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RELIABLE AFFORDABLE CLEAN ENERGY

RMIT UNIVERSITY

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Strengthening Supply Chains for Residential Energy Efficiency Upgrades: A Strategic Roadmap for Australia's Transition to Clean Energy

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What is RACE for 2030?

Reliable, Affordable Clean Energy for 2030 (RACE for 2030) is an innovative, collaborative research centre for energy and carbon transition. We were funded with $68.5 million of Commonwealth funds and commitments of $280 million of cash and in-kind contributions from our partners. Our aim is to deliver $3.8 billion of cumulative energy productivity benefits and 20 megatons of cumulative carbon emission savings by 2030.

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Acknowledgement of Country

The authors of this report would like to respectfully acknowledge the Traditional Owners of the ancestral lands throughout Australia and their connection to land, sea and community. We recognise their continuing connection to the land, waters, and culture and pay our respects to them, their cultures and to their Elders past, present, and emerging.

Disclaimer

The authors have used all due care and skill to ensure the material is accurate as at the date of this report. The authors do not accept any responsibility for any loss that may arise by anyone relying upon its contents.

Executive summary

Improving the energy performance of Australia's existing homes is central to reducing household energy costs, lowering greenhouse gas emissions, improving indoor comfort and supporting the transition to residential electrification. Achieving these objectives requires more than the availability of efficient technologies. It depends on supply chains that can reliably source products, coordinate distribution, support skilled installation, maintain quality standards and deliver retrofit programs efficiently at scale.

Prepared as part of the RACE for 2030 Energy Upgrades for Australian Homes program, this report examines the supply chains supporting four major residential retrofit technology groups: insulation and draught-proofing; heat pump hot water systems; electric space-conditioning and cooking technologies; and high-performance windows and glazing (Figure a). Drawing on desktop research, supply-chain mapping, industry interviews, an industry survey and a national stakeholder roundtable, the report analyses how these supply chains operate, identifies the principal barriers affecting their future development, presents a decision-support tool for product selection, proposes a future delivery model and outlines a strategic roadmap for strengthening Australia's residential retrofit sector.

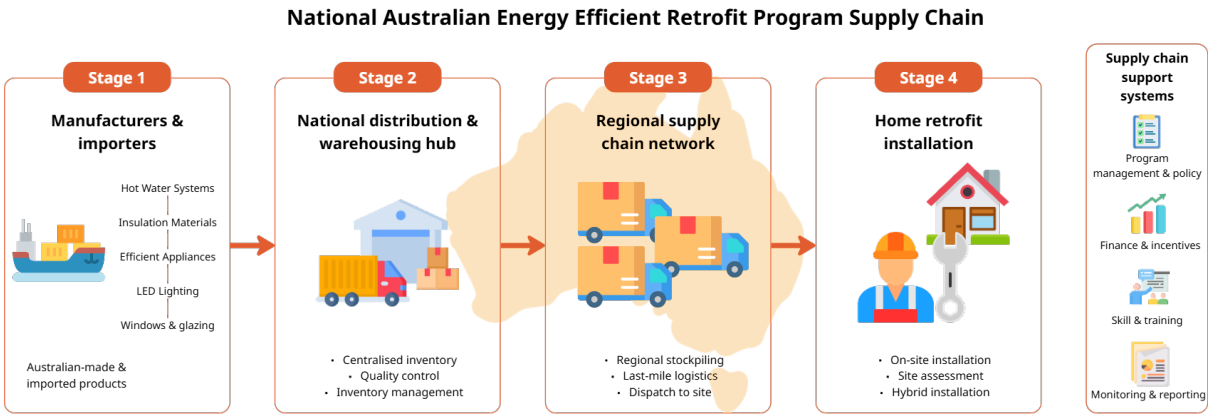

Figure a. Residential retrofit energy efficient product supply chain in Australia (Icon source: Flaticon.com)

The analysis demonstrates that the four technology groups differ considerably in their manufacturing arrangements, sourcing strategies, distribution pathways and installation requirements. Insulation and draught-proofing combine domestic manufacturing with imported materials and specialist installation services, while heat pump systems and electric appliances are more closely connected to international manufacturing and established wholesale and trade networks. High-performance windows and glazing rely on substantial local fabrication,

engineering expertise and customised installation. These differences influence workforce requirements, procurement approaches, industry capability and the way government programs should be designed and delivered.

Despite these differences, several challenges recur across all technology groups. Industry consultation consistently identified demand uncertainty, fragmented policy settings, workforce shortages, inconsistent installation quality, limited product traceability and uneven quality assurance as significant constraints on future market growth. The findings indicate that improving product availability alone will not be sufficient to expand residential retrofits. Comparable attention is required to product selection, installation quality, commissioning, customer support and ongoing system performance if expected energy, comfort and emissions benefits are to be realised.

The report also highlights the importance of strengthening consumer confidence. Households often need to navigate a complex marketplace characterised by varying product information, installer capability and program requirements. Better access to independent advice, transparent product information, reliable quality assurance and appropriately qualified installers would help households make more informed decisions. The findings further support a whole-of-home approach, recognising that building-envelope improvements, heating and cooling, hot water, cooking and electrical upgrades are most effective when planned as integrated components of a single retrofit strategy rather than implemented independently.

To support more consistent procurement decisions, the report introduces the Energy Upgrades Product Selector, an online multi-criteria decision-support tool developed for organisations responsible for planning and delivering residential energy-upgrade programs. The tool enables users to compare products using transparent and adaptable assessment criteria—including performance, cost, warranty, supplier capability, availability, installation requirements and environmental considerations—while allowing priorities to be adjusted according to the objectives of individual programs. Rather than recommending a universally preferred product, it identifies products that best satisfy the requirements of a particular procurement or delivery context.

Building on the evidence gathered throughout the project, the report proposes a future-state delivery model designed to strengthen coordination across residential retrofit supply chains. The model introduces an Integrated Retrofit Delivery Partner responsible for coordinating procurement, installation, customer communication, compliance and after-sales support, supported by complementary product-verification and installer-accreditation gateways. A Government Retrofit Coordination Platform provides the digital infrastructure

required for program administration, market intelligence, compliance monitoring and information sharing across participating organisations.

The strategic roadmap translates these findings into a staged implementation framework. Immediate priorities focus on nationally consistent product verification, installer competency, consumer information, quality assurance and improved coordination across existing programs. Medium-term actions strengthen digital infrastructure, workforce capability, market intelligence and integrated whole-of-home delivery. Longer-term priorities concentrate on enhancing domestic capability, supporting circular-economy initiatives, encouraging innovation and developing a national knowledge ecosystem to underpin continuous improvement across the residential retrofit sector.

The report concludes that strengthening Australia’s residential retrofit supply chains requires a coordinated systems approach that extends beyond individual technologies. Verified products, skilled and accountable delivery organisations, consistent quality assurance, informed consumers and effective coordination between governments and industry provide the foundation for delivering residential energy upgrades at scale and supporting Australia's long-term energy-efficiency, electrification and emissions-reduction objectives.

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1. Introduction and project overview

1.1 Background

Improving the energy performance of Australia's existing housing stock has become an increasingly important national priority. Residential buildings account for a substantial proportion of Australia's energy consumption and greenhouse gas emissions, while many existing homes continue to experience poor thermal performance, high energy costs and inadequate indoor comfort. Improving the efficiency of existing dwellings therefore represents a significant opportunity to reduce household energy consumption, lower emissions, improve affordability and enhance health and wellbeing.

While considerable attention has been devoted to the technical performance and cost-effectiveness of residential energy-efficiency technologies, less attention has been given to the supply chains responsible for delivering these technologies to households. Residential energy upgrades depend not only on the availability of high-quality products but also on the capability of manufacturers, importers, distributors, installers, program-delivery organisations and governments to coordinate procurement, logistics, installation, quality assurance and ongoing customer support. As residential energy retrofit programs expand, these delivery systems become increasingly important determinants of whether policy objectives can be achieved efficiently and at scale.

Many of the challenges associated with scaling residential energy upgrades are therefore supply chain related rather than technological. Literature attributes acute challenges in retrofit program implementation to the project-based nature of installations, involvement of multiple actors, need for coordination across procurement, logistics, installation, and after-sales support (Jenkins et al., 2021; Rosenow & Eyre, 2016; IEA, 2023). Other supply chain challenges, such as lack of delivery capacity and uncoordinated operational capability, are major hindrances as programmes scale up with scheduling failures, and inadequate quality assurance undermining consumer trust and dampened uptake, even when incentives are generous (Rosenow & Eyre, 2016; IEA, 2023). Therefore, even mature and well-established technologies can fail to achieve their intended outcomes if products are difficult to source and distribute efficiently, installers are unavailable, quality assurance is inconsistent, or program administration is fragmented. Global retrofit projects demonstrated that persistent gaps exist between projected and realised energy savings, uneven programme performance across regions, and declining marginal returns as schemes scale due to supply chain challenges (Fawcett & Killip, 2019; Jenkins et al., 2021).

Unsurprisingly, emerging literature emphasises integrating supply chain perspectives into energy policy and retrofit programme analysis, particularly for bulky products/components, import dependence, or complex installation requirements, where delivery systems and organisational capacity shape real-world outcomes (Sovacool, 2014; Rosenow et al., 2017; Kern et al., 2019) More specifically, recent Australian policy and industry assessments explicitly identified deficiencies in delivery capacity, logistics coordination, and consumer-facing resolution as constraints on residential energy-efficiency and electrification programmes (Energy Consumers Australia, 2022; RACE for 2030, 2023).

Effectively, well-coordinated supply chains can improve required the availability of required technologies, installation quality, reduce project delays, strengthen consumer confidence and increase the overall effectiveness of government-supported retrofit programs. Understanding how residential retrofit supply chains currently operate —and identifying opportunities to strengthen them — is therefore essential for enabling large-scale deployment of home energy upgrades across Australia.

This report forms part of the RACE for 2030 – Energy Upgrades for Australian Homes (EUAH) program, a national collaborative research initiative designed to accelerate residential energy upgrades and support the transition to low-carbon housing. The program brings together universities, governments, industry organisations and community partners to develop practical tools, evidence and delivery models that support the upgrade of more than one million Australian homes by 2030. Its activities span multiple research themes, including policy and regulation, community implementation models, housing typologies, household decision-making, economic analysis and supply-chain development.

This report presents the outcomes of Work Package 5 (WP5): Supply Chain Development, which focuses on strengthening the supply chains that underpin residential energy-upgrade programs. The project recognises that achieving large-scale residential retrofits requires more than improvements in individual technologies. It also requires resilient supply chains, skilled workforces, effective coordination between industry participants and delivery models capable of supporting consistent, high-quality implementation across diverse Australian housing markets. Through extensive engagement with manufacturers, suppliers, installers, industry associations, governments and program-delivery organisations, WP5 examines how residential retrofit supply chains currently operate, identifies the barriers limiting future growth, and develops practical strategies for strengthening Australia's capacity to deliver residential energy upgrades at scale.

1.2 Purpose, objectives and scope of the report

The purpose of this report is to provide an evidence-based assessment of Australia's residential energy retrofit supply chains and to identify practical opportunities for strengthening their capacity to support large-scale residential energy upgrades.

To achieve this purpose, the report has three principal objectives:

1. To examine the structure and operation of residential energy retrofit supply chains across major technology groups, identifying the principal organisations, activities and material flows involved in delivering residential energy upgrades.
2. To identify the key barriers and opportunities affecting future supply-chain development, drawing on evidence from industry interviews, stakeholder consultation and comparative analysis of different technology sectors.
3. To propose a strategic roadmap identifying immediate, medium-term and long-term priorities for strengthening Australia's residential retrofit sector and supporting future government and industry initiatives.

The report focuses on four technology groups that represent some of the most significant opportunities for improving the energy performance of Australian homes:

- insulation and draught-proofing;
- heat pump hot water systems;
- electric space-conditioning and cooking technologies, including reverse-cycle air conditioners and induction cooktops; and
- high-performance windows and glazing systems.

These technologies were selected because they play complementary roles in improving residential energy efficiency, reducing household energy demand and supporting the transition towards residential electrification. Together, they also represent a diverse range of supply-chain structures, manufacturing arrangements, distribution channels and installation models, providing valuable insights into the broader residential retrofit ecosystem.

1.3 Research approach and evidence base

A mixed-method research approach was adopted, combining desktop research, industry consultation and prototype development to produce an evidence-based assessment of Australia’s residential energy retrofit supply chains and practical

tools to support future policy and industry decision-making. As illustrated in Figure 1.1, the project was undertaken through four interrelated stages that progressively moved from evidence gathering to analysis, validation and translation into practical outputs.



Figure 1.1 Overview of the research approach

Stage 1: Desktop research

The first stage involved a comprehensive review of academic literature, government reports, industry publications and other publicly available sources relating to residential energy retrofits, supply-chain management, product certification, workforce capability and energy-efficiency policy. This review established the policy and industry context, identified current knowledge and evidence gaps, and informed the development of the research questions, interview protocol and industry survey.

Stage 2: Industry engagement, supply-chain mapping and prototype development

The second stage involved extensive industry engagement (Appendix 22) while simultaneously developing comparative supply-chain maps and an early prototype of the online Energy Upgrades Product Selector. Industry engagement comprised semi-structured interviews with manufacturers, suppliers, distributors, installers, industry associations, program-delivery organisations and other stakeholders representing the four technology groups (Appendix 25), together with an industry survey distributed through established industry networks (Appendices 23 and 24).

Approximately 150 organisations were invited to participate in the survey, resulting in 27 valid organisational responses (approximately 18% organisational

response rate). Organisations were identified through purposive sampling using established industry networks and peak industry associations, with one invitation sent to each organisation requesting participation from the individual with primary responsibility for, or substantial expertise in, supply-chain operations. Survey respondents occupied senior operational, managerial or leadership roles responsible for procurement, logistics, planning or delivery. In parallel, 17 semi-structured interviews were undertaken across the residential retrofit sector, providing detailed qualitative insights into supply-chain structures, operational challenges and future opportunities. Further details of the survey instrument, participant recruitment and interview protocol are provided in Appendices 23–25. The survey design and analytical framework are described in greater detail in the companion research paper currently under review in *Benchmarking: An International Journal*, developed as part of this project.

Development of the residential retrofit supply-chain maps also commenced during this stage. Information obtained from the literature review, publicly available industry sources and stakeholder consultation was progressively synthesised to document the principal stages of each supply chain, including manufacturing, sourcing, distribution, installation, program delivery and end-of-life management for four technology groups: insulation and draught-proofing, heat pump hot water systems, electric space-conditioning and cooking technologies, and high-performance windows and glazing.

In parallel, an early prototype of the Energy Upgrades Product Selector was developed so that emerging evidence from the literature review and stakeholder consultation could directly inform the design of the assessment framework before wider industry validation.

Stage 3: Analysis, synthesis and validation

The third stage integrated evidence from multiple sources. Interview transcripts were systematically coded and analysed thematically to identify common operational challenges, barriers and opportunities across the residential retrofit supply chain. To strengthen the robustness of the findings, evidence from the literature review, interviews, survey and supply-chain mapping was triangulated. Preliminary findings were subsequently presented to a national industry roundtable involving representatives from across the residential retrofit sector, providing an opportunity to validate key findings, identify issues common across technology groups and refine the emerging recommendations.

Stage 4: Translation into practical outputs

The final stage translated the research findings into practical outputs for government and industry. This included refinement of the Energy Upgrades

Product Selector following stakeholder feedback, completion of the residential retrofit supply-chain maps, comparative analysis across the four technology groups, and development of strategic recommendations for strengthening Australia's residential retrofit ecosystem.

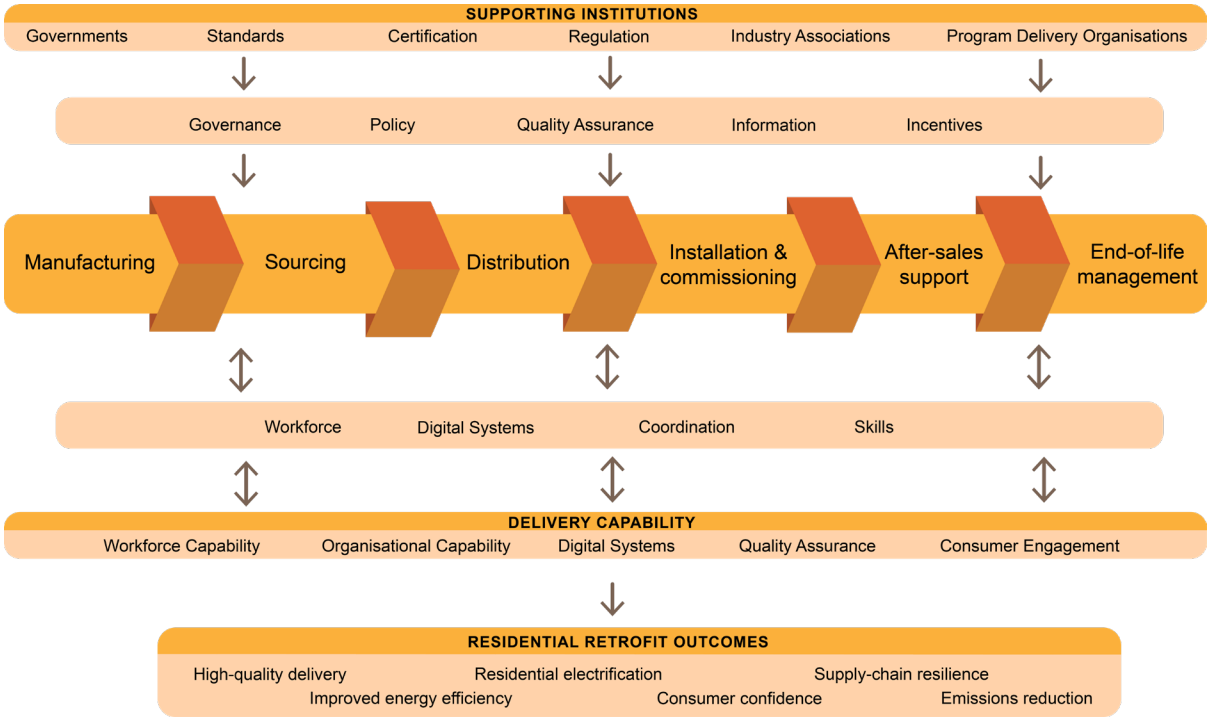
The integration of multiple sources of evidence represents a key strength of this research. Rather than relying on a single dataset or stakeholder group, the findings draw on published literature, comparative supply-chain mapping, expert interviews, practitioner surveys, prototype testing and industry validation. This triangulated approach improves confidence in the findings by enabling evidence obtained through one source to be examined and validated through others, providing a robust foundation for the findings and recommendations presented throughout this report.

1.4 Analytical framework and report structure

The report employs a systems-based supply-chain perspective. Rather than evaluating individual technologies in isolation, it examines the complete delivery system through which residential retrofit products are manufactured, sourced, distributed, installed, regulated and supported throughout their lifecycle. This perspective recognises that many of the barriers limiting residential retrofit programs arise from the interaction between organisations, governance arrangements and delivery processes rather than from deficiencies in the technologies themselves.

Figure 1.2 illustrates the analytical framework adopted throughout the report. Residential retrofit supply chains are viewed as interconnected systems comprising three complementary dimensions:

1. Physical supply chains, encompassing the manufacture, sourcing, distribution, installation and maintenance of residential retrofit products.
2. Supporting institutions, including standards, certification systems, regulatory frameworks, government programs and industry organisations that shape the operating environment for residential retrofit markets.
3. Delivery capability, including workforce skills, organisational capacity, digital systems, quality assurance, consumer engagement and coordination between participating organisations.



Adapted from Christopher (2016), Lambert and Cooper (2000), and Vrijhoef and Koskela (2000)

Figure 1.2 Conceptual framework for residential energy retrofit supply chains

These three dimensions operate simultaneously and influence one another. For example, high-quality products alone will not achieve optimal household outcomes if installation quality is poor or program administration is fragmented. Similarly, a highly skilled workforce cannot deliver projects efficiently without reliable supply chains and effective coordination between industry participants. Improving residential retrofit delivery therefore requires both technology-specific improvements and broader system-wide reforms.

The remainder of the report is organised into five substantive chapters.

Chapter 2 presents the Energy Upgrades Product Selector, a decision-support framework developed as part of Work Package 5 to support consistent and transparent product evaluation.

Chapter 3 examines the structure of residential energy retrofit supply chains across four major technology groups, mapping the principal stages from manufacturing and sourcing through distribution, installation, program delivery and end-of-life management.

Chapter 4 analyses the industry-specific barriers and opportunities affecting each technology group, drawing on evidence from industry interviews and the national stakeholder roundtable while identifying the systemic issues shared across the residential retrofit sector.

Chapter 5 proposes an integrated future-state delivery model that strengthens coordination, product assurance, workforce capability and governance across residential retrofit supply chains.

Chapter 6 concludes the report by presenting a strategic roadmap that identifies immediate, medium-term and long-term priorities for strengthening Australia's residential retrofit sector together with the respective roles of governments, industry and other stakeholders.

In a coherent sequence, these chapters provide a logical progression from understanding how residential retrofit supply chains currently operate, to identifying the barriers affecting their performance, developing an integrated future-state delivery model and establishing a practical roadmap for implementation.

2 Product selection tool and decision support framework

2.1 Product selection challenge in residential energy upgrades

The Energy Upgrades for Australian Homes program aims to accelerate the large-scale deployment of residential energy-efficiency technologies across Australia. Achieving this objective requires more than simply increasing the availability of products. It also depends on the capacity of program-delivery organisations to make informed, evidence-based product-selection decisions. Stakeholder consultation identified three interconnected challenges that complicate product selection: (1) the rapid expansion and increasing complexity of the residential retrofit market, (2) the diversity of technology categories that must be assessed, and (3) the need to balance multiple product-selection criteria.

The rapid expansion of the residential retrofit market has created a complex and continually evolving product landscape. Interviews and stakeholder roundtable discussions highlighted how difficult this environment can be to navigate. Products enter the market through a wide range of supply-chain models, including fully imported systems, locally manufactured goods, hybrid local–global arrangements, and distributor-led procurement pathways. Consequently, product information is dispersed across manufacturers, suppliers, distributors, and installers, making it difficult for organisations to obtain a comprehensive, consistent, and up-to-date understanding of the products available.

Compounding this complexity is the diversity of technologies included in residential energy-upgrade programs. Program-delivery organisations are often required to evaluate fundamentally different technologies—including insulation, heat pump hot water systems, high-performance glazing, induction cooktops, and reverse-cycle air conditioners—using a common decision-making process. These technologies differ substantially in their technical characteristics, performance measures, market structures, and supply-chain arrangements, making direct comparison difficult. The breadth and diversity of this mix create a substantial information burden, requiring significant time, resources, and technical expertise to identify products that best align with program objectives.

Beyond market and technology complexity, organisations must also reconcile multiple—and often competing—product-selection criteria. Discussions with government partners, community organisations, and housing-sector representatives indicate that product decisions are rarely driven by a single consideration. Instead, organisations must simultaneously evaluate factors such as upfront and operating costs, technical performance, supplier capability, warranty coverage, environmental outcomes, product availability, and long-term value for money. Reconciling these competing priorities within budget constraints,

procurement requirements, and program objectives makes product selection a complex and resource-intensive decision-making process.

Together, these factors create significant information and coordination challenges across the residential energy-upgrade ecosystem (Figure 2.1). Fragmented product information, inconsistent evaluation approaches, and differing procurement practices increase transaction costs and often lead to duplicated effort across programs and jurisdictions. Without a common evaluation framework, purchasing decisions can vary considerably, and the rationale underpinning product-selection decisions is not always transparent.



Figure 2.1 Challenges of product selection in residential energy-upgrade programs

2.2 Energy Upgrades Product Selector: usage description

To address the product-selection challenges identified in the previous section, Work Package 5 developed the Energy Upgrades Product Selector, an online decision-support platform designed to support organisations involved in the planning and delivery of residential energy-upgrade programs. Rather than identifying a single 'best' product, the Product Selector enables users to evaluate and compare alternatives using a transparent and evidence-based framework, helping identify products that best align with the objectives, constraints, and delivery requirements of a particular program.

Unlike consumer comparison tools, which are primarily intended to support household purchasing decisions, the Product Selector has been developed for organisations responsible for delivering retrofit programs at scale. Potential users include local governments, community organisations, social housing providers, government agencies, and program managers. These organisations often need to assess large numbers of products simultaneously while balancing technical performance, cost, supply-chain considerations, and broader program objectives.

The tool supports assessment across six major residential retrofit technology categories: insulation and draught-proofing products, heat pump hot water systems, electric cooktops, split-system air conditioners, LED lighting products, and high-performance windows and glazing systems. Collectively, these categories represent some of the most significant opportunities for improving the energy performance of Australian homes.

The Product Selector has been designed to accommodate different levels of data availability and user expertise. Product information can be entered manually or uploaded using standardised templates developed for each technology category. This flexibility enables users to evaluate anything from a small number of products to large product datasets containing hundreds of alternatives.

The assessment process follows a structured workflow (Figure 2.2). Products are first screened against user-defined eligibility requirements before being evaluated using a common assessment framework. Users can then adjust the relative importance of different evaluation criteria to reflect program priorities and explore how alternative objectives influence product rankings. Assessment results can be reviewed within the application and exported for procurement, reporting, stakeholder engagement, and program-planning purposes.

By combining product screening, multi-criteria evaluation, scenario testing, and reporting within a single platform, the Product Selector provides a consistent framework for product assessment across multiple technology categories. This enables organisations to make more transparent, evidence-based, and defensible product-selection decisions while reducing the time and effort required to compare complex alternatives.

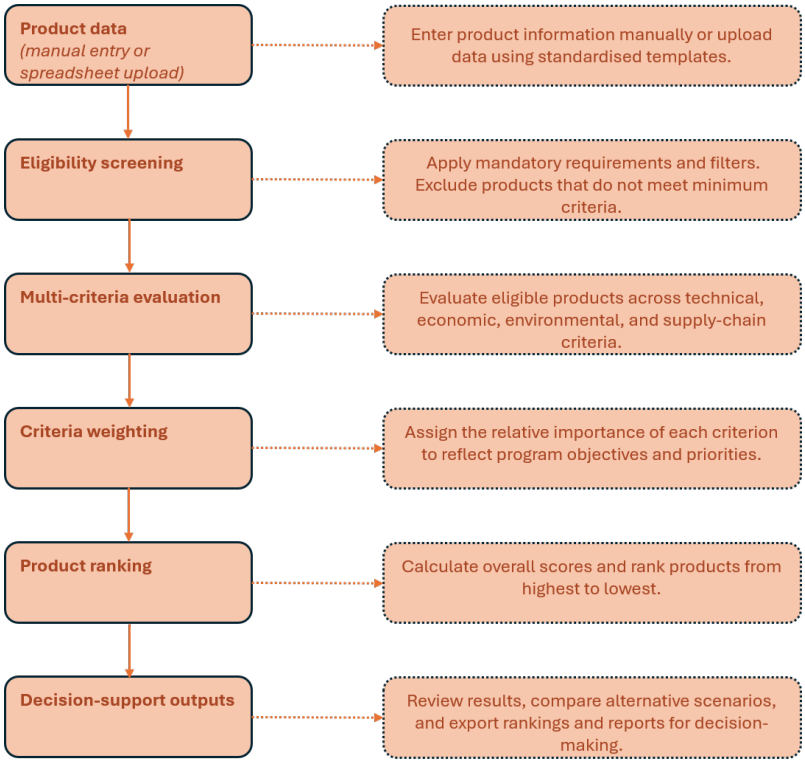


Figure 2.2 Workflow of the Energy Upgrades Product Selector

2.3 Energy Upgrades Product Selector: assessment methodology and selection algorithm

The Product Selector uses a multi-criteria decision analysis (MCDA) framework based on the Weighted Sum Model (WSM), a widely used approach in government procurement, infrastructure planning, and policy evaluation (Triantaphyllou, 2000; Kaliszewski & Podkopaev, 2016; UK Government Analysis Function, 2024). The methodology provides a transparent and auditable process for comparing products across multiple criteria while accommodating different program objectives and priorities.

The assessment process consists of four stages.

2.3.1 Eligibility screening

The first stage involves applying mandatory eligibility requirements. These requirements vary according to program objectives and product categories but may include minimum performance standards, certification requirements, supplier eligibility criteria, warranty provisions, or maximum purchase-price thresholds. Products that do not satisfy these requirements are excluded from further consideration.

2.3.2 Multi-criteria product evaluation

Products that pass the eligibility screening stage are assessed against a range of technical, economic, environmental, and supply-chain criteria. Because these criteria are measured using different units, they are converted to a common scoring scale to enable consistent comparison across products.

Depending on the technology category and program objectives, assessment criteria may include:

- purchase and operating costs;
- technical performance;
- warranty provisions;
- supplier capability;
- product availability;
- geographic service coverage;
- installation and maintenance requirements; and
- category-specific environmental characteristics.

2.3.3 Weighting and program priorities

Recognising that different organisations operate under different objectives and constraints, the framework allows users to assign varying levels of importance to individual criteria. These weightings determine the relative contribution of each criterion to the overall product score.

This functionality enables organisations to tailor assessments to specific program objectives and to explore how alternative priorities affect procurement outcomes. For example, one program may prioritise minimising upfront costs, while another may place greater emphasis on long-term performance, supplier capability, or environmental outcomes.

2.3.4 Product ranking and reporting

The final stage combines the weighted criterion scores into an overall product score and generates a ranked list of alternatives. The methodology retains information on the contribution of individual criteria, allowing users to understand how rankings are generated and which factors have the greatest influence on outcomes.

Figure 2.3 summarises the criterion weighting and product ranking process.

Example application: exploring alternative program priorities

Scenario A: Social housing retrofit program

- Priorities:
- low upfront cost;
- strong warranty coverage;
- broad supplier coverage.

Outcome: Product A receives the highest ranking because it offers the best combination of affordability, warranty protection, and supplier support.

Scenario B: Emissions reduction program

- Priorities:
- energy performance;
- product durability;
- lifecycle cost savings.

Outcome: Product B receives the highest ranking because it delivers stronger long-term energy and emissions outcomes despite a higher upfront cost.

Key message: The Product Selector does not identify a universally "best" product. Instead, it identifies products that best align with the objectives, constraints, and priorities of a particular program.

Figure 2.3 Criterion weighting and product ranking process used by the product Selector

To maintain transparency, the Product Selector does not estimate or substitute missing values. Products are assessed using the information provided, thereby avoiding assumptions about unreported characteristics while maintaining a consistent evaluation framework across all products. A detailed description of the assessment methodology—including the Weighted Sum Model (WSM), normalisation procedure, treatment of cost and benefit criteria, handling of missing values, sensitivity analysis and worked examples—is provided in Appendix A.

2.4 Governance, data quality and maintenance

The tool is designed as a decision-support platform rather than a centrally managed product database. The application provides a standardised framework

for evaluating and comparing products across multiple residential energy-upgrade technologies; however, responsibility for collecting, maintaining, and verifying product information remains with the user organisation.

Users may upload product information using the standardised templates provided within the application or enter information manually through the user interface. Consequently, the quality and reliability of assessment outcomes depend on the accuracy, completeness, and currency of the data supplied by users. The Product Selector does not independently verify product specifications, supplier information, pricing, certification status, warranty conditions, or other product attributes.

The Product Selector applies a consistent assessment methodology to the information provided by users and generates rankings based on user-defined eligibility requirements, evaluation criteria, and weighting preferences. Assessment outcomes therefore reflect both the quality of the underlying data and the priorities specified by the user. The tool is intended to support informed decision-making rather than endorse particular products, suppliers, or technologies.

2.5 Conclusion

The Product Selector represents an initial decision-support framework and, like any assessment tool, is constrained by the availability and quality of underlying product information. The framework also cannot capture every factor that may influence procurement decisions in specific program settings.

Future development could include expansion of product databases, incorporation of additional supply-chain indicators, enhanced scenario-testing capabilities, and refinement of assessment criteria based on user feedback and evolving market conditions.

Despite these limitations, the Energy Upgrades Product Selector provides a transparent and consistent framework for comparing products across multiple technology categories and procurement objectives. The tool does not seek to identify a universally ‘best’ product; rather, it helps organisations identify products that best align with their particular objectives, constraints, and delivery requirements. In doing so, it has the potential to support more informed decision-making, improve procurement efficiency, and contribute to the development of more effective residential energy-upgrade supply chains.

3 Comparative analysis of residential energy retrofit supply chains

Although residential retrofit technologies contribute to common objectives of improving household energy efficiency, reducing greenhouse gas emissions and supporting residential electrification, they differ substantially in the way their supply chains are organised. Some technologies rely primarily on domestic manufacturing, while others depend heavily on exports from global production networks. Some products are distributed through mature retail and wholesale markets, whereas others require specialised fabrication or engineering before installation. Similarly, installation requirements vary considerably, ranging from relatively straightforward household installation to highly specialised work requiring multiple licensed trades and extensive post-installation support. These differences influence supply-chain resilience, local value creation, workforce requirements and the capacity of each industry to respond to increasing demand.

Recognising these differences is particularly important for designing and delivering residential energy-upgrade programs. Policies that are effective for one technology may be less appropriate for another because the underlying supply chains differ in their sourcing/procurement, manufacturing arrangements, market structure, distribution channels and installation requirements. A detailed understanding of these characteristics is therefore essential for identifying potential logistics and delivery constraints, designing effective procurement strategies and supporting the expansion of residential retrofit markets.

3.1 Overview of residential retrofit technology categories

This report groups residential energy retrofit technologies into four major categories: (i) insulation and draught-proofing products, (ii) heat pump hot water systems, (iii) electric space-conditioning and cooking technologies, and (iv) high-performance windows and glazing systems. These technologies (Figure 3.1) represent some of the most significant opportunities for improving the energy performance of Australian homes while supporting residential electrification and emissions reduction. Table 3.1 summarises their principal characteristics.

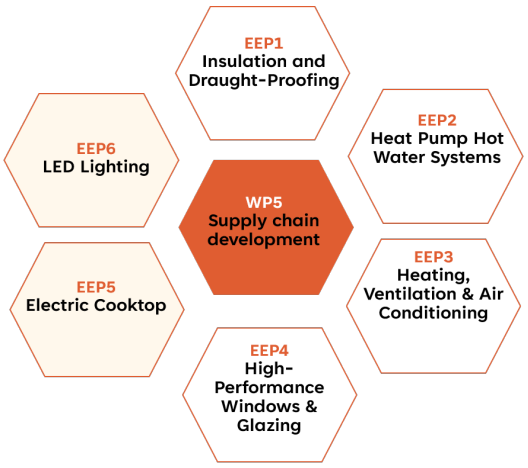


Figure 3.1 Energy efficiency products investigated

The four technology groups perform two complementary functions within residential retrofit programs. Insulation and high-performance windows improve the thermal performance of the building envelope by reducing heat transfer and uncontrolled air leakage, thereby lowering heating and cooling demand. Heat pump hot water systems and electric space-conditioning and cooking technologies support household electrification by replacing less efficient or fossil-fuel-based appliances with high-efficiency electric alternatives.

Although these technologies contribute to common policy objectives, their supply chains differ substantially. Building-envelope products generally involve greater levels of local fabrication and installation, whereas appliance-based technologies rely more heavily on international manufacturing and established wholesale and retail distribution networks. Installation requirements also vary considerably, ranging from relatively straightforward retrofit activities to highly specialised work requiring licensed trades and technical commissioning. These differences influence workforce requirements, local value creation, industry capability and the capacity of each sector to respond to growing demand.

Despite these differences, all four technology groups share several common characteristics. Each involves multiple stages extending from manufacturing and product sourcing through distribution, installation, operation and end-of-life management. Effective delivery therefore depends on coordination between manufacturers, importers, distributors, installers, program-delivery organisations and households, supported by appropriate regulatory frameworks, product assurance and skilled workforces.

Table 3.1 provides a comparative overview of the four technology categories, while the following sections examine the structure of each supply chain in greater detail. The analysis focuses on how products move through the supply chain and

the organisations involved in their delivery, rather than on the technical performance of the technologies themselves.

Table 3.1 Comparative overview of residential retrofit technology categories

Technology category	Primary function	Typical applications	Installation intensity	Principal supply-chain characteristics
Insulation and draught-proofing	Improve building-envelope thermal performance	Roof, wall and floor insulation; air sealing	Moderate	Hybrid domestic manufacturing and imports supported by building-product distributors and specialist installers
Heat pump hot water systems	High-efficiency electric water heating	Replacement of electric and gas hot water systems	High	Predominantly imported products supported by plumbing wholesalers, specialist installers and technical service networks
Electric space-conditioning and cooking	Household electrification and efficient appliance replacement	Reverse-cycle air conditioning and induction cooking	High	International manufacturing supported by established electrical, HVAC and appliance distribution networks
High-performance windows and glazing	Improve thermal comfort and building-envelope performance	Window replacement, insulated glazing and thermally efficient framing systems	Very high	Imported materials combined with substantial local fabrication, engineering and specialist installation

The following four sections examine each technology group in greater detail. Rather than evaluating the technical performance of the products themselves, the discussion focuses on the structure of the supply chains through which they are sourced, distributed, installed and supported.

3.2 Insulation and draught-proofing supply chain

Unlike appliance-based technologies, insulation and draught-proofing products become integrated into the fabric of the building. Their effectiveness therefore depends not only on the quality of the products themselves but also on appropriate product selection, installation methods and compatibility with the characteristics of individual dwellings. The supply chain consequently combines manufactured products with installation and building services, creating a hybrid product–service system involving manufacturers, importers, distributors, installers, retailers, program-delivery organisations and households. While Figure 3.2 and Figure 3.3 show the simplified supply chain structures of both residential insulation and draught-proofing products respectively, Figure 3.4 illustrates the principal product, distribution, installation and end-of-life pathways associated with insulation and draught-proofing products.

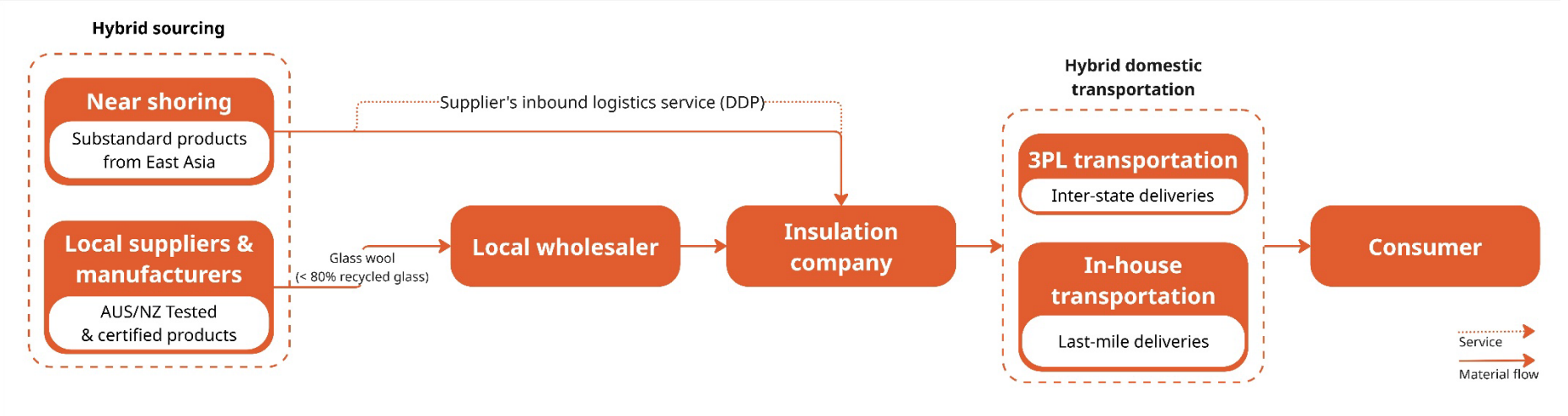


Figure 3.2 Simplified supply chain for residential insulation products

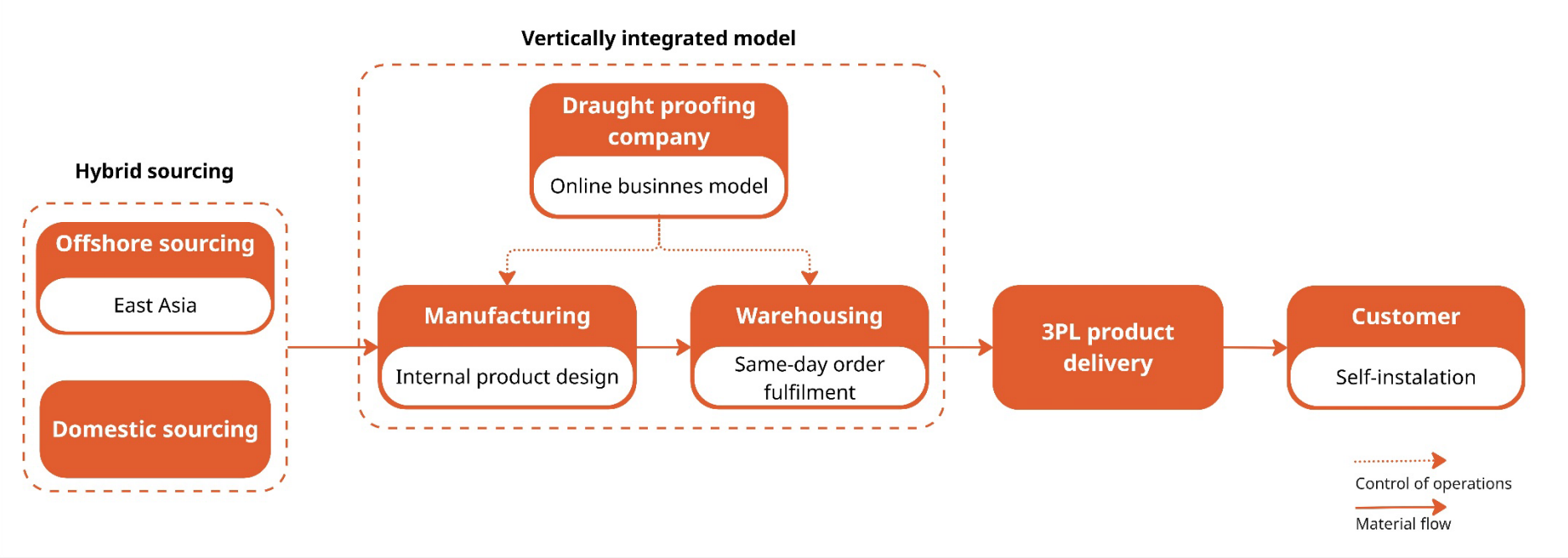


Figure 3.3 Simplified supply chain for draught proofing

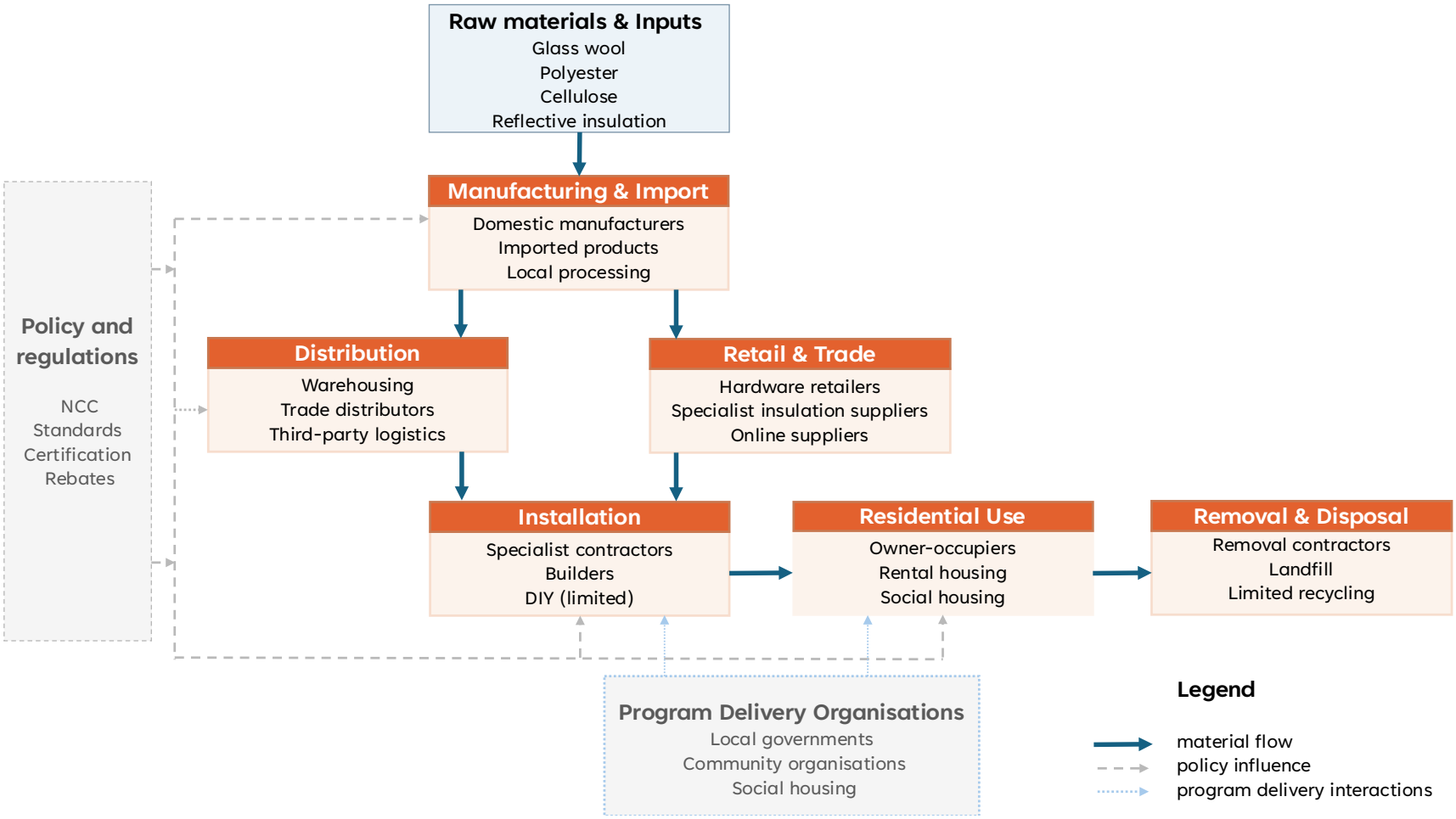


Figure 3.4 Summarised supply chain for residential insulation and draught-proofing products

3.2.1 Products and sourcing

The insulation and draught-proofing market encompasses a diverse range of products designed to improve building thermal performance. Insulation products include glass-wool and fibreglass batts, polyester insulation, cellulose products, rigid boards, reflective insulation, membranes and specialised insulation systems designed for particular climatic conditions and building types. Draught-proofing products include door and window seals, compression seals, vent covers, tapes, gap-sealing products, power-point boxes and components used to seal heating ducts and other building penetrations.

> "Polyester insulation is not practical to ship internationally—it's bulky, lightweight, and takes up a huge amount of space without adding weight, making freight prohibitively expensive. The fibres themselves are imported and then blended domestically to achieve the precise mix required. The finished insulation is then trucked to its final destination." IN 3

The upstream supply chain combines domestic manufacturing with international sourcing and local product processing. Australian manufacturers continue to produce several important insulation products, including glass-wool, fibreglass and polyester insulation, while selected adhesives, aluminium components, timber products and draught-proofing materials are also manufactured locally (Appendix 1). At the same time, imported raw materials and specialised components remain an important part of the supply chain. Polyester fibres, plastics, adhesives, magnets, tapes and other specialised inputs are sourced through international markets before being incorporated into products supplied within Australia.

As a result, insulation products cannot be classified simply as either domestically manufactured or imported. Many products combine Australian manufacturing with internationally sourced materials, while imported products frequently pass through Australian warehousing, distribution and technical support networks before reaching end users. The supply chain therefore operates as a hybrid local–

> "We have reduced SKU variability (e.g. specific R-ratings and dimensions) to optimise freight, storage, and installation workflows. Standardisation helps manage demand forecasting and improves compatibility with their installation processes" IN 1

global production system that combines domestic manufacturing capability with international sourcing.

3.2.2 Distribution

Following manufacture, importation or local processing, insulation and draught-proofing products move through a variety of distribution pathways before reaching installers and households. Conventional insulation products are commonly supplied through manufacturers, wholesalers, specialist insulation distributors, building-material suppliers and hardware retailers. These organisations perform warehousing, inventory management and transportation functions while providing access to products for builders, retrofit contractors and households.

Distribution arrangements vary according to business model and product type. Some manufacturers operate their own warehousing and transport networks, while others rely on third-party logistics providers or established building-material distribution systems (Appendix 2). Hybrid arrangements are also common, with organisations combining internally managed storage with outsourced freight services to support distribution across metropolitan and regional markets.

> "We use a mix of logistics approaches. We operate some of our own trucks, but we also partner with third-party warehouses and transport companies. As a result, distribution can be handled either directly by us or through these external providers." IN 5

Distribution channels are generally broader for insulation than for draught-proofing products. While insulation is frequently supplied through conventional building-product networks, selected draught-proofing products are increasingly distributed directly to households through digital retail platforms. These products are well suited to online sales because they are relatively standardised, lightweight and suitable for parcel delivery. Consequently, manufacturers may integrate product design, manufacturing, online retailing and customer support within a single business model, reducing reliance on traditional wholesale and retail intermediaries.

3.2.3 Installation and delivery

Installation represents the stage at which insulation and draught-proofing products are transformed into improved building energy performance. Ceiling, wall and underfloor insulation is generally installed by specialist insulation contractors, builders or other construction trades. Depending on the building and the products used, installation may involve electrical safety checks, moisture assessment, treatment of existing insulation and coordination with other building-envelope improvements.

> "Logistics is managed by the supplier [manufacturer]. The manufacturer organises door-to-door delivery, including costs, port charges, and taxes. All that is covered by the supplier or by external providers" IN 2
>
> "All of our installers are permanently employed. We have a few casual staff who handle cleaning and other support tasks, but the installers themselves are permanent employees" IN 4

Several delivery models coexist within the market. Some businesses employ their own installation workforce, while others distribute products through independent installation contractors or builders (Appendix 3). Manufacturers typically concentrate on product supply and technical support, with installation undertaken by specialist businesses or construction trades.

Draught-proofing products exhibit greater variation in delivery models. Specialist contractors commonly install more technically demanding products, while simpler products—including door seals, vent covers and selected gap-sealing systems—may be purchased directly by households and installed without specialist trades. Product instructions, online guidance and technical support therefore form an important part of the overall supply chain by assisting households in selecting and installing appropriate products.

Compared with appliance-based technologies, insulation and draught-proofing rely more heavily on successful integration with the existing building fabric. Product performance depends not only on manufacturing quality but also on the way products are selected, positioned and installed within the dwelling.

3.2.4 Program delivery and end-of-life

Governments, local councils, community organisations and social housing providers engage with the insulation and draught-proofing supply chain through a variety of residential energy-upgrade programs. These organisations may procure products directly, establish approved supplier and installer panels,

coordinate household assessments or engage integrated providers responsible for supplying and installing insulation as part of broader retrofit programs.

The supply chain operates within a regulatory environment that includes the National Construction Code, Australian Standards, occupational health and safety requirements, product certification and jurisdiction-specific program guidelines. These frameworks influence product selection, installation practices and participation in government-supported retrofit initiatives.

Unlike many consumer appliances, insulation products are not routinely replaced at the end of their service life. Existing insulation may remain in place where it continues to perform effectively, with new insulation installed over or alongside existing material during retrofit projects (Appendix 4). Removal generally occurs only where insulation has deteriorated, become contaminated or no longer meets applicable requirements. Where removal is necessary, materials are extracted and transported for disposal, although opportunities for recycling and material recovery currently remain limited. Draught-proofing products typically have simpler replacement pathways and enter conventional construction or household waste streams at the end of their service life.

> "My company doesn't recommend removing insulation unless it's damaged or doesn't meet Australian Standards. For example, if we removed cellulose insulation and it failed a burn test, we'd take it out. With glass wool. One of our main suppliers warrants overlaying as long as the existing insulation meets standards and is undamaged." IN 4

3.3 Heat pump hot water system supply chain

Heat pump hot water systems (HPHWs) are among the most important technologies supporting residential electrification and improved household energy efficiency. Unlike conventional electric resistance systems, heat pumps transfer heat from the surrounding air rather than generating heat directly, substantially reducing electricity consumption for water heating. Their increasing adoption through household electrification programs, energy-efficiency initiatives and residential retrofit schemes has made them one of the fastest-growing technology categories within Australia's residential energy-upgrade market. Figure 3.5 illustrates the simplified structure of the supply chain of hot water systems. Figure 3.6 summarises the principal product, distribution, installation, servicing and end-of-life pathways associated with residential heat pump hot water systems.

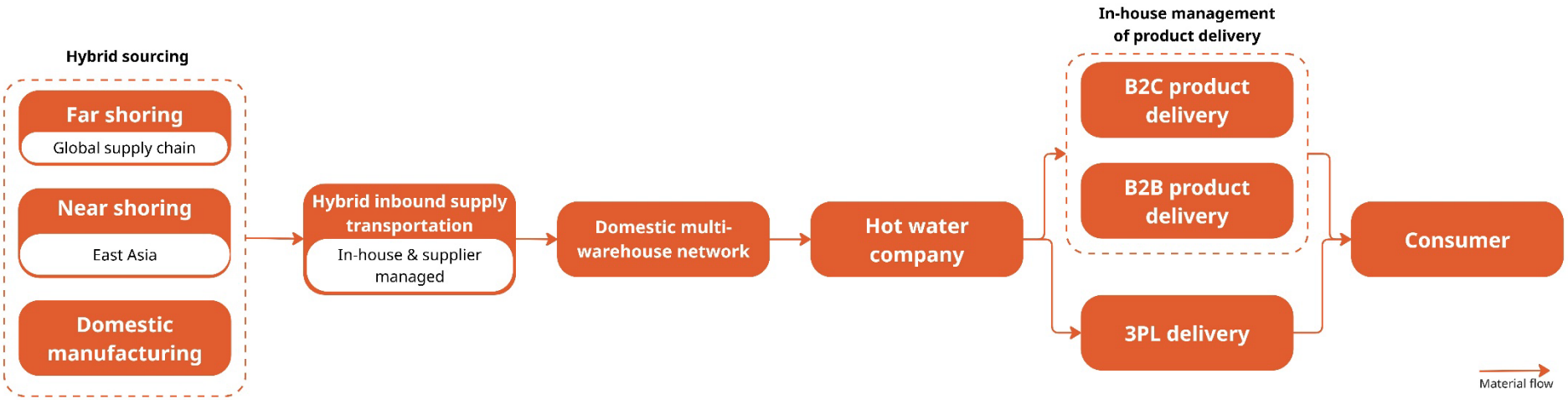


Figure 3.5 Simplified supply chain for heat pump hot water systems

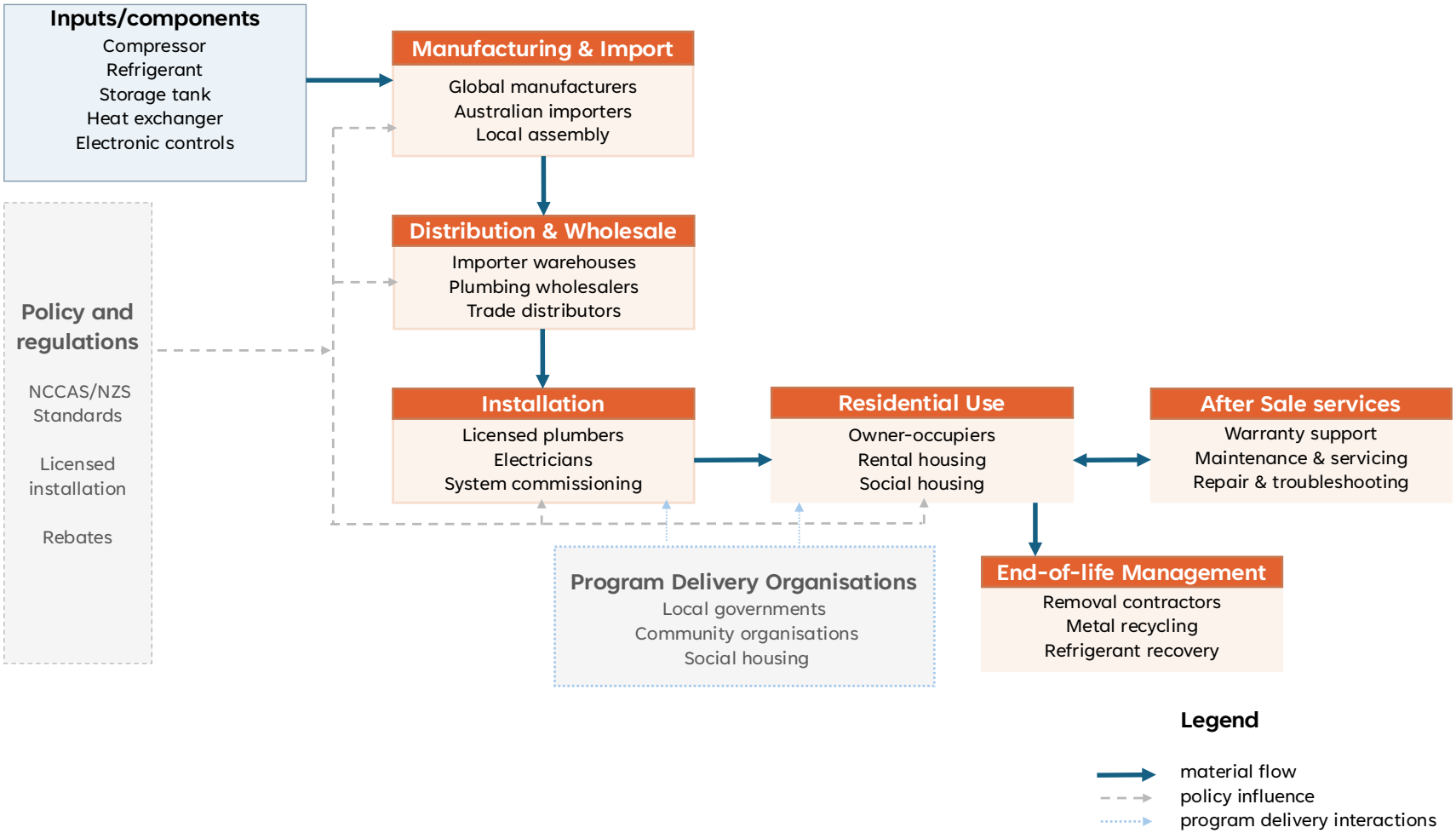


Figure 3.6 Summarised supply chain for heat pump hot water systems

3.3.1 Products and sourcing

Heat pump hot water systems comprise a range of integrated mechanical and electrical components, including compressors, refrigerants, storage tanks, heat exchangers, electronic controllers, pumps, valves and associated plumbing and electrical equipment. These components are assembled into complete systems designed to provide high-efficiency domestic hot water.

> "We have our own delivery driver and truck that pick up [items from suppliers] whenever possible. Usually, if our stock is running low we pick up. But if we can't collect it ourselves, our suppliers will deliver and drop

The upstream supply chain combines international manufacturing with varying degrees of Australian engineering, assembly and component manufacture (Appendix 5). Many finished products are imported from major manufacturing centres in Asia, while Australian businesses contribute through product design, engineering, software development, storage-tank manufacture, electronic controls and final product specification. Consequently, many systems combine Australian engineering and locally manufactured components with internationally sourced compressors, refrigeration equipment and other specialised parts.

> "We do all design, research, and development internally in Sydney. Our engineers specify exactly how our products should perform and look. Once designs are finalised, we partner with manufacturers in China, we don't own our own factories, to produce the products according to our specifications. After production, we import everything into Australia." HW 4

Business models vary across the industry. Some organisations manufacture and assemble products domestically using imported components, while others operate primarily as importers or distributors of globally manufactured systems. Other firms focus on product development and engineering while outsourcing manufacturing to overseas production partners. As a result, the market comprises several supply-chain configurations rather than a single standardised model.

3.3.2 Distribution

Following manufacture or importation, products are distributed through importer warehouses, plumbing wholesalers, specialist distributors, authorised reseller networks and retailer-installer businesses. Distribution systems range from centrally managed national warehouse networks to smaller operations supported by third-party logistics providers (Appendix 6).

> "Our company has about four vehicles, [...] and we maintain our own warehouse stock. This allows us to deliver product quickly for our own installations, to builders, or to other customers." HW1
>
> "Our third-party logistics partners deliver directly to construction sites as needed — they already service large companies [...], so it's straightforward for us." HW 3

Larger organisations often maintain multiple distribution centres to improve product availability and reduce delivery times across metropolitan and regional markets. Smaller businesses frequently rely on outsourced warehousing and freight providers while maintaining technical oversight of inventory and customer service. Products are supplied through both business-to-business channels—including plumbing merchants, builders and specialist installers—and vertically integrated businesses that combine retail sales with installation services.

Compared with building-envelope products, heat pump systems are distributed through more specialised trade networks because installation requires qualified plumbing and electrical professionals. Distribution therefore extends beyond product movement and includes technical documentation, installer support and product availability for authorised installation partners.

3.3.3 Installation and after-sales services

Installation is a defining stage of the HPHW supply chain because system performance depends on correct installation, commissioning and integration with household plumbing and electrical systems. Installation typically involves removal of the existing water heater, plumbing modifications, electrical connections, commissioning, testing and customer handover.

Several delivery models operate within the industry. Some organisations provide integrated supply-and-install services through their own workforce, while others distribute products through independent installer networks (Appendix 7). Manufacturers generally focus on product development and technical support

rather than undertaking household installation directly, relying instead on licensed plumbers, electricians and specialist contractors.

> "Our company provides all vehicles for staff. So yes — our installers use company-owned vehicles to transport themselves and the stock to site." HW 1
>
> "We don't use our own transportation—instead, we outsource all our freight logistics." HW 2

After-sales services form an integral component of the supply chain throughout the product lifecycle. Manufacturers, importers, distributors and authorised service providers contribute to warranty administration, technical support, maintenance, repairs and spare-parts supply. These services support long-term product performance and provide households with ongoing access to technical expertise following installation.

3.3.4 Program delivery and end-of-life

Governments, local councils, community organisations and social housing providers engage with the HPHW supply chain through household electrification programs, appliance-replacement initiatives and energy-efficiency schemes. Depending on program design, organisations may procure equipment directly, establish approved supplier panels or contract integrated providers responsible for supply, installation and commissioning.

The supply chain operates within a regulatory framework that includes plumbing and electrical licensing, refrigerant handling requirements, product certification, minimum energy-performance standards and program-specific eligibility requirements. These frameworks influence product selection, installation practices and participation in government-supported retrofit programs.

> "We work only with licensed trades: Electricians, Plumbers and Refrigeration mechanics. Because of these requirements — and the oversight from regulators like the Victorian Building Authority — we rarely have installation issues" HW 1

At the end of their service life, heat pump systems are removed by qualified technicians. System replacement generally involves recovery of refrigerants in accordance with environmental regulations, recycling of recoverable metals and responsible disposal of remaining components.

3.4 Electric space-conditioning and cooking supply chain

Electric space-conditioning and cooking technologies are central to Australia's transition towards residential electrification. This category primarily includes reverse-cycle air conditioners and induction cooktops, which provide efficient electric alternatives to gas heating, gas cooking and less efficient electrical appliances. Their increasing adoption is being driven by household electrification, improvements in appliance efficiency and government programs supporting the replacement of fossil-fuel-based technologies.

Compared with the other technologies examined in this report, electric space-conditioning and cooking products benefit from relatively mature consumer markets and well-established retail and trade distribution networks. Nevertheless, successful deployment depends not only on product availability but also on qualified installation, integration with household electrical systems and ongoing technical support. Figure 3.7 summarises the major stages of supply chains associated with electric space-conditioning and cooking technologies.

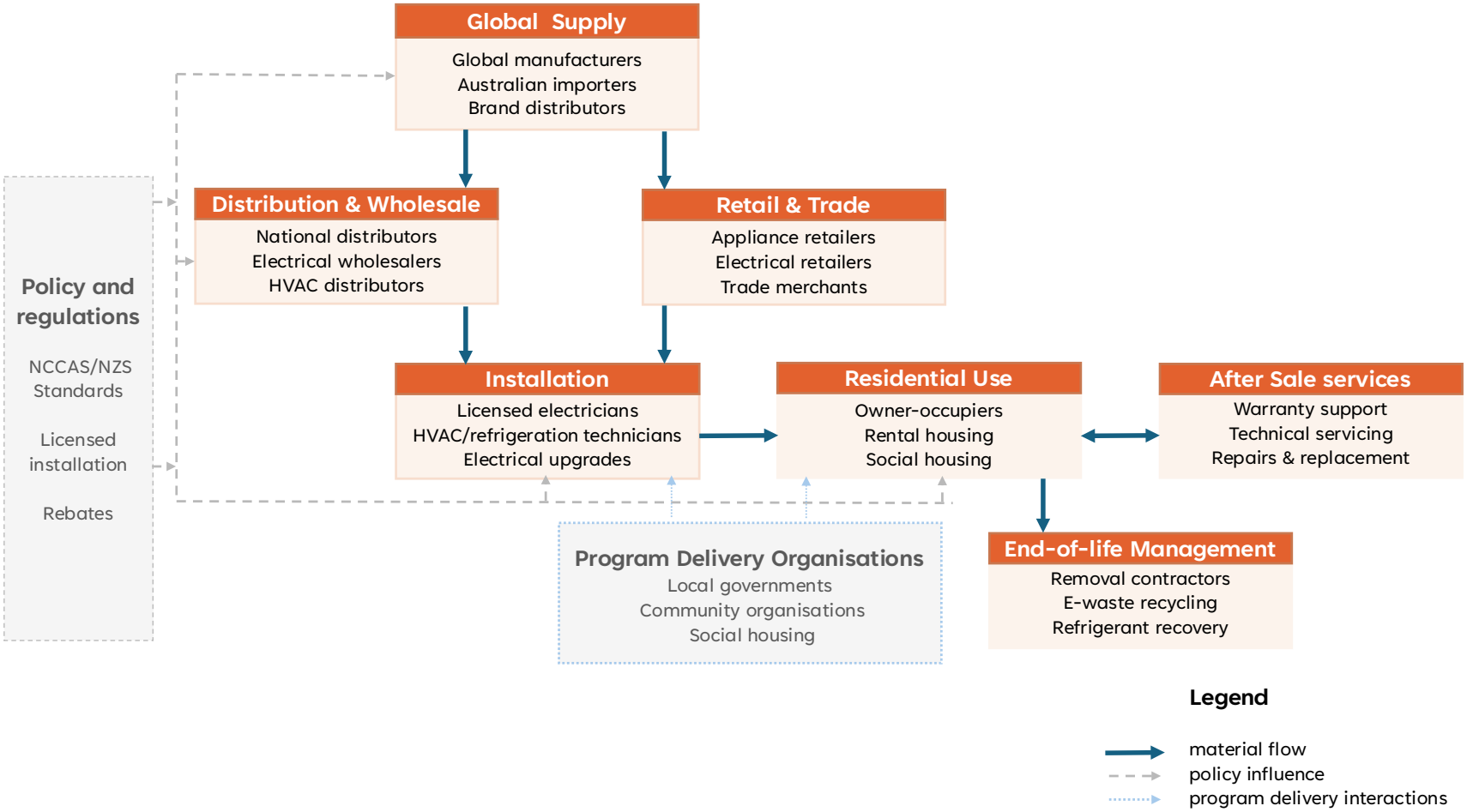


Figure 3.7 Summarised supply chain for electric space conditioning and cooking

3.4.1 Products and sourcing

The upstream supply chain is dominated by international manufacturing, with most reverse-cycle air conditioners and induction cooktops supplied to Australia as finished products. Major manufacturing centres are located in China, Japan, South Korea and other Asian economies, although individual products may incorporate components sourced through broader international production networks.

Reverse-cycle air-conditioning systems comprise compressors, heat exchangers, refrigerants, fans, electronic controllers, sensors and associated indoor and outdoor units. Induction cooktops include ceramic-glass cooking surfaces, induction coils, power electronics, control systems and associated electrical components. While manufacturing occurs predominantly overseas, Australian businesses contribute through product specification, regulatory compliance, branding, quality assurance and technical support.

Several business models operate within the market. Some organisations act as Australian subsidiaries of multinational manufacturers, while others operate as authorised importers or distributors supplying internationally manufactured products. Retailers and specialist suppliers generally source products through these established distribution channels rather than importing directly from manufacturers. Consequently, the Australian market is characterised by relatively standardised products supplied through mature international production networks.

Unlike windows or insulation products, appliances require relatively little local product customisation before sale. Product selection is instead based on household requirements such as heating and cooling capacity, kitchen configuration, energy-efficiency ratings and compatibility with existing electrical infrastructure.

3.4.2 Distribution

Following importation, products are distributed through extensive networks of importer warehouses, electrical wholesalers, HVAC distributors, appliance retailers, trade merchants and online retail platforms. Compared with other residential retrofit technologies, electric appliances benefit from highly developed national distribution systems that support both consumer and trade markets.

Distribution arrangements vary according to business model. Larger suppliers commonly operate national warehouse networks that service retail outlets, wholesalers and authorised installation partners, while smaller businesses rely on third-party logistics providers for warehousing and freight. Products may be

supplied directly to households through retail channels or distributed through specialist contractors as part of integrated supply-and-install services.

Market channels also differ between the two technology groups. Induction cooktops are widely available through mainstream appliance retailers, kitchen suppliers and online sales platforms, enabling households to purchase products independently before arranging installation. Reverse-cycle air conditioners are more frequently supplied through specialist HVAC distributors or retailer-installer businesses because product selection and installation generally require greater technical advice.

The widespread availability of these products through established commercial networks distinguishes this supply chain from those associated with more specialised residential retrofit technologies. Rather than relying on dedicated industry-specific distribution systems, electric space-conditioning and cooking technologies benefit from existing national appliance, electrical and building-services markets.

3.4.3 Installation and after-sales services

Installation is a critical stage in the delivery of both technologies. Reverse-cycle air conditioners require installation by appropriately licensed electrical and refrigeration professionals, with work typically involving mounting indoor and outdoor units, connecting refrigerant pipework, completing electrical connections, testing and commissioning the system.

Induction cooktops also require installation by licensed electricians. Depending on the dwelling, installation may involve replacement of existing gas appliances, modifications to kitchen cabinetry, installation of dedicated electrical circuits or upgrades to household switchboards. Successful deployment thus depends not only on product availability but also on the suitability of the dwelling's existing electrical infrastructure.

Several delivery models coexist within the market. Households may purchase appliances independently before engaging qualified trades, or products may be supplied as part of integrated retailer-installer packages. Manufacturers generally rely on authorised installers and service agents rather than maintaining extensive direct installation workforces.

After-sales services include warranty administration, maintenance, repairs, technical support and replacement parts supplied through manufacturers, distributors, retailers and authorised service providers. These services support product reliability throughout the operating life of the appliance and provide households with access to ongoing technical assistance when required.

3.4.4 Program delivery and end-of-life

Governments, local councils, community organisations and social housing providers engage with the electric space-conditioning and cooking supply chain through household electrification initiatives, appliance-replacement programs and residential energy-efficiency schemes. Depending on program design, organisations may provide rebates, establish approved supplier and installer panels or engage integrated providers responsible for product supply and installation.

The supply chain operates within regulatory frameworks governing electrical safety, refrigerant handling, product certification, minimum energy-performance standards and installation requirements. Compliance with these frameworks ensures that products are installed safely and operate in accordance with Australian regulatory requirements.

End-of-life management differs between the two technologies. Replacement of reverse-cycle air-conditioning systems requires removal of existing equipment and recovery of refrigerants before components are recycled or disposed of in accordance with environmental regulations. Induction cooktops enter conventional electrical-appliance and electronic waste streams, although associated electrical fittings and kitchen components may also require replacement during retrofit works.

3.5 High-performance windows and glazing supply chain

High-performance windows include double- and triple-glazed windows, insulated glass units (IGUs), thermally broken frames, secondary glazing systems and other specialised glazing products designed to improve thermal and acoustic performance. As building-envelope technologies, they reduce heating and cooling demand while complementing other residential energy-efficiency measures.

Unlike the appliance-based technologies examined in this report, the windows and glazing supply chain is characterised by a high degree of engineering, customisation and local value adding. Rather than supplying standardised products, the industry predominantly delivers bespoke systems designed, fabricated and installed to meet the specific dimensions and performance requirements of individual buildings. In this case, the supply chain extends well beyond manufacturing and importation to include significant domestic engineering, fabrication, installation and technical support activities. Figure 3.8 illustrates the simplified structure of windows and glazing supply chains. Figure 3.9 summarises the principal sourcing, fabrication, distribution, installation and end-of-life pathways associated with high-performance windows and glazing systems.

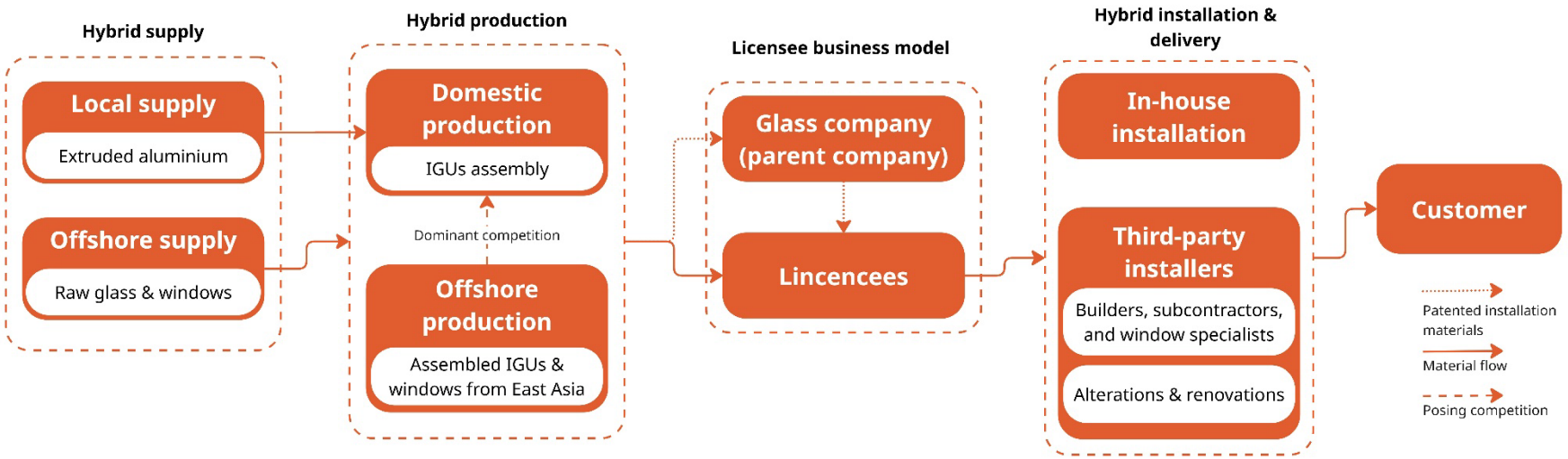


Figure 3.8 Simplified supply chain for high-performance windows and glazing

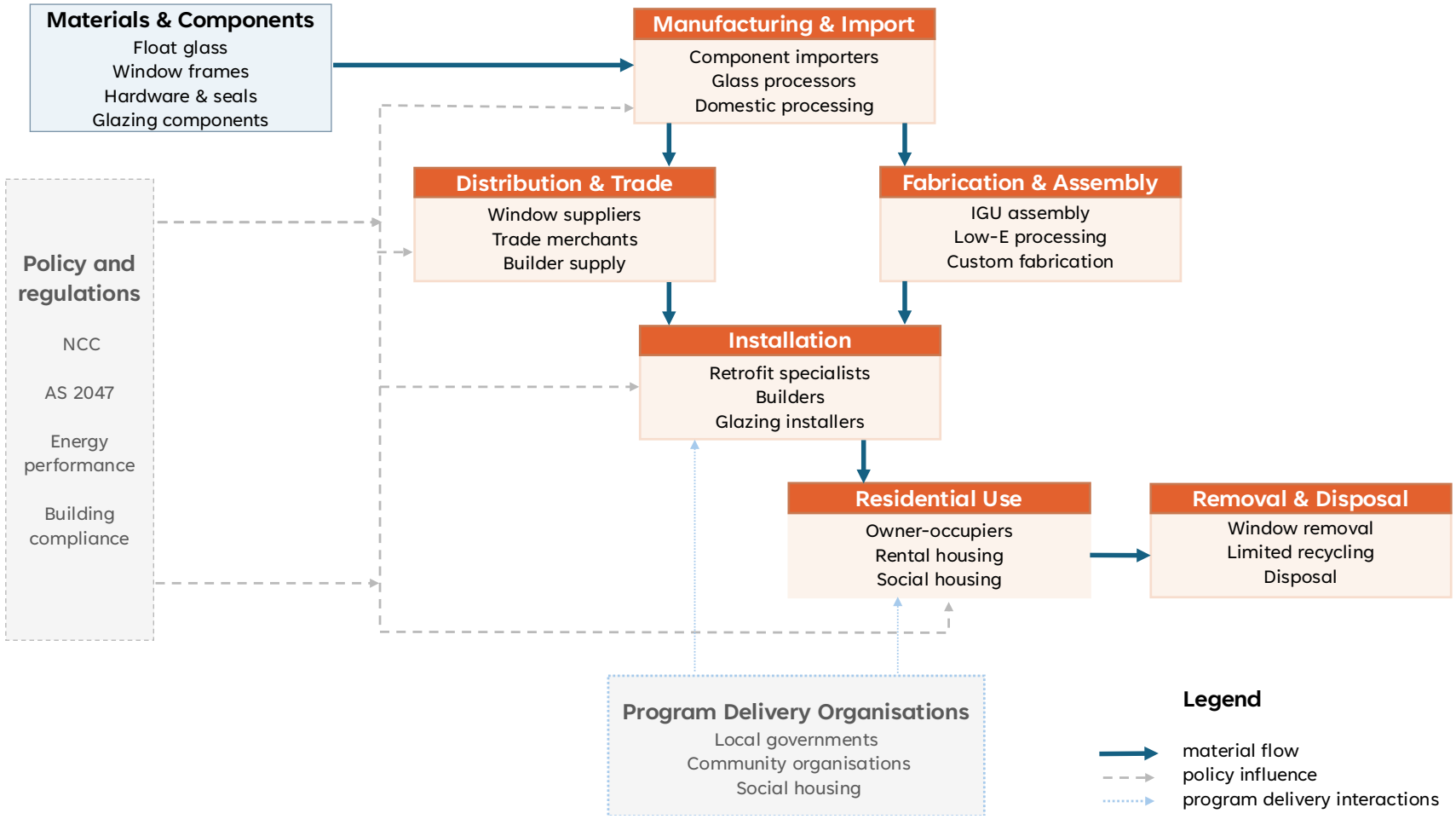


Figure 3.9 Summarised supply chain for high-performance windows and glazing

3.5.1 Products and sourcing

The upstream supply chain combines international sourcing with substantial domestic fabrication and engineering. Following the closure of Australia's remaining architectural float-glass manufacturing facility, most architectural glass is now imported as jumbo sheets or as partially processed glazing products. Hardware, seals, spacers, coatings and specialised framing components are also sourced through international supply chains before entering Australian fabrication facilities.

Unlike standard consumer products, window systems are rarely manufactured as finished products before entering the Australian market. Instead, imported materials undergo extensive local processing, including cutting, coating, laminating, insulating-glass-unit assembly and frame fabrication before becoming finished window systems (Appendix 9). Australian firms therefore contribute significant value through engineering, fabrication, quality assurance and system integration rather than through primary glass manufacture.

> "Bulk glass is imported and then coated or assembled into IGUs [Insulated Glass Unit] within Australia. In other cases, IGUs arrive fully assembled from overseas. Importing fully assembled windows is relatively new in Australia due to the logistical challenges involved" GW1

Product specification is determined by the characteristics of individual buildings. Window dimensions, structural requirements, climatic conditions, solar orientation, wind loads, acoustic performance and energy-efficiency objectives all influence product selection and system design. As a result, glazing products are typically manufactured to order rather than supplied from standard inventory, making this one of the least standardised supply chains examined in this report.

3.5.2 Fabrication and distribution

Following importation, glass and associated components enter a network of Australian fabricators responsible for transforming raw materials into completed window systems. Fabrication represents the principal value-adding stage within the supply chain and includes glass cutting, coating, tempering, laminating, insulated-glass-unit assembly, frame manufacture and final system preparation prior to installation.

Distribution pathways vary according to business model. Some organisations operate as specialist fabricators supplying builders, architects and glazing contractors, while others provide integrated supply-and-install services directly to households. Builders, subcontractors, specialist retrofit companies and

franchise networks all participate in product distribution, resulting in multiple delivery pathways rather than a single linear supply chain.

> "The majority of the market operates around new home construction, where the industry is structured primarily for supply-only. In such cases, windows are supplied by manufacturers, and installation is typically undertaken by the builder or by subcontractors engaged by the builder. Some companies specialise in supply-and-install services, but this represents a smaller, niche segment of the market." GW 1

Domestic distribution combines manufacturer-operated delivery fleets with specialist transport providers capable of handling large, fragile glazing products (Appendix 10). Products are generally transported from fabrication facilities directly to installation sites, reducing the need for prolonged storage and minimising handling prior to installation. Regional markets are commonly serviced through mobile installation teams supported by metropolitan fabrication facilities rather than permanent regional manufacturing plants.

Compared with other residential retrofit technologies, fabrication and distribution are closely integrated because products are manufactured specifically for individual projects. Product scheduling, transport and installation therefore require close coordination to ensure completed glazing systems arrive on site at the appropriate stage of construction or retrofit.

3.5.3 Installation and after-sales services

Installation is a defining component of the windows and glazing supply chain because realised performance depends heavily on the quality of installation as well as the quality of the manufactured product. Installation typically involves removal of existing windows, preparation of structural openings, installation of new framing systems, glazing, weather sealing, finishing and final inspection.

Delivery models vary according to market segment. New construction commonly involves supply through builders and subcontractors, whereas residential retrofit projects are frequently undertaken by specialist glazing companies or integrated

> "If production doesn't check quality properly, faulty glass comes to us. And we're different to new builds. With us, if we arrive on site and the glass is damaged or poor quality, we can't install it. That means the client could be left with no glass in their window overnight. So, for us, reliable supply and high quality are critical. Orders also have to arrive when

supply-and-install businesses (Appendix 11). In both cases, installation requires careful coordination between fabrication, transport and on-site construction activities to ensure products fit precisely within existing building openings.

Unlike standard consumer appliances, glazing systems cannot readily be substituted if dimensions or specifications are incorrect. Installation therefore depends on accurate measurement, fabrication and delivery scheduling, with each stage closely linked to the next. The bespoke nature of window systems means that installation forms an integral part of the overall manufacturing and delivery process rather than simply representing the final stage of product supply.

After-sales services include warranty administration, technical advice, replacement glazing, defect assessment and ongoing customer support. These services provide households with assistance throughout the operational life of the product while supporting long-term performance and customer confidence.

3.5.4 Program delivery and end-of-life

Governments, local councils, community organisations and social housing providers engage with the windows and glazing supply chain through residential energy-upgrade programs, building-performance initiatives and targeted retrofit projects. Depending on program objectives, organisations may procure products directly, establish approved supplier panels or engage integrated providers responsible for design, fabrication and installation.

The supply chain operates within a comprehensive regulatory framework that includes the National Construction Code, Australian Standards, product certification requirements and building-performance regulations (Appendix 12). These frameworks influence product specification, fabrication, installation and compliance throughout the supply chain and ensure glazing systems meet Australian structural, safety and energy-performance requirements.

> “Glass isn’t really returned as such. What happens is the customer contacts us to say they’re unhappy with the quality. In those cases, we refer to Australian Standards.” GW 2

At the end of their service life, window replacement generally involves removal of existing glazing and framing systems before installation of new products. Recoverable materials—including aluminium frames, glass and selected hardware—may enter established recycling streams, although recovery rates vary according to material type, contamination and local recycling capability.

3.6 Comparative analysis of residential retrofit supply chains

The preceding sections demonstrate that residential energy retrofit technologies cannot be considered as a single industry with a common supply-chain structure.

3.6.1 Manufacturing and sourcing models

The four technology groups exhibit distinctly different manufacturing and sourcing arrangements (Table 3.2).

Table 3.2 Comparative characteristics of residential retrofit supply chains

Characteristic	Insulation and draught-proofing	Heat pump hot water	Electric space-conditioning and cooking	High-performance windows and glazing
Primary function	Improve building-envelope performance	Efficient electric water heating	Efficient heating, cooling and cooking	Improve thermal performance and comfort
Manufacturing model	Hybrid domestic production with imported inputs	Predominantly imported equipment with Australian engineering and assembly	Predominantly imported finished products	Imported materials with extensive local fabrication
Product standardisation	Moderate	High	High	Low (custom manufactured)
Distribution model	Building-product wholesalers and retailers	Plumbing wholesalers and specialist distributors	Appliance, electrical and HVAC retail networks	Fabrication linked directly to installation
Installation intensity	Moderate	High	High	Very high
After-sales services	Limited	Extensive	Extensive	Moderate
Principal domestic value adding	Manufacturing, distribution and installation	Engineering, assembly, installation and servicing	Distribution, installation and servicing	Fabrication, engineering and installation

Insulation and draught-proofing products operate through a hybrid manufacturing model combining domestic production with imported raw materials and specialised components. Although Australian manufacturers retain important production capabilities, international sourcing remains essential for many inputs, creating supply chains that integrate local manufacturing with global procurement. Heat pump hot water systems rely more heavily on international manufacturing while retaining significant Australian capability in engineering, product specification, assembly and technical support. Australian businesses therefore contribute considerable value despite many major components being sourced through global manufacturing networks.

Electric space-conditioning and cooking technologies are characterised by the highest level of dependence on internationally manufactured finished products. Domestic activities focus primarily on product distribution, retailing, installation and servicing rather than manufacturing. By contrast, high-performance windows and glazing involve limited domestic primary manufacturing but extensive Australian value adding through engineering, fabrication and custom assembly. Imported materials undergo substantial local processing before becoming finished building products, making fabrication rather than manufacturing the principal source of domestic value creation. These differences demonstrate that the residential retrofit sector encompasses multiple production models rather than a single manufacturing system.

3.6.2 Distribution and market organisation

Distribution arrangements also differ considerably between technology groups. Insulation products are distributed primarily through building-product wholesalers, specialist insulation suppliers and hardware retailers, supplemented by increasing direct-to-consumer sales for selected draught-proofing products. Heat pump systems rely on more specialised plumbing wholesalers, importer warehouses and authorised installer networks that combine product distribution with technical support.

Electric space-conditioning and cooking technologies benefit from mature national appliance, HVAC and electrical distribution systems that already serve large consumer and construction markets. These established commercial networks provide extensive product availability through retailers, wholesalers and specialist contractors. The windows and glazing sector differs from all other technologies because distribution is closely integrated with fabrication. Products are generally manufactured to order and delivered directly from fabrication facilities to installation sites, reducing reliance on conventional retail channels and requiring close coordination between production, transport and installation activities. Consequently, while all four technologies rely on manufacturers,

distributors and installers, the structure and complexity of these relationships differ substantially according to the nature of the products being supplied.

3.6.3 Installation and service requirements

Installation represents the principal point at which residential retrofit products generate improvements in household energy performance. However, the intensity and complexity of installation vary significantly across the four technology groups. Insulation and draught-proofing products generally require specialist installation, although selected draught-proofing products can be installed directly by householders. Product performance depends largely on effective integration with the building envelope.

Heat pump hot water systems require licensed plumbing and electrical trades together with commissioning and technical verification. Ongoing maintenance, warranty support and servicing also form important components of the overall supply chain. Electric space-conditioning and cooking technologies similarly depend on qualified electrical and refrigeration trades, although they benefit from larger existing installation workforces developed through mature consumer appliance markets.

Windows and glazing require the highest degree of customisation during installation. Because products are manufactured specifically for individual buildings, installation forms an extension of the fabrication process rather than simply the final stage of product delivery. Accurate measurement, transport, installation and weatherproofing are all essential to achieving intended performance. These differences illustrate that installation should not be viewed simply as labour input but as a critical component of value creation across residential retrofit supply chains.

3.6.4 Local value creation across supply chains

Although imported products play an important role across all four technology groups, opportunities for domestic value creation differ substantially. For insulation products, value is created through domestic manufacturing, distribution and installation. Heat pump systems generate domestic value through engineering, assembly, distribution, installation and technical servicing. Electric appliances contribute primarily through retailing, logistics, installation and after-sales services.

The windows and glazing industry exhibits the highest proportion of domestic value adding because imported materials undergo extensive local fabrication, engineering and installation before becoming completed building systems. These differences suggest that increasing domestic economic benefits from residential retrofit programs requires strategies that recognise where value is created within

each supply chain rather than assuming that manufacturing represents the only source of economic activity.

3.7 Conclusion

The comparison presented in this chapter demonstrates that residential retrofit technologies operate through fundamentally different supply-chain models. Consequently, the capacity of each industry to support large-scale residential retrofit programs depends on different combinations of manufacturing capability, distribution networks, installation capacity and technical support.

Building-envelope technologies derive much of their value from installation quality and integration with the existing building fabric, whereas appliance-based technologies rely more heavily on international manufacturing supported by domestic installation and servicing networks. Heat pump systems occupy an intermediate position, combining sophisticated, imported technologies with significant Australian engineering and technical capability. Windows and glazing represent the most locally intensive supply chain, with extensive domestic fabrication and custom installation despite strong dependence on imported materials.

These structural differences have important implications for governments, industry and program-delivery organisations seeking to expand residential energy upgrades. Policies designed to strengthen residential retrofit supply chains should recognise that barriers and opportunities differ across technology groups and that a uniform policy approach is unlikely to achieve optimal outcomes.

The next chapter builds on this comparative analysis by examining the industry-specific challenges affecting each technology supply chain and identifying opportunities to strengthen their capacity to support future residential energy-efficiency and electrification programs.

4 Industry-specific barriers to supply-chain development and improvement opportunities

The four residential retrofit technology groups examined in Chapter 3 contribute to common objectives of improving household energy efficiency, supporting residential electrification and reducing greenhouse gas emissions. At the same time, they operate through distinct supply-chain structures and face different technical, commercial, workforce and regulatory challenges. This chapter examines the principal barriers affecting each technology group and identifies opportunities for strengthening industry capability.

Each industry section considers four interrelated dimensions of supply-chain capability:

- market development and demand, including factors influencing product uptake and investment certainty;
- supply-chain resilience and product provision, including sourcing arrangements, logistics and product quality;
- workforce capability and installation quality, including skills, training, certification and quality assurance; and
- policy and regulatory settings, including standards, incentives and institutional arrangements that influence industry development.

The findings are synthesised in two complementary ways. Table 4.1 provides a comparative overview of the principal barriers affecting each technology group, while Table 4.2 summarises the recurring cross-industry themes and improvement opportunities identified through the literature review, industry interviews, survey and national roundtable. These tables complement the detailed discussion presented throughout the chapter and provide an integrated overview of the issues influencing Australia's residential energy retrofit supply chains.

4.1 Insulation and draught-proofing

Insulation and draught-proofing are among the most mature and cost-effective residential energy-efficiency technologies in Australia. Industry consultation identified relatively few constraints relating to product availability but highlighted several challenges associated with market development, installation quality and policy coordination. Future industry development will therefore depend primarily on strengthening supply-chain capability rather than developing new products.

4.1.1 Market development and demand uncertainty

Insulation is widely recognised as one of the most effective residential energy-efficiency measures, yet market demand remains fragmented and difficult to predict (Appendix 13). Unlike major household appliances, insulation is generally purchased during renovations, new construction or government-supported retrofit programs. Demand therefore fluctuates with policy settings, construction activity and household awareness, creating uncertainty for manufacturers, distributors and installers.

> "Demand in our sector is unpredictable—every day is different, and we never quite know what's coming." IN 6

Demand uncertainty affects planning throughout the supply chain. Maintaining sufficient inventories to respond to changing market conditions increases warehousing costs and ties up working capital, while inadequate stock can delay retrofit projects and reduce confidence among builders, installers and program-delivery organisations. Several organisations reported improvements in demand forecasting, earlier program planning and closer coordination between suppliers, installers and governments as priorities for reducing uncertainty and improving market stability. Expanding consumer awareness through nationally consistent communication and whole-of-home retrofit approaches was also viewed as essential for supporting sustained market growth.

4.1.2 Supply-chain resilience, product sourcing and quality assurance

Australia retains significant domestic manufacturing capability for insulation products, although the industry relies on imported raw materials and specialised components. Industry representatives generally viewed the supply chain to be resilient but noted ongoing exposure to international freight disruptions, exchange-rate fluctuations and procurement delays for selected materials.

> "As an industry, we advocate for third-party certification (e.g., CodeMark or JAS-ANZ schemes) with requirements for ongoing compliance" IN 1

Greater concern centred on product conformity and quality assurance. It is broadly acknowledged that confidence in residential retrofit programs depends not only on manufacturing capacity but also on ensuring products consistently comply with Australian standards throughout procurement, distribution and installation. CodeMark certification and other recognised conformity assessment mechanisms were viewed as important components of product assurance, but stakeholders pointed out that certification should be supported by stronger compliance monitoring, improved product traceability and more consistent

inspection throughout the supply chain. Diversifying suppliers while maintaining inventories of certified, fit-for-purpose products was also identified as an important strategy for strengthening long-term resilience.

4.1.3 Workforce capability and installation quality

Workforce capability emerged as one of the most significant factors influencing insulation performance. Unlike many manufactured products, insulation achieves its intended thermal performance only when correctly installed and integrated with the existing building envelope. Installation quality should therefore be regarded as a core component of supply-chain capability rather than simply the final stage of product delivery.

The discussions revealed shortages of experienced installers, inconsistent workmanship, limited training pathways and variable supervision as continuing challenges (Appendix 15). Particular concern was expressed regarding installations undertaken under time or cost pressures, where poor workmanship can substantially reduce long-term building performance. As homes become increasingly airtight, participants also highlighted the growing importance of integrating ventilation considerations with insulation and draught-proofing measures.

> "I'd say insulation installation should be a licensed trade. Installers need to be qualified, complete competency courses, undertake working-at-heights training, hold a White Card, and have first aid certification." IN 6

Strengthening workforce capability was identified as a key priority. Suggested improvements included expanding vocational training and apprenticeship pathways, strengthening installer accreditation, introducing nationally recognised inspection competencies and increasing the use of independent quality assurance through inspections, thermal imaging, airtightness testing and post-installation verification.

4.1.4 Policy and regulatory coordination

A shared view across the sector is that Australia's existing standards and certification systems generally provide as a sound foundation for the insulation industry. However, inconsistent policy settings, changing rebate arrangements and differing jurisdictional requirements continue to create uncertainty for manufacturers, installers and households while increasing administrative complexity.

"There's no standard on how a draught stopper should perform. As long as something is labelled a draught stopper, it can be sold in Australia regardless of how effective it actually is." DP 1

Key priorities for strengthening the industry included developing nationally consistent technical requirements for draught-proofing, incorporating airtightness testing into retrofit verification, strengthening inspection processes and promoting insulation and draught-proofing as complementary components of whole-of-home energy upgrades. Stakeholders reinforced the importance of stable incentive programs, nationally consistent training and certification requirements, and stronger coordination between Commonwealth and state governments to support long-term industry investment and workforce development.

4.2 Heat pump hot water systems

Heat pump hot water systems are among the fastest-growing residential electrification technologies. Their rapid market expansion has increased the importance of maintaining product quality, installation capability and consumer confidence while supporting continued industry growth.

4.2.1 Supply-chain resilience, product quality and sourcing

The Australian heat pump market relies heavily on internationally manufactured equipment, with compressors, refrigeration components and many complete systems sourced through global supply chains (Appendix 17). While international sourcing provides access to advanced technologies and competitive pricing, a widely cited issue is continued exposure to freight disruptions, exchange-rate volatility and procurement delays for imported products and components.

"Our model is exposed to external shocks: Currency volatility (e.g., if the AUD/USD drops), Policy changes (e.g., rebates and incentives shifting overnight), Geopolitical risk with China, as we depend heavily on that supply base" HW 4

Greater concern centred on product quality and long-term performance. Products satisfying minimum regulatory requirements may still vary considerably in durability, efficiency and suitability for Australian climatic conditions and housing types. Rapid market growth was also seen as increasing the risk that lower-quality products could enter the market without adequate technical support or after-sales service.

Strengthening supply-chain resilience therefore depends not only on secure international sourcing but also on robust product assurance. Frequently mentioned priorities are improved certification, greater transparency of product testing and performance, stronger relationships with trusted suppliers, enhanced product traceability and continued investment in Australian engineering, assembly and technical support as important priorities for maintaining consumer confidence and supporting long-term industry growth.

4.2.2 Installation capability and quality assurance

Installation quality emerged as one of the most significant determinants of heat pump performance. High-quality equipment cannot achieve expected energy savings unless systems are correctly sized, installed and commissioned. Heat pump installation requires coordinated plumbing and electrical work together with specialised technical knowledge, making workforce capability a critical component of overall supply-chain performance.

Participants identified inconsistent installer capability, limited commissioning practices and variable quality assurance as continuing challenges (Appendix 18). Practical issues such as inadequate pipe insulation, poor pipe layout and inconsistent commissioning procedures were frequently cited as reducing system efficiency and long-term performance. Some rebate programs may also unintentionally prioritise installation volumes over installation quality.

> "Multi-head systems and ducted systems require advanced refrigerant piping, system design, and higher technical skills. Many installers in the market aren't yet equipped for this complexity, so installation capacity is the main constraint for air conditioning products at the moment" HW 4

Priority improvement opportunities included expanding installer training, strengthening manufacturer-supported technical education, introducing nationally recognised accreditation and increasing the use of independent inspection and post-installation verification. These measures were viewed as essential for maintaining consistent installation standards as market demand continues to increase.

4.2.3 Market development and consumer confidence

Consumer interest in heat pump technology remains strong; however, many households remain unfamiliar with system operation, expected performance and lifecycle benefits (Appendix 19). Purchasing decisions are often influenced by upfront costs, installer recommendations and available incentives rather than a comprehensive assessment of long-term energy savings or operating costs.

> "Equally important is the role of government in consumer education. One of the most effective tools would be to introduce a standardised energy efficiency rating system across key electrification products" HW 2

Industry feedback confirmed the dependence of consumer confidence on access to clear, transparent and consistent information. Improving advisory services, strengthening communication around household electrification and helping consumers identify appropriately qualified suppliers and installers were identified as important opportunities for supporting informed purchasing decisions. Building confidence in both products and installation quality was viewed as essential for sustaining long-term market growth.

4.2.4 Policy and regulatory coordination

Government incentives have played an important role in stimulating demand for heat pump technology. Industry feedback nevertheless emphasised that future market development will require more consistent policy settings and stronger quality-assurance arrangements.

Key priorities included nationally consistent certification for both products and installers, improved inspection processes and greater coordination between Commonwealth and state governments. Stakeholders also highlighted continuing challenges within multi-residential and strata developments, where existing policy settings provide limited implementation pathways for heat-pump adoption (Appendix 19). More broadly, the consultation revealed that future policy should place greater emphasis on installation quality and long-term system performance rather than simply increasing product uptake.

> "Stronger regulations are needed to ensure that only products meeting minimum efficiency and quality standards are permitted into Australia. At present, inferior products are entering the market, [...] their presence undermines businesses like ours that invest in meeting rigorous standards" IN 5

4.3 Electric space-conditioning and cooking

Electric space-conditioning and cooking technologies benefit from mature manufacturing, distribution and retail networks. Unlike the other technology groups, future development depends less on product supply than on improving whole-of-home electrification and household decision-making.

4.3.1 Household electrification and integrated retrofit planning

Electric appliances deliver the greatest benefits when implemented as part of coordinated household electrification rather than through isolated appliance replacement. Reverse-cycle air conditioners, induction cooktops, heat pump hot water systems, insulation, draught-proofing and high-performance glazing all contribute to household energy performance and should be considered within an integrated retrofit strategy.

Many households however replace appliances only when existing equipment reaches the end of its useful life. While this approach is understandable from a financial perspective, it can reduce opportunities to coordinate electrical upgrades, improve the building envelope and optimise the sequencing of retrofit activities. The discussions also highlighted the importance of considering ventilation alongside insulation, airtightness and heating and cooling upgrades to maintain healthy indoor environments, while improved duct sealing was identified as an important opportunity for increasing the efficiency of reverse-cycle air-conditioning systems.

4.3.2 Installation capability and household infrastructure

Although product supply was not considered a significant constraint, successful deployment depends on appropriately qualified installers and adequate household electrical infrastructure. Reverse-cycle air conditioners require licensed electrical and refrigeration trades, while induction cooktops frequently require switchboard upgrades, dedicated circuits or other electrical modifications before installation can proceed.

Households often receive inconsistent advice regarding the replacement of existing gas appliances, particularly the suitability of reverse-cycle air conditioners as alternatives to gas heating. Rather than identifying major workforce shortages, industry consultation emphasised the need to strengthen the capability of the existing electrical and HVAC workforce by improving knowledge of electrification technologies, household electrical systems and interactions between appliances and overall building performance.

4.3.3 Consumer awareness and market development

Reverse-cycle air conditioners and induction cooktops are widely recognised by Australian households, yet misconceptions regarding performance, operating costs and suitability continue to influence purchasing decisions. Many households remain unfamiliar with induction cooking or uncertain about the effectiveness of reverse-cycle air conditioners as primary heating systems.

Improving consumer capability was identified as a key opportunity for supporting continued market growth. There was strong agreement of the importance of

independent advisory services, nationally consistent communication and accessible information explaining technology options, expected energy savings, installation requirements and available incentives. Property managers, landlords and strata managers were also identified as priority audiences for improving understanding of residential electrification, particularly within rental housing and multi-residential buildings.

4.3.4 Policy and industry development

Industry perspectives converged on the view that government incentives have contributed significantly to the uptake of efficient electric appliances. Future policy, however, should place greater emphasis on supporting coordinated household electrification rather than encouraging the replacement of individual technologies in isolation.

Suggested improvements covers aligning appliance replacement with broader residential energy-efficiency programs, expanding independent household advisory services, improving coordination between Commonwealth and state governments and adopting nationally consistent communication supporting household electrification. Mandatory disclosure of residential energy performance could encourage more informed purchasing decisions and stimulate demand for integrated retrofit solutions.

The supply chains supporting electric space-conditioning and cooking technologies are well established and capable of supporting continued market growth. Future industry development will depend less on strengthening product supply than on improving system integration, household decision-making and policy coordination to support whole-of-home electrification.

4.4 High-performance windows and glazing

High-performance windows and glazing represent the most locally intensive supply chain examined in this report. Their bespoke nature creates significant opportunities for Australian manufacturing and fabrication while increasing the importance of specialist skills, coordination and regulatory consistency.

4.4.1 Manufacturing capability and supply-chain coordination

Australia's glazing industry combines extensive local fabrication with imported architectural glass, specialised coatings and hardware. While this hybrid model supports significant domestic value adding, the industry remains exposed to international freight disruptions, exchange-rate volatility and procurement delays for imported materials.

The bespoke nature of glazing projects also increases the importance of coordination across the supply chain. Successful delivery depends on effective communication between designers, engineers, fabricators and installers, with errors or delays at any stage potentially affecting project quality, installation schedules and overall building performance (Appendix 20). Industry consultation therefore identified improved coordination, supplier reliability and manufacturing resilience as important priorities for supporting future industry growth.

> Their [supplier] staffing was inadequate, their systems were inadequate. Most suppliers have multiple departments—customer service, sales reps, production, dispatch, management—and if one cog in the wheel fails, the whole process breaks down. For example, if customer service enters orders incorrectly, then the glass arrives wrong." GW 2

4.4.2 Workforce capability and specialist installation

Workforce capability emerged as one of the most significant determinants of glazing performance. High-performance systems require precise measurement, fabrication and installation together with specialist knowledge of thermal performance, structural requirements, weatherproofing and regulatory compliance. Installation quality continues to vary across the industry, reflecting differences in experience, training and supervision.

Strengthening workforce capability was identified as a key priority. Suggested improvements included expanding specialist training pathways, clarifying competency requirements, improving installer supervision and increasing independent quality assurance. The consultation also highlighted the importance of ensuring installers understand how glazing systems interact with building-envelope performance and broader residential electrification measures.

4.4.3 Consumer awareness and market development

Limited consumer awareness remains a significant constraint on market growth (Appendix 21). Many households underestimate the contribution of high-performance glazing to thermal comfort, energy efficiency and noise reduction, while perceived costs and installation disruption discourage investment.

Improving consumer understanding was viewed as essential for expanding demand. Stakeholders supported nationally consistent communication explaining the benefits of high-performance glazing, clearer guidance on product performance and expanded advisory services to help households evaluate retrofit options. Builders, architects, property managers and other trusted intermediaries

were also identified as important channels for improving awareness and encouraging glazing upgrades within broader residential retrofit projects.

4.4.4 Policy settings and regulatory coordination

Inconsistent policy settings and regulatory requirements continue to limit industry development. Variations in energy-efficiency standards, compliance pathways and program requirements across jurisdictions create uncertainty for manufacturers, installers and households while increasing administrative complexity (Appendix 11).

> "I would emphasise the importance of training and education. Policy efforts should focus on ensuring that the supply chain is well informed and that consumers have realistic expectations of what can be achieved" GW 1

Priority opportunities included nationally consistent performance requirements for glazing systems, clearer compliance pathways and stronger alignment between building regulations and residential retrofit programs. Participants also highlighted the importance of stable policy settings to support long-term investment in manufacturing capability, workforce development and innovation, together with improved coordination between Commonwealth and state governments to reduce fragmentation across the sector.

> "This area is further complicated by variations in licensing requirements across states and territories. [...] Many practitioners undertake installation work without realising they lack the appropriate licences or legal coverage. As a result, the retrofit market is highly variable and complex, depending on the scale of the project, the type of property, and the jurisdiction in which the work takes place" GW 1

Table 4.1 provides a comparative overview of the principal barriers affecting each technology group.

Table 4.1 Comparative summary of industry-specific barriers

Dimension	Insulation and draught-proofing	Heat pump hot water systems	Electric space-conditioning and cooking	High-performance windows and glazing
Market development and demand	High — fragmented and policy-sensitive	Medium — growing demand, but consumer	Medium — mature consumer markets, but	High — high upfront costs, low consumer awareness and

	demand; comparatively low household awareness; limited recognition within whole-of-home upgrades	uncertainty regarding product quality, performance and lifecycle costs	misconceptions and incremental household decision-making constrain coordinated electrification	limited incentives constrain household uptake
Supply-chain resilience and product provision	Medium — established domestic manufacturing, but reliance on imported raw materials and specialised components remains	High — substantial dependence on imported products and components; exposure to freight disruption, product variability and procurement lead times	Low — mature international manufacturing and established national retail and distribution networks	High — dependence on imported architectural glass and specialised components; bespoke production increases exposure to delays and coordination failures
Workforce capability and installation quality	High — performance is highly dependent on correct installation, supervision, airtightness and integration with the building envelope	High — specialised plumbing, electrical and commissioning capability required; inconsistent installation can substantially reduce performance	Medium — established workforce base, but continued need for up-to-date electrification, HVAC and household-infrastructure knowledge	High — specialist measurement, engineering, fabrication, sealing and installation skills required
Policy and regulatory settings	High — inconsistent requirements, rebate arrangements, inspection practices and definitions of draught-proofing	High — fragmented certification and incentive arrangements; limited pathways for strata and multi-residential applications	Medium — policy support exists, but incentives often focus on individual appliances rather than whole-of-home outcomes	High — inconsistent compliance pathways, standards interpretation and enforcement across jurisdictions

Primary development priority	Strengthen market coordination, installation quality and policy consistency	Manage rapid growth while protecting product and installation quality	Integrate mature appliance supply chains within coordinated whole-of-home electrification	Strengthen manufacturing resilience, specialist capability, consumer demand and regulatory consistency

4.5 Cross-industry synthesis

The industry-specific analysis presented in the preceding sections demonstrates that residential energy retrofit technologies operate through distinct supply-chain structures and consequently face different development challenges. These differences reflect the technical characteristics of individual products, their manufacturing arrangements, market maturity, distribution networks and installation requirements. At the same time, the industry consultation identified several recurring issues that extend across all four technology groups, indicating that many constraints affecting residential retrofit delivery are systemic rather than technology specific. The principal cross-industry findings and associated improvement opportunities are summarised in Table 4.2.

Table 4.2 Cross-industry findings and improvement opportunities

Cross-industry theme	Evidence from industry consultation	Implications for retrofit delivery	Principal improvement opportunities
Product quality, conformity and traceability	Concern regarding inconsistent conformity assessment, non-conforming products, limited traceability and insufficient ongoing compliance monitoring	Product certification at market entry may not ensure consistent quality throughout production, procurement and installation	Strengthen risk-based verification; improve product traceability; establish consistent product eligibility requirements; increase market surveillance and inspection
Installation quality and workforce capability	Product performance is highly dependent on installation, commissioning and integration with existing buildings; capability requirements differ	High-quality products may fail to achieve intended energy performance where installers lack specialised knowledge or quality-	Develop nationally recognised competency pathways; expand vocational and manufacturer-supported training; strengthen accreditation,

	substantially by technology	management support	supervision and continuing professional development
Independent inspection and performance verification	Variable workmanship and limited verification were identified across insulation, heat pumps, HVAC systems and glazing	Reliance on documentation or consumer complaints alone may allow poor installation to remain undetected	Adopt risk-based inspections; use photographic evidence, thermal imaging, airtightness testing and commissioning records; feed inspection findings back into training and accreditation
Consumer information and decision-making	Households often receive fragmented or inconsistent advice and may focus on individual products rather than whole-of-home performance	Information asymmetry reduces consumer confidence and can lead to poorly sequenced or inappropriate investment decisions	Expand independent advisory services; establish one-stop-shop information platforms; improve nationally consistent communication; support home energy assessments
Whole-of-home planning and system integration	Building-envelope measures, appliances, electrical infrastructure and ventilation are frequently considered separately	Isolated technology replacement can reduce potential energy savings and create missed opportunities for coordinated upgrades	Promote integrated retrofit assessments; align incentives across technologies; coordinate sequencing of envelope, electrification and ventilation measures
Policy and regulatory consistency	Differing standards, incentive programs, certification requirements and administrative arrangements create complexity across jurisdictions	Fragmentation increases compliance costs, creates uncertainty and reduces confidence in long-term industry investment	Improve Commonwealth–state coordination; align technical requirements and program rules; provide stable long-term policy signals

Demand forecasting and market coordination	Program-driven demand can fluctuate significantly, affecting stockholding, workforce planning, logistics and investment	Poor visibility over future demand increases the risk of shortages, excess inventory and delivery delays	Provide earlier program notice; improve demand aggregation and forecasting; strengthen information exchange between governments, suppliers and delivery organisations
Domestic capability and supply-chain resilience	Many industries combine imported products or inputs with Australian engineering, fabrication, distribution and installation	Resilience depends on more than local manufacture and includes supplier diversity, inventory, technical support and domestic value-adding	Diversify suppliers; support strategic domestic capability; improve procurement planning; maintain access to spare parts and technical support

4.5.1 Product quality and supply-chain integrity

A recurring finding across all technology groups was that successful residential retrofit programs depend on maintaining confidence in both products and the supply chains through which they are delivered. Industry representatives argued that product certification should form part of a broader quality-assurance framework encompassing procurement, installation and ongoing performance verification. Strengthening conformity assessment, product traceability, market surveillance and risk-based compliance monitoring was identified as a common priority for improving industry confidence and protecting households from poor-quality products and installations.

4.5.2 Workforce capability and installation quality

The consultation also highlighted workforce capability as a critical determinant of residential retrofit performance. While the skills required differ across technology groups, participants consistently emphasised that future workforce development should focus on improving capability rather than simply increasing workforce numbers. Nationally recognised competency frameworks, continuing professional development, stronger installer accreditation and independent quality verification were identified as important mechanisms for improving installation quality and ensuring that residential retrofit products achieve their intended performance.

4.5.3 Consumer capability and integrated retrofit planning

Across all four industries, consultations highlighted the central role of households in determining residential retrofit outcomes. Fragmented information, inconsistent advice and technology-by-technology purchasing decisions continue to limit opportunities for coordinated household upgrades. Strengthening consumer capability through independent advisory services, nationally consistent communication and whole-of-home planning was therefore viewed as an important component of supply-chain development rather than simply a consumer education initiative. Improving household decision-making has the potential to increase technology uptake while encouraging more integrated and effective residential retrofit solutions.

4.5.4 Policy coordination and industry development

The strongest system-wide message emerging from the consultation was the importance of greater policy coordination across Australia's residential retrofit sector. Participants acknowledged the contribution of existing incentive programs to market development but argued that fragmented regulations, inconsistent technical requirements and differing jurisdictional approaches continue to increase compliance costs and create uncertainty for industry and households. Greater national consistency in certification, installer competency, technical standards and program delivery was viewed as essential for supporting long-term investment and strengthening coordination across residential retrofit supply chains.

4.6 Conclusion

The analysis presented in this chapter demonstrates that strengthening Australia's residential retrofit sector requires action at two complementary levels. Industry-specific initiatives are needed to address the distinctive characteristics of individual supply chains, while broader reforms are required to improve quality assurance, workforce capability, consumer confidence and policy coordination across the residential retrofit ecosystem.

These findings indicate that many of the constraints limiting residential retrofit delivery arise from the way products, organisations and institutions interact rather than from the technologies themselves. Improving supply-chain capability therefore requires coordinated action spanning manufacturing, product assurance, installation, consumer engagement and program governance.

Building on these insights, the following chapter presents a future-state delivery model that translates the evidence from this chapter into an integrated framework for strengthening Australia's residential energy retrofit supply chains.

5 Future-state delivery model for residential energy retrofit supply chains

The preceding analysis examined Australia's residential energy-retrofit supply chains from two complementary perspectives. Chapter 3 explored the structure and operation of supply chains across four major technology groups, while Chapter 4 assessed the principal barriers and opportunities shaping their future development. Taken as a whole, this evidence shows that many of the constraints limiting large-scale residential energy upgrades are systemic rather than technology-specific. Building on these findings, this chapter presents a future-state delivery model for residential energy retrofit supply chains. The model adopts an integrated governance framework that strengthens coordination, quality assurance and accountability while preserving the flexibility of existing industry structures. It is designed to support residential retrofit delivery across multiple technologies through a coordinated and consistent approach.

Figure 5.1 presents the proposed framework. It combines an Integrated Retrofit Delivery Partner with two complementary quality-assurance gateways—Product Certification and Verification and Installer Accreditation and Quality Assurance—supported by a Government Retrofit Coordination Platform that provides program administration, digital information management and compliance oversight. The following sections explain how these elements operate together to support the delivery of safe, efficient and scalable residential energy retrofit programs.

5.1 Integrated delivery through accountable retrofit service providers

Fragmented project delivery remains one of the principal barriers to effective residential retrofit programs. Manufacturers, suppliers, installers and program administrators each perform essential functions, yet responsibility for procurement, installation, compliance and customer support is often dispersed across multiple organisations. This fragmentation increases transaction costs, complicates coordination, weakens accountability and makes quality assurance more difficult—particularly for whole-of-home retrofits involving several technologies.

The proposed future-state model addresses these challenges by introducing an Integrated Retrofit Delivery Partner as the central coordination point for government-supported residential retrofit programs (Figure 5.1). This delivery partner provides a single accountable interface between upstream supply chains, households and program administrators, coordinating project delivery and

ensuring that products, installation activities and customer outcomes meet program requirements.

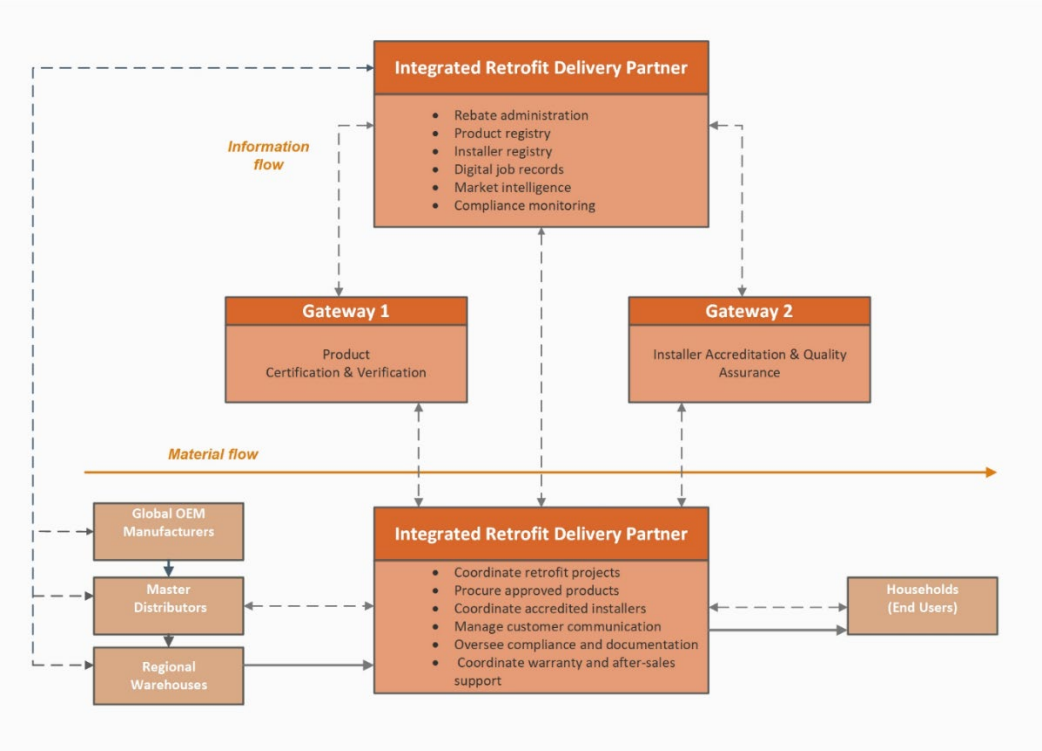


Figure 5.1 Proposed consolidated value chain for residential retrofit supply chains

The approach builds on delivery models already operating within parts of the residential retrofit sector. Industry consultation identified several examples where procurement, installation and after-sales support were managed by a single organisation, resulting in improved project coordination, clearer customer communication, more efficient inventory management and stronger quality control. The proposed framework extends these principles by establishing an integrated delivery pathway that can be applied across government-supported programs while preserving existing market structures and competition.

Manufacturers, importers, distributors and specialist installers continue to perform their established roles within the supply chain. The key change is that these activities are coordinated through an accountable delivery partner responsible for managing the retrofit process on behalf of households and program administrators. This arrangement reduces the need for households to engage multiple contractors and provides clearer accountability for project delivery, compliance and customer satisfaction. The core coordination functions of the Integrated Retrofit Delivery Partner are summarised in Table 5.1.

Table 5.1 Principal functions of the integrated retrofit delivery partner

Function	Purpose
Procurement of approved products	Source products through verified supply chains and approved suppliers
Project coordination	Manage logistics, scheduling and sequencing of retrofit activities
Installer coordination	Engage appropriately accredited installers and specialist contractors
Customer communication	Provide a single point of contact throughout project delivery
Compliance and documentation	Record installation, commissioning and quality assurance activities
After-sales support	Coordinate warranty, maintenance and customer service
Program reporting	Submit project information through the Government Retrofit Coordination Platform

The Integrated Retrofit Delivery Partner should be understood as a functional coordination role, not a prescribed business model. Depending on program objectives and local market conditions, this role may be undertaken by integrated contractors, energy-service companies, community organisations, consortia of local businesses or government delivery agencies. This flexibility allows different commercial models to operate while maintaining consistent coordination, accountability and quality assurance across residential retrofit programs.

5.2 Gateway 1: Product verification and conformity assessment

The long-term success of residential retrofit programs depends not only on making products available but also on ensuring they consistently meet expected safety, quality and performance standards. Existing certification systems provide an important foundation; however, industry consultation indicated that greater emphasis should be placed on ongoing product verification, conformity

assessment and market surveillance rather than relying solely on compliance at the point of market entry.

The proposed future-state model therefore incorporates Gateway 1: Product Verification and Conformity Assessment. The gateway adopts an "evidence before entry" principle, requiring products participating in government-supported retrofit programs to demonstrate compliance with relevant technical, safety and performance requirements before becoming eligible for program delivery. The objective is not to create additional regulatory barriers but to strengthen confidence that approved products continue to satisfy Australian standards throughout their lifecycle.

The gateway applies equally to Australian-manufactured and imported products. Consistent with the findings from the industry consultation, assessment is based on verified product performance rather than country of origin. This approach recognises that high-quality products can be manufactured globally while acknowledging the need for greater assurance as product diversity and international sourcing continue to expand. A key feature of the proposed framework is the adoption of risk-based verification. Products associated with higher technical complexity, greater safety implications or higher manufacturing variability would receive proportionately greater verification and market surveillance. Product conformity is therefore treated as an ongoing process rather than a once-off certification activity, supported by periodic verification, targeted market surveillance and, where appropriate, batch-based conformity assessment.

The gateway also supports greater transparency through a national product registry maintained within the Government Retrofit Coordination Platform. The registry would provide a central source of information on approved products, certification status, declared performance characteristics and program eligibility, supporting procurement, product traceability and more consistent decision-making across jurisdictions. Table 5.2 summarises the principal functions of Gateway 1.

Table 5.2 Principal functions of Gateway 1

Function	Purpose
Evidence before entry	Ensure products meet relevant technical, safety and performance requirements before program participation
Risk-based verification	Target verification and market surveillance according to product risk
Ongoing conformity assessment	Support periodic verification rather than relying solely on initial certification
National product registry	Provide verified information on approved products and program eligibility
Product traceability	Improve monitoring, recalls and compliance management
National consistency	Promote common procurement requirements and reduce duplication across jurisdictions

Gateway 1 complements rather than replaces existing certification systems such as Australian Standards, CodeMark and other recognised conformity assessment schemes. Existing certification continues to provide the technical basis for product approval, while the gateway strengthens ongoing verification, information sharing and program-level quality assurance within a coordinated national delivery framework.

By shifting quality assurance upstream within the supply chain, Gateway 1 provides a stronger foundation for government-supported residential retrofit programs. Greater confidence in product conformity, transparency and procurement processes reduces reliance on downstream inspection and supports more consistent outcomes for manufacturers, installers, governments and households.

5.3 Gateway 2: Installer accreditation and delivery accountability

While Gateway 1 ensures that products entering residential retrofit programs meet appropriate safety and performance requirements, successful outcomes also depend on the capability of the organisations responsible for installing them. Across all four technology groups examined in this report, installation quality emerged as one of the strongest determinants of long-term system performance. Even high-quality products may fail to achieve their intended outcomes if they are poorly installed, commissioned or integrated with existing building systems.

The proposed future-state model therefore incorporates Gateway 2: Installer Accreditation and Delivery Accountability. The gateway establishes workforce capability and organisational accountability as prerequisites for participation in government-supported retrofit programs. Rather than replacing existing occupational licensing, it complements current arrangements by ensuring that accredited organisations possess the technical capability, quality-management systems and documentation processes needed to deliver consistent, high-quality retrofit outcomes.

A key finding of the research was that existing licensing arrangements do not necessarily demonstrate competence in emerging residential retrofit technologies or whole-of-home energy upgrades. As residential electrification and building-performance requirements continue to evolve, accredited organisations should demonstrate ongoing technical capability through professional development, recognised installation standards and documented quality-management systems.

The proposed framework also shifts accountability from individual installers to the organisations responsible for project delivery. Accredited organisations would remain responsible for installer competency, supervision, subcontractor management, quality assurance and completed work regardless of changes in individual personnel. This approach provides clearer accountability for governments, program administrators and households while encouraging continuous investment in workforce capability and quality management.

To support consistent delivery, accredited organisations would maintain project documentation throughout the installation process, including installation records, commissioning data, quality-control checklists and customer handover information. These records would be integrated with the Government Retrofit Coordination Platform to support auditing, warranty management and long-term program evaluation.

Consistent with Gateway 1, accreditation would be supported by risk-based inspection and auditing. Rather than inspecting every installation, quality assurance activities would focus on projects where technical complexity, safety implications or previous performance indicate a greater likelihood of non-compliance. This approach strengthens program integrity while making more efficient use of compliance resources. Table 5.3 summarises the principal functions of Gateway 2.

Table 5.3 Principal functions of Gateway 2

Function	Purpose
Organisation accreditation	Verify technical capability and quality-management systems
Installer competency	Ensure personnel possess appropriate qualifications and ongoing professional development
Delivery accountability	Assign responsibility for project quality to the accredited delivery organisation
Installation documentation	Maintain records supporting compliance, commissioning and warranty
Risk-based auditing	Target inspections according to project risk and previous performance
Continuous improvement	Encourage ongoing training, quality assurance and adoption of best practice

Gateway 2 thus complements Gateway 1 by ensuring that both products and installation services meet consistent quality standards before entering government-supported retrofit programs. These two gateways provide a coordinated quality-assurance framework that strengthens confidence across residential retrofit supply chains while supporting safe, reliable and high-quality delivery outcomes.

5.4 National coordination, digital governance and market intelligence

As already stated, Australia's residential retrofit sector operates within a fragmented institutional environment. Numerous organisations—including manufacturers, importers, distributors, installers, certification bodies, regulators, local governments, utilities and program administrators—contribute to residential energy-efficiency programs, yet the information supporting these activities is often dispersed across multiple systems with limited coordination. This diversity increases administrative costs, reduces transparency and limits the ability of governments and industry to monitor supply-chain performance or respond effectively to emerging issues.

The proposed future-state model therefore incorporates a Government Retrofit Coordination Platform that provides the digital and administrative infrastructure supporting residential retrofit programs. Not replacing existing government agencies or industry organisations, the platform acts as a shared coordination layer, connecting existing participants through common information systems, consistent administrative processes and improved data sharing.

A key function of the platform is to support nationally consistent administration of government-supported retrofit programs. It provides the digital infrastructure underpinning Gateway 1 and Gateway 2, including a national product registry, an accredited installer registry and standardised project records. These systems improve transparency, reduce duplication and provide governments, delivery partners and installers with access to consistent and authoritative information.

The platform also supports digital project tracking by maintaining records of approved products, accredited installers, commissioning results, inspection outcomes and compliance documentation for each retrofit project. Integrating these records within a common digital framework improves traceability, supports warranty management and enables more effective auditing and quality assurance.

Beyond program administration, the platform provides an important source of market intelligence. By integrating information across government programs and industry participants, it can support forecasting of product demand, workforce requirements, regional delivery activity and emerging supply constraints. These data strengthen evidence-based policy development while assisting industry with investment planning and resource allocation. Table 5.4 summarises the principal functions of the Government Retrofit Coordination Platform.

Table 5.4 Principal functions of the Government Retrofit Coordination Platform

Function	Purpose
Program administration	Support nationally consistent administration of retrofit programs
Product registry	Maintain information on approved products and program eligibility
Installer registry	Record accreditation status and organisational approvals
Digital project records	Document installations, inspections, commissioning and compliance
Market intelligence	Monitor demand, workforce capacity and supply-chain performance
Compliance monitoring	Support auditing, quality assurance and continuous improvement

By strengthening information flows, supporting evidence-based decision-making and improving coordination between governments and industry, the Government Retrofit Coordination Platform provides the institutional backbone of the proposed future-state delivery model. Together with the two quality-assurance gateways, it establishes a more transparent, efficient and accountable framework for delivering residential energy retrofit programs at scale.

5.5 Building consumer confidence through system-level quality assurance

Residential retrofit markets are characterised by significant information asymmetry. Households are generally unable to directly assess the technical quality of products, installation practices or system performance and must therefore rely on the integrity of the delivery system rather than their own technical expertise. Confidence in residential retrofit programs depends not only on the performance of individual technologies but also on the transparency and reliability of the processes used to procure, install and verify them.

The proposed future-state delivery model addresses this challenge by embedding quality assurance throughout the delivery process. Gateway 1 ensures that products entering government-supported programs satisfy recognised safety,

quality and performance requirements, while Gateway 2 requires installation to be undertaken by accredited organisations operating within documented quality-management systems. Together, these gateways reduce the likelihood of non-conforming products or poor-quality installation before work reaches households.

The Integrated Retrofit Delivery Partner further strengthens consumer confidence by providing a single accountable organisation responsible for coordinating procurement, installation, documentation and after-sales support. Rather than requiring households to engage separately with manufacturers, suppliers, installers and program administrators, the model establishes a clear point of responsibility for project delivery, communication and warranty management.

The Government Retrofit Coordination Platform complements these arrangements by maintaining digital records of approved products, installer accreditation, commissioning activities, inspection outcomes and completed projects. These records improve traceability, support auditing and warranty management, and provide governments and program administrators with reliable information for monitoring program performance and continuous improvement.

Consumer confidence also depends on access to clear, independent information before retrofit decisions are made. Nationally consistent advisory services, supported by standardised project documentation and transparent performance information, would help households understand available technologies, expected outcomes, warranty arrangements and ongoing maintenance requirements. This reduces reliance on commercial marketing as the primary source of technical advice while enabling more informed decision-making.

These measures shift quality assurance upstream within residential retrofit supply chains. Rather than relying primarily on consumer complaints or post-installation inspections to identify problems, the proposed framework establishes confidence through verified products, accredited delivery organisations, transparent documentation and ongoing oversight. By reducing information asymmetry and strengthening accountability, the model provides a more trusted foundation for expanding residential energy-efficiency and electrification programs.

5.6 Conclusion

This chapter has presented an integrated future-state delivery model for strengthening Australia's residential energy-retrofit supply chains. Moving beyond a narrow focus on product flows, the framework emphasises governance,

coordination and accountability across the residential retrofit ecosystem. By combining an Integrated Retrofit Delivery Partner, two complementary quality-assurance gateways and a Government Retrofit Coordination Platform, the model offers a practical structure for improving the consistency, transparency and scalability of residential energy-retrofit delivery while preserving existing market dynamics.

6 Strategic roadmap for strengthening Australia's residential retrofit supply chains

This chapter presents a strategic roadmap for strengthening Australia's residential energy retrofit supply chains. It translates the report's findings into a practical sequence of actions designed to improve energy-efficient technologies' supply chains through governance, quality assurance, workforce capability and industry coordination while supporting the long-term delivery of residential energy-efficiency and electrification programs.

The roadmap is organised around three implementation horizons that reflect different levels of investment, institutional development and industry maturity (Figure 6.1). Immediate priorities (0–12 months) focus on strengthening governance and quality assurance within existing institutional arrangements. Medium-term priorities (1–3 years) build the organisational capability, workforce and digital infrastructure needed to support integrated residential retrofit delivery. Long-term priorities (3–5 years) focus on strengthening industry resilience, innovation and continuous improvement to support Australia's transition to a mature residential retrofit sector.

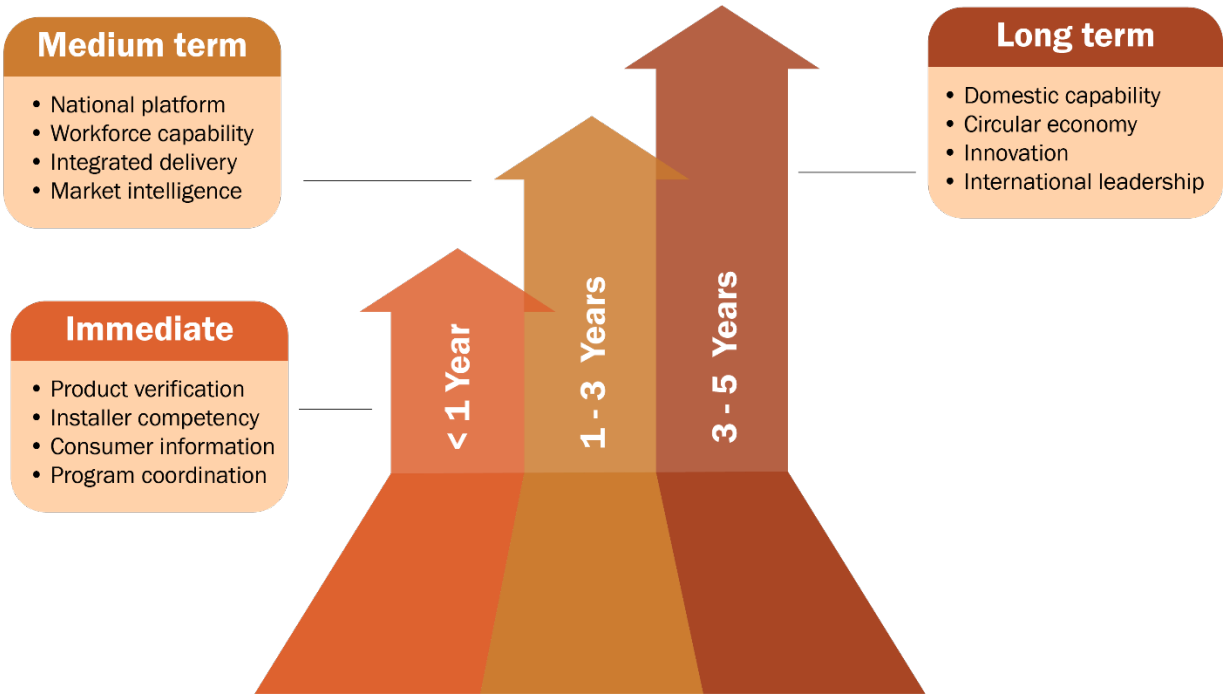


Figure 6.1 Strategic roadmap

6.1 Immediate priorities (0–12 months)

Immediate priorities focus on strengthening governance, quality assurance and coordination within existing institutional arrangements. Most of these can be implemented in the short term to provide a strong foundation for the medium- and long-term initiatives that follow. Collectively, immediate priorities address key barriers to residential retrofit delivery, including fragmented program administration, inconsistent product verification, variable installation quality, limited consumer confidence and weak coordination across supply chain jurisdictions.

6.1.1 Establish nationally consistent product verification principles

A nationally consistent approach to product verification should be adopted across Commonwealth and state government programs. The framework should establish common expectations for product standards and performance, conformity assessment, traceability and ongoing compliance monitoring while building on established certification schemes. Consistent verification requirements would reduce duplication across jurisdictions, simplify participation for manufacturers and strengthen confidence among governments, installers and households across the nation.

Lead organisations: Commonwealth and state governments, Standards Australia, certification bodies and industry associations.

6.1.2 Develop a nationally consistent installer competency and certification framework

Installation quality is one of the most important determinants of residential retrofit performance. An immediate priority is to develop a nationally consistent installer competency framework that complements existing trade qualifications by defining minimum competency requirements, continuing professional development and organisational quality-management expectations. The framework should remain flexible enough to accommodate different technology sectors while providing consistent expectations across jurisdictions.

Lead organisations: Governments, vocational education providers, licensing authorities and industry associations.

6.1.3 Improve consumer information and independent advisory services

Households often receive fragmented information from multiple suppliers, installers and government programs, making it difficult to compare technologies or plan whole-of-home retrofits. Expanding independent advisory services

supported by nationally consistent information resources would provide impartial guidance on technology selection, sequencing of upgrades, available incentives and expected household outcomes. Improving access to trusted information would strengthen consumer confidence and support more informed retrofit investment decisions.

Lead organisations: Governments, energy agencies and industry associations.

6.1.4 Strengthen quality assurance and compliance monitoring

Quality assurance should extend beyond product approval and installer accreditation through ongoing inspection, auditing and feedback. A risk-based approach would focus compliance resources on higher-risk technologies, delivery organisations and installation types, while inspection outcomes should be systematically incorporated into training, accreditation and program improvement. This approach supports continuous improvement rather than compliance alone.

Lead organisations: Program administrators, regulators and accreditation bodies.

6.1.5 Improve coordination across existing residential retrofit programs

Improving coordination across existing government programs offers significant short-term benefits without requiring major institutional reform. Greater alignment of technical requirements, terminology, reporting processes and quality-assurance expectations would reduce administrative complexity while improving consistency for manufacturers, delivery organisations and households. Incremental policy alignment across jurisdictions provides a practical foundation for the more integrated delivery arrangements proposed in later stages of the roadmap.

Lead organisations: Commonwealth and state governments.

6.2 Medium-term priorities (1–3 years)

Medium-term priorities focus on building the institutional capability required to support large-scale residential energy retrofit delivery. These initiatives strengthen workforce capability, digital infrastructure and organisational coordination, providing the systems needed to support integrated residential retrofit programs over the longer term.

6.1.6 Establish a Government Retrofit Coordination Platform

A Government Retrofit Coordination Platform should be established to provide the digital infrastructure supporting product verification, installer accreditation, program administration and market monitoring. As already described, the platform should provide a shared administrative framework that improves coordination, reduces duplication and supports evidence-based policy development.

Lead organisations: Commonwealth and state governments, industry associations, certification bodies and research organisations.

6.1.7 Strengthen workforce capability and vocational education

Future residential energy retrofit programs will require a workforce with skills extending beyond traditional trade qualifications. Vocational education and industry training should therefore expand to include whole-of-home retrofit planning, building performance, commissioning, quality assurance and emerging technologies. Stronger collaboration between governments, education providers and industry will help ensure training remains aligned with changing workforce requirements.

Lead organisations: Governments, VET providers, universities and industry associations.

6.1.8 Support integrated whole-of-home retrofit delivery

Government programs should progressively encourage integrated whole-of-home retrofit delivery rather than isolated technology replacement. Funding models that support coordinated assessment, product selection, installation and after-sales support would improve household outcomes while increasing efficiency through better project planning, procurement and delivery.

Lead organisations: Governments, delivery organisations and industry.

6.1.9 Improve market intelligence and demand forecasting

Improved market intelligence is essential for supporting investment and long-term planning across residential energy retrofit supply chains. Data generated through the Government Retrofit Coordination Platform should be used to monitor product demand, workforce requirements, regional delivery activity and emerging supply constraints. Regular publication of industry indicators would improve transparency and support evidence-based investment decisions.

Lead organisations: Governments, research organisations and industry.

6.1.10 Strengthen collaboration across the residential retrofit ecosystem

Effective implementation depends on ongoing collaboration between governments, industry, education providers, research organisations and program-delivery organisations. National advisory groups, technical working groups, collaborative research partnerships and regular industry forums would support information sharing, joint planning and continuous improvement across the sector.

Lead organisations: Governments, industry, research institutions and professional bodies.

6.2 Long-term priorities (3–5 years)

Long-term priorities focus on creating a mature, resilient and innovative residential retrofit sector capable of supporting Australia's ongoing transition to more energy-efficient, electrified and climate-resilient housing. These initiatives strengthen domestic capability, encourage innovation and establish the knowledge systems needed to support continuous improvement.

6.2.1 Strengthen domestic manufacturing capability and supply-chain resilience

Future policy should strengthen supply-chain resilience by investing in and expanding domestic capability in areas where Australia has existing competitive advantages, including engineering, fabrication, component manufacture, product assembly and technical support. Rather than pursuing self-sufficiency, the objective should be greater local value creation, supplier diversification and stronger partnerships with international manufacturers.

Lead organisations: Governments, manufacturers and industry associations.

6.2.2 Develop a circular economy for residential energy retrofit products

As residential retrofit activity expands, greater emphasis should be placed on product life-cycle management, including material recovery, recycling, reuse and responsible end-of-life disposal. Circular economy principles should be incorporated into product design, procurement and program delivery to reduce waste and improve the environmental sustainability of residential retrofit programs.

Lead organisations: Governments, manufacturers, recyclers and industry.

6.2.3 Foster innovation and continuous industry improvement

Governments, universities and industry should continue investing in collaborative research, demonstration projects and innovation partnerships that accelerate the adoption of new technologies, digital tools and advanced retrofit solutions. Emerging technologies—including artificial intelligence, digital twins and smart-home systems—offer significant opportunities to improve planning, quality assurance and long-term building performance.

Lead organisations: Governments, universities, industry and research organisations.

6.2.4 Create a national residential retrofit knowledge ecosystem

A coordinated national knowledge ecosystem should integrate data from the Government Retrofit Coordination Platform with applied research, industry benchmarking, workforce intelligence and program evaluation. This capability will strengthen evidence-based policy development, support continuous learning and enable more adaptive management of Australia's residential retrofit sector.

Lead organisations: Governments, research institutions and industry associations.

6.2.5 Position Australia as a leader in residential retrofit delivery

Australia can become a global leader in residential retrofit delivery by building on the above recommendations and on its strengths in building science, energy efficiency, product certification and program administration. Continued participation in international research, standards development and knowledge exchange would strengthen domestic capability while enabling Australia to contribute to global best practice in residential retrofit delivery.

Lead organisations: Commonwealth Government, industry and research organisations.

6.3 Conclusion

The roadmap presented in this chapter translates the findings of this report into a practical framework for strengthening Australia's residential retrofit supply chains. By focusing on immediate, medium-term and long-term priorities, it provides a staged approach to improving governance, quality assurance, workforce capability and industry resilience. These priorities provide a pathway towards a more coordinated, trusted and scalable residential retrofit sector

capable of supporting Australia's long-term energy-efficiency, electrification and emissions reduction objectives.

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7 Appendices

Appendix 1 – Insulation's Configuration of Supply Chain - Upstream

B1. Regarding the product(s) that your firm currently handles, please indicate who are the upstream product supply chain members? And their locations?

Aggregate Dimension	2nd Order theme	Product type
Hybrid Sourcing	Far shoring (USA, UK, EU)	Imported insulation (UK, USA), HVAC, Ceilings: Earthwool batts, Walls: Superfil blown fiberglass (UK), Spray foam (USA), chemical products (possibly USA), adhesive and tapes (USA and China), Brown Cavity insulation (Europe)
	Near shoring from Asian countries (China and *Malaysia*, Thailand, Vietnam)	Seals and tapes (China), Polyester fibres (Thailand and Vietnam), Magnets (China), Compressive seals (China), Ceiling batts and Earthwool (Malaysia).
	Local suppliers	Polyester underfloor, some adhesives, polyester fibres (final manufacturing: blending, carding, and product formation), underfloor (card laying), fibreglass and glass wool.
Local manufacturing constraint (*also nearshoring driver)*	Resource capacity limitations (production and distribution) of local manufacturers.	
Procurement	Procurement through local wholesaler.	
Logistics driver	Convenient inbound logistics service (DDP)	Gyprock, plasterboard, fibreglass, roofing, bricks, etc.
	Predictable lead times	

Simple Supply Chain structure	Easy demand planning - Reduced product variety to enhance product volume. (Less variety more volume and good quality)	
	Simple supply chain structure	

Appendix 2 - Insulation's Configuration of Supply Chain – Downstream

B1. Regarding the product(s) that your firm currently handles, please indicate who are the downstream product supply chain members? And their locations?

Aggregate theme	2nd order	Rationale
Hybrid domestic transportation model	3PL transportation for inter-state deliveries	Lower freight costs, access to 3PL freight network.
	In-house transportation for last-mile deliveries	Quick delivery and control of transportation.

Appendix 3 - Insulation's Handling of Installations

Does your company handle installations? How do you handle workforce and quality control?

Installation management	Rationale
Use in-house resources (full time and permanent)	Direct control Good staff commitment - Use full-time staff and well trained. Quality assurance
Outsourced installation (3P)	Cost benefit
Use in-house resources (full time seasonal)	Seasonal business.

Appendix 4 - Insulation's Sustainability Ways Products are Recycled at the end of Life

What are the ways used to recycle products at the end of the supply chain?

Waste management methods	Reason
Landfill for waste management	Due to the absence of recycling facilities for old insulation in Australia.
Product recovery is not a standard practice	Removal is not recommended unless the existing insulation is damaged, fails performance tests (e.g., cellulose burn test), or does not meet Australian Standards. Layering is the practice.
Product removal protocol (extraction, cleaning and transportation)	Responsible waste management, and to protect company image with customers.

Appendix 5 – Hot Water's Configuration of Supply Chain - Upstream

B1. Regarding the product(s) that your firm currently handles, please indicate who are the upstream product supply chain members? And their locations?

Aggregate dimension - Supply chain actor/component	Second order theme	Product type
Hybrid sourcing	Globalised supply chain network	compressors
	Hybrid inbound supply transportation (in house and supplier managed)	
	Domestic manufacturing.	Storage tanks: Australian-made (both stainless steel and glass-lined). Controllers: Developed and manufactured in Victoria.
	Near shoring manufacturing from Asian countries	CO_2 compressors: Manufactured in Japan. R290 product line: Manufactured in China. All goods imported from China

Outsourced warehousing	Domestic multi-warehouse network	
	3PL warehousing	
Type of supply chain partnerships	"Energy efficient" partnerships.	Partners almost exclusively with energy efficiency organisations, solar PV and battery installers, and a small number of specialists plumbing firms.
	Specialised sourcing for solar systems	Solar systems sourced via larger retailers.
	Partnerships with reputable manufacturers	
In-house logistics	Internal logistics management	

Appendix 6 - Hot Water's Configuration of Supply Chain – Downstream

B1. Regarding the product(s) that your firm currently handles, please indicate who are the downstream product supply chain members? And their locations?

Aggregate theme – Downstream supply chain structure	Second order theme	Rationale
In-house management of product delivery	In-house delivery and installation	Greater control over timelines, service quality, and customer experience.
	In-house road transportation logistics	Quick delivery of product for installations, to builders, or to other customers.
Hybrid business models for product delivery	B2C product delivery	Tighter control over delivery timelines, customer experience, and cost structures
	B2B product delivery	Supply to corporate customers nationwide
Product delivery structure	Preference for bulk delivery (economies of scale)	Fewer delivery failures, and greater operational efficiency.

	Costumer segmentation (one-stop shops and Energy-efficiency–focused specialists)	Market diversification
Outsourced delivery management	3PL delivery	Cost efficiency and scalability without owning physical logistics infrastructure.

Appendix 7 – Hot Water's Issues with Transportation of Products

Have you come across any issues in the performance of your transportation management regarding the products that your firm currently handles?

Issues related to transportation of products	Second order themes	Implications
Hybrid delivery management	In-house transportation to installation sites.	For structured, controlled and standardised logistics model.
	3PL transportation	It offers flexibility and scalability. Logistics is not dependent on a single provider.
Delivery cost	Delivery cost absorption by customer	Cost structure is reduced and focus on delivery management and support
Product handling	Product damage related to transportation to installation sites	Bigger products face higher chances of damage during transportation.

Appendix 8 – Hot Water's Issues with Installation/Installer

Have you come across any issues with installation/installer of the products that your firm currently handles?

Issues related to installation processes	Second order theme	Implications
Regulations	Installation regulations and compliance	The combination of regulation, audits, and rebate checks results in very low defect rates.
	Uneven installation regulations across states	Certain installers omit recommended but non-mandatory components (e.g. certain valves), which can affect long-term performance.
Installers training	Dedicated workforce training for installations	To ensure that the installation of products meets the standards.
	Installers training scope	Training focuses on product-specific nuances, not core plumbing skills.
Customer satisfaction	Installers' expert recommendations influence on customers	Customer satisfaction is related to installers advice on certain products.
Installation management	Dedicated internal installation support	Support staff support installers by offering ongoing troubleshooting support, installation advice and product guidance in the field
	Installation lead time optimisation supported by installers own stock	Installers stock for quick replacements reduces product replacement lead times.
	Installation as part of stock management	Stock availability and installer scheduling are tightly coordinated, increasing installers respond rates.

Appendix 9 – Glass Window's Configuration of Supply Chain - Upstream

B1. Regarding the product(s) that your firm currently handles, please indicate who are the upstream product supply chain members? And their locations?

Supply chain structure - Second order theme	Products
Offshore supply	Raw glass and imported jumbo sheets. These are cut, shaped, and processed (coating, laminating, assembling) by domestic fabricators.
Hybrid production (domestic vs offshore)	IGUs (Insulating Glass Units) are either imported fully assembled or produced locally using imported raw glass.
Franchise business model	Only patented installation materials are centrally controlled
Lean production (Made-to-order)	Glass is custom-made. Glass and patented materials for installation.

Appendix 10 – Glass Window's Handling of Installations

Does your company handle installations? How do you handle workforce and quality control?

Handling of installations	Second order theme	Rationale
De-centralised installation process	Hybrid installation models (supply-only vs supply-and-install).	Varying by market segment (new builds, large renovations, standalone retrofits, commercial projects).
	Multiple actor installation	Builders, subcontractors, and specialist window companies all play roles.

Appendix 11 – Glass Window's Issues with Installation/Installer

Have you come across any issues with installation/installer of the products that your firm currently handles?

Issues related to installation/installer	Second order themes	Implications
Risk mitigation measures	Training as a risk mitigation for installation.	Dedicated resources to ensure franchise owners properly train installers.

	Voluntary absorption of costs from faulty installation	To preserve brand integrity, the company absorbs the cost of rectifying defective installations, despite holding no indemnity under franchise contracts
Installation risks	Installation process deviation (corner-cutting)	Installation issues are consistently attributed to installers deviating from prescribed systems usually in an attempt to save time or cost.
	Uneven skills across installation actors	Where a licensed builder manages the project, training needs are lower. Training gaps emerge primarily when suppliers act as both product provider and installer.
	Installation risks of retrofit projects	If glass is damaged or incorrect Installation cannot proceed, homes may be left without windows overnight. Retrofit installations have far lower tolerance for supplier failure than new builds
Regulation and product expectations	Uneven regulation and mandates across states (retrofit projects)	Confusion around NCC compliance (current standards vs standards at the time of building). This creates legal, technical, and practical uncertainty for practitioners and consumers alike.
	Product performance gap (expectations vs feasibility)	This is worsened by cost competition, where compliant companies lose out to cheaper, non-compliant operators

Appendix 12 – Glass Window's Issues in the Performance of your Returned Product Management

Have you come across any issues in the performance of your returned product management regarding the products that your firm currently handles?

Issues in the Performance of Returned Product	Second order theme	Implications
Lack of supplier support	Lack of post-purchase support from offshore supplier	Leaves builders responsible for managing defects or incorrect deliveries. Return processes are unclear, informal, or entirely absent.

Faults standards and protocols	Local defect detection standards	Defect evaluation is guided by Australian Standards
	Protocol for product returns and consumer satisfaction	Consumer experience management and product replacement at the company's expense.

Appendix 13 – Insulation's Issues in the Performance of your Order Planning

Have you come across any issues in the performance of your order planning regarding the products that your firm currently handles?

Aggregate themes – Issues related to ordering	Order planning issues	Implications
Irregular orders and fulfilment	Unpredictable lead times	Affects planning cycles, stock replenishment schedules, and coordination with installation teams or customers.
	Back order/incomplete order fulfilment	It creates uncertainty, inefficiency, and difficulty matching supply to sales
	Customer order flexibility	Order planning is driven by on-spot customer orders rather than structured forecasts.
	Irregular demand patterns	Order planning becomes unpredictable due to seasonality and project-specific work, forcing the company to cope with fluctuating workloads, inventory requirements, and cash flow pressures
	Project-dependent demand	Ordering is demand is program-dependent, not market-driven.
Logistical shortcomings	Reliance on safety stock	Unwanted levels of stock
	Vendor contract management issue	Staff spend excessive time chasing suppliers, managing customer expectations and verifying fulfilment.

Demand management	Lean-agile production strategy	Orders based on maintaining stock levels and project-based orders.
	Market intelligence to anticipate demand changes	Plan Environment, Development and Sustainability and manufacture large volumes to meet expected demand
Collaborative order and procurement management	Direct procurement with manufacturer	Removing intermediaries reduces procurement costs.
	Reliance on 3PL providers	Dependence on partners to buffer stock and manage distribution
	Demand forecasting supported by supplier	The suppliers forecast demand quite accurately

Appendix 14 – Insulation - Policy support which would help with your business

What policy support would help with your business?

Aggregate theme - Areas for policy development	Opportunities for policy support	Objective
Product certification and compliance	Need for Stronger Product Certification and Compliance.	Eliminate inadequacy of existing Australian insulation standards.
	Need for mandatory testing and certification of imported products	To ensure safety for installers, end users, and long-term durability. Avoid correction costs
	Need for detailed product import guidelines including product performance.	To focus on product safety and quality, rather than solely on whether it is Australian made
Licensing and accreditations	Need for installation staff licensing options.	To maintain performance standards and consumer trust.
	Need for company-level licensing and accreditations	To ensure organisational accountability for training, supervision, and compliance.
Organisational behaviour policy	Need for taxation cut-offs for energy upgrades.	To incentivise expected behaviour
	Inclusion of incentives methods for regulatory compliance.	To move from relying primarily on penalties or obligations.

Appendix 15 – Insulation - Policy support which would help with your business

What policy support would help with your business?

Aggregate theme - Areas for policy development	Opportunities for policy support	Objective
Product certification and compliance	Need for Stronger Product Certification and Compliance.	Eliminate inadequacy of existing Australian insulation standards.
	Need for mandatory testing and certification of imported products	To ensure safety for installers, end users, and long-term durability. Avoid correction costs.
	Need for detailed product import guidelines including product performance.	To focus on product safety and quality, rather than solely on whether it is Australian made.
Licensing and accreditations	Need for installation staff licensing options.	To maintain performance standards and consumer trust.
	Need for company-level licensing and accreditations	To ensure organisational accountability for training, supervision, and compliance.
Organisational behaviour policy	Need for taxation cut-offs for energy upgrades.	To incentivise expected behaviour
	Inclusion of incentives methods for regulatory compliance.	To move from relying primarily on penalties or obligations.

Appendix 16 – Draught Proofing - Policy support which would help with your business

What policy support would help with your business?

Areas of policy support	Second order themes	Rationale

Local manufacturing	Policy support for locally manufactured products (funds)	Issue is not bias against Australian-made products, but the reality that local manufacturing costs are higher
Product standards	Product performance standards	Any product can be sold regardless of effectiveness. Impact on market quality: Low-performing products compete directly with high-quality alternatives.

Appendix 17 – Hot Water's Challenges in Overseas Supply Chain Process

What are the challenges faced by your company in dealing with overseas supply chain process?

Aggregate dimension – Challenging areas of overseas supply	Overseas supply chain challenge	Implications
Difficult relationship with suppliers	Lack of supplier reliability	Higher post-sales costs. Low reliability and willingness to support post-sales issues.
	Lack of supplier compliance	No supplier support. Warranty and after-sales solutions with Chinese suppliers are difficult to manage.
	Misaligned supply goals	Breach of contract and inefficient warranty service processes
Supply dependence	Heavy reliance on a single supply market (China)	High vulnerability to geopolitical risks, breakdown in Australia – China relations, resulting supply disruption or trade restrictions
	Limited supplier pool for sourcing diversification.	Facing potential supplies that are inferior in quality and come at a higher cost. Thus, affecting competitiveness
Lead times	Far shore supplier variable lead times	Delayed production and variable lead times from suppliers in Japan and Europe. Possible stockouts.
Production models	Mismatch between made-to-order and made-to-stock models	Operational inefficiencies and capacity conflicts. Ongoing adjustments to planning and demand forecasting to ensure customer demand is met.

Appendix 18 – Hot Water's Installers Skills Gap and Training

What are the skills gaps and training challenges faced by your installers?

Issues related to skills gaps and training	Implications
Adequate skill levels for LED Lighting	No major training or capability constraints related to LED lighting.
Training for new installation processes	Learning curve management.
Air conditioning installation skill gap	Bottle neck on workforce with the skills the required skills creating an installation capacity constraint.

Appendix 19 – Hot Water - Policy support which would help with your business

What policy support would help with your business?

Areas of policy support	Second order themes	Rationale
Policy reliability	Simpler and clearer regulatory mandates	Ambiguous and complex licensing and rebate frameworks limit the participation of small businesses, restricting industry growth and limiting service delivery, especially in regional areas
	Stable and reliable policy and rebate programs	Sudden changes to state-based incentive programs, sometimes with only days of notice, create immediate financial risk
	Suitable adaptation windows for new policies	Predictability and reasonable lead times for new policies would support supply chain resilience
Government market mediation	Government market mediation	Product regulation and customer education that enable confident, informed participation in the energy transition.

Product compliance and certifications	Expansion of the Energy Efficiency Rating System.	Absence of a clear, standardised rating framework for electrification products beyond traditional appliances. Thus, impacting decision making processes in industry and for customers.
	Investment on industry's technical capabilities improvement.	The absence of sufficient independent testing capacity limits the ability to rigorously assess product quality and performance before market entry
	Strict Product Certification and Ongoing Compliance	Need for benchmarking and systematic reporting to identify non-compliant imports and communicate risks to regulators.

Appendix 20 – Glass Windows - Issues in the Performance of your Supplier Management

Have you come across any issues in the performance of your supplier management regarding the products that your firm currently handles?

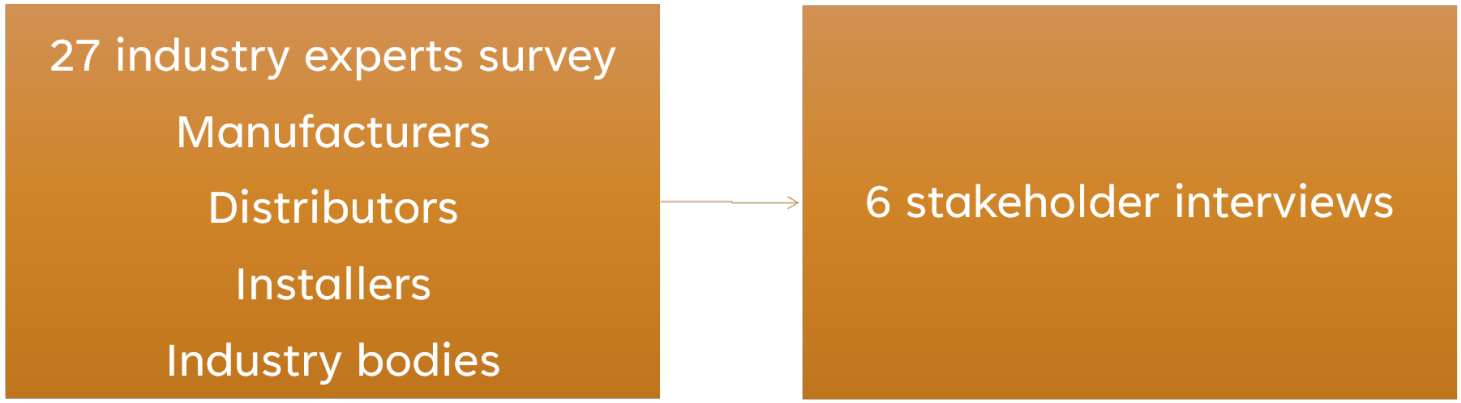
Issues related to supply management	Second order themes	Implications
Supplier reliability	Supplier underperformance	Supplier problems are organisational and process-driven because of their poor internal systems.
Risk management	Diversification of the supplier base across franchises	Franchisees are now encouraged to spread orders across multiple suppliers. This reduces systemic risks.

Appendix 21 – Glass Window - Policy support which would help with your business

What policy support would help with your business?

Areas of policy support	Second order themes	Rationale
Training policy	Training and education support across the supply chain	Education and training are more impactful than punitive regulation in reshaping industry behaviour.

Appendix 22 - Data Collection: Mixed Methods Design



Appendix 23 – Profiles of survey respondents

Role	Firm Type / Organisational Context	Primary Product or Sector Focus	Procurement Or Supply-Chain Involvement	Experience In Role	Count (% of n=27)
Managing Director / Director	Manufacturer; supplier–installer	Insulation, heat pumps, EEPs	Yes (majority)	Mostly >5 years	9 (33%)
Product Manager	Manufacturer; national distributor	Heating, cooling, heat pumps	Yes	Mixed (1–5 and >5 years)	8 (30%)
Owner / Owner–Director	Small–medium supplier or installer	Energy-efficiency products (general)	Mixed (Yes)	Mostly 1–5 years	3 (11%)
Procurement / Supply Chain Manager	Manufacturer; distributor	Heating, cooling, water heating	Yes	1–5 years	1 (4%)
CEO	Large supplier or manufacturer	Energy-efficiency technologies	Yes	>5 years	1 (4%)
Other (industry association, research, admin/support)	Industry bodies; research or support organisations	Windows, glazing, non-product-specific	Indirect	Mixed	5 (19%)
Total					27 (100%)

Appendix 24 - Mapping of Survey Items to SCOR Domains

SCOR Domain	Survey Items
Plan (Order Planning)	1.1 Order handling accuracy 1.2 Managing order discrepancies 1.3 Convenience of order placement 1.4 Consistency of order-handling process 1.5 Customer order time 1.6 Order-processing cost
Source (Supplier Management)	2.1 Supplier location convenience 2.2 Supplier flexibility capacity 2.3 Supplier defect rate 2.4 Supplier problem-solving support 2.5 Supplier defect-free deliveries 2.6 Supplier price competitiveness 2.7 Supplier lead-time performance 2.8 Supplier payment convenience
Make/Store (Warehousing)	3.1 Warehouse inventory turnover 3.2 Warehouse processing errors 3.3 Timeliness of warehouse processing 3.4 Cost of warehouse processing
Deliver (Delivery Management)	4.1 Delivery service flexibility 4.2 Accuracy of delivery documentation 4.3 On-time delivery rate 4.4 Delivery time competitiveness 4.5 Customer-facing defect-free delivery 4.6 Delivery cost competitiveness
Return (Returns Handling)	5.1 Speed of response to claims 5.2 Speed of defective-product collection 5.3 Speed of refunds or replacements 5.4 Cost of handling product returns

Appendix 25 – Interview respondents' characteristics

Respondent	Role	Firm Type / Organisational Context	Primary Product or Sector Focus
Resp-A	Managing Director	Mid-sized supplier–installer	Insulation
Resp-B	Owner / Managing Director	Supplier–installer	Heat pumps
Resp-C	Supply Chain Manager	Manufacturer	Heating, cooling, water heating
Resp-D	Managing Director	Manufacturer	Heat pumps
Resp-E	Master Franchisee	Component supplier	Energy-efficient windows
Resp-F	National Supply Chain Manager	Industry association	Windows and glazing