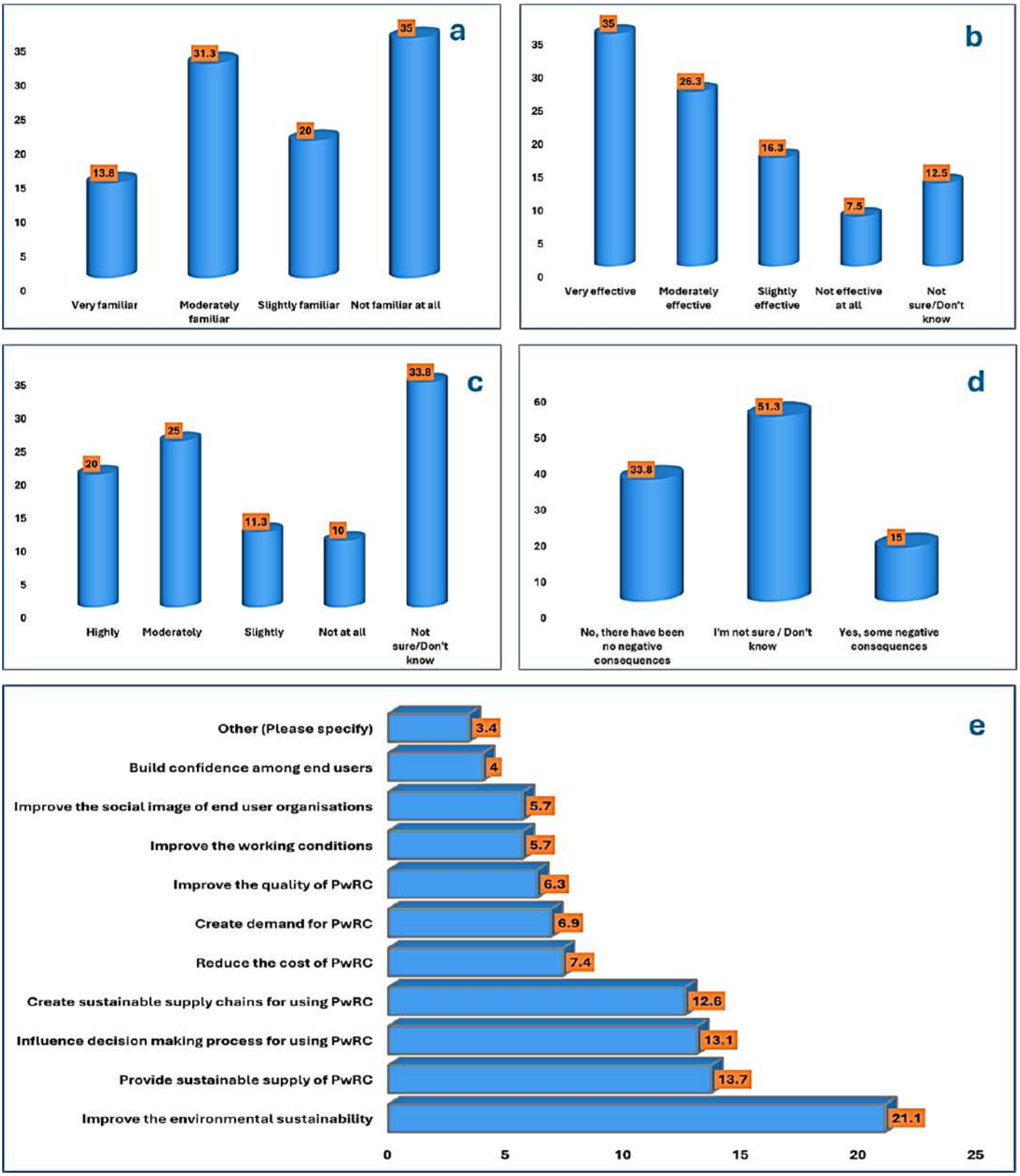

Figure 23. Participants' responses (frequency distribution %), restriction on the disposal of priority waste resources

Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 26. Key issues and impacts of implementing restrictions on the disposal of priority waste resources

No	Issue	Description
1	**Increased effort for hazardous material use**	Significant effort is needed to safely utilise potentially hazardous materials, with consideration of long-term environmental impacts
2	**Corporate lobbying for exemptions**	Large corporations may lobby regulators or governments for exemptions, which could undermine policy effectiveness
3	**Rise in illegal dumping activities**	The policy could drive an increase in illegal dumping activities as entities seek to bypass legal disposal methods
4	**Black market for illegal dumping**	Policies may inadvertently encourage the development of a black market for illegal dumping to avoid fees and regulations
5	**Limitations on innovation**	Strict policies may restrict innovation in recycling and reuse methods, limiting advancements in sustainable practices
Positive impact		
Investment confidence		Improves investment confidence in recycling infrastructure.

Table 27. Key measures to enhance the effectiveness of restrictions on the disposal of priority waste resources

No	Measures	Description	No	Measures	Description
1	**Landfill levy**	•C&D waste materials are rarely banned but levies and incentives could help push it away from landfill •While inert construction waste isn't usually banned from landfill, big levies can push it towards recycling facilities	9	**Accelerated permission for recycling**	Government support in approvals and fast-tracking licenses can help the recycling industry
2	**Financial incentives for recycling**	•Offer tax credits and grants to encourage companies to adopt PwRC and achieve higher recycling rates •Use incentives to reduce landfill disposal, promoting PwRC use and avoiding illegal practices •Balance landfill bans with incentives to encourage sustainable practices	10	**Flexible policies for innovation**	Flexibility is necessary to allow innovative solutions that align with policy intentions, ensuring practicality and encouraging compliance
3	**Effective project design process**	•Implement effective project design process and material selection •Promote modular and easily deconstructable materials to maximise recovery in construction and demolition projects	11	**Market development initiatives**	•Invest in market promotion for PwRC, support demonstration projects and run campaigns on PwRC benefits •Support the creation of local markets a nd dependable supply chains, it is essential for recycling hazardous and priority waste materials effectively
4	**Higher value PwRC potential**	Promote the use of higher-value PwRC to benefit both industry and the environment	12	**Development of recycling facilities**	•Emphasise that a balance between recycling and safety is essential to prevent illegal dumping and promote recycling •Recycling infrastructure is necessary for effective sorting and separation before processing, diverting them from landfill effectively
5	**Industry education and awareness**	•Promote industry awareness and education on proper material handling •Increase industry awareness on their responsibility in waste management •Highlight that diverting waste from landfill supports environmental sustainability and generates economic benefits through PwRC sale	13	**Hazardous waste management**	•Encourage industry to properly manage hazardous materials, diverting them from landfill •Due to limited locations, valuable or hazardous waste materials often end up in general waste, necessitating broader awareness for proper disposal practices •Use science-based restrictions to prevent hazardous waste from entering landfills and improve compliance •Encourage organisations to embed disposal practices for valuable or hazardous materials within core operations
6	**National EPR implementation**	•Federal intervention can enforce manufacturer responsibility, especially for toxic or long-lived chemicals in waste that local/state policies cannot effectively manage •Make manufacturers responsible for end-of-life disposal which may also incentivise PwRC adoption	14	**Effective waste regulations**	•Develop clear regulations that discourage free-riding and ensure competitors in the recycling sector follow responsible practices •Differences in regulations for floor renovations versus new builds create loopholes, often leading to incomplete hazardous material assessments
7	**Potential for stockpiling**	Address risks of stockpiling or illegal disposal when landfill bans lack complementary demand-side policies	15	**Mandatory sorting and separation**	Require on-site sorting and separation of construction waste to support recycling and reuse efforts
8	**Mandated use of PwRC in public projects**	•Mandate PwRC use in public projects to boost demand and strengthen recycling infrastructure •Prioritise PwRC in government-funded construction projects to drive demand and support sustainable practices •Bans need to be enforced alongside policies mandating PwRC use to avoid unintended consequences	16	**Incorporation of industry insight**	•This policy should incorporate industry insights rather than solely serving political agendas to address underlying issues •Industry collaboration with government to establish high standards and consistent regulations ensures effective implementation of waste disposal policies

Accelerated permission for on-site recycling

This policy is a regulatory or administrative process designed to fast-track the approval of temporary waste recovery facilities that are conducted on-site. Accelerated permission for on-site recycling can facilitate the uptake of PwRC in the building and construction sector. On-site recycling typically offers greater environmental and economic benefits compared to off-site recycling. This is because transporting waste resources between the construction site and recycling facility incurs costs and emissions.

In a research project concluded in 2023[115], it was found that the absence of this policy poses a significant challenge to reusing PwRC in construction projects. For instance, in a government-led residential development project in WA, the initial plan was to recover demolition waste on-site and utilise the resulting PwRC. However, securing approval for on-site recycling took almost 12 months, which significantly prolonged the project's timeline[116]. Currently, no state in Australia offers fast-tracked permission for on-site recycling of C&D waste resources. One study in Hong Kong[117] identified the key barriers and facilitators of on-site recycling for construction and demolition projects (Figure 24). One key barrier was found to be 'lack of government policy support' which was further suggested to be addressed by 'providing more government support'.

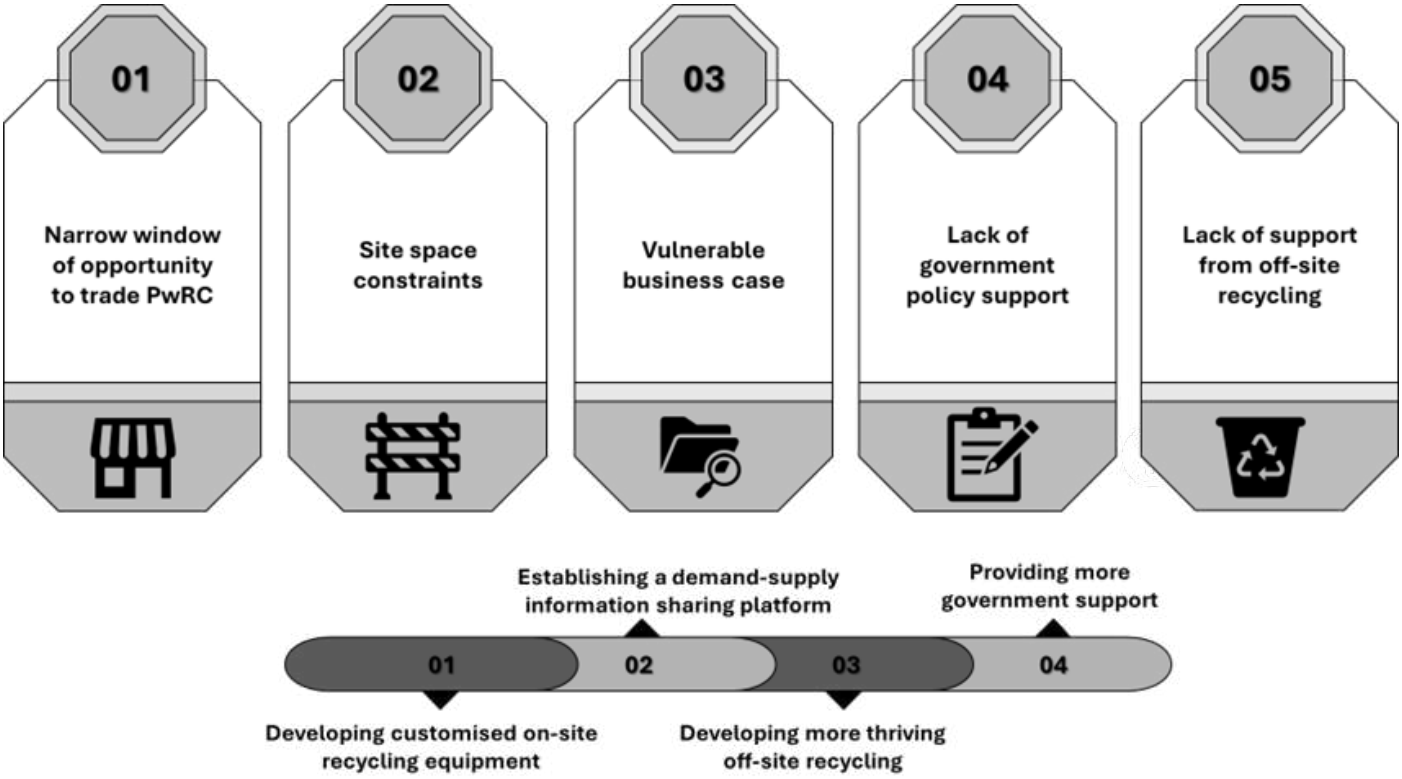

Figure 24. Major barriers and facilitators of on-site recycling
Source: Adapted from Bao et al (2020)[117]

[115] Shooshtarian S, Maqsood T, Zaman A, Caldera S, Ryley T and Wong PSP (2024) 'Enhancing the use of products with recycled contents in the Australian construction industry'. Nova Science Publishers. P. 238. Doi: 10.52305/KKEK0064

[116] Murray RL (2019) Construction and demolition waste in Western Australia: a case study on best practice demolition. Honours Thesis. Murdoch University. https://shorturl.at/dmRT0

[117] Bao, Z., Lee, W.M. and Lu, W., (2020). Implementing on-site construction waste recycling in Hong Kong: Barriers and facilitators. Science of the Total Environment, 747, p.141091.

Overview of Key Findings

- Approximately **36%** of participants reported being very to moderately familiar with this policy **(Figure 25a)**
- **54.6%** participants indicated that **'Accelerated Permission for On-site Recycling'** can be very to moderately effective in optimal use of PwRC in construction **(Figure 25b)**
- About **34%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 25c)**
- About **10%** of participants indicated that the policy's application might have some negative consequences **(Figure 25d)**
- Participants identified **seven** potential negative impacts of this policy **(Table 28)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'reducing the cost of PwRC'** and **'influencing decision making process for using PwRC' (Figure 25e)**
- They proposed **12 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 29)**
- **~23%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **65%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Accelerated Permission for On-site Recycling'

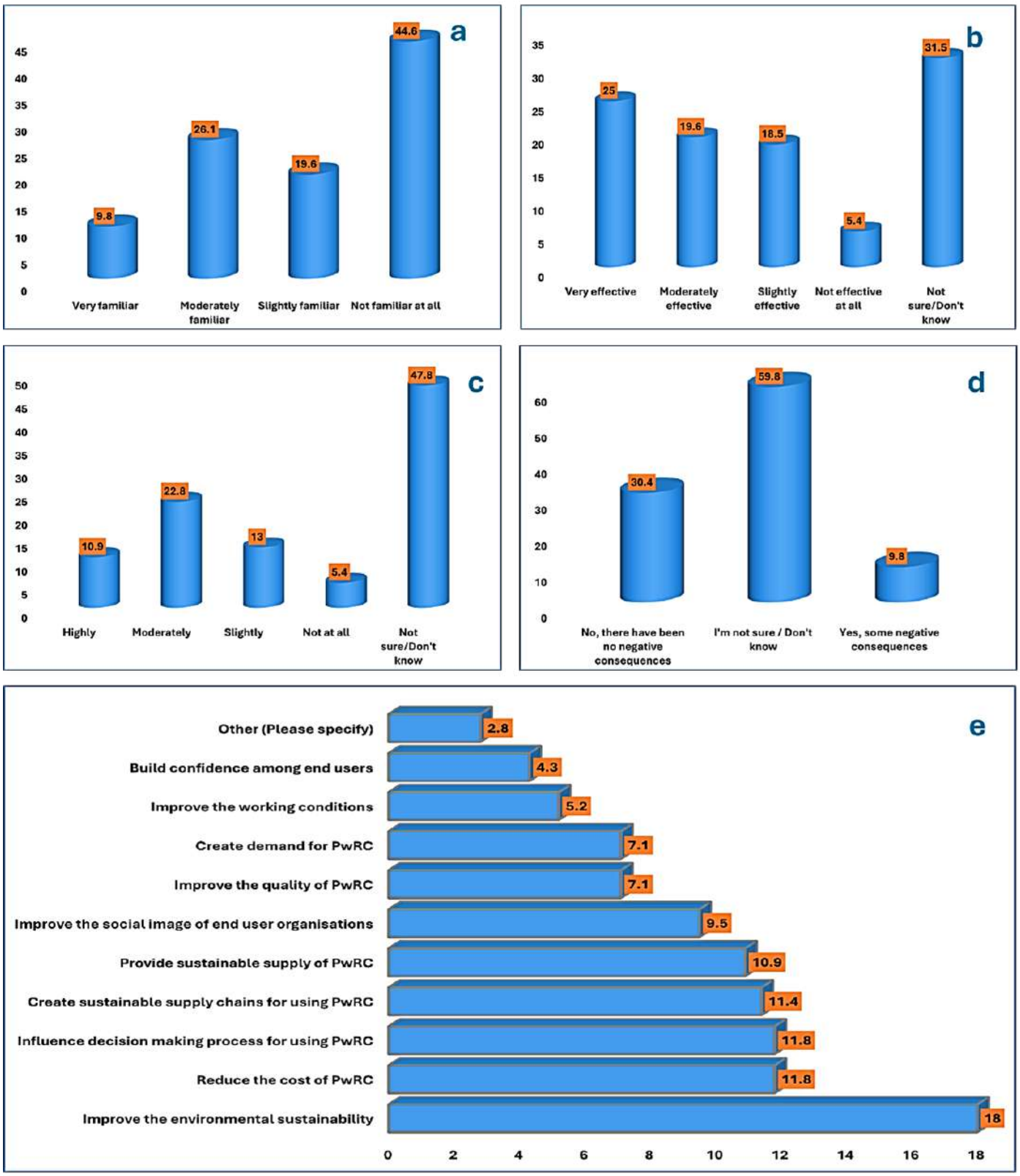

Figure 25. Participants' responses (frequency distribution %), accelerated permission for on-site recycling. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 28. Key issues and impacts of implementing accelerated permission for on-site recycling

No	Issue	Description
1	**Local environmental impacts**	• Potential for contamination, especially if recycling activities occur onsite, leading to local environmental issues like noise and odour • Policies can lead to local impacts, such as increased noise, dust and potential safety hazards, affecting surrounding communities • Local residents may experience inconvenience from policy impacts, including noise, odour and dust from nearby construction or recycling activities
2	**Limited project capacity**	Not all projects have the capacity or resources to effectively implement this policy, reducing its overall impact
3	**Quality of PwRC**	There is a risk that PwRC may not meet minimum quality requirements, potentially compromising construction integrity
4	**Fast-track safety risks**	Fast-tracked projects may overlook necessary safety considerations, which could result in long-term environmental and structural issues
5	**Lack of scale and optimisation**	Policies are not yet applied at a large enough scale to achieve optimal efficiency and effectiveness
6	**Limited by Australia's import dependency**	Australia's status as a net importer limits the impact of local recycling efforts
7	**Risk of contaminated materials**	Use of contaminated materials on construction sites, due to lower costs, poses safety and environmental risks if not properly managed
Positive impact		
Potential for lower operational costs		Streamlined approvals and on-site recycling incentives lower operational costs, benefiting businesses and the environment.
Innovation encouragement		It encourages innovative recycling concepts specific for construction sites
Increased volume with efficiency		Streamline processes to increase material availability and improve waste processing efficiency
Emission reduction		On-site recycling reduces costs and emissions by eliminating transport and double handling

Table 29. Key measures to enhance the effectiveness of accelerated permission for on-site recycling

No	Measures	Description	No	Measures	Description
1	**Acknowledging limitations**	Off-site processing may remain necessary in areas lacking sufficient space for on-site recycling	7	**Innovation encouragement**	Encourage innovative recycling concepts specific for construction sites to enable new solutions and supply chain expansion
2	**Circular design practice**	Encourage recyclable materials in project designs and builds	8	**Government-industry collaboration**	Foster collaboration between industry and government to establish best practices for on-site recycling and sustainable waste handling
3	**Quality assurance and certification**	•Ensure qualified inspectors certify material quality to meet design specifications •Implement a system to ensure on-site generated PwRC meet quality standards would build confidence in their reuse •Perform quality assurance for PwRC to ensure their safety and compliance with design specifications; promoting trust in the construction industry's use of PwRC	9	**Technical and financial support**	•Provide financial incentives and technical guidance to encourage investment in recycling infrastructure •Standardised guidelines for on-site recycling, supplemented with quality audits, can increase safe recycling operations •Government support fosters sustainable practices and innovation in the industry •Incentives for on-site recycling reduce operational costs, benefiting both businesses and the environment
4	**Investment in waste recovery infrastructure**	•Boost confidence in recycling infrastructure investment to support market demand for PwRC •Provide low-interest loans or subsidies to promote recycling facility investment	10	**Encourage local recycling to reduce emissions**	Enable more local recycling options to cut emissions from material transport
5	**Process simplification**	•Simplify processes to promote recycling, lower waste volumes and improve waste management •Streamline processes to increase material availability and improve waste processing efficiency	11	**Prioritise trusted organisations**	•Fast-track approvals for trusted organisations that meet quality standards to lower entry barriers and increase recycling output •Fast-track permits for trusted companies and set guidelines for on-site checks to support PwRC growth •Streamline approvals for trusted companies to retrofit existing sites to encourage broader adoption of recycling practices
6	**Health and safety concerns**	•Balance regulatory approaches to maintain safety while supporting efficient recycling operations •Understand and address work health and safety impacts to prevent unintended consequences •Subject on-site processes to EPA risk analysis to ensure compliance and minimise environmental impacts •Address noise and dust control to reduce community opposition to recycling facilities	12	**Education and case studies**	•Highlight successful examples to encourage adoption and sustainable practices across the industry •Educate policy makers on how quicker approvals lead to lower set-up costs, encouraging companies to start recycling sooner •Highlight that on-site recycling reduces costs and emissions by eliminating transport and double handling •Communicate that streamlined processes can reduce costs and emissions, delivering economic and environmental benefits

Demolition deposit-refund

The deposit refund policy involves mandated financial security for eligible construction and demolition projects, designed to ensure the responsible recycling and disposal of C&D waste materials. Although this policy is not yet fully developed or implemented across Australia, some local governments require a demolition deposit as a condition for development approval. However, these existing deposit schemes typically overlook critical aspects such as deconstruction, waste segregation and on-site recycling, limiting their effectiveness in promoting sustainable waste management practices.

This policy has been successfully implemented overseas for several years. For example, in certain Canadian cities, developers are required to pay a refundable fee to obtain demolition permits. This fee is reimbursed once they demonstrate that at least 75% of their demolition waste has been recycled[118]. Various models have been proposed to illustrate the application of this policy in the building and construction sector[119,120]. For instance, Liu et al (2019)[120] introduced a six-step model that provides a structured approach to implementing the policy:

(1) Firstly, the project owner (developer) estimates the C&D waste of a project and then submits the waste assessment report to the waste regulatory body that will inform the owners to submit a deposit. The amount of the payment depends on the type of the project involved and the waste assessment report.

(2) The owner submits a pre-deposit, and the body issues a construction permit for the construction or demolition of the project.

(3) Based on the waste assessment report, the owner will make a construction waste management plan in person, or by entrusting a contractor, specialised in resource recovery, to be then implemented by a contractor.

(4) Contractors treat the C&D waste according to the waste management plan, such as transporting waste materials to recycling sites or conducting on-site recycling.

(5) After the completion of the project, the Waste Assessment Centre will evaluate the waste treatment of the project and decide whether or not to issue the waste disposal certificate to the owner and contractor depending on the assessment results. The Centre is an organisation belonging to the waste regulatory body.

(6) The body then returns the pre-deposit to developer. In the meantime, it will make cost compensation or reduce the tax to the contractor. If the compensation is taken, the amount of compensation will be multiplied by the appropriate proportion based on the construction waste estimate report and the disposal cost.

[118] Chen, Z., Feng, Q., Yue, R., Chen, Z., Moselhi, O., Soliman, A., Hammad, A. and An, C., 2022. Construction, renovation, and demolition waste in landfill: a review of waste characteristics, environmental impacts, and mitigation measures. Environmental Science and Pollution Research, 29(31), pp.46509-46526.

[119] 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.

[120] Liu, J., Teng, Y., Jiang, Y. and Gong, E., 2019. A cost compensation model for construction and demolition waste disposal in South China. Environmental Science and Pollution Research, 26, pp.13773-13784.

Overview of Key Findings

- Only **23.6%** of participants reported being very to moderately familiar with this policy **(Figure 26a)**
- **~40%** participants indicated that ***'Demolition Deposit-Refund'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 26b)**
- About **83%** of participants indicated uncertainty regarding the effectiveness of the current implementation of this policy **(Figure 26c)**
- Around **79%** of participants expressed a lack of awareness about potential negative consequences associated with the application of this policy **(Figure 26d)**
- Participants identified **one** potential negative impacts of this policy **(Table 30)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'providing sustainable supply of PwRC'** and **'influencing decision making process for using PwRC' (Figure 26e)**
- They proposed **18 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 31)**
- **~34%** of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **~47%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Demolition Deposit-Refund'

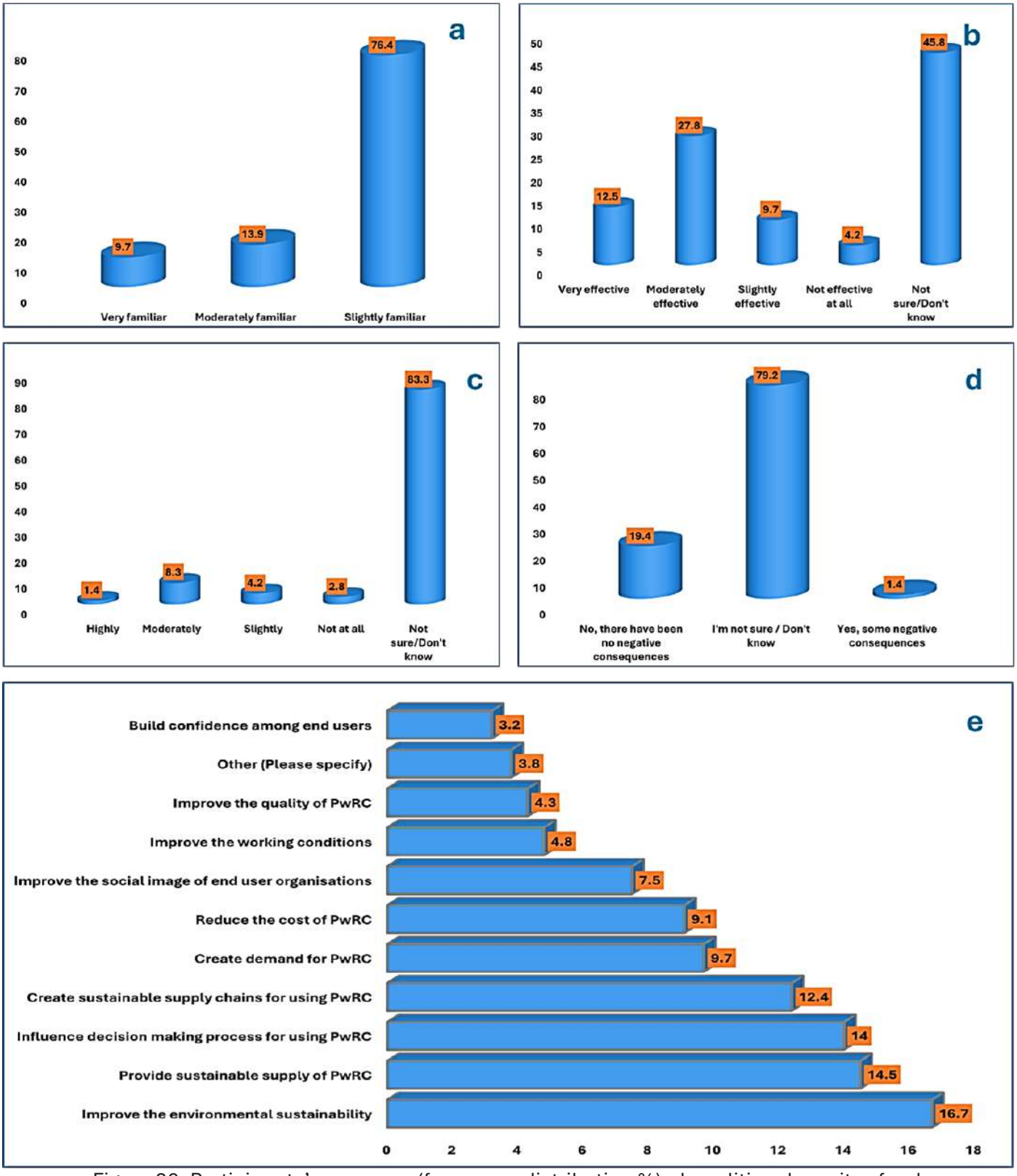

Figure 26. Participants' responses (frequency distribution %), demolition deposit-refund. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 30. Key issues and impact of implementing demolition deposit-fund policy

Issue	Description
Pushback from businesses with tight cash flow	Businesses with limited cash flow may resist implementing the policy due to the financial strain it imposes, potentially reducing overall compliance
Positive impact	
Incentive for circularity	Incentives like deposit/refund schemes can encourage circular practices in construction, supporting CE goals

Table 31. Key measures to enhance the effectiveness of demolition deposit-refund policy

No	Measures	Description	No	Measures	Description
1	**Recycling and disposal awareness**	•Raising awareness to encourage about recycling and disposal of C&D waste encourages early adoption of PwRC materials in project designs •Raise awareness of recycling locations, such as Community Recycling Centres, to prevent improper material disposal •Increase awareness about material disposal to create more responsibility around waste management and reuse •Highlight that the incentives like deposit/refund schemes to support circular practices in construction	10	**Combined application of CE policies**	•Combine policies like demolition deposit schemes with other frameworks to strengthen waste management practices •Integrate construction recycling incentives with CE policies to enhance adoption industry-wide •Use incentives like deposit/refund schemes to support circular practices in construction. •If on-site recycling is mandated, the policy could better support circularity in the sector
2	**Effective demolition planning**	Proper demolition planning can improve material supply and waste segregation for recycling and reuse in the construction sector	11	**Streamlined policy procedures**	•Streamline deposit/refund systems to reduce barriers and encourage responsible waste management •Establish a simplified approach to encourage recycling in smaller projects without imposing too many procedural burdens
3	**Immediate supply availability**	Enabling recycling practices to ensure a ready supply of materials, minimising potential project delays	12	**Enforcement on large organisations**	Implement deposit schemes first for larger companies to ease adoption and reduce pressure on smaller enterprises
4	**Transportation and accessibility**	Availability of accessible recycling facilities and proper transportation options supports material recycling efforts	13	**Prevention of stockpiling**	Address potential stockpiling through complementary measures and supply chain support
5	**Circularity model requirement**	Establish effective circularity models to meet recycling and disposal demand in construction sector	14	**Refund amount**	Ensure sufficient refund amounts to encourage effective waste management and support circularity in construction
6	**Recycling infrastructure development**	Develop new recycling facilities to meet growing recycling demands	15	**Adaptation for market and policy needs**	Align recycling incentives with local and federal policies to encourage innovation and adaptability in recycling
7	**Policy impact on supply chain**	Highlight that diverting material from landfill can help build recycling infrastructure and improve supply chain efficiency	16	**Addressing asbestos concerns**	Market development and asbestos contamination concerns must be addressed for safe material reuse
8	**Partnership with waste industry**	•Collaborate with industry to encourage recycling, efficient demolition and PwRC use •Partnership between recycling businesses and demolition contracts to reduce waste management costs and improve waste diversion outcomes	17	**Financial incentives for waste management**	•Provide financial incentives like refunds to offset waste management costs and divert waste from landfills •Incentives could foster a new deconstruction market, supporting CE efforts in the building sector
9	**Tracking system**	•Develop material tracking systems and offer higher returns for valuable materials to promote waste management •Implement consistent tracking systems from demolition to recycling for quality control and environmental impact management	18	**Applicability challenges**	Address challenges like brand ownership and long-term deposit management in buildings with extended lifespans

Proximity principle

The underlying concept of this policy is to compel companies that create waste to deliver it to a location for processing that is within a particular distance from where it originated. The application of the proximity principle (PP) can help stop waste transport from one location to another to avoid and minimise levy liabilities. The need for implementation of this policy was highlighted in submissions to the Environment and Communications References Committee (2018)[110]. In NSW, the PP was introduced in 2014 to limit the transportation of waste over long distances, aiming to reduce environmental impacts and encourage local waste management. This regulation prohibited transporting waste more than 150 kilometres from its origin unless it was to one of the two nearest lawful disposal facilities. The Waste Contractors and Recyclers Association of NSW argues that the adoption of a nation-wide PP would lead to better outcomes. In turn, the Law Council of Australia (LCA) argues that any nation-wide PP must consider the Constitution's Section 92 stipulation that commerce and trade between Australian states must be completely free.

Meanwhile, the Waste Management Association of Australia (WMRR) submits that long-distance waste transportation must cease, stating 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).

Another contentious aspect of the PP is the need for authorities to carefully consider its broader environmental impacts. Critics argue that while the PP aims to reduce waste transport distances, the environmental benefits may be undermined if local facilities lack the capacity or technology for effective processing. In some cases, limiting transport could lead to inefficient waste treatment or increased reliance on landfills, which may offset the intended environmental gains of the policy. Furthermore, it is argued that market development for PwRC may rely on the exchange of waste materials (both recovered and unrecovered) across various regions as it supports and maintain sectors and companies within the economy.

To address the impact of this policy on the Australian context, the government and the waste recovery industry have pledged that they will create an effective, long-term national market for the trade of Australian waste products[121]. To address the impact of this policy on the Australian context, the government and the waste recovery industry have pledged that they will create a robust, effective, self-sustaining, long-term national market for the management and trade of Australian waste products domestically. PP policy objectives align with these objectives by encouraging shorter, more efficient waste transport and minimising environmental impact, supporting Australia's transition towards CE.

[121] WMRR (2023) Strategic Business Plan 2023-2026. Waste Management and Resource Recovery Association of Australia. https://bit.ly/3V5XVF1

Overview of Key Findings

- Approximately **47%** of participants reported that they are not familiar with this policy **(Figure 27a)**
- Around **47%** participants indicated that ***'Proximity Principle'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 27b)**
- Around **54%** of participants expressed a lack of awareness about potential negative consequences associated with the application of this policy **(Figure 27c)**
- About **9%** of participants indicated that the policy's application might have some negative consequences **(Figure 27d)**
- Participants identified **seven** potential negative impacts of this policy **(Table 32)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'reducing the cost of PwRC'** and **'influencing decision making process for using PwRC' (Figure 27e)**
- They proposed **15 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 33)**
- **~34%** of participants who supported the national application of CE policies recommended that this policy be implemented nationwide **(Figure 32b)**
- **~42%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Proximity Principle'

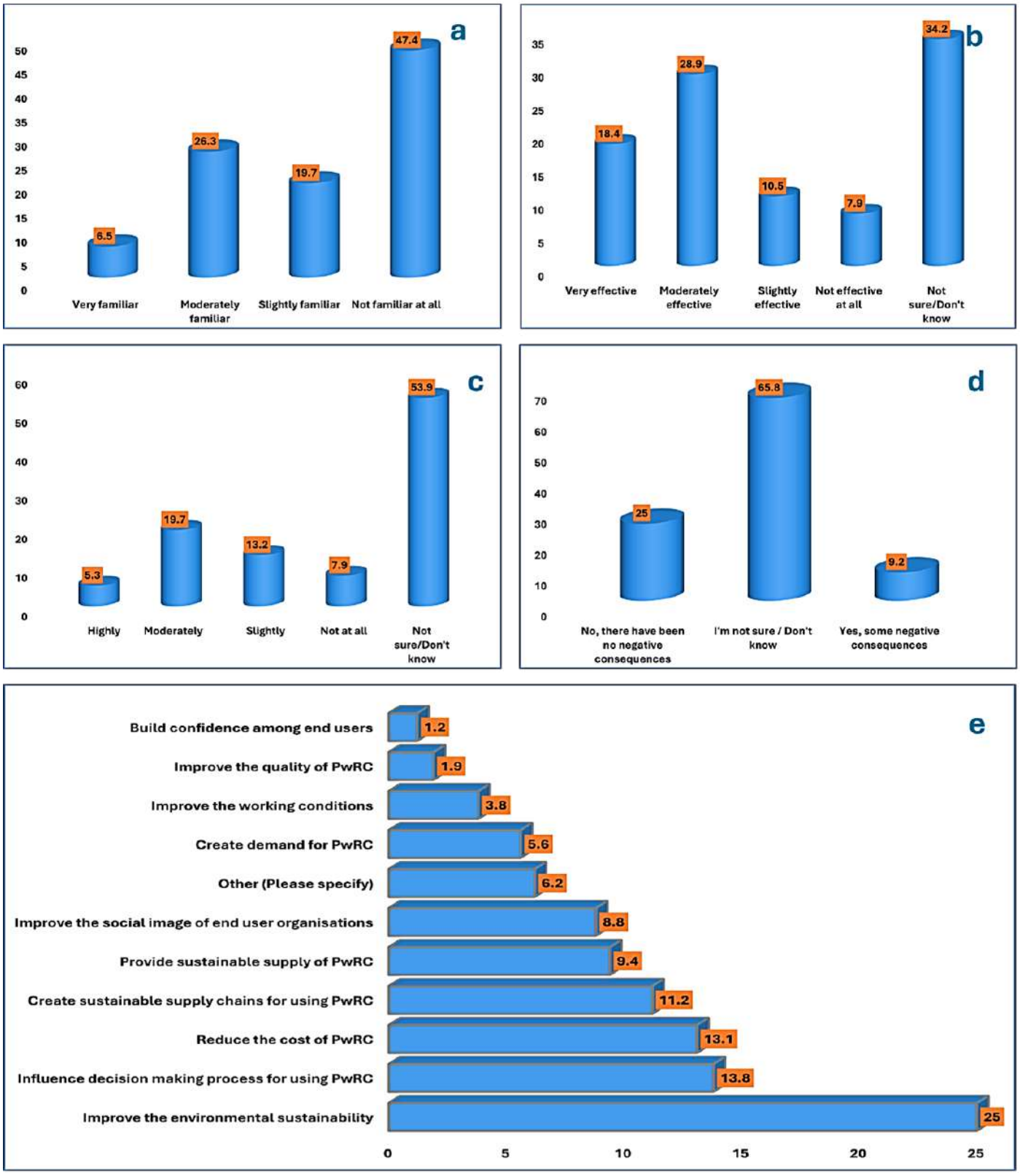

Figure 27. Participants' responses (frequency distribution %), proximity principle. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 32. Key issues and impacts of implementing proximity principle policy

No	Issue	Description
1	**Site location in regional areas**	The policy may not be feasible for regional areas where access to recycling facilities and resources is limited
2	**Location suitability**	The policy may be inappropriate for certain areas, such as highly developed suburbs, where recycling and waste management infrastructure is limited or unsuitable
3	**Recyclable commodities treated as waste**	Treating recyclable materials as waste can undermine recycling efforts and result in lost opportunities for reuse
4	**Proximity requirements**	The need for proximity to recycling facilities may limit options for projects, particularly those outside the policy's boundary, stifling some opportunities
5	**Economic structure limitations**	The current economic setup may not fully support the policy's recycling and CE initiatives, limiting its effectiveness
6	**Waste flow to Queensland**	Waste continues to be sent to Qld, highlighting enforcement challenges and difficulty in administering cross-border regulations
7	**Incentive for illegal dumping**	The policy might unintentionally incentivise illegal dumping as businesses seek to avoid costs and restrictions
Positive impact		
Social outcomes		Ensures traceability of materials within the supply chain
Carbon emissions		• At best, lowers carbon emissions created from logistics • Reduced carbon emissions
Market development		A proximity principle for construction and demolition waste can support a regional recycling market and reduce emissions
Job creation		Local recycling reduces emissions and supports job creation in the recycling industry, contributing to market development

Table 33. Key measures to enhance the effectiveness of proximity principle policy

No	Measures	Description	No	Measures	Description
1	**Regional recycling hubs**	•Develop community hubs, like council tip stores, to facilitate material exchange and promote local reuse and CE practices •Facilitate material exchange and encourage circular practices through community recycling hubs	9	**Government mandates**	•Mandate local sourcing for government projects to drive demand for local PwRC •Prioritise local recycling for public projects to boost the local economy and reduce the carbon footprint •Enact policies promoting proximity-based waste management and local PwRC usage to strengthen sustainable practices
2	**On-Site recycling**	Encourage on-site recycling to reduce transportation needs and enhance waste processing efficiency on the construction site	10	**Online material exchange**	Use online platforms for material exchange to support local reuse and circularity in construction projects
3	**Addressing regional adaptation challenges**	•Address challenges in implementing proximity practices in rural or geographically dispersed areas •Support infrastructure that enables sustainable local disposal and recycling, particularly in remote areas	11	**Development of eco-parks**	•Foster circular material flows through industrial hubs or eco-parks •Promote local processing and reuse of PwRC through eco-parks and industrial symbiosis
4	**Incentives for local sourcing**	Offer financial incentives for local sourcing to support the economy and lower emissions from long-distance transport	12	**Standardised reporting**	Use standardised reporting to monitor local emissions savings and improve compliance and performance tracking
5	**Industry education & public awareness campaigns**	•Provide education on the benefits of PwRC and proper recycling techniques fosters support for local waste management •Educate stakeholders on PwRC benefits to build broader support and demand for sustainable construction practices •Provide education to contractors on local waste processing and recycling practices promotes compliance with proximity principles	13	**Defined policy radius**	•Specify a policy radius based on proximity to recycling facilities to prioritise local processing •Define clear boundaries for waste processing policies to align with environmental goals and support local suppliers •Engage recyclers in defining boundary areas to ensure policies meet industry needs effectively
6	**Additional frameworks required**	Implement additional frameworks to support circularity in the building and construction sector	14	**National harmonised application**	Expand proximity initiatives nationally to enhance waste reduction efforts
7	**Impact on early design decisions**	Integrate waste diversion targets into early project designs to reduce transport needs and support CE objectives	15	**Balancing supply and demand**	•Align supply and demand for PwRC in local sourcing to improve sustainability without reducing reusability efficiency •Partner with local recycling centres to integrate PwRC into construction supply chains, reducing reliance on virgin resources •Source locally to reduce transportation and support emissions reduction targets
8	**Availability of recycling options**	•Ensure sufficient recycling facilities are near construction sites for effective local waste management •Promote local recycling centres near construction sites, reducing waste transportation and increasing local PwRC adoption •Recognise that insufficient local facilities can increase transportation distances, limiting proximity policy impact			

Ban on the export of C&D waste resources

The policy involves bans implemented by a government or an authority to prohibit or restrict the export of C&D waste materials to other countries. In Australia, the regulatory responsibility for exporting waste materials was shifted from the state level to the national level in 2020. In this year, Australian governments agreed that the export of some waste materials (tyre, plastic, glass, paper and cardboard) would be regulated by the federal government[122]. Following this agreement, *Recycling and Waste Reduction Act 2020*[123] was developed to provide statutory power to waste exports ban. This Act, however, does not include a ban on the export OF C&D waste resources.

Nevertheless, glass, plastic and cardboard arising from C&D activities are subject to this regulation. For instance, this includes materials like plastic or cardboard used in packaging construction materials. An export ban can serve as a significant incentive for recycling, prompting further investment in waste recovery facilities and technologies. This, in turn, enhances the quality and cost-effectiveness of PwRC, leading to its optimal adoption within the sector. It also instils confidence in the waste recovery industry, ensuring that sustainable feedstock is available for waste recovery facilities. The findings from a survey[124] revealed that only 23.5% of stakeholders indicated that the ban on waste imports by foreign countries (e.g., China, Malaysia and Thailand) had a negative impact on Australian C&D waste management.

This policy should be pursued in conjunction with capacity building in the waste recovery industry and the stimulation of markets for PwRC. Otherwise, it could lead to the accumulation of large stockpiles of recyclables or PwRC, which can pose various risks, including the risk of fire[125].

[122] Australian Government (2021) Waste exports. Department of Climate Change, Energy, the Environment and Water. Available from https://www.dcceew.gov.au/environment/protection/waste/exports

[123] Australia Government (2021). Recycling and Waste Reduction Act 2020. https://www.legislation.gov.au/C2020A00119/latest/text

[124] Shooshtarian, S., Maqsood, T., Wong, P., Khalfan, M. and Yang, R. (2021) The impact of new international waste policies on the Australian construction and demolition waste stream, 44th AUBEA 2021: Construction Education – Live the Future, Virtual, 17-20 October, 2021, 635-644.

[125] ACOR (2022) Waste and Recycling Industry Fire Forum Report. https://bit.ly/3AC4ngc

Overview of Key Findings

- Approximately **58%** of participants reported being very to moderately familiar with this policy **(Figure 28a)**
- **50%** participants indicated that ***'Ban on the Export of C&D Waste Resources'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 28b)**
- Around **47%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 28c)**
- Around **47%** participants indicated that the policy's application might have some negative consequences **(Figure 28d)**
- Participants identified **fourteen** potential negative impacts of this policy **(Table 34)**
- The three primary ways this policy can boost PwRC use include **'creation of sustainable supply chains for using PwRC', 'providing sustainable supply of PwRC'** and **'improving the environmental sustainability' (Figure 28e)**
- They proposed **11 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 35)**
- **~51%** of participants who supported the national application of CE policies recommended that this policy be implemented nationwide **(Figure 32b)**
- **~53%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Ban on the Export of C&D Waste Resources'

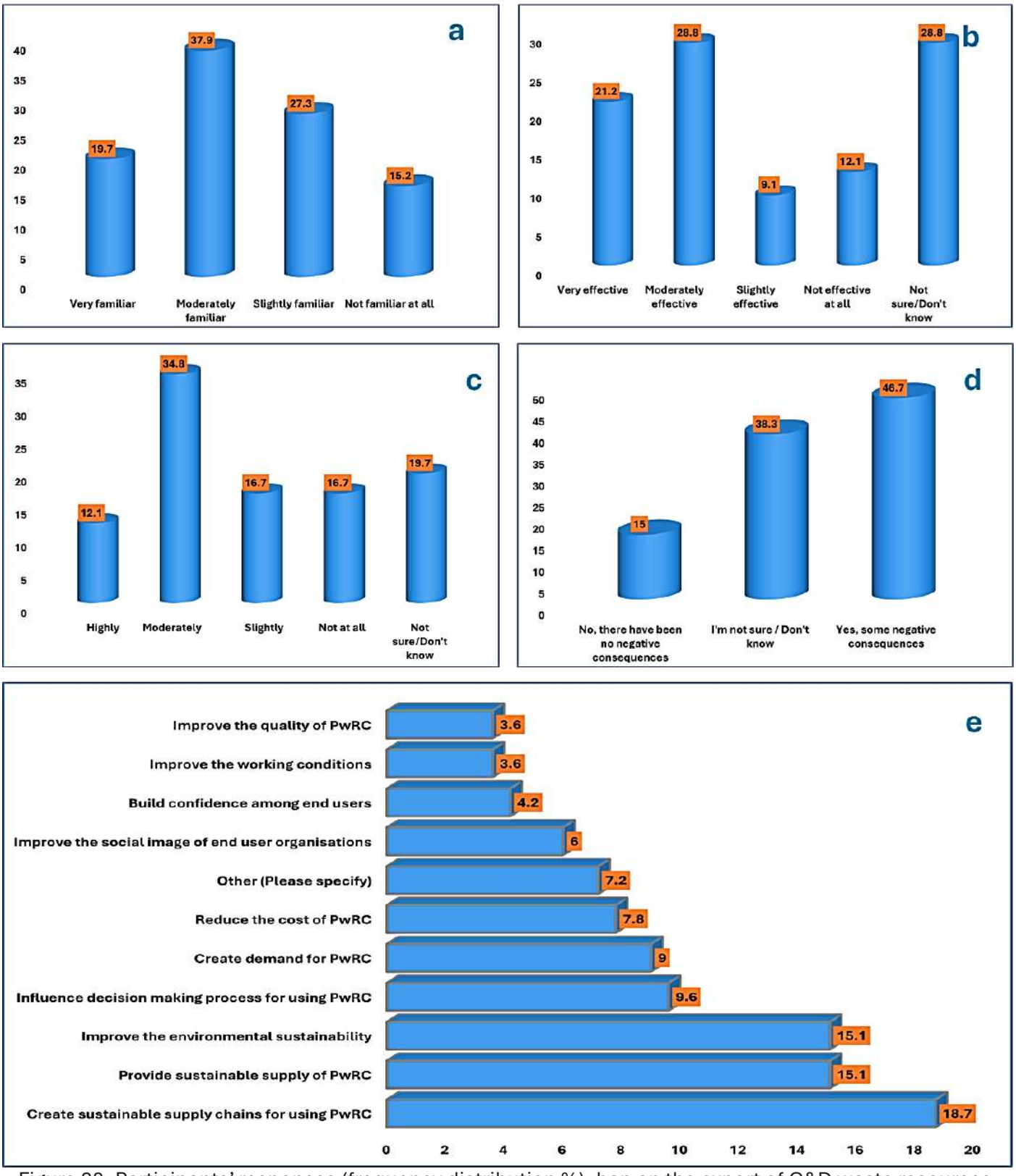

Figure 28. Participants' responses (frequency distribution %), ban on the export of C&D waste resources. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 34. Key issues and impacts of implementing ban on the export of C&D waste resources policy

No	Issue	Description
1	**Illegal dumping and disposal of waste**	Waste materials continue to be illegally dumped, bypassing proper disposal channels and causing environmental issues
2	**Avoiding waste transport costs**	Policies may incentivise avoiding transport to regions with better or cheaper treatment, leading to inequities in waste management
3	**Inadequate recycling facilities**	Certain recyclable wastes may not be processed due to a lack of local facilities capable of handling them, limiting recycling potential
4	**Poor waste management due to capacity issues**	Insufficient capacity in waste management facilities results in improper handling of waste materials
5	**Need for matured local markets**	• Without local markets for PwRC, waste may end up in landfills or be illegally dumped, increasing environmental risks • The underdeveloped Australian market struggles to absorb all C&D waste generated, leading to difficulties in reclaiming valuable materials • Without sufficient market demand, recycling may not occur, as global warming solutions require international collaboration
6	**Contamination management**	Contaminants, such as asbestos, need to be managed carefully to prevent health hazards in PwRC
7	**Illegal export of contaminated materials**	Contaminated waste may be exported illegally due to high domestic treatment costs, circumventing regulations
8	**Stockpiling of waste materials**	• Bans on certain waste exports can lead to unintended consequences, such as increased stockpiling and local landfill use • The industry struggles to manage the volume of waste generated, leading to stockpiling due to insufficient processing infrastructure
9	**Import/export imbalance**	Banning exports without restricting imports results in accumulating low-quality materials domestically, worsening the waste problem
10	**Soft plastics export ban impact**	Australia's ban on exporting soft plastics has led to oversupply and supply chain issues, highlighting the need for more recycling facilities
11	**Misuse of high-priority waste materials**	Using critical waste materials in unsuitable applications prevents recycling at end-of-life, reducing CE effectiveness
	Positive impact	
Ban on the export of high value waste materials		Industries like steel and aluminium are still exporting to Asia, which should stop to support local jobs and industry
Minimising carbon footprint		Restricting exports reduces emissions from transport, supporting the carbon goals of CE policies and favouring domestic processing

Table 35. Key measures to enhance the effectiveness of banning on the export of C&D waste resources

No	Measures	Description	No	Measures	Description
1	**Application of landfill levy**	Generate stricter policies on exporting C&D waste and raising landfill levies will foster PwRC and sustainable development domestically	7	**Certification and labelling**	Foster confidence in domestic markets and drive demand for PwRC in construction projects through utilisation of transparent certification and labelling systems
2	**Market development**	Create long-term demand for PwRC and invest in market development to help establish a sustainable local supply chain for PwRC	8	**Regulatory support**	Develop supportive waste regulations and clear quality standards for PwRC to mainstream their use in the construction sector
3	**Investment in domestic infrastructure**	•Invest in recycling centres and processing facilities to supports local C&D waste management and reduces export reliance •Enhance domestic recycling infrastructure to avoid landfill disposal •Pair export restrictions with infrastructure investment to prevent illegal dumping •Plan for increased investments in recycling plants and local processing facilities •Provide financial assistance for recycling start-ups to enhance local processing capabilities, meeting the demand generated by export bans •Balance regulatory enforcement and infrastructure capacity to manage increased recycling demands domestically	9	**Effective policy enforcement**	•Apply strict enforcement and inspections to ensure compliance with PwRC policies and prevent illegal exports •Provide strong regulatory support and penalties for non-compliance to ensure the effectiveness of waste export restrictions and drive companies towards sustainable practices •Enforce strict standards on handling contaminated materials domestically to ensure better control and quality in recycling processes
4	**Sustainable procurement**	Consider subsidies and procurement preferences for PwRC in public project to reduce export reliance and promote domestic recycling	10	**Innovation and technology**	Invest in R&D for advanced C&D waste recycling technologies to reduce export reliance
5	**Collaboration with industry**	•Engage stakeholders in joint efforts to increase awareness and uptake of PwRC in construction projects to encourage recycling and supports market uptake of recycled materials domestically •Build capacity to process and recycle C&D waste locally, supporting a CE and reducing environmental impacts	11	**Priority material analysis**	•Analyse materials to determine domestic recyclability versus those requiring export •Identify high-value materials that can be effectively processed and recycled locally to maximise the utility of restricted materials and align with the CE goals •Analysis onshore processing feasibility for specific materials like asbestos, requiring appropriate infrastructure
6	**Education and outreach**	•Conduct outreach campaigns to inform stakeholders of the environmental benefits of PwRC to encourages more responsible practices and supports domestic recycling efforts •Raise awareness of local C&D processing benefits to reduce exports and encourage more support for domestic recycling policies •Highlight those restricting exports reduces emissions from transport, supports the carbon goals of CE policies and favours domestic processing			

Product stewardship

Product stewardship acknowledges those involved in designing, manufacturing and selling products have a responsibility to ensure those products or materials are managed in a way that reduces their environmental and human health impacts, throughout the product's life cycle and across the supply chain. It aims to drive environmentally beneficial outcomes through good design and clean manufacturing, including the use of components and materials that are easier to recover, reuse and recycle. Developing product stewardship schemes targeting construction materials supports the production of PwRC and contributes to optimal uptake of these resources in construction projects.

Product stewardship schemes may be voluntary (industry-led) , mandatory (under law) or shared with the industry (co-regulatory arrangements between government and industry)[127]. Currently, in Australia there are three active product stewardship schemes.

Companies administrater a voluntary product stewardship arrangement can apply to be accredited by the Australian government[128] . This accreditation program enables companies to demonstrate to businesses and consumers that the arrangement's environmental and human health outcomes have been verified and will contribute to Australia's recycling and waste reduction objectives.

Table 36. Current product stewardship schemes in Australia

Product	Arrangement	Description
Oil	Mandatory	The Government provides industry incentives to increase recycling of used oil
TVs and computers	Co-regulatory	The National Television and Computer Recycling Scheme (NTCRS) was established in 2011. It gives Australian households and small businesses free access to industry-funded collection and recycling services
Plastics and packaging	Co-regulatory	The Australian Packaging Covenant (APC)[126] requires companies to minimise their packaging waste
Mobile phones	Voluntary	MobileMuster collects and recycles mobile phones, batteries, modems and accessories. This includes running public awareness campaigns to increase uptake in recycling of unused and damaged mobile phones.
Tyres	Voluntary	Tyre Stewardship Australia manage the national Tyre Product Stewardship Scheme. The scheme promotes the development of viable markets for tyre-derived products
Large plastic bags	Voluntary	Big bag recovery collects and recycles bags used for products over 15kg or 15L that would otherwise be sent to landfill
Batteries	Voluntary	The Battery Stewardship Scheme B-cycle is a national battery collection network that recovers and recycles used hand-held batteries. It also raises public awareness on battery safety and disposal options.
Aluminium cladding	Voluntary	The Fairview aluminium cladding scheme – Ecoloop takes used aluminium cladding and recycles it into new materials for local manufacturers
Plastic paint pails	Voluntary	Dulux Project Earth recycling and remanufacture of used Dulux brand plastic paint pails from commercial and industrial work sites.

Source: Authors

[126] Australian Government (2023) Australian Packaging Covenant Organisation (APCO) Arrangement. Department of Climate Change, Energy, the Environment and Water. Available from https://shorturl.at/bdDU1

[127] Australian Government (2023) Product stewardship in Australia. Department of Climate Change, Energy, the Environment and Water. Available from https://shorturl.at/cfim9

[128] Australian Government (2023) Product stewardship accreditation. Department of Climate Change, Energy, the Environment and Water. Available from https://shorturl.at/qzALV

The product Stewardship Centre of Excellence[129] was established in Australia to help businesses, industries and product stewardship organisations adopt a product stewardship approach to deliver their Environmental, Social, Governance (ESG) and CE objectives. This Centre is an independent, non-for profit charity that provides independent advice on product stewardship priorities to the Australian Government. The 2023-24 priority product list[130] for product stewardship includes clothing textiles, tyres, plastic in health care products, mattresses and child car seats. The Centre's product stewardship assessment framework[131] comprises 33 key performance indicators (KPIs), which encompass the environmental, social and economic benefits of applying product stewardship. Several of these KPIs, including the use of PwRC, recovery rate, sustainable procurement and local recycling, directly contribute to maximising the uptake of PwRC.

It is noteworthy to know that Product Stewardship and EPR policies differ in their scope and responsibility level. Product Stewardship and EPR differ in their scope and responsibility. Product Stewardship involves shared responsibility among all stakeholders, including producers, consumers and waste managers, and it can be either voluntary or regulated. Its focus is broader, covering sustainable product design and lifecycle management. In contrast, EPR places the primary responsibility on producers, typically through mandatory legislation, to manage the end-of-life disposal and recycling of their products. While Product Stewardship fosters collaboration across the value chain, EPR aims to reduce government waste management burdens and incentivise producers to consider their products' end-of-life stage.

[129] Product Stewardship Centre of Excellence (2021) Available from https://stewardshipexcellence.com.au/

[130] Australian Government (2023) Minister's product stewardship priority list. Department of Climate Change, Energy, the Environment and Water. Available from https://shorturl.at/exFMP

[131] Product Stewardship Centre of Excellence (2023) Evaluating product stewardship benefits and effectiveness. Available from https://shorturl.at/cwGV7

Overview of Key Findings

- Approximately **71%** of participants reported being very to moderately familiar with this policy **(Figure 29a)**
- **59%** participants indicated that ***'Product Stewardship'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 29b)**
- Around **59%** of participants reported that the current application of this policy is highly to moderately effective **(Figure 29c)**
- Only **~18%** of participants indicated that the policy's application might have some negative consequences **(Figure 29d)**
- Participants identified **8** potential negative impacts of this policy **(Table 37)**
- The three primary ways this policy can boost PwRC use include **'creation of sustainable supply chains for using PwRC', 'providing sustainable supply of PwRC',** and **'improving the environmental sustainability ' (Figure 29e)**
- They proposed **15 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 38)**
- More than **50%** of participants who supported the national application of CE policies recommended that this policy be implemented nationwide **(Figure 32b)**
- **80%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Product Stewardship'

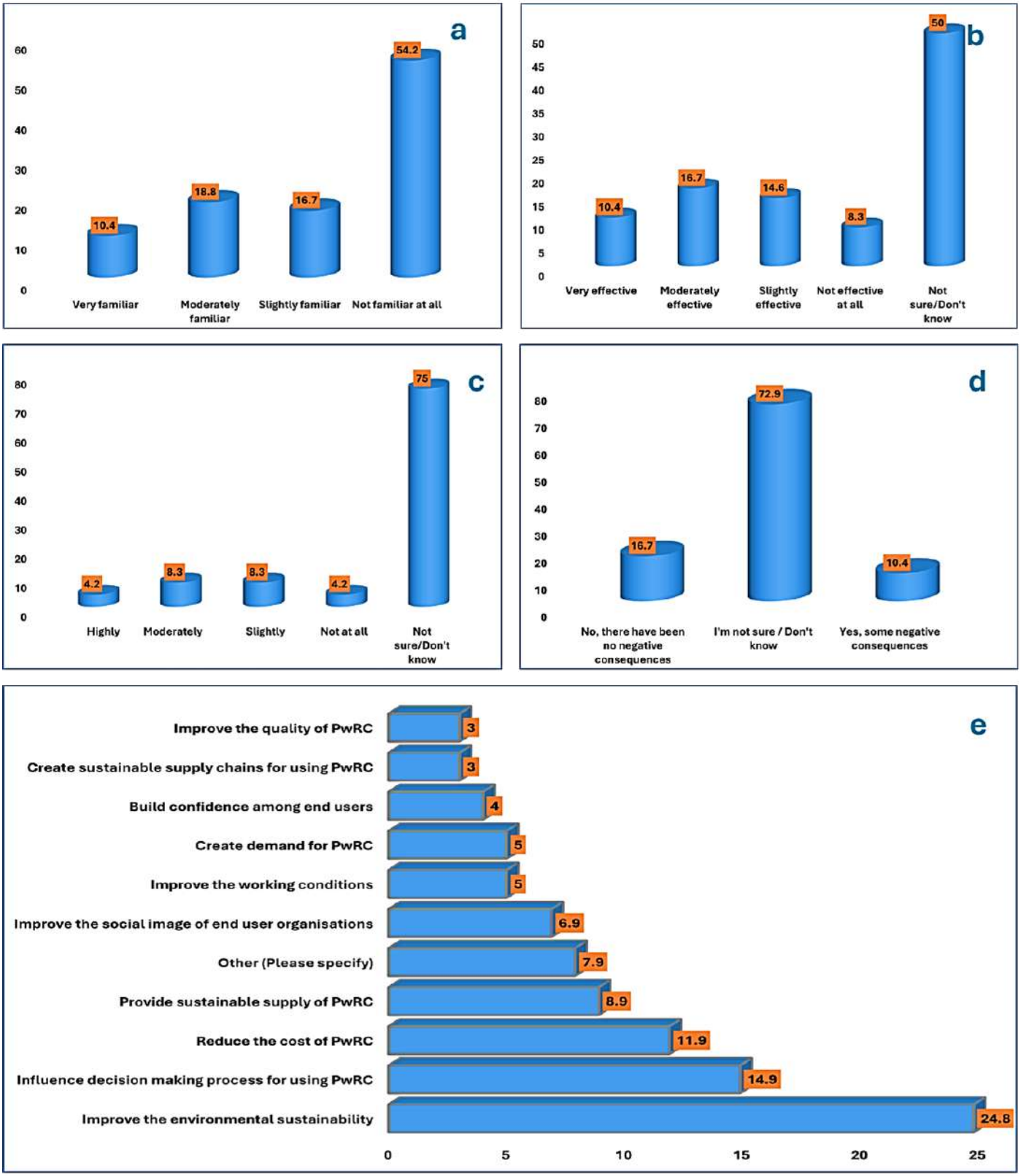

Figure 29. Participants' responses (frequency distribution %), product stewardship. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 37. Key issues and impacts of implementing product stewardship policy

No	Issue	Description
1	**Greenwashing**	Companies may engage in greenwashing, giving a misleading impression of environmental responsibility without significant action
2	**Product stewardship cost leakage**	Poorly designed product stewardship can result in cost leakage, allowing free-riders and rogue operators to avoid financial responsibilities
3	**Quality monitoring by stewardship organisations**	Stewardship organisations must monitor the quality of materials processed to ensure the PwRC meets necessary standards
4	**Increased costs**	Policies and stewardship schemes can increase costs for businesses, potentially impacting compliance and profitability
5	**Reduced material quality**	Shortened stewardship cycles may result in reduced material quality, as producers rush to meet policy timelines
6	**Limited domestic production**	Low production capacity in Australia limits the effectiveness and scope of product stewardship schemes due to constrained supply
7	**Supply constraints**	Limited availability of PwRC restricts the ability to meet demand, impacting policy success
8	**Obstacles to material reuse**	Some policies actively hinder the reuse of materials, especially when dominated by new material producers who may design products to limit recyclability
	Positive impact	
Production creation		Creates production opportunities for PwRC
Circular economy support		Take-back initiatives allow for recycling of materials at end-of-life, supporting CE objectives

Table 38. Key measures to enhance the effectiveness of product stewardship policy

No	Measures	Description	No	Measures	Description
1	**Support local recyclers**	Support local recyclers in product stewardship programs to strengthen CE practices and mitigate overseas waste dependency	9	**Government role and enforcement**	•Government enforcement ensures compliance with product stewardship policies, preventing rogue operations •Government support, including grants and policies, fosters industry compliance and investment in sustainable practices
2	**Circular design approach**	•Encourage designers to choose recyclable, easily dismantled materials, reducing environmental impact over a product's lifecycle •Implement design for recycling to simplify recycling and resource recovery, reducing costs and environmental impacts •Have a lifecycle focus to encourage sustainable design choices, enhancing PwRC utilisation from initial stages	10	**Analyse and manage implementation challenges**	•Understand and address implementation challenges like high collection costs and material recovery across diverse regions •Lack of control over end-of-life for certain products limits recycling efficiency without supportive policies
3	**Role of co-regulators**	Appointing co-regulators, such as local recycling organisations, can help manage and support product stewardship policies effectively	11	**Standardisation of stewardship programs**	Establishing clear, uniform standards for product stewardship can address quality inconsistencies and improve outcomes
4	**Education and awareness**	•Raise awareness about product stewardship to help suppliers and manufacturers adopt sustainable practices •Educate suppliers, manufacturers and contractors on product stewardship to facilitate mainstreamed PwRC adoption •Highlight that product stewardship programs assign responsibility to manufacturers to promote recycled content and infrastructure investment	12	**Funding and financial support**	•Financial aid and incentives for SMEs to enhance product stewardship efforts and to encourage sustainable design practices •Provide tax credits, grants and support for PwRC use to enable sustainable practices in the construction sector •Support recycling start-ups and provide funding to enhance the local recycling ecosystem and achieve stewardship objectives
5	**Effective reporting**	Require product stewardship schemes to publicly report recycled product volumes to enforce environmental responsibility	14	**Certification and labelling**	•Utilise certification schemes and product labels to guide consumers towards PwRC •Apply environmental impact labelling that details recycled content percentages to drive informed choices among builders and developers •Clear labelling and lifecycle tracking of products build trust and traceability, encouraging adoption of PwRC
6	**Supply chain collaboration**	•Make cross-supply chain efforts with suppliers and contractors to drive PwRC use and streamline recycling processes, benefiting the building and construction sector •Collaborate with all parties in the supply chain to create continuity for PwRC use and ensure end-of-life management	15	**Policy design**	• •Develop minimum standards to ensure product stewardship policies effectively meet waste management goals •Draw inspiration from tyre stewardship, which highlights the potential benefits and challenges of structured recycling systems. It underscores the importance of stricter regulations to prevent free-riders and ensure the system's effectiveness •Mandated stewardship schemes achieve higher compliance than voluntary programs, which may result in limited participation •Account for true recycling costs to make PwRC economically feasible
7	**Investment in recycling infrastructure**	•Develop waste infrastructure to support handling and recycling of construction waste, and to prevent overseas export and pormote local recycling •Sustained support and investment are essential for significant waste reduction and recycling reliability			
8	**Conducting LCA**	Conduct LCA to inform environmentally sound construction material choices.			

Levy waiver on waste recycling residuals

Recycling residual waste is a complex mix of materials that can be difficult to recover. This is because the mix requires expensive and complex infrastructure to recover. It is estimated that the residual waste from C&D waste recycling is around 20%[132]. The application of levy waivers policy should ideally lead to greater C&D waste recovery and PwRC cost reduction and market development. Imposing a levy on the disposal of recycling residuals can significantly reduce PwRC competitiveness in the market. By adding this cost, the economic advantage of recycling activities diminishes, making PwRC less appealing for stakeholders who might otherwise choose them over virgin alternative.

A study in Victoria showed that for each $15/t levy rate rise, the steel recycling industry in this state sustained an extra $738 k per annum cost[133]. At present, in all jurisdictions, waste recycling facilities' residuals are defined as waste, and therefore, the owners of such businesses incur a landfill fee. Recycling facilities face substantial expenses in disposing of residuals, naturally prompting them to explore lower-cost alternatives. This financial burden often justifies transporting waste to interstate locations with more favourable disposal fees. Consequently, the relevant industries suggest that these residuals be excluded from the waste definition by regulations; some examples include:

A levy on the disposal of recycling residuals reduces the competitiveness of materials sold into the international market **[National Waste and Recycling Industry Council]**

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 **[The Australian Council of Recycling]**

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 **[Re Group]**

Landfill levies penalise the recycling industry for the disposal of residual rubbish that enters the recycling stream **[Visy, Owens-Illinois and SKM Recycling]**

[132] Low, J.K., Wallis, S.L., Hernandez, G., Cerqueira, I.S., Steinhorn, G. and Berry, T.A., (2020). Encouraging circular waste economies for the New Zealand construction industry: Opportunities and barriers. Frontiers in Sustainable Cities, 2, p.35

[133] EPA Victoria (2007) Impact of Landfill levy on the steel recycling sector in Victoria, Melbourne, Australia.

Overview of Key Findings

- More than **54%** of participants indicated that they were entirely unfamiliar with this policy **(Figure 30a)**
- Only **27%** of participants indicated that ***'Levy Waiver on Waste Recycling Residuals'*** can be very to moderately effective in optimal use of PwRC in construction **(Figure 30b)**
- **50%** of participants reported that they are not sure about the effectiveness of the current application of this policy **(Figure 30c)**
- Over **72%** of participants expressed a lack of awareness about potential negative consequences associated with the application of this policy **(Figure 30d)**
- Participants identified **four** potential negative impacts of this policy **(Table 39)**
- The three primary ways this policy can boost PwRC use include **'improving the environmental sustainability', 'influencing decision making process for using PwRC'** and **'reducing the cost of PwRC' (Figure 30e)**
- They proposed **15 key measures** to improve this policy's effectiveness in optimising PwRC use in construction projects **(Table 40)**
- Only ~11% of participants who supported the national application of CE policies recommended that this policy be implemented **nationwide (Figure 32b)**
- **~47%** of participants indicated that this policy has **more positive than negative impacts (Figure 33)**

'Levy Waiver on Waste Recycling Residuals'

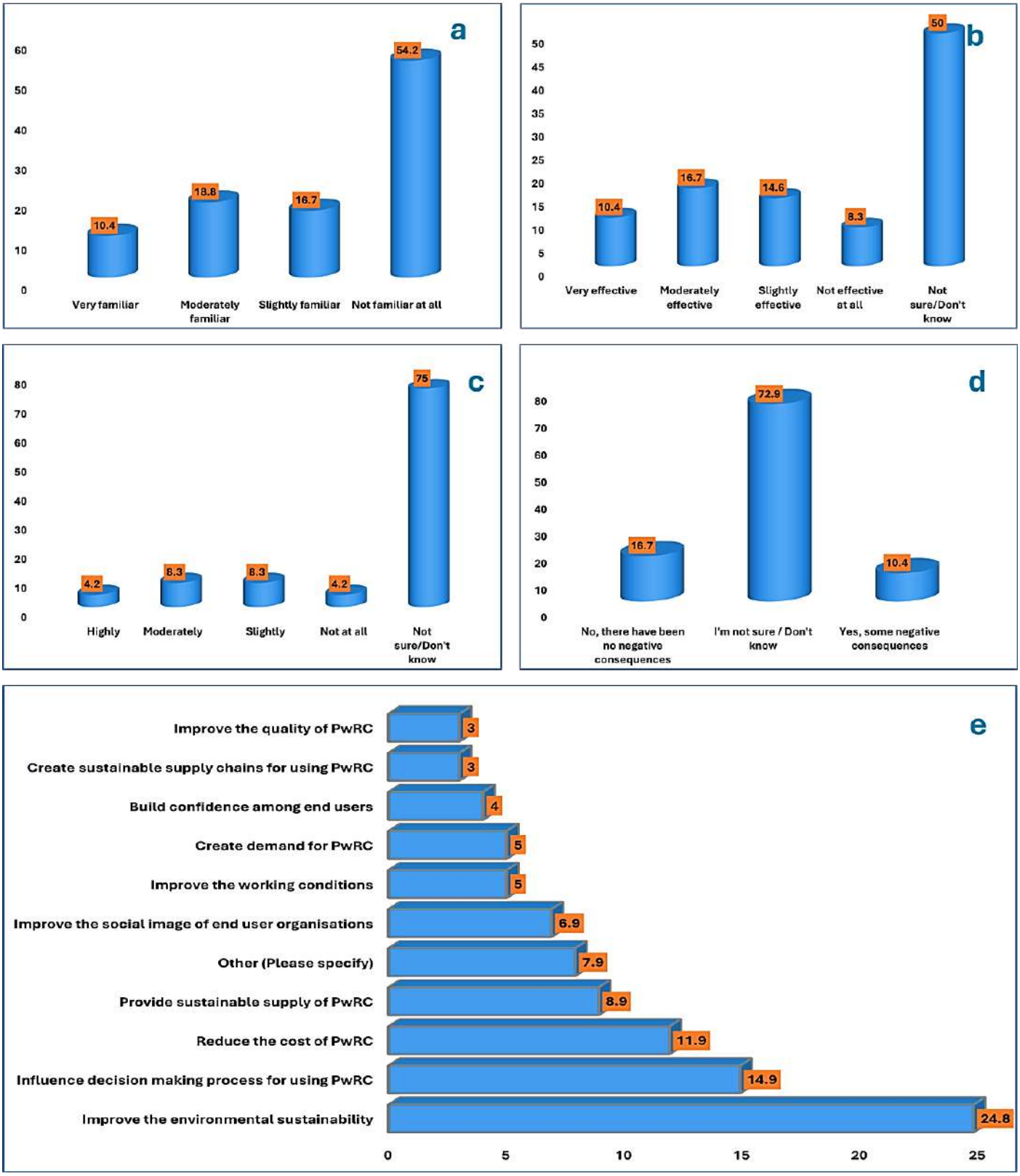

Figure 30. Participants' responses (frequency distribution %), levy waiver on waste recycling residuals. Familiarity with the policy (a), overall effectiveness (b), actual effectiveness (c), potential negative impacts (d), positive impacts (e).

Table 39. Key issues and impacts of implementing levy waiver on waste recycling residual policy

No	Issue	Description
1	**Ineffective recycling facilities**	Some recycling facilities may not efficiently recycle all materials they receive, reducing the overall impact of recycling policies
2	**Ongoing residual waste generation**	It does not fully eliminate the production of residual waste, requiring continued disposal solutions
3	**Tax avoidance**	• Some businesses may falsely claim recycling activities to receive levy waivers, especially in construction and demolition where material weight makes it financially beneficial • Certain entities may engage in tax avoidance strategies to circumvent recycling levies and reduce costs
4	**Abuse of recycling policies**	Policies are open to abuse, allowing some operators to exploit recycling schemes without contributing to genuine environmental outcomes

Table 40. Key measures to enhance the effectiveness of levy waiver waste recycling residual

No	Measures	Description	No	Measures	Description
1	**Auditing and verification**	•Conduct audits to prevent misuse of waivers and ensure adherence to recycling practices •Implement verification systems to maintain program integrity and reduce loopholes •Ensure transparency in waiver audits to build trust and hold stakeholders accountable for meeting their recycling targets •Introduce voluntary self-audits while ensuring safeguards against misuse	9	**Clarity in the policy criteria and definitions**	•Provide transparent criteria for waivers to manage residual waste responsibly •Provide clear and specific definitions are needed for recycling waivers to prevent loopholes •Ensure waiver policies are specific and clear to avoid exploitation and ensure compliance •Address vagueness in current waiver policies to prevent "greenwashing" by some organisations •Establish clear criteria for waivers to incentivise continuous improvements (i.e. performance based criteria) and define the requiremnets for recycling elgibility •Waivers must ensure that organisations meet set quality standards to expedite processing while maintaining adequate oversight and quality control
2	**Financial incentives**	Provide tax breaks and grants to entities that exceed PwRC targets	10	**Collaboration and partnerships**	Foster partnerships among government, industry and community groups to maximise recycling efforts
3	**Potential adverse impacts**	Recognise and address potential negative impacts of the policy on PwRC usage	11	**Adjust pricing**	•Adjust pricing based on the recyclable portion of waste to ensure organisations are not overcharged for residual waste disposal •Adjust waste drop-off prices based on recyclability could incentivise better recycling practices
4	**PwRC utilisation minimum**	Link waiver eligibility to meeting PwRC usage to encourages organisations to meet recycling goals and support sustainable practices in the construction sector	12	**Material innovation support**	Expand waivers to include innovative materials that may not currently be recyclable but have potential in future sustainability practices
5	**Documentation and reporting**	Require regular recycling documentation to promote transparency and accountability	13	**Alignment with other policies**	Should work in tandem with other policies for effective implementation
6	**Investment in recycling infrastructure**	Waivers should encourage entities to invest in recycling technology, funding upgrades, or infrastructure to boost recycling outcomes	14	**Policy regular evaluation**	Conduct regular program evaluation to ensure that the waiver remains aligned with current recycling objectives and adjusts to feedback
7	**Recognition and incentives**	•Recognise organisations that exceed recycling targets with awards and certifications •Organisations delivering tangible recycling outcomes could benefit from reduced levies, promoting higher commitment to sustainability	15	**Waivers prioritisation**	•Prioritise waivers for materials with limited recycling options (hard-to-recycle materials) to encourage innovation •Prioritise waivers for organisations using local PwRC sources to strengthen regional recycling networks •Allow waivers for entities with strong recycling commitments to support responsible waste management while avoiding unnecessary fees
8	**Education**	Support initiatives to raise public and internal awareness about recycling importance			

COMPARATIVE ANALYSIS AND FURTHER FEEDBACK

Levels of policy understanding

To determine which policy is most familiar to research participants, a comparative analysis was conducted. As shown in Figure 31, the level of participants' understanding of each policy varies significantly, ranging from 9.7% for the demolition deposit-refund policy (moderately familiar) to 88.5% for the environmental sustainability rating policy (moderately or very familiar). Consequently, the least known policies—where fewer than one-fourth of participants reported moderate to high familiarity—included the demolition deposit-refund, waiver for recycling residual waste, proximity principle and harmonised PwRC specifications.

be implemented at a national level (Figure 32a). Among those advocating for national application, participants identified specific policies they deemed most critical for national implementation. The results indicate that sustainable procurement (80%), recycled product certification (~71%), financial incentives (~66%) and a carbon pricing scheme (~63%) are prioritised for application on a national scale (Figure 32b).

Benefits, challenges and impacts of policies

The following figure provides a comparative overview of the positive versus negative impacts of the study's policies (Figure 33). Participants identified sustainable procurement, financial incentives, recycled product certification and product stewardship as the top four policies with significantly more positive than

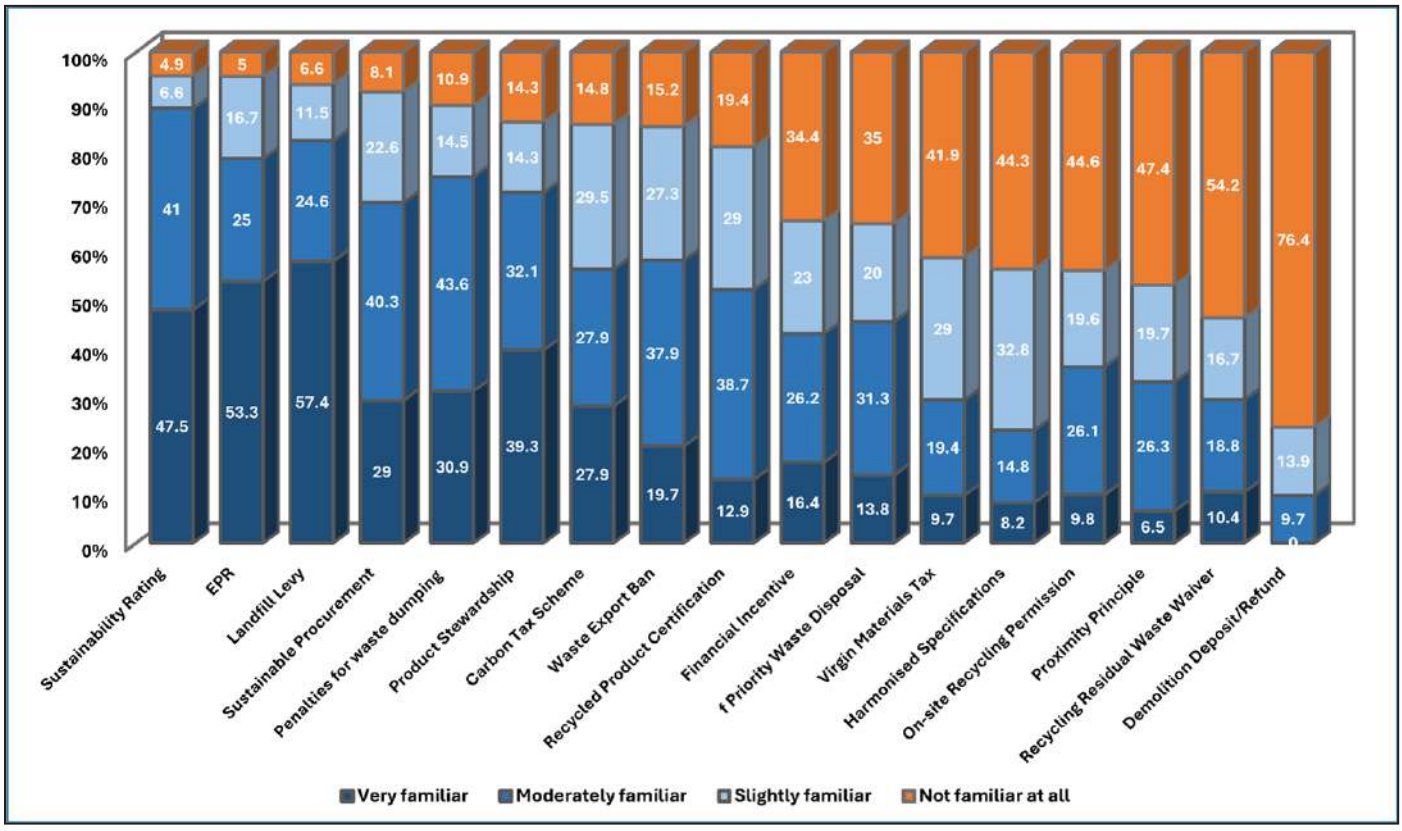

Figure 31. Comparative overview of familiarity levels across study policies (frequency distribution %)

Scope of application

In response to the question regarding the scope of application for the study's policies, over 65% of participants suggested that certain policies should

negative impacts. Conversely, participants noted that the proximity principle and virgin material tax are the most challenging policies, potentially hindering the optimal use of PwRC in the building and construction sector.

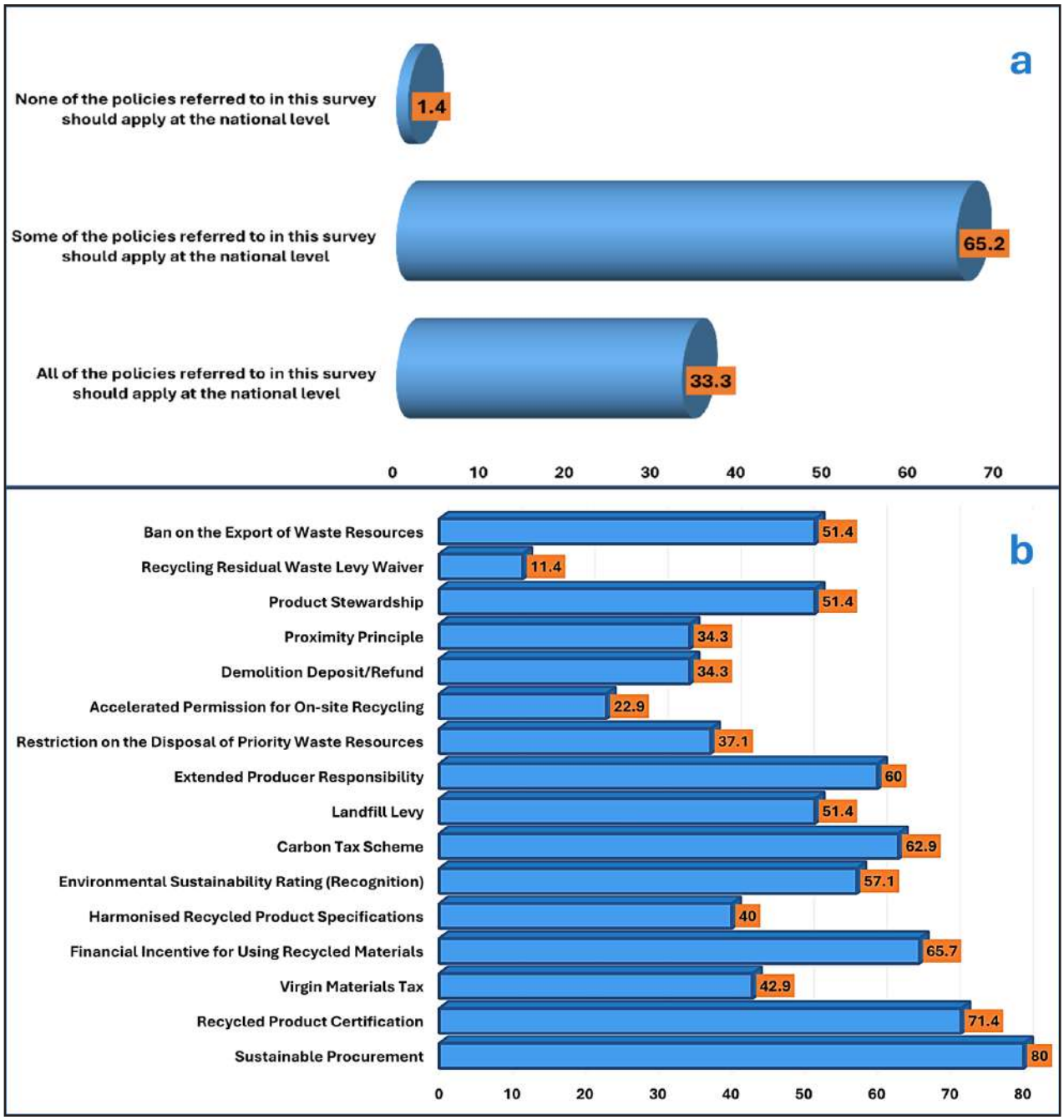

Figure 32. Participants' perspectives on the implementation scale of each CE policy (frequency distribution %)

The participants' responses on the impact mechanism for each policy were comparatively analysed to identify the five most pivotal policies that have the greatest impact on each impact mechanism. The results are shown in Table 41. The following bullet points outline the top five policies identified for each impact mechanism:

- **Building end-user confidence in PwRC:** The five most impactful policies are EPR, Environmental Sustainability Rating, Harmonised PwRC Specifications, Recycled Product Certification and Sustainable Procurement.
- **Creating demand for PwRC:** The top policies driving demand include Virgin Material Tax, EPR, Financial Incentives, Carbon Pricing Scheme and Sustainable Procurement.
- **Establishing sustainable PwRC supply chains:** Key policies for effective supply chain creation are EPR, Sustainable Procurement, a Ban on the Export of C&D Waste, Financial Incentives and Virgin Material Tax.
- **Enhancing environmental sustainability in construction**: The leading policies for sustainability improvement are the Proximity Principle, EPR, Accelerated On-Site Recycling

Table 41. The frequency distribution (n) of responses for the policies' impact mechanisms

	Build confidence among end-users	Create demand for PwRC	Create sustainable supply chains	Improve the environmental sustainability	Improve the quality of PwRC	Improve the social image of end-user organisations	Improve the working conditions	Influence decision making process	Provide sustainable supply of PwRC	Reduce the cost of PwRC	Others
Sustainable Procurement	21	29	31	27	17	18	3	27	21	18	3
Recycled Product Certification	21	10	16	20	15	17	4	16	14	6	2
Virgin Materials Tax	6	36	26	31	11	14	2	24	18	18	5
Financial Incentive for Using PwRC	7	32	27	23	8	15	4	23	19	23	3
Harmonised Recycled Product Specifications	24	14	21	23	22	13	10	19	12	6	4
Environmental Sustainability Rating	25	24	19	29	12	25	11	29	15	9	4
Carbon Pricing Scheme	2	29	21	36	15	16	4	28	17	20	12
Landfill Levy (Tax)	5	13	21	34	7	3	3	20	15	10	3
Extended Producer Responsibility	36	34	33	39	32	28	6	28	35	20	6
Penalties for illegal waste dumping	3	5	6	15	0	10	4	8	5	3	7
Restriction on the Disposal of Priority Waste	7	12	22	37	11	10	10	23	24	13	6
Accelerated Permission for On-site Recycling	9	15	24	38	15	20	11	25	23	25	6
Demolition Deposit/Refund	6	18	23	31	8	14	9	26	27	17	7
Proximity Principle	2	9	18	40	3	14	6	22	15	21	10
Ban on the Export of C&D Waste Resources	7	15	31	25	6	10	6	16	25	13	12
Product Stewardship	6	26	9	34	12	14	7	20	19	10	5
Recycling Residual Waste Levy Waiver	4	5	3	25	3	7	5	15	9	12	8

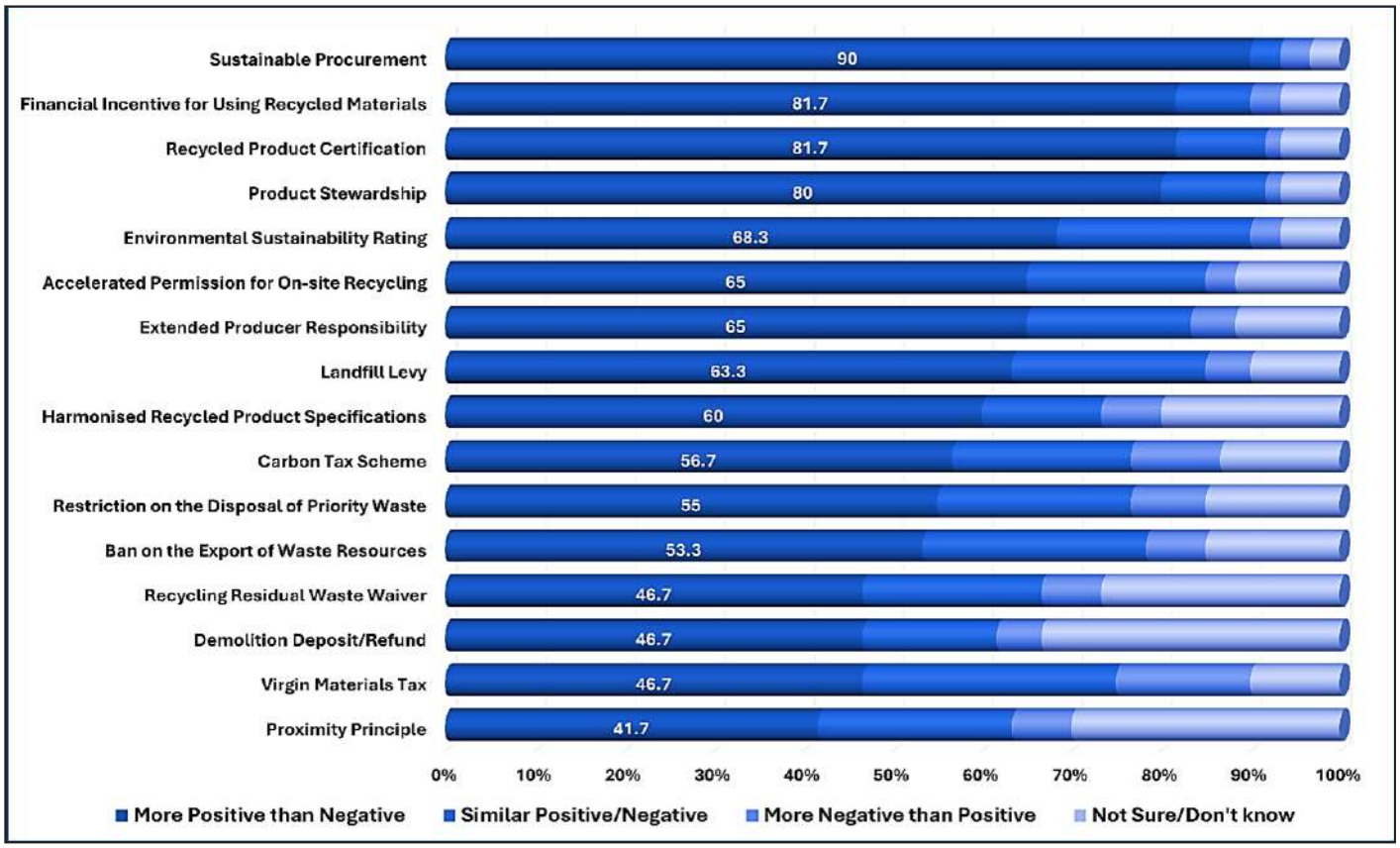

Figure 33. Participants' perspectives on the positive vs. negative impacts of each CE policies (frequency distribution %)

Permissions, Restrictions on the Disposal of Priority Waste and the Carbon Pricing Scheme.

- **Improving PwRC quality:** The main policies influencing quality include EPR, Harmonised PwRC Specifications, Sustainable Procurement Recycled Product Certification and the Carbon Pricing Scheme.
- **Boosting the social image of PwRC end-user organisations:** Key policies enhancing social perception include EPR, Environmental Sustainability Rating, Accelerated On-Site Recycling Permissions, Sustainable Procurement, and Recycled Product Certification.
- **Enhancing working conditions with PwRC**: The most effective policies for improved working conditions are Environmental Sustainability Rating, Accelerated On-Site Recycling Permissions, Harmonised PwRC Specifications, Restrictions on the Disposal of Priority Waste and Demolition Deposit-Refund.
- **Influencing decision-making on PwRC use:** The primary policies impacting decision-making are Environmental Sustainability Rating, EPR, Carbon Pricing Scheme, Sustainable Procurement and Demolition Deposit-Refund.
- **Ensuring a sustainable PwRC supply:** Policies supporting a reliable PwRC supply include EPR, Demolition Deposit-Refund, Ban on the Export of C&D Waste, Restrictions on the Disposal of Priority Waste and Accelerated On-Site Recycling Permissions.
- **Reducing PwRC costs:** Top policies for cost reduction include Accelerated On-Site Recycling Permissions, Financial Incentives for PwRC use, Proximity Principle, Carbon Pricing Scheme and EPR.

Further policies and participants' descriptive feedback

At the end of the survey, participants were invited to share their knowledge of any additional policies not covered in this study. Among the respondents, 22 indicated awareness of supplementary policies or related directives, while 39 reported no knowledge of policies beyond those addressed in the survey. Table 42 provides a summary of participants' responses on this topic.

Participants also shared their perspectives on the implementation of CE policies designed to enhance the utilisation of PwRC in construction projects. Their comments emphasised the need for better enforcement of policies, along with actionable outcomes. Advocacy for national standards was also supported, with some stating policies should be complementary and not conflicting to maximise impact. The feedback highlighted that this field is new in Australia, with limited familiarity for many in industry or government. The complexity caused by Australia's geographic and demographic context was also mentioned, along with limited awareness of policies across respondents.

Table 42. Summary of participant's perspective regarding additional circular economy policies

Category	Description
Implementation & Practice	Side system needs better implementation, traceability, quality, industry standard practices
Specific Policies Mentioned	NSW Sustainability Policy, Circular Economy Action Plan, LCA targets, Recycled First Policy, State Environmental Planning Policies, EPA requirements, Circular Economy in NSW, Digital Product Passports, Right to Repair, Traceability Standards, and Federal Social and Environmental Product Procurement
Policy Suggestions or Gaps Identified	Suggestions include waste reduction incentives, tax benefits for households and companies, waste credits, mandatory traceability and reporting, investing profits from mining and gas into sustainability, affordable housing initiatives, promoting C&D waste for private sector usage, incentives for CE in the private sector
Noteworthy Examples Cited	Policies in EU countries (e.g., Sweden's construction waste guidelines), Recycled First in Victoria, London's Circular Economy Statement, NSW Circular Design Guide, Modernisation Fund for waste recycling
Feedback on Current Policy Landscape	Some find existing policies one-dimensional, suggesting that they take a multi-dimensional approach. Respondents mention the need for alignment between policy and infrastructure roadmaps, as well as the inclusion of conditions in business leases to boost PwRC demand
Awareness Challenges	Low awareness in sustainability industry despite time in field; limited school education on sustainability; greater familiarity with CE policies and use of secondary raw materials seen as a need

CONCLUDING REMARKS

This study explored the perceptions of Australian stakeholders concerning CE policies aimed at promoting the use of PwRC within construction projects. The findings reveal varied levels of familiarity and nuanced views on the effectiveness of different CE policies, highlighting certain limitations and potential strategies for improving their implementation. Responses regarding whether policies should be applied nationally or at the state level underscore the complexity of aligning CE approaches across Australia's diverse regulatory landscapes. Specifically, while some stakeholders advocate for a national framework to ensure uniformity and scalability, others argue that state-specific policies are better suited to address local resource recovery needs and infrastructure constraints.

The research findings make significant contributions to knowledge development by mapping current awareness gaps and perceived barriers to the application of CE policies. These insights are essential for academics and policymakers seeking to understand the obstacles to CE adoption and identifying areas where targeted education or policy adjustments are necessary. The findings also serve as empirical evidence for policy development, pinpointing the specific areas where policy clarity or standardisation is needed to boost stakeholder confidence and engagement in circular practices and the optimal utilisation of PwRC. For industry practice, the research provides actionable insights, particularly in identifying practical strategies that stakeholders believe could enhance CE policy effectiveness, such as improved incentives, clearer communication of policies and alignment of CE objectives across construction project phases.

For the building and construction and waste resource sectors, the study offers insights to refine current practices. Construction organisations can leverage these findings to integrate CE principles more effectively into project planning and material procurement, focusing on materials with established recycling pathways and minimal environmental impact. Waste management and resource recovery organisations may use these insights to align processing capabilities with the demand generated by new CE policies, supporting the industry's transition towards higher recycled content usage. Industry peak bodies have a crucial role in disseminating these findings to promote the CE. By developing guidelines, training programmes and policy recommendations informed by this research, peak bodies can encourage the optimal use of PwRC and foster collaboration between stakeholders, driving industry-wide progress towards sustainable resource management.

Overall, this study provides policymakers, industry leaders and peak bodies with a robust understanding of current perceptions and actionable pathways to enhance CE policy efficacy, supporting a sustainable transition for Australia's construction and waste management sectors.

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