RACE for 2030

RELIABLE
AFFORDABLE
CLEAN
ENERGY

H2 Fast Track

Pathways to scale: Retrofitting One Million+ homes

Final report

Australian Government
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Final Report
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Research Theme H2: Enhancing home thermal inertia

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What is RACE for 2030?

The Reliable Affordable Clean Energy for 2030 Cooperative Research Centre (RACE for 2030 CRC) is a 10-year, $350 million Australian research collaboration involving industry, research, government and other stakeholders. Its mission is to drive innovation for a secure, affordable, clean energy future. https://www.racefor2030.com.au

Project partners

Executive Summary

Australia needs a targeted and coordinated effort to retrofit the millions of existing homes. This report presents the foundational research that will underpin an effort to engage private finance to begin by retrofitting over one million Australian homes for thermal and energy efficiency. The scheme aims to retrofit homes so that they can support Australia's current and future comfort and energy needs and facilitate the transition to renewable energy.

The way we generate and use energy is transforming. Our homes need to evolve alongside this to support our needs for comfort, efficiency, and resilience.

Maximising thermal and energy efficiency in homes, moving energy demand into periods of maximum renewable generation, and enabling electrification can also support the transition toward net zero.

Based on modelling in this report, retrofitting one million existing Australian homes across five years could:

- Reduce average home energy use by up to 9,000kWh per year
- Reduce average home emissions by up to 5.8 tonnes CO_2 eq per year
- Create an up to $55 billion private finance investment opportunity

A bespoke home retrofit, addressing needs identified through a whole-of-home assessment could reduce an average home energy bill by up to $1,600 per year.

A large-scale home retrofit scheme can create jobs for Australian communities, reduce energy use for heating and cooling and cut carbon emissions whilst stimulating private investment. This is evidenced by international retrofit programs. This project reviewed eight international programs from the United Kingdom, Europe, United States of America, and New Zealand. These programs demonstrated that large-scale retrofits can be effectively implemented and yield positive impacts including stimulate investment, save energy, reduce greenhouse gas emission, increase employment and local business activity, provide good return on investment of public money (1:4+), create health benefits for home occupants and increase property value.

The research outlined in this report supports development of a public-private partnership to retrofit one million plus homes, across five years. It recommends that a large-scale home retrofit scheme aims to create future ready homes. That is; improved thermal comfort with a path toward electrification.

The report outlines key insights to inform the design and implementation of an effective retrofit scheme. It then recommends a suite of coordinated actions required from stakeholders across the Australian home retrofit ecosystem to support a large-scale scheme. It also paves the way for a longer-term research program that can fill gaps in our current understanding to maximise the effectiveness of home retrofits at scale.

There is a substantial market opportunity in Australia. The task ahead is large and complex, yet feasible through collaborative efforts. And now more than ever before. The

insights for effective retrofit scheme design and recommendations for a portfolio of coordinated action outlined in this report can guide this effort and transform Australia's existing homes for a prosperous, net-zero emissions future.

Methodology

The project was delivered through a mix of desk-top research, literature review, modelling, and stakeholder consultation.

A literature review was undertaken of the impacts of large-scale energy efficiency retrofit programs and the determinants for success of such programs.

Modelling was used to explore the benefits that could be shown from various retrofit upgrades in three priority locations across Australia.

This work was complemented by desktop research, one legal and governance workshop, two Industry Reference Group (IRG) workshops, eight semi-structured IRG participant interviews and three Project Partner committee (PPC) meetings to collect further insight and support scheme design.

Findings

Retrofits have been shown internationally and locally to yield benefits including:

- Reducing mortality, hospitalisations, and health costs
- Reduce demands on the grid
- Supporting economic activity, job growth and energy prices

Numerous studies report significant health and well-being improvements due to improving the energy efficiency of housing, and these benefits are frequently reported to be much greater than the energy use and cost benefits (IERC, 2021; MEEA, 2021; Telfar Banard et al, 2011, Thomson et al, 2013, Chapman et al, 2009, Prevar et al, 2010, Gilbertson and Green, 2008). Vulnerable groups that benefitted particularly are the elderly and infants, and people with chronic illness. Quantifying the exact health and wellbeing benefits is complex, however, a report by the International Energy Agency states that they could equate to 75% of the overall benefits and return on investment (IEA, 2014).

Modelling of a selection of Australian homes has shown that home energy and thermal efficiency retrofits offer energy and thermal benefits at a household scale. A basic building envelope retrofit saves between 18% (in New South Wales, terrace home) and 31% (in Victoria, detached home) of energy use. Poorer quality homes would benefit from an increased impact. In New South Wales and Western Australia, a comprehensive home retrofit including improvements to the building envelope as well as solar PV and other building technology and appliance upgrades or additions enabling home electrification can obtain a near 100% saving in overall energy use.

Care is required to balance the thermal and energy benefits with financial benefits to create financially viable yet bespoke home retrofit packages. Novel value flow, including

capturing the value of health benefits could further boost the case for public and private investment in home retrofits.

Enabling a large-scale delivery of the scheme is a critical element of the schemes direction that can only allow the scheme to tap into private finance. The scheme could operate at a community scale (geographical or other community basis), to allow aggregation of demand and efficiency in supply and installation. A place-based roll out will enable addressing issues of capacity and the ability to work with community groups to enable shared success.

Research identified an initial target market to establish the drive for thermal and energy efficiency home retrofits. The scheme will target National Construction Code (NCC) Class 1a single dwellings that are owner occupied or tenanted. This accounts for up to 8.6 million dwellings and represents 86% of Australian households. This target market reaches most of the private Australian housing stock which would allow for the scale and impact required. The scheme will also prioritise targeting poorer quality homes due to the increased household and economy scale impact from home retrofit improvements to poor quality housing stock.

Social and public housing inclusion could be implemented dependant on Government appetite to provide funding for delivery, assessment, and installation of home retrofits. Low-income households will be wholly reliant on governments to fund home retrofits. Minimum rental standards that would benefit mainly low-income households and would also initiate the market demand for improvement to tenanted homes are recommended. The proposed scheme delivery model could be utilised to enable a large-scale rollout for public, social and community housing, as well as low-income households, if supported by governments.

Due to complexities in providing private sector finance, and complex governance, NCC Class 2 apartment buildings could be considered for inclusion as the scheme delivery progresses.

An effective scheme will need to be supported by a range of activities from multiple stakeholders. Work will be required to shift norms and mobilise industry including:

1 Training providers and industry accreditors building the skills capability within the home retrofit building industry

2 State and federal governments setting disclosure and reporting requirements, creating supportive legislative environments, and supporting funding and financing models

3 Outreach and engagement activities that target trusted sources of information for homeowners and that seek to influence the broader social perceptions about home comfort and energy efficiency

Scheme Design Principles, Targets and Recommendations

The home retrofit scheme must have clear and demonstrable goals as is shown below in Table E1.

Table E1 Scheme design principles

The home retrofit scheme aims to create:
Future ready homes, meaning homes that are comfortable as well as highly thermal and energy efficient, with a path toward electrification
Improved NatHERS rating for each home
Market transformation
Culture shift toward demanding comfortable and energy efficient homes
Large-scale delivery of home retrofits across all states and regions in Australia
The home retrofit scheme will target:
National Construction Code (NCC) Class 1a single dwellings that are owner occupied or tenanted, mortgaged or owned outright
Poor quality homes
The home retrofit scheme must build and maintain trust with homeowners:
Scheme must benefit the homeowner through a streamlined process, including finance and retrofit options
Scheme must provide an offering that the homeowner wants and/or needs
Retrofit options provide best case outcomes with comfort and ROI benefits understood for each homeowner
The home retrofit scheme must engage at trigger points:
Point of sale/purchase of home
Point of advertisement for lease
Point of renovation
The home retrofit scheme and its partners and advocates must provide clear messaging and influence for government, industry and homeowners:
Use a values-based approach to understand customer motivations and an effective way to overcome intervention barriers
Optimised Australian home comfort benefits must be further researched and communicated to the target market and government
Whole of home assessments and a quality control process is critical:
An accredited assessment process that enables the homeowner to understand and receive independent technical guidance
A scalable yet stringent quality control process is required to ensure consistent and continued quality of workmanship and the scheme delivery model

The scheme design principles will guide further scheme development, testing and piloting. To be successful, a large-scale home retrofit scheme will need to bring together a

network of organisations and people working in collaboration and partnership with each other, as shown in Figure E1 below.

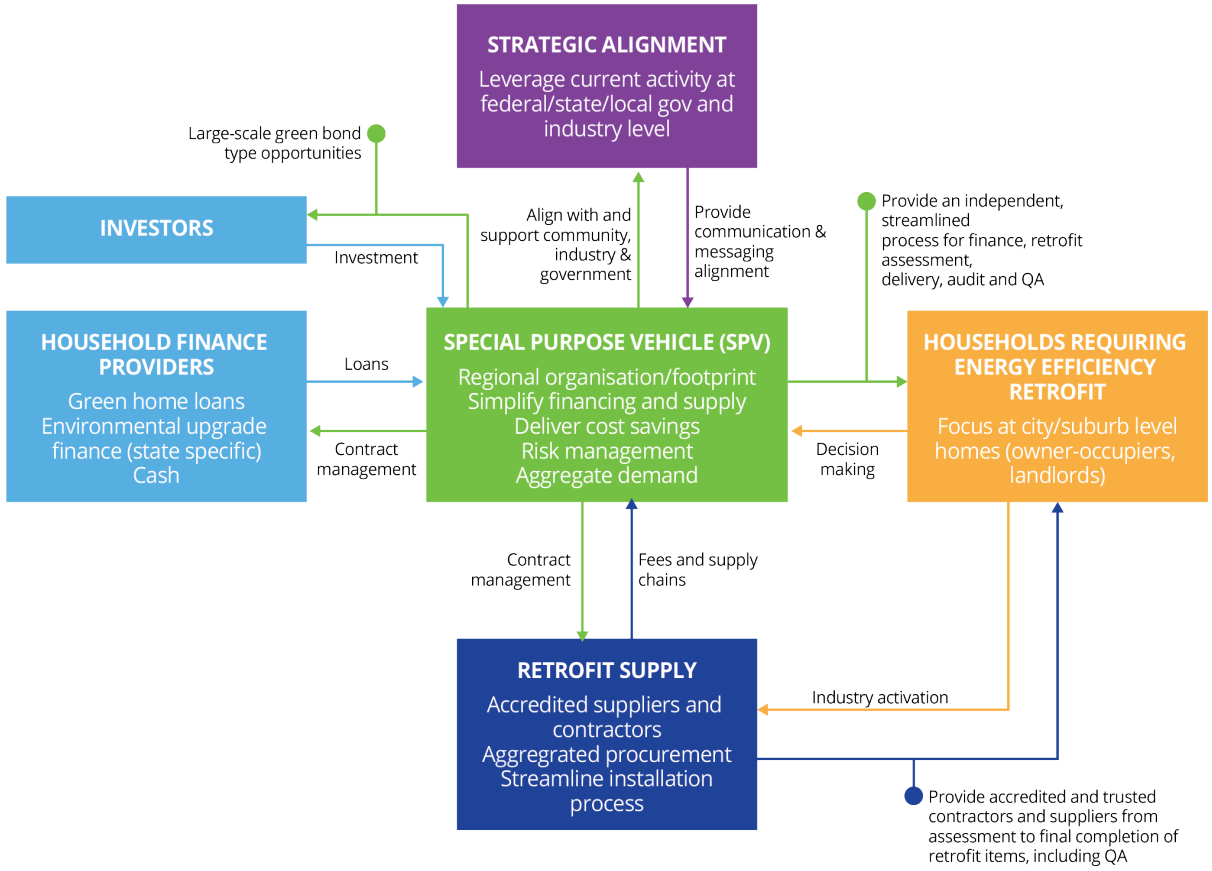

Figure E1 The proposed system model

Next Steps

A suite of work packages has been identified through the project that would support and progress a large-scale home retrofit scheme. Implementation will require coordination across the suite of work but does not need one entity to implement all the activities. Development, enablement, and implementation will require portfolio governance, with collaboration and partnership key to its success.

A Portfolio of Action

Our portfolio approach has identified six leverage points with twenty work packages between them, these packages are shown below in Figure E2. These packages cover **portfolio oversight**, which includes understanding and ensuring alignment and learning across the range of activities outlined in the other work packages.

The **operational model** group of work packages aims to understand the detail of the operational model of a retrofit scheme, while the **delivery** group of work is focussed on prototyping, piloting, improving and then expanding the delivery of large-scale home retrofits. Alongside the operational and delivery work are packages of work aimed at

creating the enabling environment for large-scale retrofits and building new narratives and norms that support the scheme. These include the **communications and engagement** activities aimed at building a national narrative while also understanding local and community scale nuances that will allow impactful messaging about retrofits. There is also work to understand and engage with the **policy and regulatory** environment. This includes appreciating the current conditions what will need to be accounted for in the scheme design, as well as understanding what the optimal environment is, and how to transition towards it. Finally, there is a package of work aimed at improving **technical** understanding of supply chains, managing waste and retiring and recycling items and monitoring and measuring impact.

Figure E2 The proposed large-scale home retrofit scheme portfolio of 20 work packages

Within this large range of work, several priority work package items that will be critical to maintaining momentum across the next 12 months and in preparation for a pilot scheme have been identified as shown below in Table E2.

Table E2 Work package priorities to maintain momentum

Market analysis and discovery
Engage with customer focus groups and public surveys, what are the consumer preferences and where is the target market demand in the current landscape (COVID)? Test the delivery model at household and community level
Driving the narrative and building profile
Work with partners to engage the target market(s), create a movement around energy and thermal efficiency broadly, and build the profile of the large-scale home retrofit scheme
Identify, align with and support policy and regulatory changes
work with enablers to progress disclosure and other policy changes
Recommend and enable industry standards and accreditation
Engage and align with industry to support and advise on progress towards achieving the required standards and accreditations
Finance system, customer segmentation model
Explore the proposed finance models with potential investors and/or financers
Business development – Partnerships and funding
Climate-KIC Australia and its partners are exploring the opportunity to progress the work as a standard track project for implementation in the RACE for 2030

A Portfolio of Research

Alongside the work packages, specific research that has been identified as lacking or required to progress the scheme design and development includes:

- Quantify the potential economy scale health benefits of a large-scale home retrofit scheme being delivered in Australia.
- Deeper analysis of the retrofit upgrades that provide optimal Return on Investment (ROI) at the household scale in different climate environments and for different housing types.
- Model how home energy efficiency measures alongside home electrification (including electric vehicle (EV) charging and solar photo voltaic (PV) with storage) can or will support and impact the grid.
- How to design the scheme to also ensure benefits to the indoor air quality (IAQ) and moisture management of a home when retrofitting for the purpose of thermal and energy efficiency, as well as optimising occupant health and comfort benefits.
- How does the scheme determine a poor-quality home? Do we consider dates based around NCC guideline changes, for example pre/post 2010? Do we consider dwelling construction type based on available data?

Glossary

IRG	Industry Reference Group
PPC	Project Partner Committee
ROI	Return on Investment
EV	Electric Vehicle
PV	Photo Voltaic
LCA	Life Cycle Assessment
VPP	Virtual Power Plant
CBA	Cost Benefit Analysis
NatHERS	Nationwide House Energy Rating Scheme
NCC	National Construction Code
NSW	New South Wales
Vic	Victoria
WA	Western Australia
KfW	Kreditanstalt Für Wiederaufbau
UK	United Kingdom
EU	Europe
USA	United States of America
NZ	New Zealand
EEC	Energy Efficiency Certificates
REC	Renewable Energy Certificates
NPV	Net Present Value
DE	Decentralised Energy
IAQ	Indoor Air Quality
EUF	Energy Upgrade Finance
ACCC	Australian Competition and Consumer Commission
AFS	Australian Financial Services
SPV	Special Purpose Vehicle
JV	Joint Venture
DER	Distributed Energy Resources
HEER	Home Energy Efficiency Retrofit

ACP	Australian Certificate Providers
ESC	Energy Savings Certificates
ESS	Energy Savings Scheme
NEM	National Energy market

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1 Introduction

Many of Australia's ten million homes are characterised by poor thermal and energy efficiency performance. Consequently, substantial energy consumption is required to maintain thermal comfort and deliver household services. Energy efficient retrofitted homes save money, decrease energy consumption, promote healthier home environments, contribute to stabilising the electricity grid, and represent a significant market opportunity.

Private finance is willing to provide loans for retrofits. However, they need scale and clear market signals to make it an attractive opportunity.

Builders, installers, and materials providers are interested in this business opportunity but need a strong market signal to justify investment in the infrastructure, training, accreditation, and staff for scale up.

State governments have energy efficiency and greenhouse gas emission reduction targets, which would be aided by residential retrofits. In addition, governments want better health outcomes, new jobs and economic growth, and affordable energy.

Significant work has been done across Australia to progress home energy efficiency and thermal performance retrofits. As shown in Appendix C, several state-based Australian pilot programs have demonstrated that retrofits can be effectively implemented and yield positive community and household scale impacts. Internationally, large-scale retrofit programs have been rolled out with varying levels of success, as will be demonstrated in Section 4. Despite this, large-scale schemes supporting home energy efficiency retrofits remain elusive in Australia, however the market is changing and demand for a collaborative effort and partnership between homeowners, tenants, industry, investors and government is growing.

This report supports and proposes the design and development of an evidence-based large-scale home retrofit scheme. It draws on international and local expertise to:

- Model the impact of retrofits at a household scale including energy savings, environmental benefits, financial benefits and improvements in thermal comfort
- Gather evidence of environmental, social and economic benefits of large-scale retrofits
- Illuminate the barriers, opportunities and market setting requirements for large-scale home retrofits
- Identify a proposed retrofit standard to offer to homeowners, depending on their home requirements and priorities
- Advance the proposed delivery model including, understanding current activity, mapping stakeholders, understanding markets, consumer preferences, recruitment options and funding and financing requirements

2 Project Scope

2.1 Project Aims

The overarching aim of this research project was to fill knowledge gaps and build capability to implement home retrofits, for the purpose of thermal and energy efficiency, in over one million homes, through public-private partnership. It answers critical scheme design and scheme development questions, analyses the barriers, opportunities and impacts of large-scale home retrofits with public-private finance whilst considering the current activity and market for home retrofits.

2.2 Project Outputs

This report describes the research approach, the research findings, and recommendations. The findings underpin a proposed scheme design, which is put forward at the conclusion of this report. The report outlines:

- Indicative economy-scale benefits of international large-scale retrofits including:
    - Financial costs and benefits
    - Health benefits
    - Impacts on the energy grid
    - Job creation and gross domestic product (GDP) effects
- A package of recommended retrofits for typical housing types across New South Wales (NSW), Victoria (Vic) and Western Australia (WA)
- Modelling of the household scale environmental, energy saving, and financial benefits of retrofits
- A stakeholder map to identify relevant organisations for the delivery of the large-scale home retrofit scheme
- A summary of complementary activities already underway in Australia
- Preliminary insights on consumer preferences, market segments and customer recruitment
- Governance and legal considerations for the scheme
- Mapping of the barriers to achieving home retrofits at scale and practical options to address priority barriers
- A scheme model that can support rapid scale up, by identifying market scale and segmentation; illuminating the business models required to become self-sustaining; and determining the level of funding and finance that is required for implementation.

2.3 Project Outcomes

The research informs the design and development of a home retrofit scheme and research that can support the rapid scale up of thermal and energy efficiency retrofits moving towards large-scale impact. The research enhances understanding of the opportunities of large-scale home retrofits in order to make the case for policy and

investment. It will explore the current state of understanding of the grid impacts of large-scale home retrofitting.

Understanding barriers and practical actions to address them may further allow for an informed design of broader responses that build the marketplace for home thermal and energy efficiency retrofits in Australia.

This work also informs the design of a larger, long-term scheme of research to support the design and implementation of a home retrofit scheme. The proposed research could monitor and evaluate approaches to retrofitting, and the opportunities for innovation to further accelerate action. The research will also include exploration of novel technology that can aid higher penetration of roof-top solar PV, and net-zero homes.

This long-term research should include:

- More robust scheme design with further insight into key design questions and a pathway to pilot project implementation
- Ability to make the case for investment in a large-scale home retrofit scheme
- Ability to articulate the complementary activity required to facilitate retrofits at significant scale.

3 Methodology

The project was delivered through a mix of desk-top research, modelling and stakeholder consultation, which is outlined below. Due to the short time frame of the project these activities progressed in parallel. Insight from the different activities fed into one another where possible along the timeline.

3.1 Literature Review

Drawing on existing literature and available data sets an exploration was undertaken of the impacts of large-scale energy efficiency retrofits and the determinants for success of such programs. This included consideration of the impacts on:

- the electricity network including possible impacts on long-term energy affordability, and greater renewable energy uptake through roof-top solar
- the economy (jobs, investment etc.) and
- society, especially considering health.

The literature review was completed using the steps outlined in the following sections.

3.1.1 High Level Literature Scan

Experts in the field of residential energy efficiency retrofits (within ISF, UTS, Project Partners Committee and Industry Reference Group) were contacted to identify key literature that would provide general and technical information across the research topics. In addition, recommendations of any specific examples of residential energy efficiency programs in Australia and overseas were obtained, as well as key journals and databases to search. A broad online search aimed to identify literature at a high level. This included grey literature and evaluation reports of energy efficiency programs in Australia and overseas.

3.1.2 Detailed Literature Scan

A more detailed and focused search was then undertaken to uncover further information on the research topics, and in particular lessons from similar schemes internationally. This began with academic search engines Google Scholar and ResearchGate, however the searches were very specific to the research topics (health, thermal comfort, electricity grid, network, economy, employment) and the results were of limited applicability or usefulness.

Three key journal databases: Web of Science, Scopus and Science Direct, were then searched utilising the same detailed search strings. However, the results were not applicable or useful in many instances. In the case of Science Direct, the search strings couldn't be applied as the database does not accept strings of a certain length.

It was then decided to conduct a more general search which uncovered a very large number of results.

The final search string included a combination of the general and specific search terms which was then adjusted for Science Direct. The relevant results which were downloaded into EndNote.

The titles were reviewed to identify relevant papers and articles that could address the research topics. This resulted in a shortlist of 80 papers.

Grey literature that was recommended in the first step was added to this list resulting in a shortlist of 88 papers and articles in total.

The abstracts were then analysed, and additional papers sourced, to bring the final literature reviewed to 29. While many papers addressed residential energy efficiency retrofits specifically, they were more applicable to the following, than high level economy-wide benefits:

- technical studies (e.g., results of a specific intervention on individual households)
- non-residential or commercial buildings
- analysis of benefits or impacts on a very small sample size of homes
- modelled and predicted outcomes of potential EE interventions and a focus on existing and proposing new modelling methods (analysis and critique)
- analysis of homeowner decision-making via qualitative surveys and studies (e.g., motivations, attitudes, participation rates etc)
- quantification of energy and greenhouse gas savings
- specific demographics such as low-income households, social housing, rental housing, programs addressing fuel poverty etc.

3.1.3 Literature Review

The shortlisted literature was then reviewed to address the research questions and gather evidence, as reported herein.

Full details of the literature review are provided in the accompanying report *Pathways to Scale: Evidence of environmental, social, and economic benefits of large-scale residential retrofits*.

3.2 Home Upgrade Modelling

Modelling was used to explore the benefits to be obtained from various retrofit packages in three priority location. The modelling aimed to address the following research questions:

1. What is the thermal performance of common housing types in New South Wales, Victoria, and Western Australia, as they were built in the early 2000's (prior to the NCC 2010 6-star NatHERS rating requirement)?
2. How can this thermal performance be enhanced through retrofitting strategies, including floor, roof, and external wall insulation, diminishing leachability, energy-saving appliances, solar PV and storage systems, lighting system?

3. How do these enhancing strategies translate into environmental impact, considering their related embodied energy and embodied carbon?
4. Which retrofit standards can be recommended to enhance common housing types in the Victoria, New South Wales, and Western Australia climates?

The modelling investigated the environmental impact of four retrofit packages. These packages were developed through research and consultation with the Project Partner Committee (PPC). The upgrades identified for modelling are summarised in tables 3-6 below:

Table 3 Upgrade 1 retrofitting interventions for detached and terraced homes

Intervention	Description	Baseline parameter	Improved parameter	Reference
Roof insulation	Improvement U-values of roof, wall, and floor insulation. (Roof U-values collected for light coloured roofs).	<1 W/m2/K	0.217 W/m2/K	https://build.com.au/bca-requirements-insulation (ABCB, 2020) – Part 3.12 of the Building Code of Australia Housing Provisions (BCA)
Wall insulation		0.5-1 W/m2/K	0.357 W/m2/K	
Floor insulation		1 W/m2/K	0.444 W/m2/K (0.364 W/m2/K in Victoria)	
Pipe lagging	Thermal insulation of the hot water pipes.	-	4% increased efficiency	(Marini, Buswell, & Hopfe, 2021)
Draught sealing/proofing	Overall improved air tightness.		15% improved airtightness after retrofitting	(Wills, Beausoleil-Morrison, & Ugursal, 2021)

Table 4 Upgrade 2 retrofitting interventions for detached and terraced homes.

Intervention	Description	Baseline parameter	Improved parameter	Reference
Ceiling fans	Addition of ceiling fans to minimise the air conditioning when cooling.	-	Cooling from the air conditioning reduced to zero (the energy use of the fan is considered negligible, when compared to that one of the aircon).	-
Reverse cycle aircon	Substitution of the traditional aircon system for a reverse cycle split system.	-	Improved coefficient of performance (COP) by 11%	https://www.energy.gov.au/households/heating-and-cooling#toc-anchor-heating-choices

Double glazing	Double glazing in place of the single glazing to improve the thermal insulation of the windows (decreased windows' U-value)	U-Value 5-6 SHGC 0.5-0.6	U-value 3.1 SHGC 0.63	(ABCB, 2020) – Part 3.12.2 External glazing of the Building Code of Australia Housing Provisions (BCA)

Table 5 Upgrade 3 retrofitting interventions for detached and terraced homes.

Intervention	Description	Baseline parameter	Improved parameter	Reference
Efficient appliances	Substitution of high-efficiency home appliances such as fridge, dishwasher, washing machine.	-	Reduced equipment power density by 55% (W/m2)	https://www.energyrating.gov.au/
LED lighting	Substitution of the incandescence lightbulbs with LED or similarly high-efficiency lights.	-	Reduced light power density by 85% (W/m2)	(European Commission Joint Research Centre, 2011; Mills & Schleich, 2014)
Clothesline	Elimination of dryer	-	Reduced equipment power density by 15% (W/m2)	https://www.energyrating.gov.au/

Table 6 Upgrade 4 retrofitting interventions for detached and terraces homes.

Intervention	Description	Baseline parameter	Improved parameter	Reference
Solar panels	Inclusion of solar panels.	-	Efficiency = 15% Tilt angle = 30° Panel area (5 kW) = 25 m^2	https://solarcalculator.com.au/solar-panel-efficiency/
Hot water heat pump	High-efficiency heat water pump (pipe lagging included)	-	30% less energy compared to traditional hot water systems	https://www.energy.gov.au/households/hot-water-systems

The baseline parameters in the above tables indicate the characteristics of the building envelope of the modelled typical detached and terraced homes before improvements.

Building envelope characteristics were extracted from the Australian Housing Data from CSIRO (https://ahd.csiro.au/) and includes class 1A existing buildings only.

The building energy simulations were in New South Wales, Victoria, and Western Australia, more specifically in Sydney, Melbourne, and Perth.

Two of the most common Australian housing types were analysed in this report: a detached home and a terraced home (or townhouse) – these two building types are building Class 1a in the Australian Building Codes Board National Construction Code (ABCB, 2020).

3.2.1 Building Energy Simulation Method

The building energy simulation unfolds in four main steps:

1. House plans were selected by the team of experts and authors as suitable typical plans in the three Australian states considered in this study.
2. The geometry of the house plans was modelled in a three-dimensional environment using SketchUp Pro 2021.
3. The 3D models were extracted into Sefaira v3.0.0, where the weather information, space use, and operations were entered.
4. The results were extracted into Excel 2105, analysed, and reported.

3.2.2 Life Cycle Assessment and Material Flow Accounting

The Life Cycle Assessment (LCA) methodology enables an evaluation of the environmental impact of products and services (ISO, 1994). The environmental impact of buildings span through their whole life cycle, usually divided in four stages: production (or construction, stage A), operation (stage B), end of life (stage C), and second life (stage D). For this study, only the operation stage was analysed, evaluating energy use and greenhouse gas emissions due to the use of the buildings and the retrofitting operations. Whilst the energy use of the buildings was analysed through the 3D modelling and energy simulation, the environmental impact of retrofitting operations was assessed through a desktop search. Results of the desktop search are shown in Section 7 of the accompanying report *Pathways to Scale: Thermal Modelling, energy efficiency and life cycle assessment of Australian homes.*

Full details of the modelling method, home plans, models and results are available in the accompanying report *Pathways to Scale: Thermal Modelling, energy efficiency and life cycle assessment of Australian homes.*

3.3 Stakeholder Engagement and Industry Insights

The scheme design was progressed through meetings of the Project Partner Committee (PPC), insight generated by the Industry Reference Group (IRG), desk-top research, insights from the literature and based on emerging information from the modelling and literature review.

The stakeholder engagement activities conducted were:

1 Meetings of the PPC:
    - Meeting 1: kick-off: Overview of project plan and goals, resource identification, modelling options
    - Meeting 2: literature review and barriers insights, modelling update, governance insights, scheme model discussion
    - Meeting 3: wrap up: final products and insights, reflection, and next steps
2 Desktop research: drawing on the literature review and other resources to
    - Summarise preliminary insights into barriers and considerations
    - Identify current government and NFP policies, programs and initiatives supporting household energy efficiency retrofits in Vic, NSW, and WA
    - Advance development of the scheme model
    - Build understanding of consumer perspectives and
    - Assess finance options in relation to the scheme
3 IRG Workshop: two IRG workshops to understand the barriers for the scheme in the Australian context and identify and test possible solutions, and to identify relevant stakeholders for implementation.
4 Semi-structured interviews: eight interviews with the IRG to provide insight on current activities, relevant stakeholders, and barriers
5 Governance and legal workshop with legal experts to explore the relevant considerations for a scheme of this nature and design.

From the two IRG workshops, the eight interviews and the three PPC meetings we collected insight which allowed us to identify:

- Stakeholder map – who are the stakeholders in the Australian ecosystem and what roles might they play
- Current activity in the Australian residential energy efficiency sector
- Barriers and opportunities from past experiences in Australia and internationally
- Key actions required to develop the scheme itself and build a supporting environment in Australia

The messages delivered have also informed the design for the proposed large-scale home retrofit delivery model.

3.3.1 Project Partner Committee

The Project Partner Committee (PPC) was formed from those organisations that made contributions to the project and were partners of the RACE for 2030 CRC. The PPC was closely consulted in the development of the project plan, and provided input throughout the project, including guidance towards the project outputs. The PPC met three times across the project timeline, meeting agendas and meeting minutes were agreed on by the PPC. The PPC members also participated in the Industry Reference Group workshops.

A table showing all PPC participant names is included in Appendix A.

3.3.2 Industry Reference Group

The Industry Reference Group (IRG) was made up of a coalition of organisations which had already mobilised to develop a proposal for large-scale energy efficiency home retrofits, the group also included additional industry representation that were able to provide insight to the process. This group includes representation from sectors that need to be engaged in a large-scale home retrofit scheme, and who are seeking critical insights from the research. Members of the IRG were encouraged to share the outputs of the research through their networks. An invitation to participate in the IRG was based on an individual's known expertise being relevant to the project research as well as their active engagement within the industry.

The group was engaged with the project through two workshops as well as eight one on one interviews that provided insights to guide the research, to hear the preliminary outcomes and provide feedback. This group was provided with targeted outputs to support the scheme development and communication about the issue.

The group was advised that companies participating in the IRG take seriously their obligations under the Competition and Consumer Act 2010 and intended to ensure that the discussions and any related communications fully comply with competition law requirements at all times.

A table showing all IRG participant names is included in Appendix A.

4 Findings

For the purposes of this project, a retrofit is considered as the act of adding a component to a building that it did not have when it was built. A renovation is the restoration of a building, the process of repairing and/or improving something about a building. It is possible for a retrofit to become a worthy addition to a building renovation.

The following chapters describe the research findings. Full details of the literature review are provided in the accompanying report *Pathways to Scale: Evidence of environmental, social, and economic benefits of large-scale residential retrofits*. Full details of the modelling method and results are available in the accompanying report *Pathways to Scale: Thermal Modelling, energy efficiency and life cycle assessment of Australian homes.*

4.1 Large-Scale International Programs, Arrangements, and Impacts

Eight International programs from the UK, Europe, USA, and New Zealand were reviewed. The range of retrofit upgrades covered by the programs were generally similar, with insulation, heating, and hot water core to most. The criteria for inclusion were that the programs had to be:

- energy efficiency upgrades to building envelopes, not solar PV installations or technology additions only,
- for residential buildings,
- large scale, nominally over one thousand homes.

Reporting and evaluation of each program confirms and quantifies the success of the program, gives reassurance that public money is well spent, and informs future program designs. Benefits from these large-scale international programs were found to be wide ranging and generally positive. Claims of benefits include:

- Investment stimulated
- Energy saved
- CO2 emissions reduced
- Employment and local business activity increased (or safeguarded)
- Good return on investment of public money (1:4+)
- Health benefits for occupants
- Property values increased

Table 7 below summarises the key aspects of the programs reviewed in the literature review, for ease of comparison.

Table 7 Summary of key aspects of international energy efficiency home retrofit programs

	Green Deal	EnEv Energy Conservation Act	Warm Front	EnergieSprong	Kirklees Warm Zone (KWZ) scheme	Warm up NZ	Property Assessed Clean Energy (PACE)	EcoBonus
PROGRAM DESCRIPTION								
Offered by	UK Government	KfW-Bankengruppe (a state-owned banking group)	Government funded	EnergieSprong	Kirklees Council	New Zealand Government	Local city councils – active in California, Florida, and Missouri	Italian Government
Jurisdiction	UK	Germany	England	Netherlands extending to France, UK, Germany, Italy and NY State	UK	New Zealand	USA	Italy
Delivery partners involved	approved Green Deal Advisor, approved Green Deal Provider, approved Green Deal Installer	Federal Ministry of Transport, Building and Urban Development (BMVBS) provides budget resources to KfW, retail banks	managed by Carillion Energy Services		managed by Yorkshire Energy Services (NFP local energy company), private installers	local government, iwi (Maori community), existing and new service providers, energy retailers	Works contractors	
Main target market	Homeowners	Owner occupiers, landlords and public bodies	owner occupied & private rented households	social housing providers and tenants, later private owners added	all households			Homeowners (luxury properties excluded) Tenants
Customer eligibility	Additional special conditions for low income or vulnerable	New houses meeting EnEV standard or	Vulnerable on income support		No restriction	No restriction	Subject to local community	Leading works to improve house energy

	Green Deal	EnEv Energy Conservation Act	Warm Front	EnergieSprong	Kirklees Warm Zone (KWZ) scheme	Warm up NZ	Property Assessed Clean Energy (PACE)	EcoBonus
	households and list of eligible measures	refurbishments exceeding standard SME, start-ups, enterprises, private individuals, municipalities, municipal companies, social organisations. For EE improvements of at least 10%						rating by 2 classes
Measures included	over 45 energy efficiency measures spread over the category's insulation (windows, internal & external walls and roof), boilers, draughts, and local energy creation	Insulation, windows, ventilation (with heat recovery), heating system, solar PV, consultancy	Heating, insulation, draught proofing,	prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installations	Insulation, energy assessments	Insulation, moisture barrier, draught proofing, hot water cylinder wraps, and pipe lagging, heating	energy efficiency, renewable energy, water conservation, and building resiliency upgrades	Leading works: insulation heater replacement, anti-seismic interventions. Secondary works: energy efficiency work, EV charging or PVs
Date commenced or operating period	Launched 2013 Pulled July 2015	KfW program: 1970s. EnEV Energy: 2002 KfW-Efficiency House 2006	2000	2010-2016 (government funded) and ongoing since 2017 (privately funded)	2007 to 2010	2009 to 2013	2008	for expenses incurred from 1st July 2020 until 30 June 2022 (expected to be extended to Dec 2023)

	Green Deal	EnEv Energy Conservation Act	Warm Front	EnergieSprong	Kirklees Warm Zone (KWZ) scheme	Warm up NZ	Property Assessed Clean Energy (PACE)	EcoBonus
REPORTED IMPACTS								
Scale of program	1,815 homes in total (against a 1m homes target) At July 2014 300,000 audits. 4,000 loans. £120m spent on Home Improvement Fund	200,000 homes per year 1.0m homes retrofitted 2004-9 KfW-Efficiency House 3.6m units since 2006 (~9% of existing stock)	2m homes in total to 2009	111,000 homes target	51,000 homes 2007–2010	241,000 insulation retrofits	200,000 homes (to 2019)	13m buildings are eligible
Accessibility	Low-high customer dropout rate – 0.6% successful conversion rate	High – extensive marketing campaigns			High level of participation and take-up			
CO2 emissions savings (Mt CO2 /year)	0.3 total	19					0.827 lifetime carbon abated in City of LA	
Cost benefit or ROI		1:4 or 1:5	Energy bill reduced by £300/year	Pilot averaged 70% reduction in total household energy consumption		>1:4 - Net benefits calculated to be worth NZ$1.3 billion over the expected lifetime of measures		Predicted to generate around €30 billion in GDP over the next decade, with a fiscal multiplier above 3.5
Success factors	Home audits have been hugely popular	Focus on customer orientation			Sustained marketing and repeated household visits		Financing terms to 20 years, so possible to undertake deep,	

Green Deal	EnEv Energy Conservation Act	Warm Front	EnergieSprong	Kirklees Warm Zone (KWZ) scheme	Warm up NZ	Property Assessed Clean Energy (PACE)	EcoBonus
	High degree of standardisation			from a trusted provider, great emphasis on customer care and the quality of installations		comprehensive retrofits that have meaningful energy savings and a significant impact on the bottom line	

4.2 Economy Scale Impacts of Large-Scale Retrofits

The literature review distilled the economy-scale benefits of large-scale retrofits that have been identified in either local or international studies and programs including:

1. Greenhouse gas emission reductions
2. Health benefits
3. Impacts on the energy grid
4. Job creation and GDP effects

4.2.1 Greenhouse Gas Emission Reductions

Energy efficiency is often seen as the easiest and most cost-effective way to reduce greenhouse gas emissions in the short term. It is important to note that the value of energy efficiency is not only determined by the quantity of energy that can be saved, but the timing of those energy savings as energy market costs vary significantly over the course of the day with costs typically highest when demand peaks. (Lilley et al, 2009)

A study by Langham et al in 2010 looked at the reduced infrastructure costs of energy efficiency in buildings in Australia and found that subject to a carbon price of $32 per tonne of carbon dioxide, emissions savings from cost effective energy efficiency measures could be increased by a further 36%, reducing total 2020 building sector emissions to 7% below 2010 levels.

The Kreditanstalt Für Wiederaufbau (KfW) is a German government-owned financing institution. KfW energy-saving programmes from 2006-2009 have saved heating costs of €1 billion per year, resulting in reduced carbon dioxide (CO2) emissions of almost 4 $MtCO_2$/year. CO_2 savings through the support programmes (low-interest loans and investment subsidies through KfW and Market Incentive Programme (MAP)) are estimated at around 1.2 $MtCO_2$ per year. Over the lifetime of the investments, the various measures are estimated to have led to long-term savings of around 72 $MtCO_2$.

4.2.2 Health Benefits

Numerous studies report significant health and well-being improvements due to improving the energy efficiency of housing, and these benefits are frequently reported to be much greater than the energy use and cost benefits (IERC, 2021; MEEA, 2021; Telfar Banard et al, 2011, Thomson et al, 2013, Chapman et al, 2009, Prevar et al, 2010, Gilbertson and Green, 2008). Vulnerable groups that benefitted particularly are the elderly and infants, and people with chronic illness. Quantifying the exact health and wellbeing benefits is complex, however, a report by the International Energy Agency states that they could equate to 75% of the overall benefits and return on investment (IEA, 2014).

Improved thermal comfort and reduced mould, damp, and draughts, means better conditions for those suffering from asthma, allergies, cardio and, in particular, respiratory illnesses. Mental health improvements were also reported (Gilbertson and Green, 2008). Reduced energy poverty frees up funds for improved medical care and medicines and reduces stress.

Outcomes:

- Reduced mortality attributed to fuel poverty and cold housing – possibly by 8 to 12%, and improved life expectancy (University of College London et al, 2005)
- Reduced hospital admissions (MEEA, 2021, Telfar Banard et al, 2011)
- Reduced health care costs (pharmaceuticals) for occupants (Telfar Banard et al, 2011)
- Alleviated symptoms of chronic illness (Thomson et al, 2013)

Measures that improve the energy efficiency of homes, such as improved glazing and daylight, have supplementary health benefits, adding to their overall value to the occupants.

Monetisation of the health and wellbeing impacts is a difficult and complex task that depends on local costs and services. The IEA (2014) report found that energy efficiency retrofits in buildings (e.g., insulation retrofits and weatherisation programmes) create conditions that support improved occupant health and well-being, particularly among vulnerable groups such as children, the elderly and those with pre-existing illnesses. Several studies that quantified total outcomes found benefit cost ratios as high as 4:1 when health and well-being impacts were included (IERC, 2021). Health benefits represent up to 75% of overall benefits in several studies, and 99% in a NZ study, and in some cases improved mental health is seen to represent almost half of that total. In NZ, low to middle income households gained nearly twice the benefits of other households. (NZBCSD, 2008).

Cost savings to both public health systems and to individuals were identified by the studies. Economic cost saving co-benefits of retrofits improving indoor air quality are due to reducing deaths, lost workforce productivity and welfare losses (IEA, 2014). Fewer hospitals stays have a knock-on macroeconomic benefit in increasing disposable income.

Health costs

A report (IERC, 2021) prepared for the Irish Government on co-benefits of retrofits highlights the benefits of improving indoor air quality from an economic cost saving, deaths, lost workforce productivity and welfare losses. It estimates that addressing indoor air quality could save the European Unions' economy €190bn annually (IEA, 2014). It found the costs of lives lost from outdoor and household air pollution in 2013 in Ireland could cost the global economy about US$225bn in lost workforce productivity and over US$5 trillion in welfare losses. Dampness and mould growth, to which Irish buildings are particularly prone, can cause and aggravate a range of illnesses, allergies, and respiratory diseases. It cites a US study which estimated "*the cost of asthma induced by dampness and mould in homes at USD$3.5bn per year*."

A New Zealand Business Council for Sustainable Development study in 2008 identified key health cost benefits of energy efficiency as 50 fewer hospital stays each day (ward beds or emergency clinic) on average will occur because homes will be warmer and drier.

This gives a total savings of 18,000 annual hospital stays for respiratory conditions, at around $3,000 per bed night. *(*NZBCSD, 2008).

(IERC, 2021) report also highlighted the reduced social costs of improving indoor air quality through transfer of spending on energy bills to medical care. It was seen to impact overall on health treatments such as medications to treat asthma, and frequent visits to healthcare facilities because of asthma*.* The same report highlighted a study of 30,000 tenants over a ten-year period in Carmarthenshire County Council in Wales that showed that admissions to hospital fell by between one quarter and one third across the improved homes, depending on the measures that had been retrofitted. This was calculated as potential annual savings to patients of €2.04m and to the health service (HSE) of €21.39m. It noted that all savings to the patient have a knock-on macroeconomic benefit in increasing disposable income. Where improvements included improved ventilation, and carbon monoxide and fire alarms, occupants in the over 60 age category were admitted to hospital 39% less often after the measures were installed, and there was a 57% drop in emergency admissions for respiratory illness in particular.

The study acknowledges that monetisation of the health and wellbeing impacts is a difficult and complex task which varies by country/region depending on the cost of public healthcare, childcare, social services, pharmaceutical prices, and minimum and average wage rates. A cost-benefit analyses of the return on investment that could accrue from preventing fuel poverty amongst children and young people in Northern Ireland, suggested that, for every pound spent on reducing fuel poverty, a return in NHS savings of 12 pence can be expected from children's health gains. When adults in the family are also included, this increases to 42 pence. The Building Research Establishment (BRE) in the UK conducted research into the cost of poor housing to the NHS and found that improving 3.5 million 'poor homes' in England, could save the NHS £1.4bn in first year treatment costs alone. Their method included a list of 29 indicators of hazards in poor homes, including excess cold/ heat, falls, dampness, and radon amongst others (IERC, 2021).

The IERC attempted to make calculations for the overall health and wellbeing savings based on two different international studies, which show a potential for approximately €600m per annum in healthcare savings. It found:

- A Catalonian study concluded that renovating 1.5 million dwellings would save the Spanish public administration €555m in healthcare and labour costs savings annually.

- Another study in France estimated that the indirect costs (including absenteeism at work or school, productivity losses, grade retention) cost almost 22 times more than direct medical costs of poor housing. It calculated that the direct costs to the HSE could be up to €28m annually, therefore the indirect cost savings could be €616m annually (28x22=616). (IERC, 2021)

The Kirklees Warm Zone scheme implemented large scale insulation retrofits in the UK. In their assessment of it, Webber et al (2015) found that research on the health-related impacts of the scheme has estimated that it generated health benefits of UK£4.9m, primarily in quality-of-life improvements (Liddell et al., 2011).

A study by Telfar Banard et al (2011) evaluating the Warm Up New Zealand: Heat Smart Programme (WUNZ:HS), noted changes in the incidence and costs of health services, pharmaceutical usage, and mortality in the first 46,655 houses retrofitted under the programme, introduced in July 2009. It attributed most of the benefits to improved insulation and only small costs benefits to heating upgrades, although the study noted this may be a factor of the intervention criteria for installing heaters. The sum of health benefits for all households from changes to total hospitalisation and total pharmaceutical use was found to average NZ$563 from insulation compared to NZ$4.64 from heating. The savings increased due to insulation, and mortality markedly decreased from interventions, for those with circulatory and respiratory illnesses. There was a very small but highly statistically significant reduction in monthly pharmaceutical costs as a result of receiving ceiling or floor insulation. The calculated benefits do not include those for improvements in comfort.

The Grimes et al (2012) cost benefit analysis of the Warm Up NZ scheme concluded that health benefits differ depending on the income level of houses, with low to middle income households gaining nearly twice the benefits of other households.

The study also looked at the NPV of total costs and health and energy benefits for the scheme and found net benefits of NZ$951m to NZ$1,492m (across a range of discount rates and assumed additionality). The results suggest that there are positive net benefits of the programme at all discount rates examined, including with assumptions of low levels of additionality. The results are dominated by the health benefits, which represent approximately 99% of the total benefits.

A New Zealand Business Council for Sustainable Development study in 2008 identified a key health cost benefit of energy efficiency being improved productivity due to fewer days lost due to illness. Insulation and double glazing were retrofitted to counter cold and damp. The study calculated a potential saving of 180,000 work days equating to at least $17 million a year in lost production based on a conservative minimum wage of $12ph. It also estimated lower health bills of $54 million, and "*that more than $17 million in extra production can be captured, energy and water use will fall, more people will be available for work and thousands fewer will have to go to hospital each year. Previous work found for every $1 you invested in insulation, health and other benefits worth $2 can be captured." (*NZBCSD, 2008).

Other social outcomes

Energy efficiency retrofits were identified to have the potential to benefit a range of social circumstances. They can:

- create an effective increase in home size by increasing usable space which promotes improvements in diet, privacy, household, and family relationships (Thomson et al, 2013).
- reduce absences from school or work – In Ireland a 15% reduction in days off school was measured (Thomson et al, 2013)
- address gender-based inequalities in energy (IEA, 2014)
- reduce fuel poverty or increase disposable income (IERC, 2021).

The literature review looked for evidence of energy efficiency upgrades improving occupant ability to participate in activities, including employment and school, behaviour change, improved energy literacy or reduction in fuel poverty. It also noted discussions of consumer motivations to participate in upgrade programs.

Thomson et al (2013) Found that in addition to general health, respiratory health, and mental health improvements, other impacts of warmth improvements were found to be:

- an effective increase in house size by increasing usable space which promotes improvements in diet, privacy, household, and family relationships, as well as opportunities for leisure and studying
- reduced absences from school or work.

A report (IERC, 2021) prepared for the Irish Government on co-benefits of retrofits highlights the social outcomes in relation to social inequalities associated with retrofit programs. It linked inequalities in housing quality to inequalities in general quality of life, health and wellbeing, and access to educational and career prospects. A 15% reduction in days off school has been measured among children in homes that received energy efficiency upgrades. Older people are more likely to experience fuel poverty and are also particularly vulnerable to health and social harm because of this experience and over-represented among houses which are in poor condition, and which lack central heating. Fuel poverty rates for disabled people in the UK private rental sector are particularly high, for example 35% of UK households with a disabled occupant are in fuel poverty.

The EnergieSprong (Energy Leap) program implemented in the Netherlands demonstrates social outcomes (European Commission, 2017) in a case study of a resident/tenant perspective of the retrofits where the tenants viewed the experience very positively and described the retrofit as transformational, talking about their ‘old home’ and their ‘new home’ even though the basic structure of their house was unchanged.

Some studies indicate the improvements in housing quality led to improved property values, which may also lead to increased rents (Thomson et al, 2013 and Hyland et al, 2013).

4.2.3 Impacts on the Energy Grid

Benefits to networks of energy efficiency measures can be substantial and include lower costs for energy generation, transmission and distribution, improved system reliability, dampened price volatility in wholesale markets and the possibility of delaying or deferring costly system upgrades (IEA, 2014, Mims et al, 2017, Langham et al, 2010, Langham et al, 2011, Relf et al, 2018). Energy consumption is reduced in a reliable, predictable, long-term, and measurable way.

The lower rate of growth in peak demand due to energy efficiency improvements reduces the number and magnitude of constraints on the network, treating the problem of peak demand growth at the source, with no network augmentation costs associated with alleviating constraints.

Energy efficiency was claimed to support system reliability by reducing demand, which effectively increases the reserve margin and thereby offsets generation that otherwise would be needed. Reductions of throughput needs on installed equipment can delay, reduce, or offset the need for traditional grid infrastructure upgrades to handle increased power flows.

Relf et al (2018) claims that e*nergy efficiency supports system reliability by reducing demand, which effectively increases the reserve margin and thereby offsets generation that otherwise would be needed. Efficiency can also function like a transmission and distribution (T&D) resource, reducing throughput needs on installed equipment. These reductions can delay, reduce, or offset the need for traditional grid infrastructure upgrades to handle increased power flows. In this way, energy efficiency can play a role alongside other distributed energy resources (DERs) to meet T&D system needs and maintain reliability.*

Energy efficiency benefits the electric power system by reducing electricity consumption and peak loads in a reliable, predictable, long-term, and measurable way. The value of the demand reduction achieved by customer energy efficiency programs is a function of the amount, timing, and location of the savings, as well as the utility system's physical and operational characteristics such as the timing of peak demand (summer or winter and time of day), load factor, and reserve margin. Energy efficiency improvements that reduce load during times of electric system peaks are more valuable from a grid perspective than those that occur during off-peak periods. Similarly, additional value accrues to investments located in areas experiencing T&D constraints. The ways in which these reliability contributions are being valued can be difficult to find, vary across the country, and differ based on goals and market structure. Nonetheless, there are indications that these reliability benefits can be substantial.

The recent trend of adding connected and smart features to energy-efficient technologies promises additional reliability benefits. For example, ENERGY STAR©-certified smart thermostats save on average 8% of heating and cooling bills and can also function as a demand response resource.

The report notes the example of California during its electricity crisis in 2000–2001 when energy efficiency and demand management played key roles in addressing the system's

reliability challenges, and the state's utility programs achieved energy and demand savings that prevented rolling outages.

The lower power demand of efficient buildings puts less stress on the system and facilitates a smoother, quicker restoration of power after an outage, as well as maintaining more liveable conditions for the occupants during the outage.

The IEA report (2014) notes that direct benefits from energy efficiency measures include *lower costs for energy generation, transmission and distribution, improved system reliability, dampened price volatility in wholesale markets and the possibility of delaying or deferring costly system upgrades. Providers can also benefit indirectly through benefits that accrue to customers from improved affordability of energy services, which in turn can reduce arrears and the associated administrative costs for utilities. To date, these and other customer benefits have proven difficult to integrate properly into cost-effectiveness tests and therefore have not been accurately measured.* This view is also confirmed by 2017 study by Mims et al that focussed on the time-varying value of energy efficiency savings to grid infrastructure.

A study in 2010 (Langham et al, 2010) which looked at the reduced infrastructure costs of energy efficiency in buildings in Australia found that improved energy efficiency in buildings could save up to an estimated $16.7 billion in infrastructure costs by 2020, in the context of energy infrastructure spending of around $165 billion. It estimates an annual avoided infrastructure value for residential buildings in Australia of $0.024 for fixed electricity infrastructure and $0.037 for fixed electricity and gas infrastructure per m2 per percentage reduction in energy consumption.

Research conducted in 2011 (Langham et al, 2011) for the Victorian government in Australia analysed the benefits of decentralised energy (DE) on the state economy. Its definition of 'decentralised energy' includes energy efficiency measures such as retrofits, as well as distributed generation and power load management.

It found that there is substantial untapped cost-effective potential of DE in Victoria, which if implemented strategically, could reduce electricity sector emissions by 6.2% and save electricity consumers in the order of $437 million per annum by 2020. It is estimated that this saving would result in reductions in average consumer bills of 4.7%. It also identified reduced risks of the Victorian electricity sector being exposed to a combination of reliability problems, declining load factors, rising network capital expenditure, and rising prices, customer bills and carbon costs. It suggests that, in practice, the main economic benefits of a well-implemented DE strategy may never be 'visible'.

The economic benefits of DE could be realised by Victorian electricity consumers if electricity network businesses are encouraged and supported to implement DE options at sufficient scale to defer or avoid capital intensive network; lower peak demand growth requires less network infrastructure investment; from lower wholesale energy generation costs resulting from lower overall and peak demand in the wholesale energy market; reduced electricity sales and incentives cost are offset by reduced capital investment. As network businesses become more inclined to plan in extensive DE solutions, this limits the need for new growth-related network expenditure in the upcoming regulatory period.

The lower rate of growth in peak demand due to DE implementation reduces the number and magnitude of constraints on the network, treating the problem of peak demand growth at the source.

Energy efficiency options in particular offer large potential to reduce costs to customers, in part because there are no network augmentation costs associated with alleviating energy constraints through demand reduction. Energy efficiency delivers both peak demand and volume reductions, and as such raise's prices, but lowers volumes by a greater amount and thus lowers bills. Emissions are also strongly reduced. (Langham et al, 2011)

4.2.4 Job Creation and GDP Effects

Independent analysis of BZE's Million Jobs Plan considered the economic impacts of a national scheme involving 1.4 million home retrofits over five years. The analysis found that the scheme would lift GDP by 0.19% and real after-tax wages by 0.31%. It would also lead to increases in the value of several industries, in particular:

- housing services – 1.2% increase
- residential building construction – 1.7% increase
- construction services (mainly tradespeople) – 0.6% increase.

A number of reports quantified benefits from energy efficiency upgrades across the whole economy, with impacts on economic activity employment, trade balance and energy prices (IEA, 2014, Langham et al, 2010, IERC, 2021, Briggs et al, 2020b, SEAI, 2015). The benefits include reduced government expenditure (on energy, health care, unemployment payments) and come though greater economic activity and increased tax revenues.

Significant employment increases have been identified in association with retrofits and renewable energy improvements, mostly in construction and installation but also in employment induced by the increase in activity. This can lead to challenges finding enough suitably experienced specialist workers. A particular benefit in Europe is that employment opportunities are spread across the region where retrofits occur, not centralised in major urban hubs. The benefit should be measured as the additional jobs that would not occur without the program.

The EnergieSprong program in the Netherlands worked with stakeholders to actively create market contexts and a viable path to scale that is attractive to both industry and consumers, providing a good example of successful market activation. Supply chain analysis is recommended to focus resources and understand barriers when designing and implementing a program, as different actors can influence decision making for different products or stages of work.

The IEA (2014) report on the multiple benefits of energy efficiency highlighted potential improvement across the whole economy "*with direct and indirect impacts on economic activity (measured through GDP), employment, trade balance and energy prices. In general, analysis of GDP changes due to large-scale energy efficiency policies show positive outcomes*

with economic growth ranging from 0.25% to 1.1% per year. How energy efficiency measures influence these areas (i.e., positively or negatively) depends on a country's economic structure and on the design and scale of the underlying policies."

Whether by reducing government expenditures on energy or by generating increased tax revenues through greater economic activity and/or increased spending on energy efficiency-related and other goods and services, energy efficiency improvements can have important impacts on the budgetary position of national and sub-sovereign entities. One of the greatest impacts overall is the reduced budget for unemployment payments when energy efficiency policies lead to job creation. Public budget impacts are thus closely linked to macroeconomic impacts.

A study in 2010 (Langham et al, 2010) which looked at the reduced infrastructure costs of energy efficiency in buildings in Australia found:

- Australia could eliminate all forecast growth in energy consumption and related carbon emissions from residential, commercial, and industrial buildings to 2020 through cost effective energy efficiency improvements.
- After allowing for the costs of implementation, these energy efficiency improvements could deliver a net economic benefit of $1 billion per year.

Webber et al (2015) estimated costs and savings of the UK Kirklees Warm Zone scheme to be costs of £21m and annual savings of £6.2m, with the direct benefits of retrofit expected to outweigh the costs in around 3.4 years. Allowing for a practical life span for insulation of 25 years, they calculated the direct savings of these measures as being in the range of £148–218 million over a 25-year period.

In a cost benefit analysis of the Warm Up NZ scheme, Grimes et al (2012) found overall net economic benefits of the program with their central estimate of programme benefits being almost five times resource costs attributable to the programme.

Choi et al (2018) evaluated the economic performance of South Korea's housing support program for new and renewable energy: a policy measure to supply new and renewable energy to homes, and, thus, the government subsidises a part of the installation costs for related facilities. The results show that solar PV achieved economic feasibility for both the Korean government and consumers, in 2014.

Net benefits to New Zealand from the Warm Up NZ program are calculated to be worth NZ$1.3 billion over the expected lifetime of measures delivered under the programme, with a benefit:cost ratio of more than 4:1. The majority (99 per cent) of the measured net benefit is from improved health resulting from warmer, drier conditions after insulation is installed (IEA 2021).

In Germany, energy efficiency in new buildings has doubled over 2002 - 2009, reducing calculated energy use from 120 kWh/(m2) to 60 kWh/(m2), while renovation has reduced it to approximately 80 kWh/(m2) in existing buildings. It is estimated that every €1 of subsidy has leveraged €9 in loans and private investment, with a leverage ratio of 1:10 for the KfW programmes and 1:12.5 for the Market Incentive Programme (MAP).

Evaluations of the precursor KfW-programs showed positive results, not only in terms of investment stimulated, energy savings, CO2 reduction and the impact on employment, but also regarding impact on public budgets. For every euro that went into the promotion of energy-efficient construction and refurbishment in 2010, public authorities collected four to five euros in revenue. KfW's promotional loans of EUR 8.9 billion initiated investments worth EUR 21.5 billion. This has primarily benefited regional tradespeople and construction contractors to whom the construction and converting contracts are usually awarded. As a result, these firms are said to have created or safeguarded some 340,000 jobs for one year.

Under the EnEv Energy Conservation Act in Germany, 1 million old homes were retrofitted, and 400,000 new highly efficient homes built (as this is not just a retrofit scheme). The Act promoted investment safeguarding roughly 51,000 jobs, particularly among SMEs. 894,000 jobs were created between 2006 and 2009, mainly in construction and the supply chain (SEAI, 2015). As of 2010, KfW had financed in total the rehabilitation to high energy efficiency standards of 9 million pre-1979 housing units.

In considering economy wide benefits, the IEA report (2014) finds the potential for job creation ranges from 8 to 27 job years per €1 million invested in energy efficiency measures.

The IERC 2021 report identified employment opportunities from a national retrofit program (IERC, 2021) stating that "*a renovation wave to bring all homes currently rated C or lower to a B-Rating would generate €35bn worth of work, the vast majority of which would be in the construction industry over the period from 2021 to 2030, equating to an average of approximately €3.8bn per annum over 9 years. This work would also be spread across the country, not centralised in the major urban hubs.*

According to a recent report by the Buildings Performance Institute of Europe (BPIE), for every €1m invested in retrofits, an EU average of 18 jobs are created. The job creation potential of retrofitting homes to a B-rating would be 32,832 total direct and induced jobs. Much of the spending in home retrofitting is in labour and services, including site labour, technical expertise, and provision of financial services. 33% of which would be directly employed in retrofitting, 52% indirectly employed in manufacturing, and 15% 'induced' employment i.e., adjacent neighbourhoods, coffee shops etc."

The Grimes et al (2012) cost benefit analysis of the Warm Up NZ program estimated the net employment impacts of the programme, i.e., additional jobs that would not exist in the absence of the programme, to be approximately 71-424 full time equivalents (FTEs) in the first year and to peak at 94-560 FTEs in 2001/12.

In examining the impacts on the industry supplying insulation and clean heating of the Warm Up NZ program, Denne and Bond Smith (2012) found (across 3 scenarios) 29–555 additional direct and indirect FTE jobs for insulating 51,600 houses, and 4-84 for installing clean heating in 12,658 houses.

For the EnergieSprong program in the Netherlands, various market benefits were achieved by implementing the program at scale (European Commission, 2017) Its major achievement in 2013 was to broker the Stroomversnelling (Rapids) deal, to retrofit 111,000 homes to Net Zero Energy (NZE). The Stroomversnelling network is made up of contractors, component suppliers, housing providers, local governments, financiers, DSOs, and other parties.

4.2.5 Recommendations

- Look for opportunities to capture the additional benefits, in particular health benefits of retrofits, in order to off-set the upfront costs of installation and / or encourage investment from groups seeking public good outcomes (governments, philanthropy, social impact investors)
- Explore partnerships with those organisations which could benefit from large scale energy efficiency retrofits – e.g., energy network operators, health providers etc.
- Establish a comprehensive monitoring program throughout roll out to identify benefits and challenges and enable communication of benefits and refinement of approaches
- Financing must be competitive with commercial loans
- Benefit should be measured, often in terms of improvement to building rating, or reduction in energy consumed, sometimes measured as household energy cost savings
- Good communication is essential for encouraging participation
- Good oversight in the form of home audits, advice to homeowners, in customer care and quality assurance of workmanship, to build trust in the program
- Government funding or backing, or philanthropic funding is prevalent, as is partnership with community groups, local government, and utilities

4.3 Household Impacts of Retrofits

The following sections describe the results of the upgrade improvements modelled on the two baseline typical homes (detached and terraced) in Victoria, New South Wales, and Western Australia.

- The detached home has a usable area of 202 m^2.
- The detached home includes a living area with dining and kitchen, four bedrooms, two bathrooms, a theatre room and garage.
- The terraced home has a usable area of 124 m^2, distributed across two floors.
- The terraced home includes a living and dining room, three bedrooms, one bathroom, two balconies and a carport.

Further details regarding the typical home descriptions are included in Section 4 of the accompanying report *Pathways to Scale: Thermal Modelling, energy efficiency and life cycle assessment of Australian homes.*

The retrofit items that have been modelled here aim at improving the thermal insulation and air tightness as well as the energy efficiency of the typical homes, as agreed by a team of experts included in the Project Partner Committee (PPC) and Industry Reference Group (IRG) for this project as well as recommendations drawn from the most updated version of the Building Code of Australia (ABCB, 2020). The term energy includes a combination of electricity and gas unless stated otherwise.

Building envelope characteristics (listed in Table 3) were extracted from the Australian Housing Data from CSIRO [accessed June 2021] and includes only class 1A existing buildings. A poorer quality home would reap bigger benefits from these improvements than are shown in the modelling for this project.

4.3.1 Detached Home Upgrade 1

Upgrade 1 includes the retrofit items that are listed in Table 3. Upgrade 1 aims at improving the thermal insulation and air tightness of the detached home through a series of interventions that target the envelope of the detached home, including roof, wall and floor insulation, pipe lagging, and draught proofing. Specifically, the upgrades are focussed on improving the U-values of roof, wall, and floor insulation from the baseline U-values of current detached homes in Victoria, New South Wales, and Western Australia listed in Table 3and Table 4. The improved parameters of U-Value were sourced from the Building Code of Australia (ABCB, 2020).

Upgrade 1 enables the occupants of this typical home to save between 18% and 31% of annual energy use, up to 6% of energy cost and 11% of emissions, shown below in Table 8. Results show improved annual energy use, energy cost and emissions as kWh as well as a percentage of improvement.

Table 8 Annual energy use, energy cost, and emissions results of the model with upgrade 1 implemented to the detached home

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	12,655	8,734	31	1,841	1,726	6	7,887	7,025	11
New South Wales	9,604	7,918	18	2,326	2,290	2	6,541	6,227	5
Western Australia	9,827	7,603	23	2,035	1,932	5	5,345	4,824	10

The annual energy use decreases more in Victoria than in New South Wales and Western Australia, where the climate is more moderate. The improved building envelope helps to minimise the energy use; however, the impact of lighting and appliances remains unchanged.

It is notable that although roof, wall and floor insulation drastically decrease energy use, energy cost and emissions are not as greatly improved. This is largely driven by the assumption in the modelling for the use of gas heating being typical in homes. As the cost and emissions of gas are lower than those of grid electricity, the decreased use of gas reflects only marginally on the annual energy cost and emissions. The impact of Upgrade 1 would be mostly felt as increased occupant comfort through an improvement to the thermal capacity of the building envelope but would also have a larger impact on a poorer quality home.

4.3.2 Detached Home Upgrades 2, 3 and 4

Upgrade 2, 3 and 4 (see details of the upgrades in Table 4, Table 5, and Table 6, respectively) were assumed to be implemented subsequentially to Upgrade 1.

- Upgrade 2 includes the addition of ceiling fans, reverse cycle aircon, and double glazing
- Upgrade 3 includes efficient appliances, LED lighting, and clothesline (feature that helps reduce the need for a dryer)
- Upgrade 4 includes the addition of solar PV and hot water heat pump

Table 9 repeats the results obtained from Upgrade 1 and summarises the results of the three subsequent upgrades included in the detached home. Also including the improvement in percentage. The improved percentage values of Upgrades 1, 2, 3, and 4 are calculated against the baseline.

Table 9 Annual energy use, energy cost, and emissions results of the baseline and upgrades for the detached home

	Victoria		New South Wales		Western Australia	
ANNUAL ENERGY USE (ELECTRICITY AND GAS) (kWh)						
Baseline		12,655		9,604		9,827
Upgrade 1	8,734	31%	7,918	18%	7,603	23%
Upgrade 1 + Upgrade 2	7,298	42%	7,815	19%	7,215	27%
Upgrade 1 + Upgrade 3	5,210	59%	3,476	64%	3,577	64%
Upgrade 1 + Upgrade 4	2,169	83%	669	93%	710	93%
All upgrades	103	99%	0	100%	4	100%
ANNUAL ENERGY COST (ELECTRICITY AND GAS) (AU$)						
Baseline		1,841		2,326		2,035
Upgrade 1	1,726	6%	2,290	2%	1,932	5%
Upgrade 1 + Upgrade 2	1,811	2%	2,341	0%	2,006	1%
Upgrade 1 + Upgrade 3	583	68%	840	64%	620	70%
Upgrade 1 + Upgrade 4	538	71%	200	91%	197	90%
All upgrades	25	99%	0	100%	1	100%
EMISSIONS (ELECTRICITY AND GAS) (kg CO_2 eq)						
Baseline		7,887		6,541		5,345
Upgrade 1	7,025	11%	6,227	5%	4,824	10%
Upgrade 1 + Upgrade 2	7,151	9%	6,330	3%	4,905	8%
Upgrade 1 + Upgrade 3	2,636	67%	2,365	64%	1,717	68%
Upgrade 1 + Upgrade 4	2,126	73%	542	92%	483	91%
All upgrades	101	99%	0	100%	3	100%

The combination of Upgrade 1 and Upgrade 2 retrofits implemented to the detached home enable the occupants to save between 19% and 42% of annual energy use and up to 9% of emissions, while the annual energy cost remains almost constant (Table 10.)

Table 10 Annual energy use, energy cost, and emissions results for the detached home when upgrades 1 and 2 are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	12,655	7,298	42	1,841	1,811	2	7,887	7,151	9
New South Wales	9,604	7,815	19	2,326	2,341	0	6,541	6,330	3
Western Australia	9,827	7,215	37	2,035	2,006	1	5,345	4,905	8

The combination of Upgrade 1 and Upgrade 3 implemented to the detached home enable the occupants to save between 59% and 64% of annual energy use, between 64% and 70% annual energy cost and between 64% and 68% of emissions (Table 11).

Table 11 Annual energy use, energy cost, and emissions results for the detached home when upgrades 1 and 3 are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	12,655	5,210	59	1,841	583	68	7,887	2,636	67
New South Wales	9,604	3,476	64	2,326	840	64	6,541	2,365	64
Western Australia	9,827	3,577	64	2,035	620	70	5,345	1,717	68

The combination of Upgrade 1 and Upgrade 4 implemented to the detached home enable the occupants to save 83% of annual energy use in Melbourne and 93% in Perth and Sydney, cities which usually enjoy more hours of sun throughout the year. Also, these interventions enable the occupants to save between 71% and 91% in terms of energy cost, and between 73% and 92 % in terms of emissions (Table 10). It is important to consider that the energy cost is calculated using the purchase cost of energy, not the selling price or feed in tariff (FIT) of solar energy to the grid. The energy (and related costs) generated by the solar panels is cut in the results of Upgrade 4. The term energy includes only electricity for these results.

Table 12 Annual energy use, energy cost, and emissions results for the detached home when upgrades 1 and 4 are implemented

Location	Baseline annual energy	Improved annual energy use (kWh)	%	Baseline annual energy	Improved annual energy	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%

	use (kWh)			cost (AU$)	cost (AU$)				
Victoria	12,655	2,169	83	1,841	538	71	7,887	2,126	73
New South Wales	9,604	669	93	2,326	200	91	6,541	542	92
Western Australia	9,827	710	93	2,035	197	90	5,345	483	91

4.3.3 Detached Home – All Proposed Upgrades

A combination of all four upgrades yields the maximum thermal and energy efficiency in all modelled locations (Table 13). Specifically, applying thermal insulation, improving the efficiency of appliances and lighting, introducing solar panels enable occupants to decrease the energy needed to maintain comfort at home with a minimal impact on energy use, cost and related greenhouse gas emissions. In all the analysed weather conditions, these upgrades allow to save nearly 100% of annual energy use, annual energy cost, and annual greenhouse gas emissions.

Table 13 Annual energy use, energy cost, and emissions results for the detached home when all proposed upgrades are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	12,655	103	99	1,841	25	99	7,887	101	99
New South Wales	9,604	0	100	2,326	0	100	6,541	0	100
Western Australia	9,827	4	100	2,035	1	100	5,345	3	100

4.3.4 Terraced Home – Upgrade 1

This improved design includes the retrofit items in Upgrade 1 that are listed in Section 3.2, Table 3.

- Upgrade 1 includes roof, wall, and floor insulation, pipe lagging, improved airtightness

The improved design of the terraced home allows the occupants to save between 17% and 24% of annual energy use, up to 6% of energy cost and 10% of emissions (Table 14).

Table 14 Annual energy use, energy cost, and emissions results with upgrade 1 implemented to the terrace home

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	9,930	7,506	24	1,227	1,151	16	5,431	4,876	10
New South Wales	6,491	5,391	17	1,176	1,137	3	4,849	4,586	5
Western Australia	6,883	5,473	20	1,195	1,135	5	4,960	4,594	7

Not surprisingly, the annual energy use decreases more in Victoria than in New South Wales and Western Australia, where the climate is more moderate. The improved envelope helps to minimise the energy use; however, the impact of lighting and equipment remains unchanged.

The results highlighted in Table 14, however, allow for an interesting observation. In the table, we notice that the walls, floors, and roof insulation drastically decrease energy use, but energy cost and emissions remain less improved. Energy use decreases while cost and emissions remain at a less improved level because improved insulation effectively maintains the spaces warmth, thus decreasing the need for heating. (In the cases analysed in this report, we assumed the use of gas heating in the baseline homes.) However, the same amount of electricity will be needed for cooling, appliances, and lighting. Therefore, as the cost and emissions of gas are lower than those of electricity, the decreased use of gas reflect only marginally in the annual energy cost and emissions.

Regardless of the limited effect of insulation to cost and emissions, it is essential to underline that insulation is critical to improving healthier and more comfortable homes. Indeed, insulation can lead to a significantly warmer and drier indoor environment, resulting in decreased mould formation and related respiratory symptoms alongside many other diseases (Howden-Chapman et al., 2012).

Alongside the results obtained when modelling the following upgrades, this analysis proves that insulation and electrification are needed and should be implemented together with improved home appliances and lighting as well as renewable electricity generation to achieve a maximum impact.

4.3.5 Terraced Home - Upgrades 2, 3 and 4

Upgrades 2, 3 and 4 were assumed to be implemented subsequentially to Upgrade 1.

- Upgrade 2 includes ceiling fans, reverse cycle aircon, and double glazing
- Upgrade 3 includes efficient appliances, LED lighting, and clothesline (feature that helps reduce the need for a dryer)
- Upgrade 4 includes solar PV and hot water heat pump

Table 15 repeats the results obtained in the baseline and improved designs of the terrace home and summarises the results of the three upgrades included in the terrace home. Also including the improvement in percentage. The improved percentage values of Upgrades 1, 2, 3, and 4 are calculated against the baseline.

Table 15 Annual energy use, energy cost, and emissions results of the baseline and upgrades of the terrace home

	Victoria		New South Wales		Western Australia	
ANNUAL ENERGY USE (ELECTRICITY AND GAS) (kWh)						
Baseline		9,930		6,491		6,883
Upgrade 1	7,506	24%	5,391	17%	5,473	20%
Upgrade 1 + Upgrade 2	5,054	49%	4,775	26%	4,791	30%
Upgrade 1 + Upgrade 3	5,250	47%	2,848	56%	2,994	57%
Upgrade 1 + Upgrade 4	3,231	67%	147	98%	153	98%
All upgrades	88	99%	0	100%	0	100%
ANNUAL ENERGY COST (ELECTRICITY AND GAS) (AU$)						
Baseline		1,227		1,176		1,195
Upgrade 1	1,151	6%	1,137	3%	1,135	5%
Upgrade 1 + Upgrade 2	1,255	0%	1,186	0%	1,190	0%
Upgrade 1 + Upgrade 3	427	65%	415	65%	422	65%
Upgrade 1 + Upgrade 4	802	35%	36	97%	38	97%
All upgrades	21	98%	0	100%	0	100%
EMISSIONS (ELECTRICITY AND GAS) (kg CO_2 eq)						
Baseline		5,431		4,849		4,960
Upgrade 1	4,876	10%	4,586	5%	4,594	7%
Upgrade 1 + Upgrade 2	4,953	9%	4,679	4%	4,697	5%
Upgrade 1 + Upgrade 3	2,102	61%	1,777	63%	1,816	63%
Upgrade 1 + Upgrade 4	3,167	42%	144	97%	150	97%
All upgrades	86	98%	0	100%	0	100%

The combination of Upgrade 1 and Upgrade 2 retrofits applied to the terraced home enable the occupants to save between 26% and 49% of annual energy use and up to 9%

of emissions, while the annual energy cost remains almost constant due to the reduced use of gas and increased use of electricity (Table 16).

Table 16 Annual energy use, energy cost, and emissions results for the detached home when upgrades 1 and 2 are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	9,930	5,054	49	1,227	1,255	0	5,431	4,953	9
New South Wales	6,491	4,775	26	1,176	1,186	0	4,849	4,679	4
Western Australia	6,883	4,791	30	1,195	1,190	0	4,960	4,697	5

The combination of Upgrade 1 and Upgrade 3 retrofits applied to the terraced home enable the occupants to save between 47% and 57% of annual energy use, 65% of annual energy cost and around 63% of emissions (Table 17).

Table 17 Annual energy use, energy cost, and emissions results for the detached home when upgrades 1 and 3 are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	9,930	5,250	47	1,227	427	65	5,431	2,102	61
New South Wales	6,491	2,848	56	1,176	415	65	4,849	1,777	63
Western Australia	6,883	2,994	57	1,195	422	65	4,960	1,816	63

The combination of Upgrade 1 and Upgrade 4 retrofits applied to the terraced home enable the occupants to save 67% of annual energy use in Melbourne. However, the saving of energy cost and emissions in Melbourne is only 35% and 42%, respectively. This is because of the predominantly overcast weather in combination with harsher temperatures, which require a more abundant use of mechanical heating whilst the home is not powered by solar energy.

Conversely, in Perth and Sydney, cities which usually enjoy more hours of sun throughout the year the saving is more substantial. Indeed, there, these interventions enable occupants to save 98% of energy use and 97% both in terms of energy cost and emissions (Table 18). It is important to consider that the energy cost is calculated using the purchase cost of energy, not the selling price or Feed in Tariff (FIT) of solar energy to the grid. The energy (and related costs) generated by the solar panels is cut in the results of Upgrade 4. The term energy includes only electricity in these results.

Table 18 Annual energy use, energy cost, and emissions results for the detached home when upgrades 1 and 4 are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	9,930	3,231	67	1,227	802	35	5,431	3,167	42
New South Wales	6,491	147	98	1,176	36	97	4,849	144	97
Western Australia	6,883	153	98	1,195	38	97	4,960	150	97

4.3.6 Terraced Home – All Proposed Upgrades

A combination of the four upgrades yields the maximum thermal and energy efficiency in all modelled locations (Table 19). In all the analysed weather conditions, these upgrades provide savings of nearly 100% of annual energy use, annual energy cost, and annual greenhouse gas emissions.

Table 19 Annual energy use, energy cost, and emissions results for the detached home when all proposed upgrades are implemented

Location	Baseline annual energy use (kWh)	Improved annual energy use (kWh)	%	Baseline annual energy cost (AU$)	Improved annual energy cost (AU$)	%	Baseline emissions (kg CO_2 eq)	Improved emissions (kg CO_2 eq)	%
Victoria	9,930	88	99	1,227	21	98	5,431	86	98
New South Wales	6,491	0	100	1,176	0	100	4,849	0	100
Western Australia	6,883	0	100	1,195	0	100	4,960	0	100

4.3.7 Recommendations

The results obtained in the modelling draw five main upgrade recommendations to enhance common housing types in Victoria, New South Wales, and Western Australia. It is crucial to note that these recommendations are only marginally depending on the dwelling's type, i.e., detached home and terraced home. These two dwelling types behave similarly when the upgrades are implemented.

- It is recommended to apply, as a foremost intervention, Upgrade 1 (roof, wall, and floor insulation, pipe lagging, and airtightness) to both dwelling types and in all locations. Upgrade 1 alone saves energy use between 18% (in New South Wales, terrace home) and 31% (in Victoria, detached home).
- Target poor quality homes to benefit from larger improvements in energy use and cost savings, as well as improved occupant comfort.
- In New South Wales and Western Australia, a substantial saving in energy use, cost, and emissions is obtained with insulation and solar PV (Upgrades 1 and 4).
- In Victoria, the overall benefit of implementing solar PV is less than that in New South Wales and Western Australia. That is because the Victorian climate is typically more overcast and, on average, colder. Therefore, to obtain substantial savings in Victoria, it is recommended to integrate solar panels with insulation and high-efficiency home appliances and lighting (Upgrades 1, 3, and 4).
- In New South Wales and Western Australia, all proposed upgrades should be implemented to obtain a near 100% saving in energy use.

- Insulation should be coupled with electrification (avoiding gas) to contextually decrease energy use and related costs, as suggested in Upgrades 3 and 4.

Future analysis should include a more nuanced analysis of heating energy sources across multiple Australian states or climates, as well as including electric vehicle (EV) charging plus solar PV and storage impacts on the home, and effects on the grid.

Future analysis should include more dynamic modelling of the optimal package of retrofits for achieving cost benefits at a household scale.

4.4 Retrofit Cost Estimate

The following table represents a cost analysis of the items included in the retrofit upgrades for the detached home and the terrace home. It also includes some recommended retrofit items that were not included in the modelling due to complexity and modelling limitations. It is important to emphasise that this cost analysis represents a preliminary evaluation only. For the purpose of this analysis, item costs are considered the same across Victoria, New South Wales, and Western Australia.

Table 20 Cost of the items included in the retrofit upgrades of the typical detached home

Upgrade	Item	Cost per unit	Amount	Total cost ($)
Home assessment	Remote/home walk through/hybrid. Trained and employed home energy assessors will be required	$30 - $400 per home	1	30-400
Upgrade 1	Roof insulation	$24 installed per m^2	296 m^2	7,104
	Wall insulation	$23 installed per m^2	143 m^2	3,289
	Floor insulation	$24 installed per m^2	205 m^2	4,920
	Pipe lagging	$30 (plus labour)	5 m	150
	Draught sealing	$1,020	1	1,020
	Window treatments (not modelled)	$700 per window	7	4,900
	Total			**21,383**
Upgrade 2	Ceiling fans	$500	4	2,000
	Reverse cycle aircon	$2000 per fixture, installed	1	2,000
	Pool pump upgrade (not modelled)	$40	1	40
	Double glazing	$500 per window	7	3,500
	Total			**7,540**

Upgrade 3	Efficient appliances	Dishwasher - $2,000	1	6,900
		Washing machine - $1,500		
		Dryer - $1,800		
		Fridge - $1,400		
	LED lighting	$50 per light	15	750
	Clothesline	$200 per fixture	1	200
	Shower heads (not modelled)	$200 (4 stars)	2	400
	Total			**8,250**
Upgrade 4	Solar panels (considering a 5kW system)	$5,000	1	5,000
	Smart home energy management system (mandatory with solar PV) (not modelled)	$129	1	129
	Hot water heat pump	$3,100 installed	1	3,100
	Home battery (Virtual Power Plant (VPP) capable) (not modelled)	$7,500 installed	1	7,500
	Induction cooktop (not modelled)	$2,900 installed	1	2,900
	EV home charger/infrastructure (not modelled)	$2,200	1	2,200
	Total			**21,229**

*Cost estimates were taken from a variety of resources including commercial and retail examples as well as the following articles, https://www.solarchoice.net.au/blog/solar-power-system-prices/ ; https://enviroshop.com.au/pages/home-insulation ; https://www.ecoglaze.com.au/retrofit-double-glazing-pricing/ https://www.aef.com.au/for-home/insulation/insulation-guide/ https://grattan.edu.au/wp-content/uploads/2020/11/Flame-out-Grattan-report.pdf

These cost estimates represent the upper range of cost for a full home retrofit, including appliances. This is because, many homes will not require, nor will the homeowners perhaps want, the full list of retrofit items proposed in the table above. There may also be state based subsidies and other schemes, as well as scheme discounts that can be applied to reduce costs for the homeowner.

4.4.1 Recommendations

- The costs of retrofit can be high, and the short-term financial benefits can be unclear and uncertain
- Energy cost savings are not likely to be a sufficient motivation for homeowners

- To reduce homeowner costs, a community focussed large-scale home retrofit scheme would aim to enable labour and product buying power through larger contracts and increased quantities of material thus finding efficiencies of scale and bulk discounts in supplying and installing the retrofit items
- The ability to perform true cost benefit analysis will be enabled through case-study home retrofits of different housing types in different states/climates across Australia
- The bespoke nature of each retrofit and existing Australian homes means that a cost benefit analysis for different housing types will be a beneficial way to measure and monitor the benefit of the large-scale home retrofit scheme, as it progresses

4.5 Retrofit Aims and Priorities

Through the IRG workshop discussion and interviews the aims and priorities of the large-scale home retrofit scheme were explored. This was done through a Mentimeter survey, as well as through facilitated discussion via Miro.

4.5.1 Retrofit Aims

The IRG highlighted the importance of considering and setting clear goals for the retrofit scheme as it would guide the selection of retrofit items and aid communication about the scheme. "*A lot of this depends on the goals of the program as well, is it increasing the speed and scale of retrofits within a period of time or widespread take up?*"

Figure 3 shows that comfort and emissions reductions stood out among the respondents from the IRG as priority drivers for a large-scale home retrofit scheme. Cost savings or lower energy bills were also a consideration although not found to be as high a priority due to the greater impact and benefits created by prioritising the improvement of health and comfort for homeowners/occupants and the increased reduction of carbon emissions. It was noted that "*National Construction Code (NCC) is driving home comfort as a priority driver over energy cost off set. Thermal comfort for achieving suitable ratings cannot be compromised by fitting Photo-Voltaics.*"

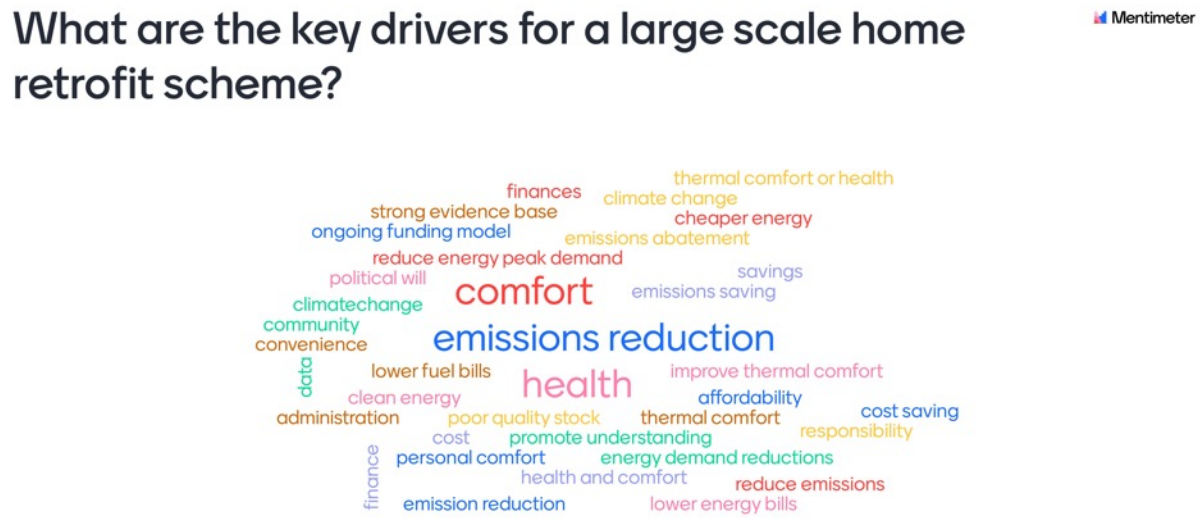


Figure 3 Key drivers for a large-scale home retrofit scheme identified by IRG

4.5.2 Retrofit Priorities

The importance of assessment and alignment with NatHERS

IRG members emphasised that whole of home assessments play a vital role in the process of retrofitting existing homes: *"A very good enthusiastic assessor is required",* that the scheme should *"Use of robust assessment tool to determine which upgrades to perform"* and that the scheme should *"undertake assessments early in discussions".*

Several members of the IRG noted the current activity around the National Scorecard and the extension to NatHERS for existing homes and recommended aligning with this work: *"Strongly recommend using the NatHERS existing homes program for assessors - and get a rating. It will eventually link to disclosure and the broader financial sector".* It was noted that *"the Scorecard can be used to model the impact of upgrades".* In addition, assessments would provide data (that is currently lacking in most states) to better understand the quality of existing housing stock in Australia and is a basis to provide sound technical guidance to the homeowner on what retrofit to undertake.

Beyond the benefits of the assessment, it was also noted that the assessors perform a key role in supporting homeowners to understand retrofits. *"Well trained assessors will be able to explain the unique situation in a house, and the dynamic between appliances and house structure / design."*

The priority of retrofit items

Within the IRG workshops participants were asked, via a survey about priority retrofit items that they would like to see form part of a large-scale home retrofit scheme. They strongly felt that insulation and draught proofing should be high priority items due to their effectiveness when installed correctly. This is supported in the literature review. However, it is also worth noting that to enable a healthy and thermally comfortable

home, ventilation must be considered especially where airflow has been decreased to prevent the growth of mould, and where gas appliances are still present, not create an uninhabitable space. This is recommended as part of a further research question to consider how to not decrease the homes indoor air quality (IAQ) through increased building air tightness.

Regardless of the limited effect of insulation on cost and emissions, in particular where heating is done with gas, it is essential to underline that insulation is critical to improving healthier and more comfortable homes. Indeed, insulation can lead to a significantly warmer and drier indoor environment, resulting in decreased mould formation and related respiratory symptoms alongside many other diseases (Howden-Chapman et al., 2012).

In addition, a cost benefit analysis of the Warm Up New Zealand: Heat Smart Programme conducted by Grimes et al (2012) gave the following recommendations for future programs:

- *Prioritise the insulation component of the programme relative to the clean heating component of the programme.*
- *Target clean heating to houses that use reticulated gas rather than electricity for heating prior to treatment.*
- *Target insulation to houses in cooler rather than warmer areas.*
- *Target insulation to low- and middle-income earners and other at-risk groups in terms of illness.*

The Irish IERC report (IERC, 2021) on co-benefits of retrofits highlights the cost of heat pumps as a retrofit. *The cost of running a heat pump in an energy inefficient home could be expensive. Therefore, the installation of a heat pump should be done in conjunction with other measures such as increasing levels of insulation and draughtproofing for example.*

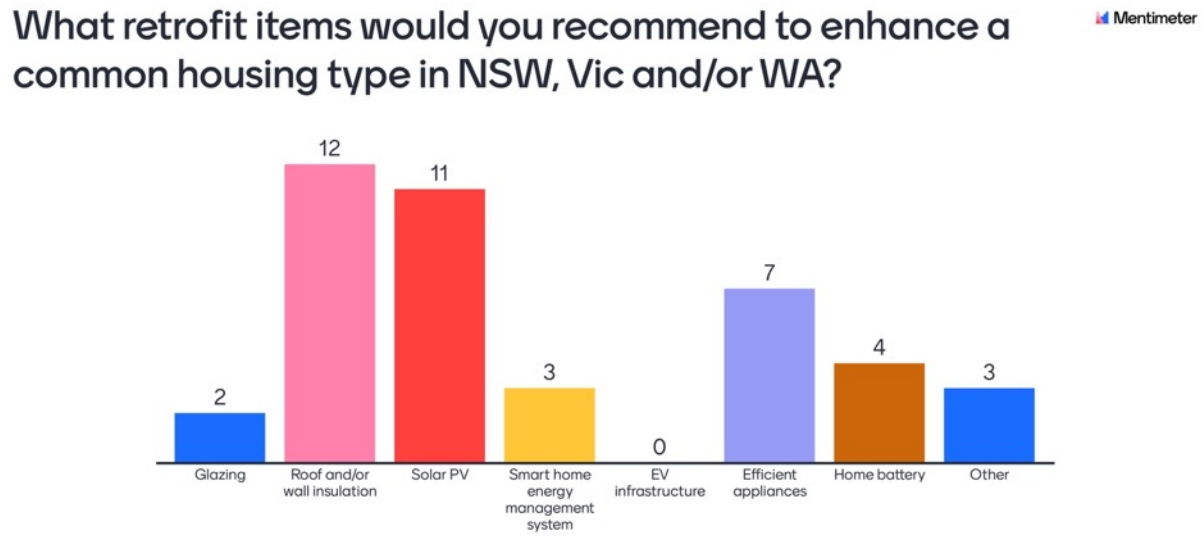


Figure 4 Recommended retrofit items as voted by the IRG

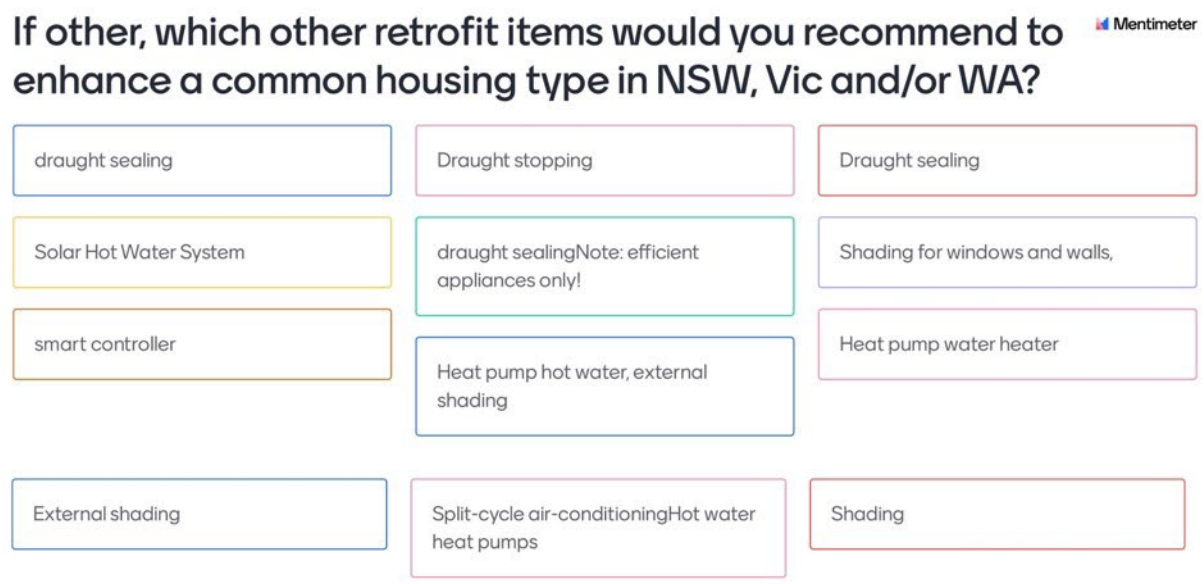


Figure 5 Detail of 'other' retrofit items as voted by IRG

4.5.3 Quality Assurance

IRG participants and the literature review were very clear, *"Poor compliance could derail the whole scheme."*

Quality assurance and safety is critical to the success of a large-scale home retrofit scheme. The quality of retrofits and the safety of workers will depend on the use of trained and accredited workers as well as certified materials and equipment only. *"Industry needs a rigorous training and certification scheme for all retrofit providers."* This provides an opportunity to enable the clean energy workforce of the future through industry focussed training and accreditation.

"The customer needs to be able to trust the program provider and parties involved." Ensuring and maintaining the quality of retrofits will grow trust among homeowners and would enable 'word of mouth' recommendations amongst communities. Enabling a quality assurance process for the scheme, homeowner and contractor ensures standards remain high and consistent across the scheme. "*Audit 10% of upgrades to ensure standard of work delivered and require a desk top audit from the contractor on completion of every job, including photos."*

4.5.4 Scheme Design

Pilot schemes will be required to test and tweak the scheme design and the delivery model where required. The pilot must be able to "*trial and understand the complexities of the upgrade work being completed and enable something within the process to support those high priority retrofit items so that minor issues don't make them too hard*" for a large-scale home retrofit scheme to deliver.

"Homeowners want a streamlined process from assessment to finance and installation, and quality assurance included." Understanding the needs and wants of the target market is

crucial to delivering a model that engages with homeowners who require technical and retrofit process guidance, there also needs to be a clear demonstration of value to the homeowner. The scheme should provide *"A model that enables a central party to educate homeowners and listens to their needs is valuable."*

Knowledge and social networks can play an important role in shaping the ways in which energy-related renovations are carried out, or not. Interventions can raise homeowners' awareness of their energy use and enable them to be more informed consumers. Homeowners being involved in making decisions based on technical input, is the best framing of energy retrofits. Using a values-based approach to understand customer motivations is an effective way to overcome intervention barriers.

The scheme must enable a customer journey that removes the current 'hassle factor' of an energy efficiency home retrofit. *"The process of a retrofit is currently very hard to navigate, there is nobody available to guide the homeowner through the process. We need to be able to provide a specification to the homeowner and then how they go ahead with the retrofit, at least."*

4.5.5 Recommendations:

- A successful scheme will need to have clear and demonstrable goals and target market that have been adapted from other programs learnings
- The scheme should aim toward achieving improved thermal comfort and energy efficiency with a path toward electrification
- The scheme should aim to improve the NatHERs rating of the home
- Whole of home assessment will be critical and will require independent trained assessors doing walk through assessments and/or high-quality desk-top assessment processes
- Good oversight in the form of home audits, advice to homeowners, in customer care and quality assurance of workmanship, to build trust in the program
- Develop a list of retrofits that prioritise the most impactful retrofits and can be adapted to the requirements of individual homes and homeowners
- Develop a robust auditing process for ensuring quality of retrofits and estimating and measuring their impacts
- For owners to have confidence in the scheme it will be important that quality and performance are promoted, developed, maintained, and recognised over time.
- The scheme must use industry trained and accredited installers and assessors only – support for industry training and accreditation programs will be required
- Use of government or industry certified materials and equipment only
- The scheme and its providers must provide a streamlined process that builds trust and delivers guidance, value, and benefits to the homeowner

4.6 Barriers, Opportunities and Market Setting Requirements

"Energy efficiency isn't sexy".

4.6.1 What We Learnt from International Examples

The successful Dutch energy transition program Energiesprong implemented in 2014 highlights the market conditions as a key barrier for successful implementation of an energy efficiency scheme. Issues identified include:

- *Market conditions are not set right for the innovation process in the building sector to take off*
- *Regulators and market players have not managed to introduce energy efficiency building upgrades that are attractive to the public or for investors*
- *Buildings are seldom refurbished more often than once every 30 years. Energy efficiency in buildings cannot be optimised through piecemeal insulation measures and gradual improvements. These measures thus lead to an opportunity lockout*
- *Solutions have not been integrated and holistic to deliver net zero energy refurbishments (the performance level required for the majority of houses to meet the CO2 targets) set out*

- *Solutions can only be delivered if they are attractive to the consumer. In order to ensure that the resulting energy costs savings cover the costs for these refurbishments, prices have to go down dramatically. In order to make these refurbishments attractive, delivery times have to go down to days instead of months. In order to turn energy costs into a revenue stream to recover the costs of investment, in many cases a financier is needed to put up the necessary upfront capital. To convince the financier that this investment is worthwhile and secure, we need a long-year energy performance warranty on the refurbished house.* (Platform 31,2017)

Webber et al (2015) highlight a range of barriers to implementing energy efficiency that include *lack of awareness and concern, limited access to reliable information from trusted sources, fears about risk, disruption and other 'transaction costs', concerns about upfront costs and inadequate access to suitably priced finance, a lack of confidence in suppliers and technologies and the presence of split incentives between landlords and tenants (IEA, 2013b; IPCC, 2014; Long et al., 2014; Owen et al., 2014).*

The 2010 Langham et al study looked at the reduced infrastructure costs from energy efficiency in buildings. It outlined some key barriers to energy efficiency, naming institutional obstructions as a key barrier, as well as:

- Imperfect information – a lack of timely and relevant information, such as lack of knowledge of energy efficiency measures, data on their performance and subsequent savings.
- Split incentives – where the outcome of an economically desirable outcome is obstructed because it is not in the interest of all parties involved.
- Payback gap – customers generally require a shorter payback period for demand side investment relative to the supply industry.
- Inefficient pricing – two aspects of inefficient pricing exist that represent barriers to EE: unpriced 'external costs' (e.g., the costs associated with greenhouse gases) and inefficient price structures.
- Cultural values – includes 'cultural lag' where prevailing attitudes and values are no longer appropriate to the current circumstances; and 'tragedy of the commons', where individual attitudes lead to behaviour of individuals which conflict with the collective interests of society.

It provides recommendations for energy efficiency policy measures for the National Electricity Market (NEM) using the following diagram Figure 6.

It can be seen in Figure 6 that to overcome the existing barriers to energy efficiency within the NEM and significantly increase uptake:

- objectives must be identified, which will "guide the selection of instruments"
- instruments must be implemented, which will "drive energy savings action"
- action (EE measures/interventions) must be taken
- performance must be evaluated.

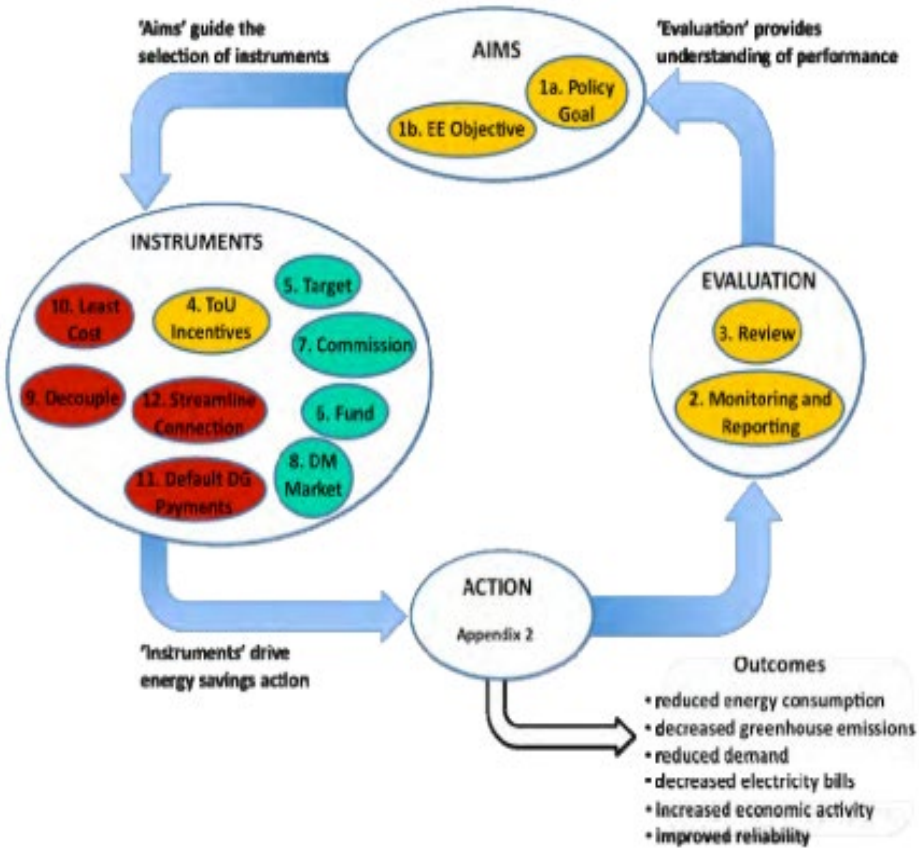


Figure 6 Recommendations for energy efficiency policy measures (Langham et al, 2010)

The IERC report (IERC, 2021) on co-benefits of retrofits highlights funding and participation should come from both public and private realms. It also outlines key phases for capturing stakeholder requirements and benefits:

- *pre-rollout preparations when government departments and organisations put together a plan of action for rolling out a nationwide policy of retrofitting. This plan should include collaboration with other government departments, and stakeholder groups to ready the retrofit and energy sectors with the personnel, products and services that will be required to carry out the retrofits. This phase should also include a comprehensive nationwide stakeholder engagement process, to ensure the needs of all beneficiaries are considered, especially the homeowners and occupants, and those in fuel poverty.*
- *retrofit renovation wave would begin once all these preparations have been made and the roll-out is launched. This is the execution phase, when all of the actual retrofitting takes place on-site through a coordinated delivery approach to achieve the required number and level of retrofits in a timely manner, while maintaining a high level of stakeholder engagement throughout*
- *post occupancy evaluation phase. This phase will examine the results of the works carried out, to evaluate if they meet basic project management criteria; finished on*

time, on budget and according to the scope, as well as addressing the energy performance gap. Where works have not been a success, this phase will provide valuable lessons learned as to why the retrofit did not meet expectations, and to ensure future works rectify systemic failings. This phase will also enable assessments of macroeconomic gains, public health and wellbeing gains, national energy, and carbon emissions savings, and so on. This will be the most important phase to determine whether or not the benefits of a retrofit renovation have been realised.

Recommendations for adopting or modifying EnergieSprong program in the Netherlands for implementation in New York State include the following:

- *Consider more work in the areas of lighting, appliances, and energy-efficient resident behaviour.*
- *Set clear goals for energy reduction that are deep, consistent, and defensible. The success of the Dutch program appears to be at least partially due to the clarity and depth of their net zero goal.*
- *Standardise the scope of work (to reap the benefits of economies of scale, messaging, and more) while allowing for some flexibility in implementation. Again, the Dutch program appears to have benefited from a combination of flexibility, in areas such as building appearance and "add-on features," while delivering a standard set of energy improvements.*
- *Seek to unleash entrepreneurial spirit, excitement, and "can-do" attitude, as the Dutch have done. (Shapiro, 2018)*

4.6.2 Enablers and Benefits

Webber et al (2015) highlights the importance of considering the background trends in domestic energy use that occur during delivery of retrofit programs. They estimated that background trends generated a 12.3% drop in domestic space and water heating energy use within the study area during the 2007– 2011 period, which can be attributed to a range of factors, including the gradual upgrading of the housing stock, the steady replacement of older and less efficient space heating technologies, the impacts of various government energy efficiency policies and behavioural responses to increases in energy prices and changing economic conditions (including those that drive increases in fuel poverty). In comparison, the KWZ scheme, that offered free insulation to homeowners and that led to 29% of households having insulation installed, led to a 4.2% drop in domestic energy use across all households in the area. At the area-wide level, the influence of background trends therefore seems to be much greater than the influence of even a large-scale retrofit scheme. However, at the householder level the KWZ delivered a saving of 14.8%, which is comparable to 5 years of average background energy reductions. If it were possible to achieve higher participation levels, this demonstrates that retrofit schemes have the potential to exceed current trends in reductions in domestic space heating energy use.

The European Commission (2017) analysis of Energiesprong described conditions needed for success.

Achieving scale is essential to the long-term success of Energiesprong and exporting the business model to international markets is an important step to achieving that aim. The larger the market, the bigger the component supply chain. This is important to drive the development of new NZE components, improve quality and drive down costs to the benefit of all.

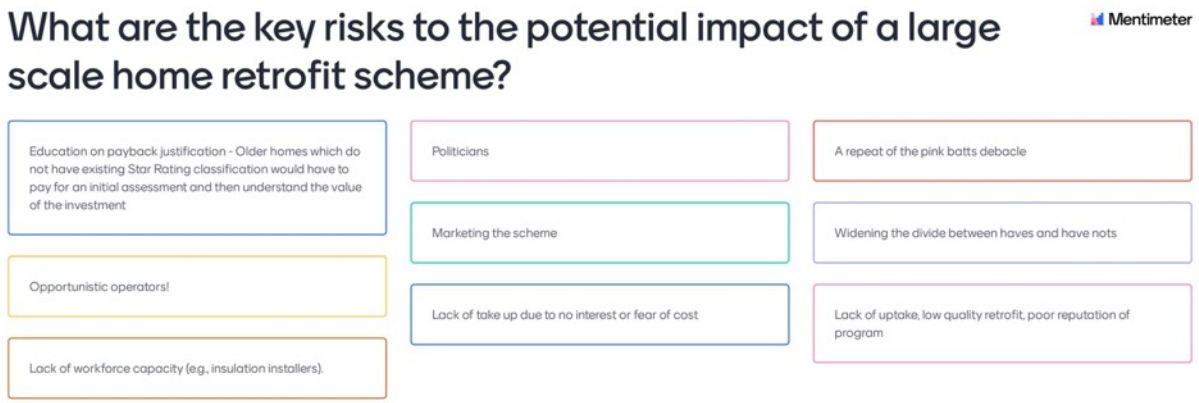
The Energiesprong model works because it delivers results whilst also being an attractive offer for contractors, housing providers and residents. Unlike existing retrofit models, Energiesprong uses an energy performance contract to guarantee the long-term energy saving performance of retrofits for a minimum of 30 years. This provides the property owner with financial security, giving assurance that the property will perform at the expected level. For the solution provider(s), there is a confirmed order pipeline with a minimum volume that justifies investment in innovation and solution development.

To make the scheme attractive and financially viable at scale the targeted cost per unit for a terraced house is EUR 40,000. To date, economy of scale, 3D technologies and prefabricated materials have enabled Energiesprong partnerships to lower the unit cost by about half of the pilot cost to about EUR 65,00017.

Unlike energy retrofit schemes, the Irish Home Renovation Incentive (HRI) does not necessarily lead to notable improvements in efficiency or renewable energy output, as it is typically used to build extensions, and for general repair and maintenance works. To invest more in energy retrofitting, it will be important that quality and performance are promoted, developed, maintained, and recognised over time, so that owners can have confidence to invest more in the energy performance of what is usually their most valuable asset, without risks of technical failure. (IERC, 2021)

4.6.3 What We Heard from the IRG

Building on the initial understandings from the desktop research, the IRG was consulted during the first workshop, to provide additional Australia-specific insight. We spoke about what barriers exist for a large-scale home retrofit scheme in the current market. Participants shared their expert knowledge and present/past experiences with similar programs in Australia and overseas, some of which are shown in Figure 7 as well as throughout this section and Appendix D.



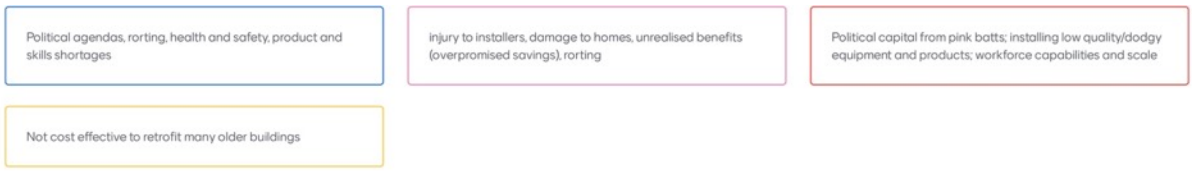


Figure 7 Key risks to a large-scale home retrofit scheme identified by IRG members

4.6.4 What is Required for Australian industry Enablement?

Evaluations of the precursor KfW-programs showed positive results, not only in terms of investment stimulated, energy savings, CO2 reduction and the impact on employment, but also regarding impact on public budgets. For every euro that went into the promotion of energy-efficient construction and refurbishment in 2010, public authorities collected four to five euros in revenue. KfW's promotional loans of EUR 8.9 billion initiated investments worth EUR 21.5 billion. This has primarily benefited regional tradespeople and construction contractors to whom the construction and converting contracts are usually awarded. As a result, these firms are said to have created or safeguarded some 340,000 job years of employment.

Ensuring the scheme can support the creation and maintenance of local jobs will be paramount to enabling the Australian industry. The large-scale home retrofit scheme could provide opportunity to grow local jobs through community scale retrofits, especially in regional areas. It is *"worth thinking through how to ensure the delivery model does not exclude local delivery partners and agencies at the expense of efficiency and scale".* By enabling the required training for new jobs and accreditation to local existing providers or installers the scheme could strive to support jobs growth through home retrofits.

Sufficient training is required to ensure that industry professionals are capable and willing to maintain a high level of skill and service. The delivery model will require an influx of newly trained assessors as the "current workforce requires upskilling". These newly created roles will need to be supported by a large-scale scheme that enables and draws on their experience and new training. It is considered that *"a well-trained assessor will be able to explain the unique situation in a house, and the dynamic between appliances and house structure/design"* which would ensure the best service for the homeowner.

The concept of new jobs and training is promising for communities however, IRG participants pointed out that "*we require a functional industry to deliver it".*

It was also noted that industry development and enablement will need to be sensitive to the context. In particular "*Different delivery model required for regional areas*".

When considering the industry that supports retrofits it will be important to not only consider the new products being installed, but also the waste generated by installation and ensure that the environmental impacts are managed.

The IRG noted that there is an opportunity to '*drive innovation in design of product to minimise environmental impacts such as reduction of waste*.'

4.6.5 Legal and Governance Considerations

The following issues and considerations were discussed and advised on in a legal and governance workshop with our legal team following the first IRG workshop and conceptual scheme ideas.

It was advised that a Special Purpose Vehicle (SPV) employing a securitisation model would likely be a useful mechanism to handle the risk and investment capability required for a large-scale scheme of this nature. An SPV could be standalone, the parent company could be Climate-KIC Australia or another equity partner with Joint Venture (JV) partners also. Independent management of the SPV would be required that would align with the governance requirements of the proposed delivery model for the large-scale home retrofit scheme.

Licences that could be required and utilised by the SPV include:

- Australian Financial Service (AFS) licence
- Australian Credit Licence

An SPV also provides potential for joint venture arrangements with providers and suppliers, they could be technology providers for example. Possible JV partners could provide equity funding also.

For the purposes of a home retrofit it was considered that the ability to tie debt to the house could be an attractive option for homeowners. Would it be feasible to use the local council as an intermediary, with an Energy Upgrade Finance (EUF) for residential? This would require legislative changes across most states, as has been done to the Local Government Act 2020 in Victoria.

We were advised that the Industry Reference Group (IRG) engaged in this project and any projects with an IRG moving forward should function with the understanding of their obligations under the Competition and Consumer Act 2010 and their intentions to ensure that the discussions and any related communications fully comply with competition law requirements at all times. A protocol for future projects will be considered.

Under the Australian Competition and Consumer Commission (ACCC), The Australian Consumer Law is designed to protect consumers from scams, unsafe products, and unfair treatment from businesses. The Australian Consumer Law sets out consumer rights that are called consumer guarantees. These include your rights to a repair, replacement, or refund as well as compensation for damages and loss and being able to cancel a faulty service. The scheme and its providers must ensure that they are always guaranteeing consumers their rights to all the above requirements. All third parties involved must work to the same obligations.

The issue of false marketing and the potential for misleading communication was raised. Businesses are not allowed to make statements that are incorrect or likely to create a false impression. The scheme and its providers must ensure that they are always accurate in their messaging to consumers, they must never create a false or misleading impression. All third parties involved must work to the same obligations.

A framework agreement between the SPV and its providers and suppliers with separate customer agreements sitting underneath it may be beneficial to the scheme arrangement. This would require further investigation as the SPV is set up.

Further investigation is required to consider the following points:

- Who will own the Renewable Energy Certificates (REC)/Energy Efficiency Certificates (EEC)?
- What are the legal options available to support and take this scheme to scale?

4.6.6 Recommendations

- Consider the current market conditions and consumer preferences in the locality
- Build industry capability and capacity through training and certification programs
- Engage across supply chains to understand their current capacity and needs if they were to meet demand associated with a large-scale retrofit scheme – especially in the context of the current coronavirus pandemic and its impact on global supply chains
- Explore and analyse current waste management systems for retrofit and identify best-practice approaches to minimising waste and potential for circular economy approach.

4.7 Stakeholder Map

Table 21 shows the stakeholders involved in the large-scale home retrofit ecosystem. This is a result of interactive work performed in the first IRG workshop. The process of stakeholder mapping indicated the strengths and weaknesses of each stakeholder and where the stakeholder might add most value in a home retrofit process. Based on this information, potential roles for stakeholders in the large-scale home retrofit delivery model have been identified.

Table 21 Potential roles of key stakeholders in the household retrofit ecosystem

Stakeholder	Potential role(s)
Federal Government	Loan securitisation Funding support for establishment Setting supportive policy and legislative arrangements
State Government	Housing energy and thermal efficiency standards Trade licencing and accreditation Link to existing schemes Setting supportive policy and legislative arrangements
Local Government	Recruiting homeowners Engaging local suppliers
Community NGOs	Recruiting homeowners Supportive messaging to government
Electricity network operators	Data collection

Electricity Retailers	Allow retrofits repayments through energy savings on bills Communications with customers
Banks	Finance for retrofits – through home loans or separate loans Financial assessments
Superannuation	Finance loans
Industry Associations	Inform program design and roll out Aligned messaging to government for standards etc
Manufacturers	Scale up production as required by retrofit demand Aligned messaging on benefits of retrofit
Retrofit service providers (incl assessors)	Simplify experience for homeowners Provide advice
Installers / builders	Engage homeowners through broader renovation discussions Communicate benefits
Auditors	Assess retrofit requirements Communications with energy users Check quality of installations
Homeowner – occupiers	Self-assessment? Decide finance arrangement for their property Fund some upgrades
Homeowner – landlords	Fund some upgrades Decide finance arrangement for their property
Tenants	Pressure landlords and property managers for energy efficiency upgrades through rental property preferences
Social Housing providers	Support piloting of model retrofits where funding is available
Registered Training Organisations	Training for assessors, auditors, and installers
Universities	Monitoring and evaluation Training and course design

4.7.1 Recommendations

- Leverage the capabilities and capacities of key stakeholders to support ongoing work to develop and deliver a large scale retrofit program
- Understand and detail the relationships and agreements required to underpin effective collaboration for delivery of a large-scale home retrofit scheme

4.8 Current Activity

The Trajectory for Low Energy Buildings and its Addendum (the Trajectory)[1], agreed by state, territory, and Commonwealth Energy Ministers in 2019, is a national plan that set a trajectory towards zero energy (and carbon) ready buildings for Australia.

The Trajectory outlines a suite of initiatives to improve the energy efficiency of Australia's buildings and included a measure to:

Establish a national framework for energy efficiency disclosure, building on existing jurisdictional work, including the National Collaborative Approach to Residential Building Ratings and Disclosure – Principles, which outlines the policy parameters for adaptation and implementation by jurisdictions, subject to a jurisdiction regulatory impact statement.

Disclosure of a home's energy efficiency performance at the point of sale can ensure buyers have relevant information to make more informed choices. This information may encourage improvements by either the seller or buyer.

As a recommendation from the Trajectory, a National Framework for Disclosure of Residential Energy Efficiency Information (the Framework) is being prepared. This will build upon established disclosure markets already present in Australia, including the ACT Mandatory disclosure and the voluntary National Scorecard Program. Other active residential building measures listed in the Trajectory that support and/or enable the disclosure of residential building energy efficiency information are:

- Expansion of NatHERS to provide whole of home ratings and whole of home assessments for existing homes
- National Framework for Minimum Rental Requirements
- Updated minimum energy efficiency provisions in National Construction Code (NCC) 2022.

Through the IRG workshops and interviews, and via desktop research, the current activities related to housing energy efficiency in Australia have been identified. Appendix C Current Relevant Activity in Australia, provides the full detail of the current complementary activities that are underway in Australia.

The assessment of this activity shows that there is currently no national, or regional large-scale home retrofit scheme. It also highlights a private sector gap where there is growing demand from homeowners and as well as interest in offering green finance.

The only home retrofit schemes that are currently active are state government run programs that are engaged with industry delivery partners and accredited suppliers and providers. They are mostly targeted at low-income households and small in scale.

However, some aspects of these schemes show precedence for a model that could enable a national retrofit market that could be managed state by state. For example, the Energy Upgrade Finance (EUF) extension to Victorian residential building owners provides

[1] https://energyministers.gov.au/publications/trajectory-low-energy-buildings

a financing mechanism that can enable a homeowner who does not have access to cash or other finance options for the purposes of a home retrofit. A large-scale home retrofit scheme could enable, support, and direct such homeowners through a streamlined process, which allows them to leverage the benefit from the EUF as well as stimulating the jobs demand for retrofit work in the local area, improving housing stock and reducing emissions.

The table also highlights the Victorian State Government as being the most active in this space.

4.8.1 Recommendations

- Align with and build from the existing activities in the space – especially voluntary and mandatory disclosure requirements, low-income retrofit programs, solar PV subsidies and finance arrangements
- Align with and support the Framework to create the ecosystem that enables a market for national disclosure
- Analyse how current subsidies and incentives can best be integrated with a large-scale retrofit scheme
- Work with leading organisations and jurisdictions to progress the scheme

4.9 Market Scale and Segmentation

Desktop research was undertaken to analyse the current Australian Bureau of Statistics on Household Estimates from 2019. This work was complemented by insights generated from the IRG and PPC, and from the literature review. Together these provided substantial initial understanding of the market scale and potential segmentation was developed.

4.9.1 Market Scale

National Construction Code (NCC) Class 1a single dwellings that are owner occupied account for up to 6.0 million dwellings and tenanted dwellings account for up to 2.6 million dwellings. This represents 86% of Australian households.

This data was further analysed to understand how these homes are distributed across Australia, with a particular focus on capital cities as their density was seen as important for getting large-scale uptake.

Table 22 Distribution of dwellings across Australian capital cities, by dwelling type

Dwelling Type	Gtr Syd %	Gtr Melb %	Gtr Bris %	Gtr Adl %	Gtr Prth %	Gtr Hbt %	Grt Dwn %	ACT %
Separate house	26	29	16	10	14	2	1	2
Terrace house	25	39	12	7	12	1	1	3
Flat or apartment	55	23	9	5	5	1	1	2

All types	30	30	15	9	12	2	1	3

Based on the data on where Class 1 homes are located the roll out rate shown in Table 23 was suggested. This roll-out model provides an initial estimate of the potential market and stages the scale up from smaller initial efforts to test the model, up to very large number of retrofits in later years.

Table 23 Preliminary roll-out proposal for retrofits across major cities in Australia

	Sydney	**Melbourne**	**Brisbane**	**Adelaide**	**Perth**	**Canberra**	**Other**	**Regional**
0-6 months	250	250	250	250	250	250	250	
6-12 months	1,000	1,000	500	500	500	250	250	
Year 2	10,000	10,000	5,000	1,000	5,000	500	500	5,000
Year 3	50,000	50,000	25,000	5,000	25,000	2,500	2,500	10,000
Year 4	75,000	75,000	50,000	15,000	50,000	7,500	7,500	25,000
Year 5	150,000	150,000	100,000	50,000	100,000	35,000	35,000	50,000
TOTAL	286,250	286,250	180,750	71,750	180,750	46,000	46,000	90,000

While there are up to 8.6 million Class 1a single dwellings in Australia, not all of these require retrofit, not all are suitable for retrofits, and not all homeowners will want to retrofit.

Further analysis should focus on deeper understanding of the likely state of the homes within these markets and their need for retrofitting. It should also explore the current renovation rates and customer appetite for retrofits in these areas to further refine the understanding of the target market to allow effective targeting of marketing and identify the most appropriate delivery mechanisms.

This research also identified that:

1. Social housing is up to 0.4 million dwellings
2. NCC Class 2 apartment buildings that are tenanted or owner-occupied account for 1.2 million dwellings, 12% of Australian households.

Several in the IRG identified that it was important to prioritise low-income households as they would benefits disproportionately from retrofits. "*Recommend commencing with low-income households, most of which are living in older properties which will receive the greatest impact*." However, this was balanced with the acknowledgements that "*Low-income households need 100% funded assistance*" and "*Low-income programs have some inherent challenges that may make roll out more difficult."*

A related perspective from the IRG was to focus on the building quality rather than the homeowners. It was suggested to "*Focus on worst homes first (in terms of star rating) [as this] gives biggest bang for buck*."

Feedback from the IRG identified that there are substantial complexities in approaching retrofits in apartment buildings. These include the need to work with strata committee and strata management companies as well as substantial variation in construction types. However, the IRG also identified that apartments represent a growing percentage of the building stock: "I*... personally I think the program design should consider apartments as these are a growing proportion of building stock."* Therefore, it is proposed that Class 2 buildings will be considered as part of a longer-term roll-out of the scheme.

4.9.2 Market Segmentation

Initial market segmentation was focussed on the financial status of the homeowners, as the propensity to pay is a key driver of how they may participate in a scheme and how a scheme would be designed. New financing models may be considered which incentivise homeowners as owner occupiers and/or landlords.

Three segments were identified based on the type of funding or finance that homeowners would likely prefer to access to support retrofits. These are shown below in Figure 8.

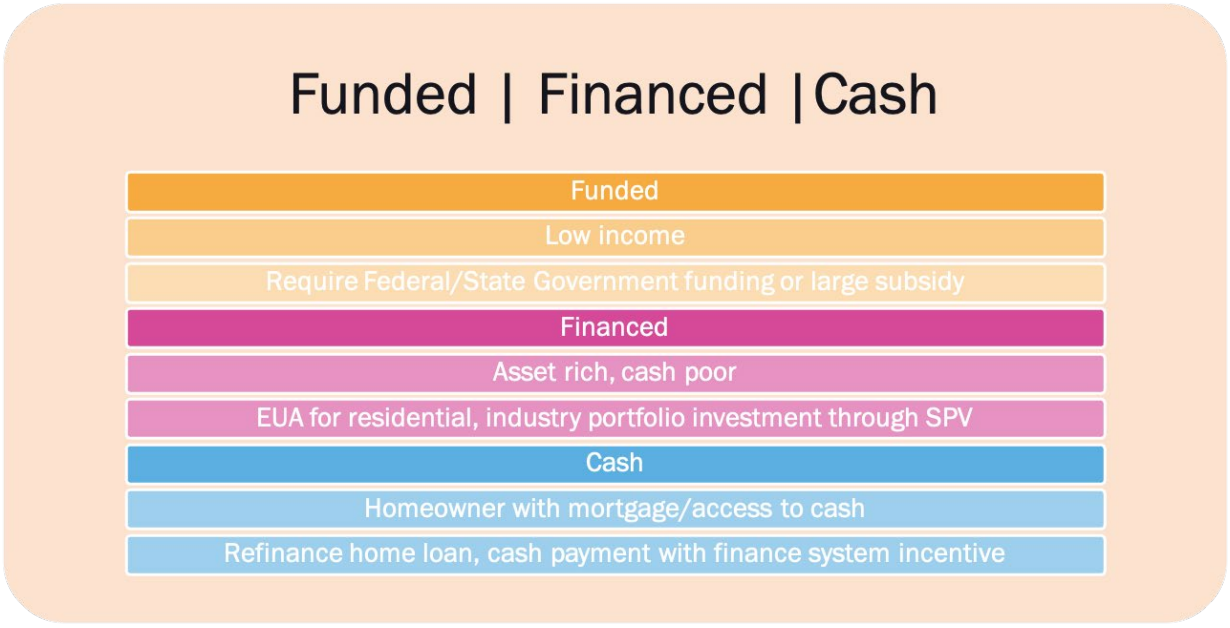


Figure 8 Market segments based on likely payment approach from customer

Which funding or financing approach is more likely driven in part by the ownership status of the home. Therefore, within the nominated focus group of Class 1a homes analysis was undertaken to identify the percentage of homes that were owned outright, have an existing mortgage, or were tenanted. The results are shown below in Figure 9.

- Approximately 29% of all Class 1a dwellings are owned outright,

- 36% of Class 1a dwellings have a mortgage and,
- 20% are tenanted.

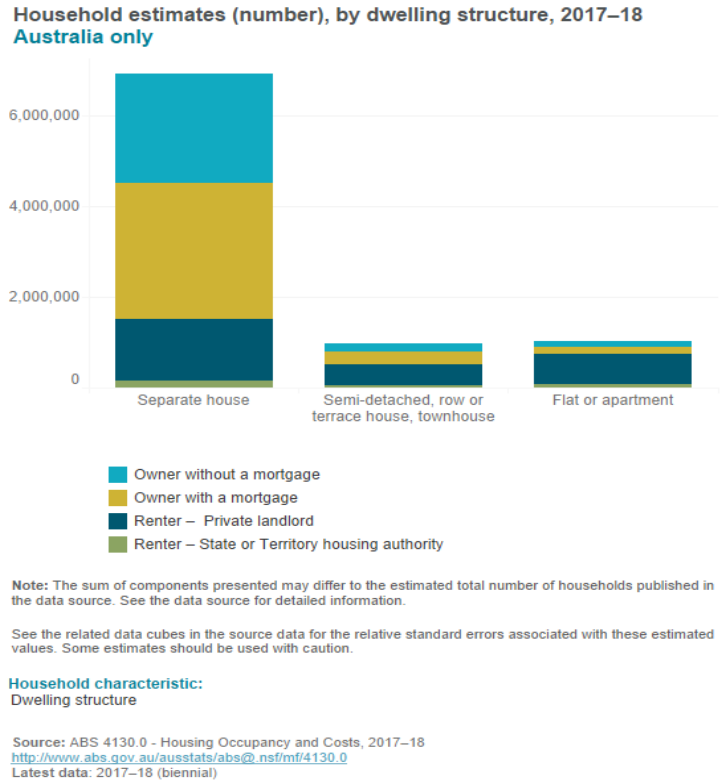
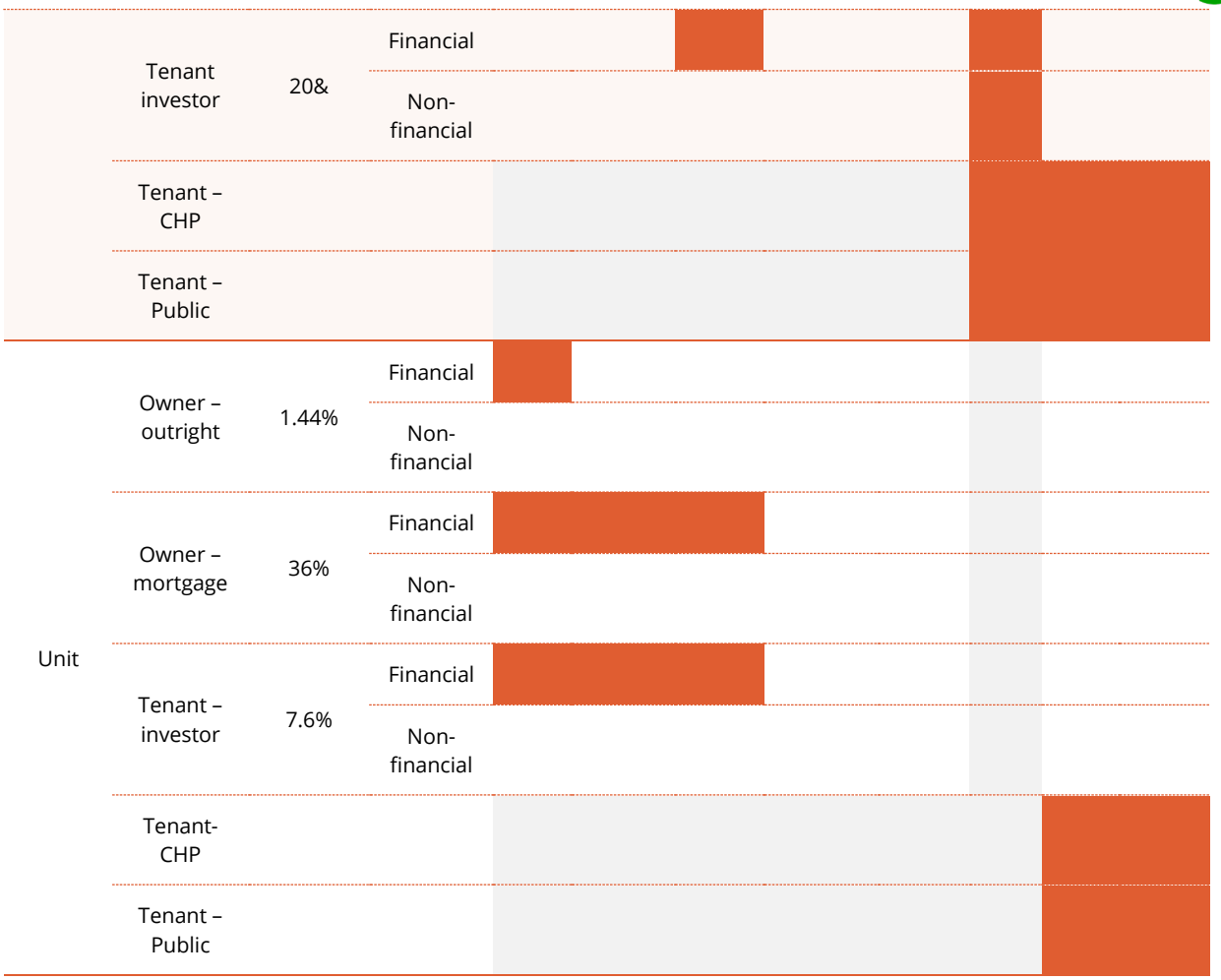


Figure 9 Number of dwellings in Australia, by dwelling type and ownership status

Based on this breakdown of ownership status the possible funding or financing options likely to be of interest to each group was mapped. This shows that the range of options available for homeowners with a mortgage is greatest, and that the options available for tenants in public and community housing is most reliant on government or philanthropic support.

Table 24 Breakdown of % of dwellings in each ownership category and associated potential finance or funding mechanisms

Type of Building	Ownership	% of all dwellings	Occupant	Cash	Redraw / Offset	Home loan	Personal loan	Power retail	EUA	Govt	Philan
House	Owner - outright	29.15%	Financial	■			■				
			Non-financial					■	■		
	Owner – mortgage	36%	Financial	■	■	■	■				
			Non-financial		■	■			■		



Analysis by the Green Finance Institute (2020) provides further insight into this market segment and breaks down homeowners based not only on whether they own outright but also on how recently they purchased the home and the scale of mortgage left to be repaid. Analysis of this type focussed on the Australian market would provide further insight into the opportunities and approaches required for large-scale retrofits to be effective. A suite of approaches will likely be required to suit the varied needs of households.

Sub-segment / profile features	First-time buyer	High loan to value	Low loan to value	Own outright (recently repaid)	Own outright (sufficient savings)
Decision Maker	Y	Y	Y	Y	Y
Characteristics	Cash poor, generally lower credit rating, more likely to own a new home (Help to Buy etc.)	A: Mixed ability to access credit, typically 30-49 | B: highly leveraged property developers	Typically 45-65, first time buyers with parental support, mature career stage	Generally older; often asset rich and cash poor; fixed income; less efficient home	A: Generally older, sufficient savings and/or fixed income; less efficient home / B: cash-rich property developers
Key influencers	Lenders, mortgage brokers, surveyors	Lenders, mortgage brokers, surveyors, architects, supply chain (for property developers)	Surveyors/valuers, architects, advisors of home retrofit	Peers, advisors of home retrofit, financial advisors	Valuers/ surveyors, architects/designers, financial advisors
Level of Awareness	Generally very low | EPC data is the only item and not all OOs consider it | High climate awareness not linked to home and not translated into action				
Drivers	To buy an already energy efficient home | concerned about cost of living | growing family	Desire improvements | aesthetics, comfort | consider dwelling as an investment/ asset value increase | rapid turnover	Changing family circumstances | consider home as retirement plan | aesthetics, comfort	Minimising costs | consider home as retirement plan	A: Aesthetics, health, comfort | minimising costs | B: consider dwelling as an investment/ asset value increase | rapid turnover
Trigger Points	About to move / recently moved	Recently moved | growing family | recently acquired investment	Becoming empty nesters | recently moved | extensions and repurposing	Becoming empty nester | retirement | moving to downsize	A: Adapting home for future | B: recently acquired investment
Barriers - Financial	Highly leveraged | seeking to minimise outgoings | limited options/desire for further borrowing	High upfront costs, low certainty of savings | combination of financial products required| improvements not reflected in asset value	High upfront costs, low certainty of savings | combination of financial products required| improvements not reflected in asset value	Limited options/desire for borrowing | high upfront costs, low certainty of savings	Improvements not reflected in home value
Barriers – Non-financial	Uncertain performance of EE | lack of access to good information	Uncertain performance of EE | lack of access to good information | trust in supply chain	Uncertain performance of EE | lack of access to good information | hassle | trust in supply chain	Uncertain performance of EE | lack of access to good information | hassle | trust in supply chain	Lack of access to good quality information | hassle | trust in supply chain

Figure 10 Profile of the owner-occupied market segment (from Green Finance Institute, 2020)

4.9.3 Recommendations

- The scheme should target NCC Class 1a single dwellings that are owner occupied or tenanted. This target market reaches most of the private Australian housing stock which would allow for the scale and impact required.
- The Scheme should further explore the sub-sections within the NCC Class1a dwelling sector to identify the best mechanisms to engage these market segments
- Social housing and NCC Class 2 apartment buildings should be considered for inclusion as the scheme delivery progresses.
- Scheme should explore mechanisms to support retrofits in low-income households and for social housing, including opportunities for Government funding.
- Scheme should target poor quality homes to achieve the largest improvement and impact.

4.10 Consumer Profile and Preferences

Insight from the IRG on consumer preferences suggests that energy efficiency is not a high priority for homeowners, and that they are "*Not really interested*" in energy efficiency retrofits. This is supported by evidence gathered through the literature review and desk-top research.

The ARENA 'DER Customer Insights Series' investigated the experiences of customers involved in twenty ARENA-funded Distributed Energy Resources (DER) projects, mostly on-grid residential solar and battery storage trials. The projects were across almost all states and territories and involved over 1,300 customers who chose to have DER systems

installed in their homes. The study analysed the values of DER customers and their motivations. It suggests that customer motivations can be a barrier to successful implementation of DER interventions.

Nonetheless, international experience shows that there is significant appetite for retrofits where funding is available - e.g., Warm Up NZ, UK Warm Front and the Green Deal Home Improvement Fund all had significant uptake, in many cases exceeding the capacity of the program.

A significant motivator for customers to engage in these schemes appears to be financial benefits. Where that benefit is not clearly articulated and evidenced, then uptake can be impacted. Webber et al (2015) state that the Green Deal *"failed to persuade large numbers of households to participate, partly due to concerns about financing arrangements and partly because of scepticism that the scheme will actually generate the savings that it claims (c.f. Harvey, 2013; Collinson, 2014)".*

While financial benefits can be a strong motivator, they have not been found to be the greatest driver of decision making in households. Survey research by the NSW Department of Environment (2014) has shown that the main conscious consumer drivers are comfort, functionality, cost, and perceived value. Reducing the running costs comes in around 8th with 20% saying it is an important factor. This was even more pronounced among households that had undergone major renovations in the past 3 years. If energy efficiency is not a high priority for homeowners, then how should a large-scale retrofit scheme approach and engage with them? The ARENA 'Distributed Energy Resources (DER) Customer Insights Series' proposes a values-based approach as an effective way to engage and tailor messages to many types of customers, especially where they may not prioritise energy.

NSW Office of Environment and Heritage (2014) Sustainable Households Survey of homeowners for the NSW Office of Environment and Heritage, NSW OEH

Figure 11 DER customer types and their values (Alexander et al, 2020b)

The analysis revealed:

- Financial benefit is a core motivator for DER customers, however it cuts across values modes and should be communicated in multiple ways.
- Settlers are motivated by security, expressed as a desire for reliability and 'maintaining the status quo'.
- Prospectors who will be driving the first wave of mainstream DER adoption are excited by 'getting ahead' or 'making a smart investment'.
- Pioneers desire fairness and are willing to support 'the greater good'.
- Trust also cuts across the values modes and is critical to successfully achieve a customer-centred energy future (Alexander et al, 2020b).

In addition to those things that motivate them, homeowners will also face barriers to engaging with a home retrofit scheme. The Green Finance Institute (2020) identifies a range of financial and non-financial barriers that can be experienced by owner-occupiers (Table 25). Similar barriers exist for other sections of the market.

Table 25 Financial and nonfinancial barriers to retrofit projects in the owner-occupied households

Financial Barriers	Non-financial barriers
High upfront costs for improvements. Lack of access to capital. Low confidence in energy bill savings: A barrier or homeowners seeking full repayment via energy savings. Duration of tenancy: Energy bill savings may not accrue to the original homeowner if they move property. Property value-add: Efficiency improvements not considered to increase and/or protect property values. Availability and accessibility of products: Low penetration and availability of attractive financial offers for efficiency measures.	Low awareness among homeowners, and disconnect between a genuine concern about climate change and the energy efficiency of their property Professional influencers fail to inform and educate homeowners of benefits. Lack of good quality information and support on products, choices, and suppliers. to embark on a renovation 'journey'. Duration, hassle and complexity (i.e., supply chain, installation, finances) of retrofit projects. Lack of confidence in the supply chain. Leaseholders gaining permission: Getting collective agreement amongst groups of share-of-freeholders.

The scheme will need to acknowledge and address household scale barriers to reach scale. The ARENA 'DER Customer Insights Series' also drew-on and analysed almost one-hundred reports arising from twenty of ARENA's DER projects. The following summary (Table 26 and Table 27) outlines barriers and opportunities of the "customer journey" for the implementation of DER interventions (Alexander et al, 2020a).

Table 26 Part 1 Barriers and opportunities of the "customer journey" for the implementation of DER interventions (Alexander et al, 2020a)

What worked	The Customer Journey	What didn't work
- Undertaking detailed customer research and segmentation - Carefully planned, regular communication and engagement - Communicating your offer, options, and pricing simply - Providing customers with a single, accessible, point of contact - Responding and addressing frequently asked questions quickly and effectively - Maintaining online resources that are relevant, accessible, and up to date - Creating excitement of the offer with the target customer group/ community - Working with trusted partners/ local champions - Established and smooth process for acquiring customers	**Engagement & Acquisition** This stage involves all steps in the lead up to product's installation, including all awareness raising up to the point of the financial transaction and signing of contracts.	- Complex messaging - Providing too many options - Slow and/or cumbersome acquisition processes - An irregular or impersonal point of contact
- Including installers in the design phase of the main project - Investing suitable resources in the installation process - Providing comprehensive training and upskilling of installers - Quick, effective, non-intrusive installation with a single site visit - Consideration of home aesthetics - Transparency over final installation requirements and cost - Plan ahead for common pitfalls, such as internet connectivity issues where required - Responding and addressing any installation issues quickly and effectively - Customer research before and after installation to identify any concerns early	**Installation** This stage involves all the steps directly related to the installation, including any pre-installation site visit.	- Underestimating the time, complexity, and cost - A slow, drawn-out, and "diffuse" process requiring multiple site visits - Over-stretched supply chains that can be slow to respond - Variable installer quality, some offering lower levels of service, ability, knowledge, and technical competence - Poor aesthetics of installed equipment that doesn't fit with an existing home's look and feel

Table 27 Part 2 Barriers and opportunities of the "customer journey" for the implementation of DER interventions (Alexander et al, 2020a)

What worked	The Customer Journey	What didn't work
- Responding and addressing any operational issues quickly and effectively - Providing accessible technical information and updated FAQs to allow customer troubleshooting - Comprehensive technical and customer engagement training for installers and support service personnel - Providing all project partners, stakeholders, and subcontractors in the supply chain with clear, end to end processes	**Operation and Maintenance** This stage covers all ongoing activities related to the operation of the DEP system (firmware and hardware), including any scheduled or unscheduled maintenance	- Poorly managed processes, and undefined supply chain partner roles and responsibilities - Lack of training for customer-facing roles - Intermittent issues with DEP functionality and continuity of operation - Issues and discomfort with third-party ownership / control of the DER.
- Certainty of financial costs and returns preferred to variable rates, even if those variable rates offer greater benefit - Ongoing and planned engagement directed at customer retention and advocacy - Changing consumer behaviour, such as through time-of-use tariffs - Tailored engagement depending on customer preferences, such as through different degrees of control offered for optimised their DER	**Retention** This stage covers the post-installation phase that ensures customers continue to be satisfied with their product and service.	- Complex pricing structures or value propositions that change over time - Designing optimisation algorithms without customer participation or acknowledging different types of customers - Not planning for legacy and how customers will be supported at the conclusion of each trial

Knowing what messages might be impactful is part of the challenge, the other is knowing how and when to delivery those messages. International experience has shown that good communication is essential for encouraging participation. This includes knowing when homeowners are likely to be receptive to messages about retrofits. Potential trigger points for home assessment and retrofits include selling/buying a home, renting a home, replacing old or broken fixtures and/or undertaking other home renovations intended for aesthetic or functional purposes only. Mechanisms need to be identified to integrate energy efficiency retrofit messages into these processes, either through partnerships, disclosure requirements or training and certification of service providers.

Knowledge and social networks can also play an important role in shaping the ways in which energy-related renovations are carried out, or not. Interventions can raise homeowners' awareness of their energy use and enable them to be more informed consumers. Homeowners being involved in taking decisions based on technical input, is the best framing of energy retrofits.

Information about the opportunity of energy efficiency also needs to reach homeowners from their trusted information sources. Surveys suggest that when deciding what to do in a home renovation, and who to hire to do the work, family, friends, and neighbours are highly influential along with trades people that they have used before (OEH, 2014).

Internet searches, TV shows and home improvement magazines were also among the most influential sources of information. This suggests that messages need to be targeted through these groups, and that operating regionally, or on a community scale could assist the transmission of information about the benefits of retrofits as people would be likely to hear about them from friends and neighbours, as well as local tradies.

This framing may, however, fail to consider some of the more complex influences of societal norms on individual decision-making and action. In an analysis of the impact of the Kirklees Warm Zone scheme, Webber et al (2015) included a literature review that points out the focus of key assessments of residential energy efficiency schemes *which emphasise the significance of the often deeply embedded social practices that shape energy use in buildings (c.f. Spaargaren, 2011; Judson and Maller, 2014; Viasova and Gram-Hanssen, 2014; Bartiaux et al., 2014).*

Bartiaux et al (2014) analyse energy-related renovations in Europe with a conceptual framework drawn from social practice theories. They conclude that homeowners should be seen not as isolated individuals who should 'choose' to carry out energy-related renovations but rather as 'carriers' of social norms of what is normal to do and say, and of established routines and knowhow. The importance of knowledge and social networks in providing advice and help before and during renovations (e.g., friends, family, and specialist craftsmen/tradesmen) shape the ways in which energy-related renovations are carried out, or not.

A study by Vlasova and Gram-Hanssen (2014) also looked at the importance of social practice theory and how everyday practices of households have to be understood in relation to the physical layout of buildings and technologies. They concluded that context-rich retrofits, in which homeowners are involved in taking decisions on the basis of technical input, are the best framing of energy retrofits. The facilitation of everyday practices (and appropriate feedback loops) can help to reduce consumption. But the underlying case for government intervention to help to promote retrofit and the diffusion of more energy efficient practices is still apparent, even though the forms of intervention advocated are often very different to those that emerge from a more technical or economic perspective.

It is important to note that the research and insights that were available to inform this project all date from before the current coronavirus pandemic. Since the beginning of the pandemic, people are spending a much greater proportion of their time at home, including working from home. This may well be driving changes in the way people view their home and the priority that they give to comfort and energy efficiency. Current information is required to fully inform the design of a successful home retrofit scheme.

4.10.1 Recommendations:

- Using a values-based approach to understand customer motivations is an effective way to overcome intervention barriers.

- Engage homeowners at key decision points including selling/buying a home, renting a home, replacing old or broken fixtures and/or undertaking other home renovations.
- Target messaging through influential sources by operating at a community (including online communities) or regional scale. This will allow information to flow from family, friends, and neighbours as well as local trades people
- Consider the opportunity for messaging through more general channels such as TV and internet information sources
- Do specific customer preference and insight analysis for the target markets identified, exploring the detail of which retrofits are preferred, what specific messages about their benefits are impactful, and from whom it would be best to hear the messages
- Establish clear success criteria to assist with monitoring the scheme's progress against expectations.
- Promote, develop, maintain, and recognise quality and performance so owners have confidence in the scheme.

4.11 Funding and Finance Models

Currently in Australia there are some financial products available commercially or through government to encourage energy efficiency and thermal efficiency retrofits. Bank Australia with the support of the Clean Energy Finance Corporation offers a Green Home Loan. The homeowner receives a 0.4 percentage point discount on their home loan rate if their home is either:

- NatHERS 7 Star+ (new homes)
- Have made ambitious green upgrades in the last 12 months and can show a 1-star improvement based on Residential Efficiency Scorecard assessments (existing homes)

To date 140 homes have taken up the offer.

The Commonwealth Bank offers a Green Loan where customers with an eligible CommBank home loan or investment home loan can buy and install eligible clean energy products at the property secured by their existing home loan.

The loan offers a 0.99% PA 10-year fixed rate no establishment fee, monthly loan service fee or early repayment fee. The minimum loan size is $5,000, maximum loan size is $20,000.

Some State governments have also created structures that allow finance to be accessed for energy retrofits. In Victoria from 6 April 2020, Environmental Upgrade Finance (EUF) able to be offered to homeowners. EUF is a council-based financing mechanism where the lender provides finance to the property owner and the local council collects repayments through the rates system. The council then passes the repayments onto the lender.

As EUF loan repayments are attached to the property, not the person, they may be attractive to homeowners who may wish to sell the property within the period of the loan.

In NSW the Energy Savings Scheme is a certificate trading scheme designed to reduce electricity and/or gas use by creating financial incentives for households and organisations to invest in upgrades to save energy.

Home Energy Efficiency Retrofit (HEER) activities can be delivered under the Energy Savings Scheme (ESS) by Accredited Certificate Providers (ACPs) to help NSW households and small businesses save energy by supporting a range of energy efficiency upgrades, including lighting, draught proofing, and equipment upgrades.

The home occupant nominates the ACP as the energy saver for the upgrade to enable them to create Energy Savings Certificates (ESCs) from the energy savings that will be made. This certificate can then be sold into the off-sets market.

Work by the Green Finance Institute (2020) has summarised the large number of potential financial product available to support energy efficiency retrofits in owner-occupied and rented homes.

Table 28 Example financial products to support energy efficiency retrofits

Name	Description
OWNER-OCCUPIED HOMES	
Property assessed clean energy financing	Property Assessed Clean Energy (PACE) financing enables homeowners to receive financing to support 100% of the upfront costs for a retrofit project. The liability is secured against the property and repaid through an additional property tax, typically over extended timescales (e.g., 15-25 years) that make repayments more affordable. Importantly, the liability remains with the property if there is a change of ownership. In the US, PACE schemes have mobilised over $5 billion into domestic retrofits and trials, and other 'property-linked' financing mechanisms are being trialled around the world.
Green Equity Release	Equity Release allows homeowners over the age of 55 to unlock the equity in their property without the requirement to move home. A Green Equity Release product would unlock cash for investment into energy efficient improvements, with favourable terms to incentivise retrofit and the ability to protect the property's value for posterity.
'Help to Green' Loan	A 'Help to Green' Equity Loan would enable homeowners to borrow against the equity in their property to invest into energy efficiency improvements, for which the Home Energy Efficiency for Scotland Equity Loan pilot offers a template. In addition, if the UK Government supported Help to Green Equity Loans for first-time buyer deposits towards the purchase of existing (rather than newly built) homes that meet energy efficiency criteria, either pre- or post-sale, then favourable borrowing terms could be offered such as interest-free periods, whilst lenders could leverage the existing operational infrastructure of the Help to Buy scheme.
Add-to-my-mortgage platform	A Further Advance, or additional borrowing on an existing mortgage, is a simple route for many households to access finance for energy efficiency improvements. The Add-to-my-Mortgage digital platform aims to streamline the process for homeowners to apply for a Further Advance at the 'point of sale' of energy efficiency measures.
Domestic Energy Efficiency Salary Sacrifice Scheme	A salary sacrifice scheme that allows employees to draw a loan through their employer for investment into home energy improvements, which is repaid via gross salary contributions. The effective discount and ease of access to finance should appeal to employees, while overcoming communication challenges by marketing the scheme

	through employers who already have existing relationships with the homeowner. Parallels exist in the successful Ride to Work scheme.
Comfort as a Service	The construction or refurbishment of homes to high energy performance standards, with energy controls that support remote optimisation of the building performance, can deliver significant energy savings that outweigh the cost of home energy optimisation. Financial mechanisms that unlock these cashflows can support the investment case for housebuilders and homeowners to achieve high efficiency standards.
PRIVATELY LEASED HOMES	
Green Leases	Green Leases with an 'Energy Alignment Clause' enable landlords to recover the cost of a retrofit, based on the predicted energy savings of the retrofit measures. To protect tenants against underperformance and allow them to also benefit from the retrofit, only 80% of annual predicted savings are passed through to the landlord, offering a 20% performance buffer. Similar models have been successfully piloted for commercial tenancies in New York state.
Minimum Energy Efficiency Standards (MEES) Compliant Funding	An energy performance guarantee would allow private-rental landlords to procure long-term compliance with MEES requirements. The landlord would pay an ongoing service charge or premium to the guarantor, who would cover the capital investment required to retrofit the property should MEES regulations be tightened. Similar models are adopted for landlord boiler insurance and energy performance contracting models.
Energy Saving ISAs	Private-rented tenants are typically unaware of the financial benefits associated with energy efficiency measures, therefore have limited incentive to request energy improvements from their landlord. An Energy Saving ISA, which directs energy bill savings into an ISA or savings product following the retrofit of a private-rented property, could help tenants build up their savings for a mortgage deposit or other investments.
Long-term retail investment	Crowdsourcing investment for community-based renewable energy projects has grown in popularity over recent years. An investment product could be structured that allows retail investors to provide capital for retrofits and receive predictable long-term returns from energy efficient private-rented properties.

In addition to private sector finance, governments have played a role in supporting the financing of retrofits, in particular seeking to address the barrier of high up-front costs through low/no-interest loans and subsidies. In the low-income and social housing space government has been particularly active in offering grants and subsidies to support improvements in energy efficiency and lower energy bills through retrofits.

Internationally, retrofit schemes have employed a variety of financial mechanisms, as summarised in Table 29. There were free and subsidised measures, low interest loans, and payback tied to energy bills and property taxes. The total value of investments has tended to be very large, and success and uptake has varied. Government funding or backing, or philanthropic funding is prevalent, as is partnership with community groups, local government, and utilities

Table 29 Finance Arrangement used in a selection of international retrofit programs

Finance arrangements								
	Green Deal	**EnEv Energy Conservation Act**	**Warm Front**	**EnergieSprong**	**Kirklees Warm Zone (KWZ) scheme**	**Warm up NZ**	**Property Assessed Clean Energy (PACE)**	**EcoBonus**
Finance mechanism	Paid from projected savings on energy bills over 25 years or less	Low interest loan up to €50,000 with a 10-year repayment period	Grants of up to £3500 (£6000 for some technologies)	government-backed 40-year loans to housing associations funded by WSW Social Bank, European projects and philanthropists	Free	Subsidises 1/3 cost up to NZ$1,300 (more for low income)	100% financed upfront under a local government bond; repaid on property tax bill over 10-20 years	Superbonus: tax deduction of 110% (incl structural work) Ecobonus 65% tax deduction (EE only) Can be sold to third parties so accessible to non-taxpayers
Interest rate on loan	7-9% APR	Publicly subsidised low interest rate (1-4%)	nil		n/a			
Attachment point of loan	Electricity meter	Person or organisation					Property	
Total cost of scheme	Value of investment: €380 - €525m/year	Average of €1.4 bn/year. Value of loans and grants: ~€3 bn	£2.2 billion total to 2009	€6b	budget of £21m	NZ$347 million over 4 years	$5b (total to 2019)	new tax credits for €140 million at start of 2021 (over 6 months)

Part of the reason for the variability in uptake and success of these programs is due to the context in which they are deployed. Finance mechanisms will require supportive environments to find the appropriate customers. In addition, systemic approaches will be required to engage homeowners in the issues and provide certainty and comfort in the value provided by retrofits to have confidence to take on loans.

Green Finance Institute (2020) notes that *"Systemic change to mobilise the flow of capital into upgrading our housing stock to be 'future-ready' requires a step-change in how finance, government, supply chain and households work together around the shared ambition for net-zero emissions and climate-safety… concerted energy efficiency effort across government and industry can meet many of the criteria for economic recovery, while meeting existing long-term policy commitments and targets."*

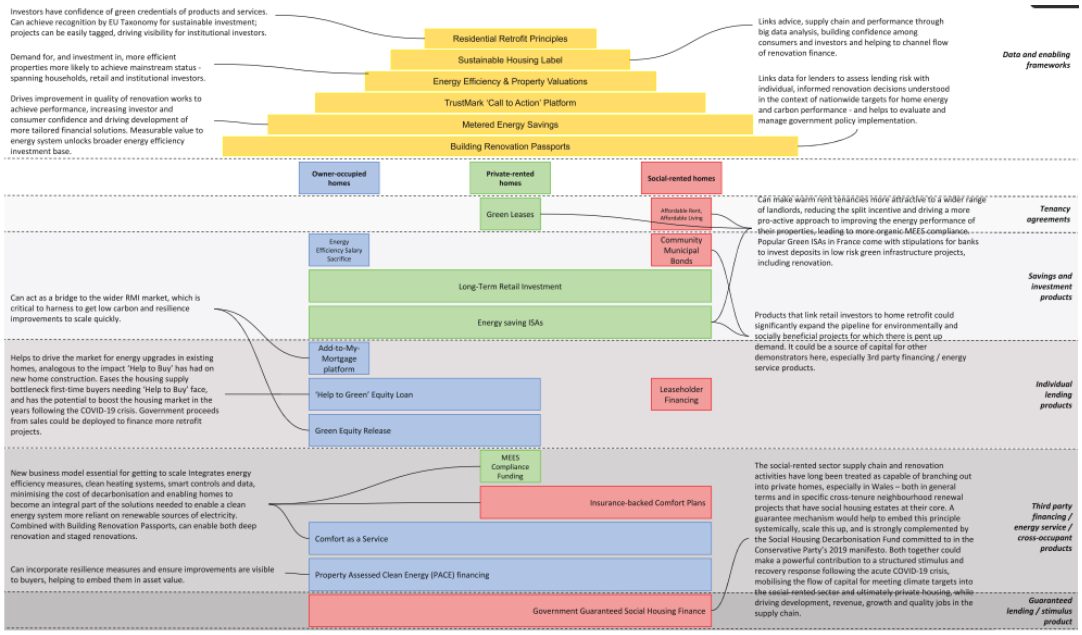


Figure 12 Summary of the ways that a portfolio of finance options, underpinned by a supportive policy and regulatory environment can create large-scale retrofit opportunities. (Green Energy Finance, 2020)

4.11.1 Recommendations

- Scheme design should seek to understand and offer the appropriate financial mechanisms for different circumstances and facilitate access in seamless ways.
- Cost must be competitive with commercial loans.
- Scheme design should seek to engage with governments on ways to maximise the value of their investments in retrofits, especially exploring opportunities to leverage private investments through loan guarantees and risk mitigation.

5 Delivery Model Recommendations

"The cheapest and cleanest energy is the energy that we do not use".

The following content provides recommendations and requirements that are deemed essential to delivering a large-scale home retrofit scheme across Australia.

5.1 Scheme Goals

The home retrofit scheme aims to create:

- Future ready homes that are comfortable and healthy, as well as highly thermal and energy efficient, with a path toward electrification
- An improved NatHERS rating for each home (based on remote or in home assessment)
- Large-scale delivery of home retrofits across all states and regions in Australia

The large-scale home retrofit scheme will aim to create *future ready homes*. Future ready homes mean existing homes that are comfortable as well as highly thermal and energy efficient, with a path toward electrification. Comfortable homes that can improve or at least support occupant's health and without the need to excessively heat or cool rooms.

As a recommendation from the Trajectory, a National Framework for Disclosure of Residential Energy Efficiency Information (the Framework) is being prepared. This will build upon established disclosure markets already present in Australia, including the ACT Mandatory disclosure and the voluntary National Scorecard Program as well as the proposed expansion of NatHERS to provide whole of home ratings and whole of home assessments for existing homes, the National Framework for Minimum Rental Requirements, and the updated minimum energy efficiency provisions in National Construction Code (NCC) 2022.

It is important that the ecosystem required to support the ratings and disclosure is delivered in parallel. Considering this, and although the disclosure may begin as voluntary, achieving an improved NatHERS rating (based on remote or in home assessment) for all eligible homes that participate in the process is deemed to be a goal for the scheme.

The energy industry is transforming, and existing homes are currently lagging in the transition, they are not yet representing or supporting our present and/or future needs for comfort, efficiency, and resilience. This scheme can enable an opportunity to transform our existing homes to align with the energy transition and to better support our future requirements as prosumers and consumers playing a role in the distributed energy grid. Enabling a path towards electrification, with thermal and energy efficiency maximised in homes first, will support the energy grid as the operators, retailers, and industry power through the transition away from fossil fuels and toward net zero energy.

Enabling a large-scale delivery of the scheme is a critical element of the schemes direction that can only allow the scheme to tap into private finance. A place-based roll out will

enable addressing issues of capacity and the ability to work with community groups to enable shared success.

5.2 Target Market

The scheme will target NCC Class 1a single dwellings that are owner occupied/tenanted only. This target market reaches most of the private Australian housing stock which would allow for the scale and impact required.

- NCC Class 1a single dwellings that are owner occupied includes up to 6.0 million dwellings and up to 2.6 million dwellings that are tenanted. This accounts for 86% of Australian households

The scheme will target homeowners with access to cash or refinance on their homes, as well as those requiring finance through the scheme. This will include landlords as well as owner occupiers.

The scheme will also target homes that are deemed to be poor quality. This may be based on assessment and NatHERS rating. Improving poorer quality homes will achieve a greater overall impact for ROI at economy and household scale, as well as improved occupant comfort and health benefits.

5.3 Retrofit Recommendations

Based on the modelling, input from the IRG and PPC and desk-top research the following retrofit items have been identified. While these represent the full and possible recommendations that support the scheme goals it is not expected that all homeowners will require or want to install all items. The scheme intention is to provide a degree of flexibility to homeowners for their custom retrofit based on the home assessment as well as their expectations. This is due to:

- Variation between homes, which may make certain retrofit items unsuitable
- Appetite of homeowners for different retrofits

More work is required to identify the most appropriate balance between flexibility and scalability. The findings of the literature review indicate that some degree of standardisation will likely be required if the ambitious scale of the scheme is to be reached.

The priority items are agreed within the industry to provide highly beneficial improvements without the requirement for user ability. They also take into consideration the importance that the building fabric has on the thermal comfort of the home and in mitigating heat and cold stress. The building also has a relatively long lifespan especially when compared to technology-based installations.

The retrofit assessment and design will involve two steps prior to finance, supply, and installation.

Step 1: Whole of home assessment

These will be of two common types available, either a walk-through assessment or a desktop assessment. The appropriate type of assessment will be determined by a mixture of homeowner appetite, location, budget, homeowner limitations/requirements, and logistics. The two types of assessment are detailed below:

- **In Home assessment**
  A trained assessor visits the home and completes a walk-through assessment using the National Scorecard that is adapted for the purposes of this scheme, a star rating is given, technical guidance and advice regarding what retrofit items will suit the home and the homeowners' requirements is provided with a specification and referral to the next stage in the process.
- **Desktop assessment**
  A remote assessment performed by the homeowners using Australian software that is adapted for the purposes of this scheme enables them to answer a targeted set of questions about their building and appliances via a web app. Independent technical guidance and specification is provided via the app and referral to the next stage in the process. A trained assessor is also available to answer any questions and provide independent technical guidance on the phone.

Table 30 Proposed whole of home assessment intention and estimated costs

Step 1: Whole of Home Assessment		
Assessor Items	**Comments for Scheme Intention**	**Estimated Cost***
Remote assessment	A desktop assessment will be suitable for a homeowner that is either confident in their ability to assessment their home, or where cost and budget is an important consideration. Ratings may be possible dependent on future accreditation of these tools.	$30 per home
In home assessment	Trained and employed home energy assessors will be required to conduct a walk-through assessment. This provides the most accurate assessment but has a larger cost impact. Ratings will be possible based on the use of an accredited tool.	$400 per home
Hybrid assessment	A mix of remote and walk-through assessment to compliment homeowners with unique requirements	<$400 per home

Step 2 – Homeowner bespoke retrofit package development

Step 2 will offer the retrofit items that are deemed to provide best value for the purpose of thermal and energy efficiency of the home. The bespoke package will be chosen by the homeowner from the list below. Building envelope improvements will be prioritised (where appropriate to the building) before big ticket technology additions to ensure retrofit items provide suitable building and homeowner benefits.

Table 31 Proposed retrofit items for the homeowner's bespoke retrofit package

Step 2: Retrofit recommendation drawing from items below	
TOWARDS COMFORT – THERMAL AND ENERGY EFFICIENCY IMPROVEMENTS FOR THE BUILDING	
Retrofit Items	**Comments for Scheme Intention**
Roof insulation	High priority item, where feasible
Wall insulation	High priority item, where feasible
Floor insulation	High priority item, where feasible
Pipe lagging	High priority item, where feasible
Draught sealing/ proofing	High priority item, where feasible
Window treatments	High priority item, where feasible (blinds/curtains intended for insulation and/or window tints)
Led lighting	High priority item, where feasible
Shower head/taps	High priority item, where feasible
Clothesline	Where suitable
Ceiling fans	High priority item, where feasible
Glazing upgrade	May require further expert technical guidance for specification
TOWARDS ELECTRIFICATION – ENABLING IMPROVED ENERGY EFFICIENCY THROUGH THE BENEFIT OF TECHNOLOGY	
Smart home energy management/monitoring system	Mandatory with solar PV
Solar PV	If completed with/after other thermal/energy efficiency upgrades
Split/reverse cycle air con	If completed/sized with/after other thermal/energy efficiency upgrades and solar PV
Appliances (plug in) upgrade	Washing machine
	Dryer

	Fridge
	Dishwasher
Pool pump upgrade	Where applicable
Smart meter upgrade/ meter check	State dependent but possibly a requirement due to standards, is it mandatory at the home's location?
Hot water heat pump	If completed with/after other thermal/energy efficiency upgrades and solar PV
Induction cooktop	If completed with/after solar PV
Home battery (VPP capable)	If completed with/after other thermal/energy efficiency upgrades and solar PV (where solar PV is not already present)
EV infrastructure/charger	If completed with/after solar PV
Home electrification	Replacement of gas fuelled appliances; induction cooktop, spilt/reverse cycle air con, hot water heat pump, isolating gas supply (where safe to do so) and disconnecting from gas supplier. Electrification following efficiency measures to avoid an increase in electricity use.

5.4 Financial Model

The scheme will require investment and/or seed funding to get it to the scale required to attract private investment that will enable the large-scale delivery model. A proposed structure that will be able to manage the risk profile of this scheme as well as the governance required for success is a Special Purpose Vehicle (SPV).

A special purpose vehicle is a subsidiary created by a parent company to isolate financial risk. Its legal status as a separate company makes its obligations secure even if the parent company goes bankrupt.

- *An SPV is created as a separate company with its own balance sheet.*
- *It may be used to undertake a risky venture while reducing any negative financial impact upon the parent company and its investors.*
- *Alternately, the SPV may be a holding company for the securitization of debt so that investors can be assured of repayment.*

An SPV in this instance can be viewed as a method of disaggregating the risks of an underlying pool of exposures held by the SPV and reallocating them to investors willing to take on those risks. This allows investors access to investment opportunities which would not otherwise exist, such as green home loans. The scheme would also enable homeowners with access to cash or refinancing through their mortgage as well as those requiring private finance. A proposed system model is shown below in Figure 13.

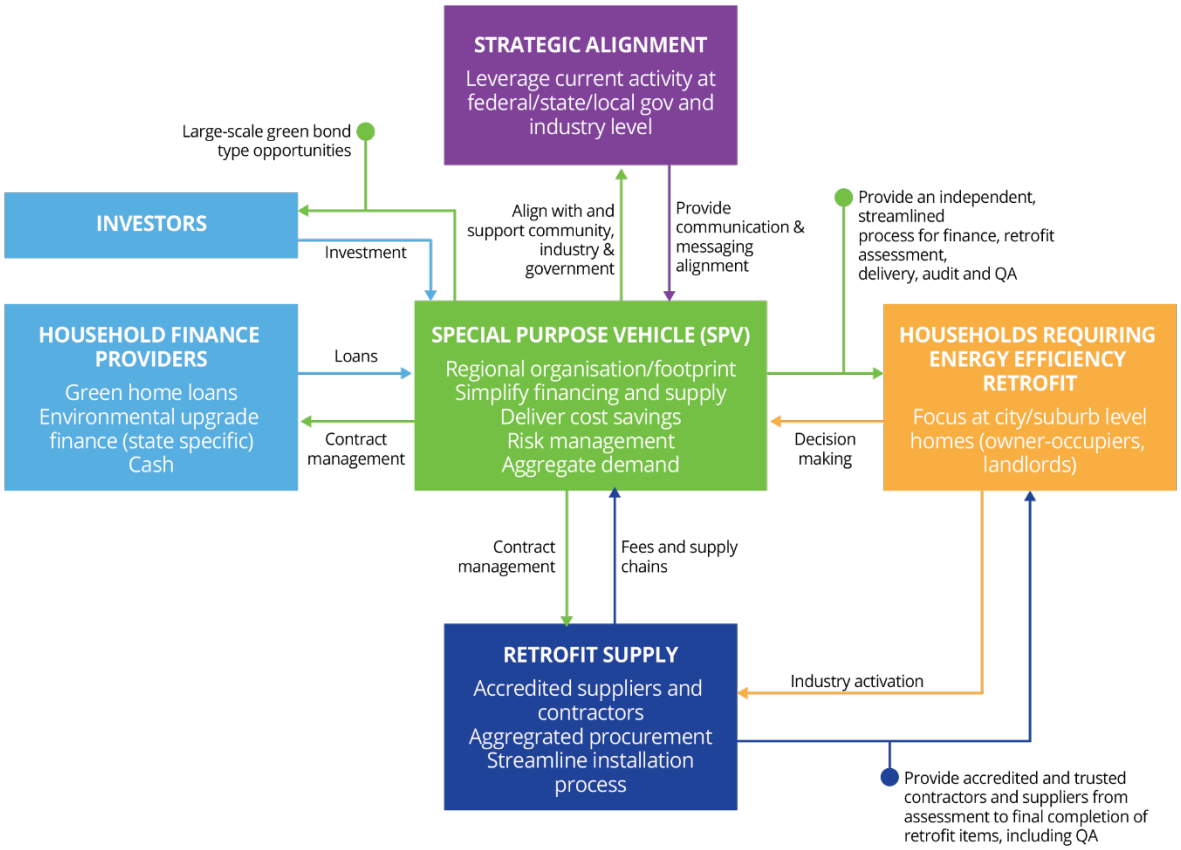


Figure 13 The proposed system model

5.5 Scheme Process

A scheme process is shown below to explain the steps required for the delivery of a large-scale home retrofit scheme. This process also includes stakeholder involvement.

Table 32 The proposed scheme process

Step	Owner Occupier Scheme Process	Alternative Steps in Scheme Process	Landlord Scheme Process
1	Engage with industry, state and local govt, community groups- marketing campaigns		Engage with industry, state and local govt, community groups- marketing campaigns
2	SPV works with local govt, community groups, or others to engage community for retrofit roadshow		SPV engages with property managers Property managers engage landlords
3	Community provide EOI to SPV		Property managers provide EOI from landlords to SPV
4	SPV contacts community EOI participants	Homeowner contacts SPV regarding retrofit EOI	

5	Trained assessor performs remote or in-house walk-through assessment	Homeowner performs remote assessment using accredited software	Trained assessor property managers perform walk through assessment at next tenant
6	Trained assessor provides independent technical guidance based on home assessment	Software provides independent technical guidance based on home assessment	Trained assessor provides independent technical guidance based on home assessment
7	Trained assessor provides specification for retrofit based on discussion with homeowner	Software provides specification for retrofit based on direction from homeowner	Trained assessor provides specification for retrofit based on discussion with homeowner
8	SPV contacts homeowner regarding funding/finance options	SPV contacts homeowner regarding funding/finance options	SPV contacts homeowner regarding funding/finance options
9	Homeowner assesses One Million Homes+ app to find local accredited trades person for retrofit	SPV searches accredited trades person panel on behalf of homeowner	Property Manager accesses One Million Homes+ app to find local accredited tradesperson for retrofit
10	Tradesperson agrees quote with homeowner, home retrofit scheme app approves	SPV agrees and signs funding/finance/discount with SPV partners and homeowner	Tradesperson agrees quote with property Manager, One Million Homes+ app approves
11	Retrofit is installed, completed	Waste items are/is recycled/repurposed	Retrofit is installed, completed
12	Contractor QA process with certified photographic evidence of renovation	Independent auditor certifies renovation for consistency of standard	Contractor QA process with certified photographic evidence of renovation
13	SPV provide funding/finance as per agreement	Homeowner pays final bill Bank/insurer/ATO provides discounts/write off as per agreement	SPV provide funding/finance as per agreement
14	SPV follows up with homeowner, contractor, and measures impact	SPV follows up with homeowner and contractor	SPV follows up with homeowner, contractor, and measures impact

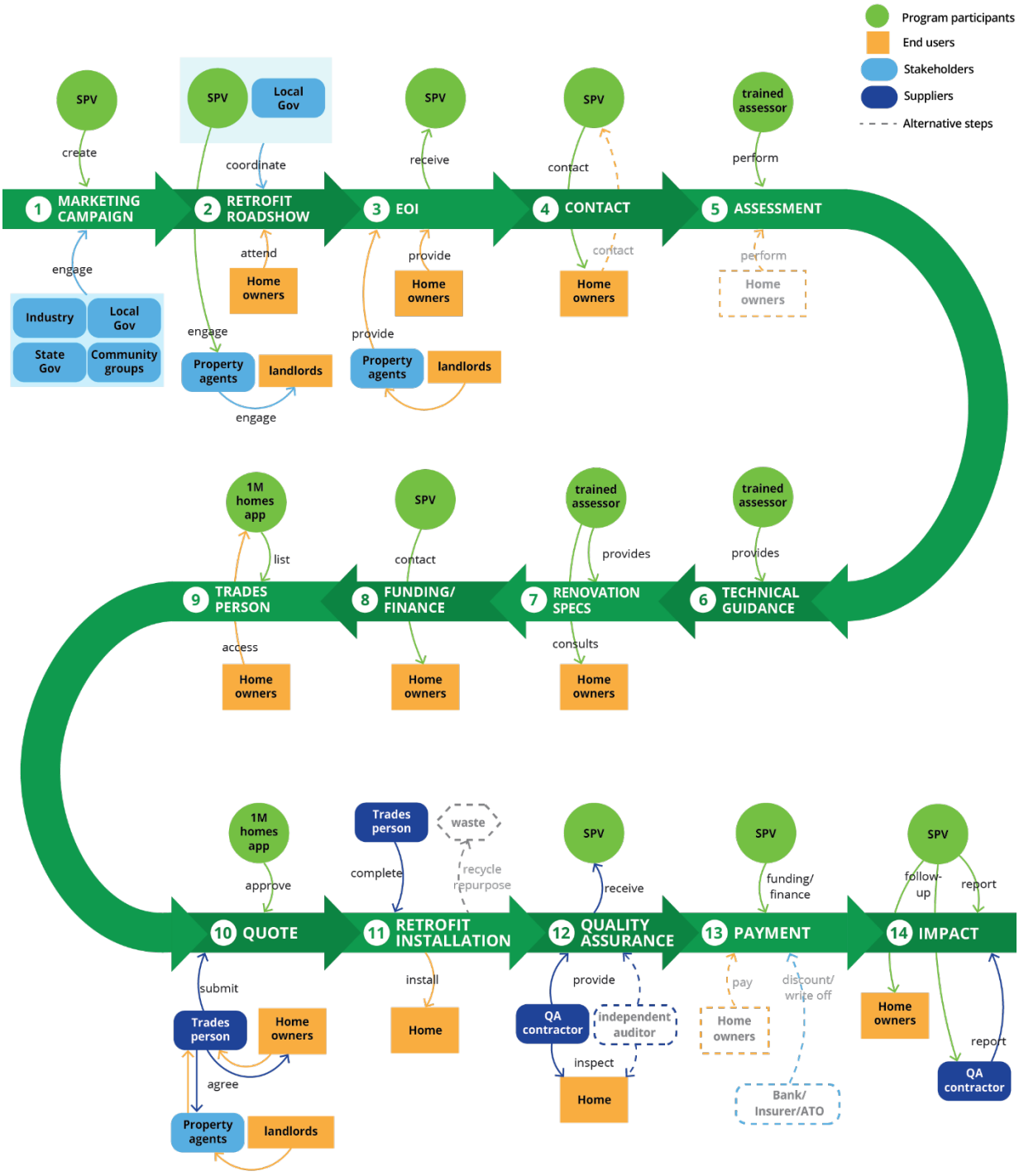


Figure 14 The proposed scheme process

6 Recommendations for Next Steps

"None of this is rocket science! It is most important to communicate and engage with people about this."

From the findings of our collective research, we have been able to identify the barriers and opportunities and to propose a large-scale home retrofit scheme delivery model. This has led us to identify twenty work packages that will be detailed in this section. These packages form a portfolio of interconnected work that will require overall governance and aligned implementation to support a large-scale home retrofit scheme.

As part of the proposed work package priorities, further engagement and development roles would continue to enable industry involvement as well as further research with progression toward prototypes and a large-scale pilot for the delivery model.

6.1 A Portfolio of Research

To maintain momentum, it is also proposed to progress research that is required to support scheme development and roll out, including exploring:

- Quantify the potential economy scale health benefits of a large-scale home retrofit scheme being delivered in Australia.
- Deeper analysis of the retrofit packages that provide optimal ROI at the household scale in different climate environments and for different housing types.
- Model how home energy efficiency measures alongside home electrification (including EV charging and solar PV with storage) can or will support and impact the grid.
- How to design the scheme to also ensure benefits to the indoor air quality (IAQ) and moisture management of a home when retrofitting for the purpose of thermal and energy efficiency, as well as optimising health and comfort benefits.
- How does the scheme determine a poor-quality home? Do we consider dates based around NCC guideline changes, for example pre/post 2010? Do we consider dwelling construction type based on available data?

As part of the proposed work package priorities, further engagement and development roles would continue to enable industry involvement as well as continuation of research with progression toward prototypes and a large-scale pilot for the delivery model.

6.2 A Portfolio of Action

Our portfolio approach has identified six leverage points with twenty work packages between them, these packages are shown below in Figure 15. These packages cover **portfolio oversight**, which includes understanding and ensuring alignment and learning across the range of activities outlined in the other work packages.

The **operational model** group of work packages aims to understand the detail of the operational model of a retrofit scheme, while the **delivery** group of work is focussed on

prototyping, piloting, improving and then expanding the delivery of large-scale home retrofits. Alongside the operational and delivery work are packages of work aimed at creating the enabling environment for large-scale retrofits and building new narratives and norms that support the scheme. These include the **communications and engagement** activities aimed at building a national narrative while also understanding local and community scale nuances that will allow impactful messaging about retrofits. There is also work to understand and engage with the **policy and regulatory** environment. This includes appreciating the current conditions what will need to be accounted for in the scheme design, as well as understanding what the optimal environment is, and how to transition towards it. Finally, there is a package of work aimed at improving **technical** understanding of supply chains, managing waste, and retiring and recycling items and monitoring and measuring impact.

Figure 15 The large-scale home retrofit scheme portfolio of 20 work packages

Table 33 and Figure 16 shown below details the priority work package items that will maintain momentum of the work undertaken in the fast-track project, whilst transitioning to the standard-track project to enable further research, industry and government engagement and delivery of a large-scale pilot. They include:

Table 33 Priorities to maintain momentum

Market analysis and discovery	
	Engage with customer focus groups and public surveys, what are the consumer preferences and where is the target market demand in the current landscape (COVID)? Test the delivery model at household and community level
Driving the narrative and building profile	
	Work with partners to engage the target market(s), create a movement around energy and thermal efficiency broadly, and build the profile of the large-scale home retrofit scheme
Identify, align with and support policy and regulatory changes	
	work with enablers to progress disclosure and other policy changes
Recommend and enable industry standards and accreditation	
	Engage and align with industry to support and advise on progress towards achieving the required standards and accreditations
Finance system, customer segmentation model	
	Explore the proposed finance models with potential investors and/or financers
Business development – Partnerships and funding	
	Climate-KIC Australia and its partners are exploring the opportunity to progress the work as a standard track project for implementation in the RACE for 2030

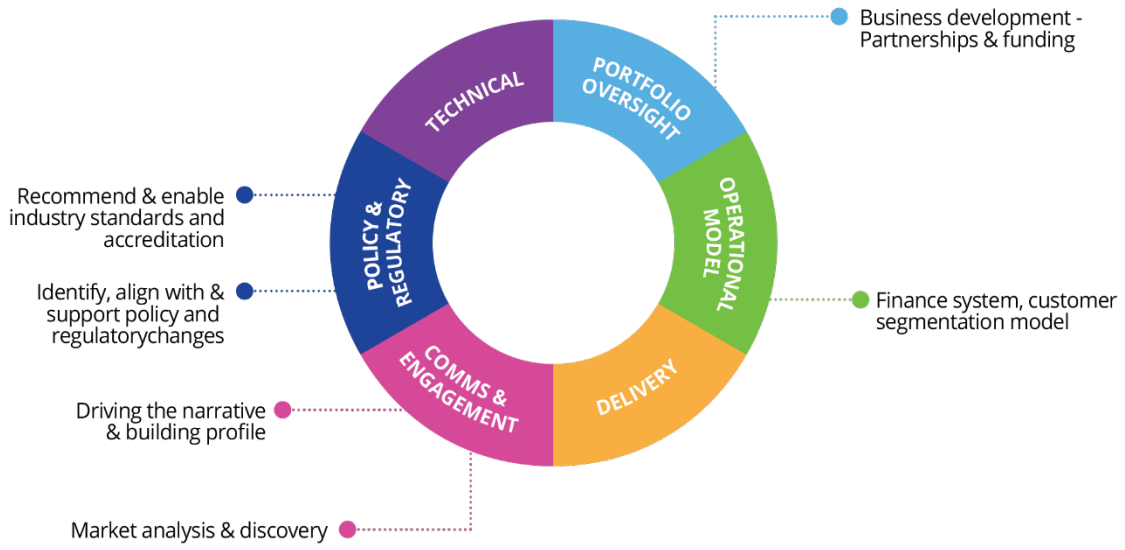


Figure 16 Priorities to maintain momentum

Figure 17 shown below indicates the approximate timeline of partnership activity and governance required to support and enable a large-scale home retrofit scheme inception.

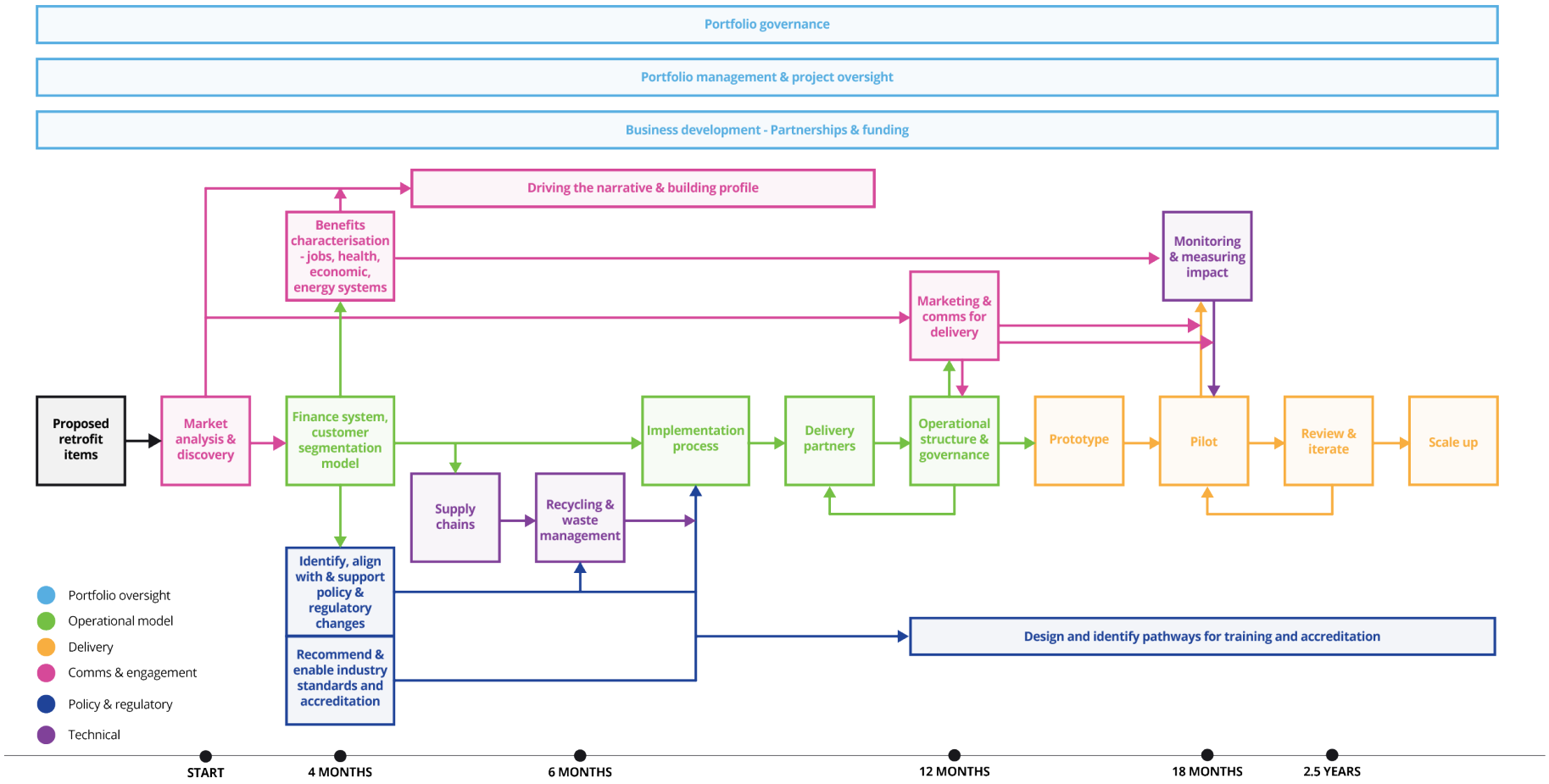


Figure 17 Preliminary timeline of implementation of work packages, and interrelationships

7 Conclusions

The fast-track project has provided opportunity to explore and learn from previous and existing programs as well as consider the current landscape, the portfolio of action and the delivery model required for a large-scale home retrofit scheme in Australia. This has shown us that the task ahead is large and highly complex, yet feasible through collaborative efforts. And now more than ever before.

The fast-track project has allowed the development of scheme design principles which will guide further scheme development, testing and piloting. The home retrofit scheme must have clear and demonstrable goals as is shown in Table 34.

Table 34 Scheme design principles

The home retrofit scheme aims to create:
Future ready homes, meaning homes that are comfortable as well as highly thermal and energy efficient, with a path toward electrification
Improved NatHERS rating for each home
Market transformation
Culture shift toward demanding comfortable and energy efficient homes
Large-scale delivery of home retrofits across all states and regions in Australia
The home retrofit scheme will target:
National Construction Code (NCC) Class 1a single dwellings that are owner occupied or tenanted, mortgaged, or owned outright
Poor quality homes
The home retrofit scheme must build and maintain trust with homeowners:
Scheme must benefit the homeowner through a streamlined process, including finance and retrofit options
Scheme must provide an offering that the homeowner wants and/or needs
Retrofit options provide best case outcomes with comfort and ROI benefits understood for each homeowner
The home retrofit scheme must engage at trigger points:
Point of sale/purchase of home
Point of advertisement for lease
Point of renovation
The home retrofit scheme and its partners and advocates must provide clear messaging and influence for government, industry, and homeowners:
Use a values-based approach to understand customer motivations and an effective way to overcome intervention barriers
Optimised Australian home comfort benefits must be further researched and communicated to the target market and government
Whole of home assessments and a quality control process is critical:

An accredited assessment process that enables the homeowner to understand and receive independent technical guidance

A scalable yet stringent quality control process is required to ensure consistent and continued quality of workmanship and the scheme delivery model

The application of these design principles will be refined and developed through further research and market discovery, then tested in pilot applications before broader roll-out.

Alongside this development and refinement process the broader suite of enabling actions must progress. In combination this will create the environment and the mechanism to allow for the thermal and energy efficiency retrofit of millions of homes across Australia.

Appendix A Project Partner Committee and Industry Reference Group Members

Project Partner Committee

Organisation	Name	Role
Climate-KIC Australia	Karla Fox-Reynolds	Principal Innovation Projects
NSW DPIE	Anne-Marie Poirrier	Manager – Home Energy Action Project
Vic DELWP	Katrina Woolfe	Manager Residential Energy Efficiency
UTS ISF	Kerryn Wilmot	Research Principal
Curtin University	Roberto Minunno	Researcher

Industry Reference Group

Organisation	Name	Role
BZE	Sanaya Khisty	Chief Strategy Officer
	Kelvin Wicks	Research Assistant
	Tom Quinn	Chief Research Officer
Australian Energy Foundation	Daniel Chadwick	General Manager – Major Projects
Bank Australia	Darren Dawson	Head of Impact Finance
Independent Investor	Jeremy Burke	
Small Giants	Kaj Lofgren	Head of Strategy
BOOMPower	Alex Houlston	Co-Founder and Director
Ecologic	John McKibbin	Founder and CEO
eleXsys Energy Pty Ltd trading as Planet Ark Power	Richard Romanowski	Executive Director and Co-founder
	Paul Hodgson	Director – Busines Development
Sustainability Victoria	Toby Cumming	Research Data Advisor Sustainable Homes
Energy Efficiency Council	Rob Murray-Leach	Head of Policy
Jason Windows	Joe Reardon	Product Development and Quality Manager
EnergyOS	Martin De Groot	Chief Technical Officer

PowerPal	Pete Neal	Chief Executive Officer
Green Gurus	Chiara Pacifici	Director
Energy Policy WA	Vicki Greenhalgh	Senior Policy Analyst
	James Eastcott	Energy Specialist
Climate Council	Morgan Koegel	Senior Campaigner
Light House Architecture and Science	Jenny Edwards	Director

Appendix B Stakeholder Map – Strengths and Weaknesses

Stakeholder	Strengths	Weaknesses	Potential role
Federal Government	• Able to establish large, national schemes • Larger scale funding and/or finance support possible under the right conditions	• Currently energy efficiency retrofits for housing are not a political priority • Less experience in energy efficiency program design (than states) • Priorities change over time, which can lead to lost funding or support • Involvement of public money requires stringent oversight and probity	Loan securitisation Funding support for establishment Setting supportive policy and legislative arrangements
State Government	• Access to data (although variable between states) • Funding available, although currently not a priority area in most States • Good capability for policy and program design • Potential for large-scale influence • Ability to support projects through legislation, trade accreditation, training programs etc	• Priorities change over time, which can lead to lost funding or support • Involvement of public money requires stringent oversight and probity • Often risk averse	Housing energy and thermal efficiency standards Trade licencing and accreditation Link to existing schemes Setting supportive policy and legislative arrangements
Local Government	• Well positioned to mobilise community • Trusted avenue for communication • Very strong links with homeowners at the local level • High levels of trust form the community • Can support mobilising local suppliers	• Lack resources to administer and deliver (especially small councils) - limited cash and staff • Limited marketing skills and resourcing • Not all residents engage with the council • Many competing priorities • May be too locally focussed if delivery scale requires regional approaches	Recruiting homeowners Engaging local suppliers
Community NGOs	• Good at community engagement and grassroots activity • Experienced in campaigning to government for action • Experience working with vulnerable populations and low-income households • Good at effectively communicating complex messages to target audiences.	• Limited resources to perform rigorous data collection or modelling	Recruiting homeowners Supportive messaging to government

Electricity network operators	• Access to data to inform programs	• Not always incentivised to reduce energy consumption • Limited relationship with end customer • Risk of vertically integrated monopolies if too involved in household retrofits	Data collection
Electricity Retailers	• Large customer base • Access to capital • Easier to access data, although still requires careful management • Want to build customer loyalty	• Limited customer trust • Low margin, high churn business often with very short-term time horizons • Limited customer engagement / typically shallow relationship	Allow retrofits repayments through energy savings on bills Communications with customers
Gas Retailers	• Large customer base • Easier to access data, although still requires careful management	• No smart meters • Lack of interest in improving transparency of energy consumption • Net-zero GHG requires shift from gas to electricity	
Banks	• Large capital available • Can offer finance based on evidence (eg Bank Australia Clean Energy Loans)	• Often need high starting value of programs (hundreds of millions of dollars of value) • Prefer low risk investments • Programs need to turn a profit	Finance for retrofits – through home loans or separate loans Financial assessments
Superannuation	• Large capital available	• Minimum $200 million investment as a start to cover their admin costs, so not great during start up • Low appetite for risk, need bankable, high-scale investments	Finance loans
Industry Associations	• Can become strong advocates and can be a trusted voice to government • Usually have representatives on government standard and other committees • Can support improved compliance from and engagement with industry • Motivated to engage with consumers and build trust	• Are at the direction of their members interests, which may not align with a retrofit program or more stringent energy efficiency requirements • Can be fragmented and not wholly representative of industry • Low trust from consumers	Inform program design and roll out Aligned messaging to government for standards etc
Manufacturers	• Potential for economies of scale at the wholesale level • Home building activity may decrease, in the near future. Recent increased capacity will need a new market	• Tendency to want to sell specific product rather than comprehensive package • Few products are locally manufactures – limited scope to influence bespoke products for Australian	Scale up production as required by retrofit demand

		environments. E.g., no local manufacturers of air conditioners and few of hot water	Aligned messaging on benefits of retrofit
Retrofit service providers (incl assessors)	• Can become a 'one stop shop' to deliver range of services for households • Can provide scalable and tailored advice and support which enables actions • Some orgs can provide assessment through to analysis plus upgrades	• Tendency to rely on 'boots on the ground' traditionally, which can add significant admin costs / overheads • Fragmented and often focussed on specific services (rare that they can package up different upgrades) • Only a few that provide high-quality work • Customer services is not a core strength and initial engagement can turn off households • Some services are new and emerging - e.g., draught sealing	Simplify experience for homeowners Provide advice
Installers / builders	• Often used for large scale rollouts • Experienced in physical realities of installation	• Often used to selling and installing specific products (not full packages) • Limited skills in upselling high-performance products • Lack of quality control • Currently low capacity / skill, especially for insulation and draught proofing	Engage homeowners through broader renovation discussions Communicate benefits
Auditors	• Great allies for these types of programs • Valuable expertise • Can assist in verification of installations for evaluation • Can leverage state government inspections (i.e., plumbing audits)	• Emerging field • Not many available • Can be expensive	Assess retrofit requirements Communications with energy users Check quality of installations
Homeowner – occupiers	• Close to the ground • Able to make decisions quickly	• Cash poor • Lack knowledge of what's in their homes • Low interest in general in energy and thermal efficiency retrofits	Self-assessment? Decide finance arrangement for their property Fund some upgrades
Homeowner – landlords	• Able to make decision about upgrades • Improving the 'asset value' is a motivator	• Hard to reach unless through property managers – property managers can act as 'gate keepers' and make decisions for landlords • Many are also low income and do not have money to upgrade • Generally, not knowledgeable about their house	Fund some upgrades Decide finance arrangement for their property

		• Some don't care about their tenants • Don't pay electricity bills, or experience thermal comfort	
Renters	• Keen for affordability • Introduction of rental standards can support action	• Can't make decisions about many retrofits • May not want to 'rock the boat' by asking for things from landlord • Can be hard to reach	Pressure landlords for energy efficiency upgrades through rental property preferences
Social Housing providers	• Have ability to organise maintenance so could engage with limited pain • Clear altruistic focus on benefitting their tenants	• Lack of time, money and focus on energy efficiency – core business is more housing and standard upgrades (as it should be) • Can find energy efficiency complicated	Support piloting of model retrofits where funding is available
Registered Training Organisations	• Can help skill up quickly – lots of training online	• Quality of training can be variable – some are just ticking boxes	Training for assessors, auditors, and installers
Universities	• Provide quality training • Can help build evidence base for retrofits at scale • Support pilots	• New accredited courses are slow to get up and running • Need publication outcomes • Can be constrained in capacity	Monitoring and evaluation Training and course design

Appendix C Current Relevant Activity in Australia

Scheme or Program Title	Location	Partners	Purpose and Status
Clean Energy Home Loan	Australia	Bank Australia Clean Energy Finance Corporation (CEFC)	With the support of the CEFC through a $60 million investment that was later extended to $90 million due to the strong take-up, Bank Australia was able to support Australians to get a discounted home loan if they buy or build housing that meets high energy efficiency standards, with low interest rates. The home owner receives a 0.4 percentage point discount on its home loan rate. To earn the discount, a home must fit in to one of the following two options: • NatHERS 7 Star+ - for newer homes that meet a high standard of energy efficiency • Property Upgrade - for existing homes that have made ambitious green upgrades in the last 12 months and can show a 1-star improvement based on Residential Efficiency Scorecard assessments 140 households have taken up the Clean Energy Home Loan which represents 1.3% of the bank's loan book, and 10% of the of the overall loan growth in FY 2021.
CommBank Green Loan	Australia	Commonwealth Bank	Customers with an eligible CommBank home loan or investment home loan can use the CommBank Green Loan to buy and install eligible clean energy products at the property secured by their existing home loan. The loan offers a 0.99% PA 10-year fixed rate no establishment fee, monthly loan service fee or early repayment fee. The minimum loan size is $5,000, maximum loan size is $20,000.
Renovate or Rebuild TV series	Australia	NSW Department Planning, Industry and Environment (DPIE) CRC Low Carbon Living	'Renovate or Rebuild' aims to crack open sustainable building options to a broad mainstream audience. It combines reality-TV with behavioural science by encouraging Australian homeowners to choose healthier and more energy efficient homes.
My Efficient Electric Home	Facebook	(FB Group Admins) Tim Forcey Katy Daily Richard Keech	Formed in 2015, membership at the Facebook group "My Efficient Electric Home" has over 35,000 members, with over 300 new members joining in most weeks. The group has become a comprehensive database of information about improving the comfort and energy performance of Australian homes. Members help each other with issues and openly

		Alison Dredge Simon Samson Talina Edwards Alessandra Whiting	discuss methods to achieve a thermal and energy efficient home, including the transition to an all-electric home.
Insulation Roadmap	Australia	NSW Govt Victorian Govt Insulation Australasia (IA) Insulation Council of Australia and New Zealand (ICANZ) Energy Efficiency Council (EEC) Australian Sustainable Built Environment Council (ASBEC)	'Ensuring quality control and safety in insulation installation. A research report to support an industry-led roadmap for healthy, comfortable buildings.' The aim of the industry-led insulation roadmap is to facilitate actions from industry, government and the community that will ensure that insulation is installed following appropriate quality-control and safety processes.
Further, faster, together: Opportunities for collaboration between Germany and Australia on energy efficiency in buildings	Australia/ Germany	German Federal Ministry for Economic Affairs and Energy (BMWi) German-Australian Chamber of Industry and Commerce (AHK) EEC adelphi	The report provides: • A high-level survey of selected initiatives as a means of orienting experts in each nation as to the policy landscape in the other; and • Recommendations on where collaborative efforts should focus, considering the relative strengths and priorities of each nation. Recommendation 1: Commission research and facilitate dialogue on energy efficiency financing in Germany, and lessons for Australia. Australia is exploring the role of finance in facilitating energy efficiency upgrades and construction of residential buildings. Germany has a well-established and sophisticated market for energy efficiency finance, driven by its KfW Bank. Research and engagement on this topic will support Australia's efforts on the creation of a home energy rating scheme, and finance systems that support home energy upgrades. It will also build relationships between policymakers and financiers in the two nations
Trajectory for Low Energy Buildings	Australia	Australian Government	The former Council of Australian Governments Energy Council (COAG Energy Council) developed and endorsed the Trajectory for Low Energy Buildings (Trajectory) and the Addendum to the Trajectory for Low Energy Buildings—Existing Buildings (Trajectory Addendum). This is a national

			plan that aims to achieve zero energy and carbon-ready commercial and residential buildings in Australia.
NCC 2022	Australia	Australian Building Codes Board (ABCB)	In accordance with the policy direction of Ministers, the Australian Building Codes Board (ABCB) is currently investigating possible changes to the residential energy efficiency provisions in the 2022 version of the National Construction Code. (NCC 2022).
The National Scorecard	Australia	Collaboration of the Commonwealth, State and Territory Governments	The Residential Efficiency Scorecard (the Scorecard) provides an energy star rating for homes. Assessments and information on ways to reduce energy costs and increase home comfort are tailored specifically for each home and are delivered by accredited assessors. A field trial to pilot using the Scorecard across Australia concluded in June 2021. The results are currently being evaluated and will inform work to extend NatHERS, ahead of the National Scorecard seeking accreditation under NatHERS for existing homes. The National Scorecard covers Australia and is based on the Victorian Scorecard and previous national pilots.
NatHERS extension to existing homes	Australia	Collaboration of the Commonwealth, State and Territory Governments	Extending NatHERS to assess existing homes creates an opportunity for governments to support a range of both government-driven and market-driven initiatives that encourage improved energy efficiency. Soon NatHERS will also provide information about the overall energy performance of the home, including appliances and renewable power generation, and assessment processes that cater for existing homes. An assessment and rating for an existing home will provide information about the thermal performance, appliances and renewable power generation, and also provide the additional benefit of being able to identify what improvements can be made after the home has been built. To support the delivery of home energy ratings for existing homes under NatHERS, a Scoping Report was developed. This report found the option to extend NatHERS to existing homes, while continuing to test and learn from the national version of the Residential Efficiency Scorecard, is the most efficient and effective use of resources. Work is now underway to establish NatHERS protocols and processes for existing home assessments. This includes further testing and refining of the national version of the Residential Efficiency Scorecard, so that it may be accredited under NatHERS. Following a transition period, any tool operator in the market may then develop other energy rating tools for existing homes and seek accreditation under NatHERS. The first version of the requirements for NatHERS to be extended to existing homes is due to be finalised in mid-late 2021, following analysis and stakeholder consultation.

Environmental Upgrade Finance (EUF) (otherwise known as Environmental Upgrade Agreements)	Victoria	Vic Department Environment, Land, Water and Planning (DELWP)	Prior to 6 April 2020, EUF was only available to commercial property owners, however, recent amendments to the *Local Government Act 2020* enable EUF to be offered to homeowners too. Environmental Upgrade Finance (EUF) is a council-based financing mechanism that gives commercial and residential building owners access to finance for sustainability or climate adaptation upgrades to existing commercial and residential buildings. Under an EUF agreement, the lender provides finance to the property owner and the local council collects repayments through the rates system. The council then passes the repayments onto the lender. As EUF loan repayments are attached to the property, not the person or company, they may be attractive to businesses, landlords or homeowners who may wish to sell the property within the period of the loan. EUF also provides a way to address differing incentives between landlords and tenants. Tenants benefit from EUF through reduced energy, water and waste costs, and improved living or working conditions (such as increased thermal comfort). Building owners increase the value of their asset and, in some cases, reduce other operational/maintenance costs. Broader public benefits of EUF include job creation and increased access to finance for building improvements.
Energy Savings Scheme (ESS)	New South Wales	NSW Government	The ESS is a certificate trading scheme designed to reduce electricity and/or gas use by creating financial incentives for households and organisations to invest in upgrades to save energy. Home Energy Efficiency Retrofit (HEER) activities can be delivered under the ESS by Accredited Certificate Providers (ACPs) to help NSW households and small businesses save energy by supporting a range of energy efficiency upgrades, including lighting, draught proofing and equipment upgrades. The home occupant nominates the ACP as the energy saver for the upgrade to enable them to create Energy Savings Certificates (ESCs) from the energy savings that will be made.
Home Energy Action Appliances Program (concluded June 2021)	New South Wales	NSW Department of Planning, Industry and Environment (DELWP)	Between 2016 and 2021, the Appliance Replacement Offer teamed up with partners across NSW including Charities and Community Service Organisations to make energy efficient appliances available to the most vulnerable households in our community. DELWP thanked the partners for their support which helped them to meet the goal of assisting vulnerable households. Many of the partners contributed substantial resources to training staff, as well as covering the financial gap for some participants.

Latrobe Valley Home Energy Upgrade Program (concluded 2020)	Victoria	Sustainability Victoria Latrobe Valley Authority Latrobe City, Wellington, and Baw Baw local Governments Hills Energy Solutions	The $5 million Latrobe Valley Home Energy Upgrade Trial Program supported 1000 low-income households to reduce energy costs and/or improve the thermal comfort of their home. The program successfully delivered energy efficiency upgrades up to $4500 per household. With every living situation different, upgrades included but were not limited to: • replacing older fixed appliances, such as heating, cooling and water heating • improving the performance of the building, such as insulation • installing solar PV systems or heat pump water heaters. This led to 2706 products installed across the 1000 homes, with many homes receiving the benefit of a heating upgrade (split system) and an improvement to the home's thermal shell (insulation). Key findings: • There were high levels of participant satisfaction, with people reporting increased comfort and well-being. • The broad range of offerings made the program complex but allowed more opportunity to meet the needs of participants. • On average, there was an 11% reduction in electricity usage. Considerations: Not all energy consumption went down: • Some residents had inefficient heaters and couldn't afford to heat their home for long. But with the updates, they were able to heat their home for longer, for the same amount of money. • Some residents now have access to air-conditioning and cooling, when previously they had gone without. The condition of homes also determined what upgrades could be installed. To ensure safety of installers or occupants, part of the allocated $4500 needed to be spent on updating switchboards, wiring or gas piping. This took away from available spend on energy efficiency or thermal comfort upgrades. It would be recommended that future programs include a contingency for such safety works.
Household Energy Efficiency Scheme (HEES)	Western Australia	Energy Policy WA	Reducing energy costs – a $13 million program to improve energy efficiency for households facing hardship, the program seeks to help around 10,000 households over four years.

		WA Council of Social Services (WACOSS) Synergy Horizon Power	Detailed design and planning for the program and small-scale pilots are underway and being led by Energy Policy WA in close partnership with Synergy, Horizon Power, and the Western Australian Council of Social Service. The commencement of small-scale pilots are anticipated in late 2021, with learnings to inform how the program can be scaled up across Western Australia. Building NGO capability and capacity in the delivery of energy efficiency advice and support to their clients is an important focus of the program to achieve scalability.
Sustainable Household Scheme	Australian Capital Territory	ACT Government Brighte	The scheme is providing zero-interest loans of between $2,000 to $15,000 to eligible ACT households to help with the upfront costs of investing in energy efficient home upgrades. The scheme will be open for five years and loans must be repaid over 10 years. Currently in pilot stage to test user and product experience. Loans will be available through the scheme for the following products: • Rooftop solar panels • Household battery storage systems • Electric heating and cooling systems • Hot Water Heat Pumps (HWHP) • Electric stove tops • Electric vehicles • Electric vehicle charging infrastructure • Installation costs for these products.
The Victorian Government Home Energy Assist Program which began in 2017, is investing $17 million over four years to support 3,300 Victorian households who are most in need. This is part of their ongoing commitment to improve well-being for Victorians on low income through more affordable energy bills and more comfortable homes. The program includes the following 3 programs:			
Healthy Homes Program	Victoria	Sustainability Victoria Australian Energy Foundation	The program is a home energy efficiency program. It provides free home energy upgrades to up to 1000 Victorians who live with complex healthcare needs and have low incomes, in Melbourne's western suburbs and the Goulburn Valley. The program aims to improve indoor winter temperatures and reduce household energy bills. Recruitment of eligible households began in January 2018 and was completed in March 2020. Upgrades to successful households will take place until late 2021.

			Potential participants within the program's target areas, were contacted by their local council or community health provider and referred to the program if they expressed interest and met the eligibility criteria.
EnergySmart Public Housing Project – Concluded in 2020	Victoria	Vic Department Health and Human Services (HSS) Australian Energy Foundation	The project replaced inefficient electric water heaters and electric heaters in 1,300 public housing properties and delivered tailored upgrades that included roof insulation to a further 200. The project achieved substantial benefits for tenants and reduced environmental impact for the state of Victoria and was a finalist in the Premiers Sustainability Awards 2020.
Energy Savvy Upgrades Program	Victoria	Vic DELWP	The Victorian Government is providing assistance to households experiencing energy stress. The program is partnering with community organisations to offer subsidised energy efficiency and renewable energy upgrades to a limited number of households struggling to pay energy bills. Participating households can expect to receive: • an in-home energy assessment. The cost of the assessment is $100, however households conducting upgrades as a result of the assessment will have the fee credited against the cost of the upgrades • free guidance on the best energy plan to suit their needs • a generous Government subsidy towards the cost of a home retrofit, which could include renovations such as sealing draughts, improving insulation and upgrading appliances to more energy efficient models. Upgrades will be performed by licensed and qualified tradespeople, and arranged by program staff on behalf of participating households • free assistance to participate in the solar homes package The programs pre and post upgrade energy data collection progression is currently being impacted by COVID.

Appendix D Key Messages from the IRG Interviews and Workshops

A successful scheme will need to have clear and demonstrable goals and target market that have been adapted from other programs learnings	'Use learning from other successful or failed programs'
	'A lot of this depends on the specific goals of the program as well, is it increasing the speed and scale of retrofits within a period of time or widespread take up'

	'Cash (homeowners with mortgage, access to cash) is easiest to target first but leaves behind those who are probably living in the worst housing stock'
Pilot(s) are required to test the delivery model of the proposed scheme	'The program needs to be able to measure impact post upgrade' – a pilot could enable this part of the process
	'Trial and understand the complexities of the upgrade work being completed and enable something within the process to support those high priority items so that minor issues don't make them too hard'
	'Would you look for a government to fund some places in the pilot?'
	'The delivery model could take on a sequence as follows: - Assessment and rating - Detailed advice and specification - Implementation and installation'
	'Need to test a variety of delivery models'
	'Use a pilot scheme to gather data and to develop case studies for messaging'
The scheme should address draught sealing and insulation first before the big-ticket items	'Sometimes the strength of individual retrofit elements (e.g., Insulation, draught proofing) is that they don't require householder interaction with smart technology'
	'Insulation and performance glass and windows are for the life of a building'
	'Over reliance on technology misses' opportunities for upgrades that are not reliant on user capabilities'
The housing stock in Australia demands bespoke requirements because housing is so heterogeneous	'A pilot scheme is critical; it would be very useful to enable understanding of the different types of homes across the states and their inefficient quirks'
	'Every house is different and needs an individual approach, you find strange spots around the house through doing a home assessment'
	'There are big differences between all states in Australia'
Homeowners want a streamlined process from assessment to finance and installation, and quality assurance included	'Customers will be interested in exactly what benefits them and optimises their house. Need to keep the engagement stage simple and tailor solutions to buildings/users'
	'A well-designed scheme could enable homeowners to leverage options such as the EUF'

	‘A model that enables a central party to educate homeowners and listen to their needs is valuable’
	‘For a mass market program, do we need an automated package selection and customisation tool?’
	‘Better that a single party is responsible for engaging trades. Ease of execution will overcome some consumer resistance, rather than having to chase around after quotes and delivery themselves’
	‘The small scale retrofit side of the industry has a lot of room to grow due to demand. Clients are sick of being cold and uncomfortable’
	‘Require a desk top audit from the contractor on completion of every job, including photos. This enables a quality assurance process for the program, homeowner and contractor’
	‘Audit 10% of upgrades to ensure standard of work delivered’
Current market demand analysis and strong messaging in the mainstream is required	‘How many homeowners want to do a home retrofit for the purpose of energy efficiency?’
	‘You must understand the consumer demand, growth projections and roll out; what drives consumer behaviour in this area?’
	‘None of this is rocket science! It is most important to communicate and engage with people about this’
	‘A very strong marketing campaign is required for successful engagement with market’
	‘Recommend that you use some focus groups or customer testing for all of this’
	‘Is there benefit to an overarching awareness campaign that sits above providers?’
	‘Priority marketing message on home comfort for building life expectancy. Sustainability of the benefit’
	‘Engagement will be the most challenging thing’
	‘Comfort and savings message also about value it adds to your home - high resale value (atm this is negligible - need this to be a driver)’
	‘Challenging messaging around net zero’
	‘Environmental incentives can be a driver but be careful to appear as greenwash’

	‘Deploying retrofits in locations/communities where education and engagement can be supported peer-peer’
This program needs to use industry accredited assessors and installers only	‘Some accreditations are yet to be developed’
	‘Need a rigorous training and certification scheme for all retrofit providers (e.g., insulation installers)’
	‘Importance of compliance auditing to manage risks (and ability to take action where required)’
	‘Residential Efficiency Scorecard to become a national rating program for existing homes’
	‘Well trained assessors will be able to explain the unique situation in a house, and the dynamic between appliances and house structure / design’
	‘Do we need specialist input regarding particular items after recommendation? i.e., windows, PV and battery sizing’
	‘Are there enough assessors? Are they sufficiently competent? Training needed to have more’
	‘Poor compliance could derail the whole scheme’
The challenge requires a sustainable funding model consisting of public/private finance, with a mix of incentives for the varied market	‘Banks, investors, superannuation funds and philanthropists are keen to support and invest in large scale finance for home retrofits, if they don’t have to be customer facing’
	‘The challenge requires a sustainable funding model, not reliant on government funding’
	‘Who will fund the assessments?’
	‘Low-income programs have some inherent challenges that may make roll out more difficult’
	‘Finance model is a priority – making the model work for the customer and building confidence for them’
	‘Gov $$ are going to be critical to meet low-income families’
	‘We need to mobilise private sector capital to make this work - admin costs make this hard for large orgs like CEFC with big overheads, so we need a nimble and innovative finance group, which can grow with the program, and facilitate super funds etc when the scale necessary is achieved’
	‘Finance needs to be attached to the house, mortgage or residential EUA/EUF’

	‘An SPV could be funded by investors at a scale of >$50 million. How do we fund the scheme to get to that point?’
	‘Consider a securitisation model, impact investor for the first $5 million’
Homeowners need independent, practical, technical guidance to inform them of the best upgrade for their property	‘Energy advice services fall flat because of lack of engagement; incentives are required and a clear demonstration of value to consumer’
	‘We need a cultural shift toward energy efficient and healthy homes’
	‘The customer needs to be able to trust the program provider and parties involved’
	‘Every home and customer is different, the approach needs to allow for a mix of solutions tailored for each home’
	‘Homeowner interface to assist user to make informed decision on justifying what value they will obtain from their investment’
	‘The process of a retrofit is currently very hard to navigate, there is nobody available to guide the homeowner through the process. We need to be able to provide a specification to the homeowner and then how they go ahead with the retrofit, at least’
Large-scale retrofits can generate new jobs in the supply chain, more jobs in the market and opportunities to sufficiently train the workforce that is required	‘Current workforce requires upskilling’
	‘Also, worth thinking through how to ensure the delivery model does not exclude local delivery partners and agencies at the expense of efficiency and scale’
	‘Fed Gov focus on manufacturing is a good link for home retrofits with strong local procurement targets’
	‘Need to consider the 'end of life' for removed and installed products (product stewardship)’
	‘Drive innovation in design of product to minimise environmental impacts such as reduction of waste etc.’
	‘We require a functional industry to deliver it’
	‘A well-trained assessor will be able explain the unique situation in a house, and the dynamic between appliances and house structure/design.

National household data is lacking in Australia – A home assessment (remote/in home) is a vital tool in the process that can provide some of the data required as well as the ability to provide the right options/advice for a homeowner	'Strongly recommend using the NatHERS existing homes program for assessors - and get a rating. It will eventually link to mandatory disclosure and the broader financial sector. A large scale retrofit scheme would ideally leverage this scheme as a recruitment channel to support both sides'
	'Perform a home assessment early in discussions with the homeowner'
	'Use of a robust home assessment tool will be required'
	'Assessments and ability to show people the benefits is helpful'
	'Who will fund the assessments?'
	'Delivery of assessments is key, doesn't need to be expensive walk-through process. Utilise a hybrid model for remote and walk-through assessment'
	'During a home assessment don't miss the opportunities to make simple adjustments that could be moving furniture to use a sunny space in a room, trim a bush that is blocking a window for example'
	'The Scorecard can be used to model the impact of upgrades and can use the original assessment as a basis for a post-upgrade assessment'
Australian evidence to support the health benefits of a thermal and energy efficient home is required	'NZ research shows health and social benefits outweigh energy cost savings of retrofits'
	'Require a pilot scheme with the ability to collect data and measure impact to generate health-benefit evidence'
	'Cost benefit analysis for health impacts is required for government engagement'
Home comfort is now a priority driver for homeowners and regulators	'Clients want to reduce their energy bills, but comfort is their driver'
	'Climate change has started to create the demand due to the uncomfortableness not felt previously'
	'NCC 2022 is driving Home comfort as a priority driver over energy cost off set. Thermal comfort for achieving suitable ratings cannot be compromised by fitting PV'
	'A/C; PV & other heaters, heat pumps, etc, are not long-term suitable solutions and have limited-service life. This is why home comfort is driving the priority with NCC 2022 provisions'

The scheme should enable a path to electrification for residential buildings, ultimately allowing for gas to be used for heavy industry that requires gas as part of the transition to net zero carbon	'Our priority is seeing mass elimination of fossil fuels so would be interested in removing gas in locations where there are highest penetrations of gas appliances'
	'This is an opportunity to shift from gas to electricity'

8 Bibliography

Alexander, D, Dwyer, S. Briggs, C. Riedy, C. (2020b). DER Customer Insights: Values and Motivations. Australian Renewable Energy Agency.

American Society of Heating, Refrigeration and Air-conditioning Engineers. (2019). *Ventilation for Acceptable Indoor Air Quality* Retrieved from https://www.ashrae.org/technical-resources/bookstore/standards-62-1-62-2

Australian Building Codes Board. (2020). *National Construction Code*. Retrieved from https://ncc.abcb.gov.au/

Australian Standards. (1991). Australian Standard AS 1668.2-1991.

Avramidis, I, Evangelopoulos, V, Georgilakis, P, Hatziargyriou, N (2018). "Demand side flexibility schemes for facilitating the high penetration of residential distributed energy resources." IET Generation, Transmission and Distribution **12**(18): 4079-4088.

Bartiaux F, Gram-Hanssen, K Fonseca P, Ozoliņa L and Haunstrup Christensen T (2014) A practice–theory approach to homeowners' energy retrofits in four European areas, Building Research & Information, 42:4, 525-538

Briggs, C., Dwyer, S., Pears, A., Alexander, D. and Berry, F. (2020a). Mapping Energy Efficiency Product Supply Chains, report produced for the Victorian Department of Environment, Land, Water and Planning.

Briggs, C., Rutovitz, J., Dominish, E., Nagrath, K. (2020b). Renewable Energy Jobs in Australia – Stage 1. Prepared for the Clean Energy Council by the Institute for Sustainable Futures, University of Technology Sydney

Chapman R, Howden-Chapman P, Viggers H, O'Dea D, Kennedy M. Retrofitting housing with insulation: a cost-benefit analysis of a randomised community trial (2009). Journal of Epidemiology and Community Health 2009;63:271– 277.

Choi, G, Heo E and Lee C (2018). "Dynamic economic analysis of subsidies for new and renewable energy in South Korea." Sustainability (Switzerland) **10**(6).

COAG Energy Council. (2019). "Report for Achieving; Low Energy Existing Homes" Commonwealth of Australia

Citherlet, S., Di Guglielmo, F., & Gay, J.-B. (2000). Window and advanced glazing systems life cycle assessment. *Energy and Buildings, 32*(3), 225-234.

Dena (German Energy Agency) (2021) "Information in the energy performance certificate" https://www.dena.de/en/topics-projects/energy-efficiency/buildings/consulting-and-planning/energy-performance-certificate/ Accessed 25/5/21

Denne, T and Bond-Smith S (2012) "Impacts of Warm Up NZ on Industry and Employment" Covec prepared for the Ministry of Economic Development.

Dowson, M, Poole A, Harrison D, Gideon S. (2012). "Domestic UK retrofit challenge: Barriers, incentives and current performance leading into the Green Deal." Energy Policy **50**: 294-305.

EnergieSprong (2021) Energiesprong explained. Accessed 17/5/21 https://energiesprong.org/about/

European Commission (2017). Policy Measure fact sheet EnergieSprong Energy Leap

European Commission Joint Research Centre, E. (2011). *European LED Quality Charter*. Retrieved from https://e3p.jrc.ec.europa.eu/sites/default/files/files/documents/Lighting/eu_led_quality_charter.pdf

Fyfe, C, Telfar-Barnard L,Howden-Chapman, P, Douwes J. (2020). "Association between home insulation and hospital admission rates: retrospective cohort study using linked data from a national intervention programme." BMJ **371**: m4571.

Gilbertson, J and Green, G a. (2008). "Health Impact Evaluation of the Warm Front Scheme."

Green Finance Institute. (2020). "Financing energy efficient buildings: the path to retrofit at scale." Coalition for the Energy Efficiency of Buildings

Grey, C. Jiang, S, Nascimento, C, Rodgers, S Johnson, R, Lyons, R and Poortinga, W, (2017). "The short-term health and psychosocial impacts of domestic energy efficiency investments in low-income areas: a controlled before and after study." BMC Public Health **17**(1): 1-10.

Grimes, A. Denne, T. Howden-Chapman, P, Arnold, A. Telfar-Barnard, L, Preval, N and Young, C. (2012). "Cost Benefit Analysis of Warm Up NZ." Prepared for the Ministry of Economic Development New Zealand

Howden-Chapman, P., Viggers, H., Chapman, R., O'Sullivan, K., Telfar Barnard, L., & Lloyd, B. (2012). Tackling cold housing and fuel poverty in New Zealand: A review of policies, research, and health impacts. *Energy Policy, 49*, 134-142. doi:https://doi.org/10.1016/j.enpol.2011.09.044

Howden-Chapman, P. (2015). "How real are the health effects of residential energy efficiency programmes?" Soc Sci Med **133**: 189-190.

Howden-Chapman, P. Viggers, H. Chapman, R. O'Dea, D. Free, S. and O'Sullivan, K (2009). "Warm homes: Drivers of the demand for heating in the residential sector in New Zealand." Energy Policy **37**(9): 3387-3399.

Hulse, K. Podkalicka, A. Milne, E. Winfree, T. Melles, G. (2015) RP3021: Report Media/Home Renovations. Low Carbon Living CRC

'I'd just Google it': media and home renovation practices in Australia

Hyland, M. Lyons, R., and Lyons, S. (2013) "The value of domestic building energy efficiency—evidence from Ireland" Energy Economics **40**, November 2013, Pages 943-952

Idealista (2021) “Italy’s 100% Ecobonus” https://www.idealista.it/en/news/financial-advice-in-italy/2020/06/17/2842-italys-110-ecobonus Accessed 18/5/21

International Energy Agency (IEA) (2021). “Warm Up NZ: Heat Smart” https://www.iea.org/policies/2079-warm-up-new-zealand-heat-smart Accessed 13/7/21

International Energy Agency (IEA) (2014). "Capturing the Multiple Benefits of Energy Efficiency."

International Energy Research Centre (IERC). (2021). "Creating shared value for all: The multiple benefits of a retrofit renovation wave in Ireland." Tyndall National Institute, International Energy Research Centre.

International Organisation for Stadardisation (ISO). (1994). *ISO 5725-1: 1994: accuracy (trueness and precision) of measurement methods and results-part 1: general principles and definitions*: International Organization for Standardization.

Kannan, R., Leong, K., Osman, R., Ho, H., & Tso, C. (2006). Life cycle assessment study of solar PV systems: An example of a 2.7 kWp distributed solar PV system in Singapore. *Solar energy, 80*(5), 555-563.

Knauf “A Story of Success – The KfW-Building Program“

Langham, E., Dunstan, C., Cooper, C., Moore, D., Mohr, S. and Ison, N. (2011) Decentralised Energy Costs and Opportunities for Victoria, prepared by the Institute for Sustainable Futures, University of Technology Sydney for Sustainability Victoria.

Langham, E. Dunstan, C. Walgenwitz, G. Denvir, P. Lederwasch, A. Landler, J. (2010) Building our Savings: Reduced Infrastructure Costs from Improving Building Energy Efficiency. Prepared by the Institute for Sustainable Futures, University of Technology Sydney and Energetics for the Australian Department of Climate Change and Energy Efficiency.

Li, G. (2015). Investigations of life cycle climate performance and material life cycle assessment of packaged air conditioners for residential application. *Sustainable Energy Technologies and Assessments, 11*, 114-125.

Lilley, B, Szatow, A and Jones, T (2009). "Intelligent Grid: A Value Proposition for Distributed Energy in Australia."

Leardini, P. and M. Manfredini (2015). "Modern housing retrofit: Assessment of upgrade packages to enerphit standard for 1940-1960 state houses in Auckland." Buildings 5(1): 229-251.

Lo, V. 2013 “The German Model for energy Efficiency Financing – Experience of the KfW”

MacDonald, S, Winner, B, Smith, L, Juillerat, J and Belknap, S (2020). "Bridging the rural efficiency gap: expanding access to energy efficiency upgrades in remote and high energy cost communities." Energy Efficiency 13(3): 503-521.

Marini, D., Buswell, R. A., & Hopfe, C. J. (2021). Development of a dynamic analytical model for estimating waste heat from domestic hot water systems. *Energy and Buildings, 247*, 111119.

MEEA Midwest Energy Efficiency Alliance, USA, (2021) "Health Benefits of Energy Efficiency, How Saving Energy Saves Lives, Factsheet," https://nascsp.org/wp-content/uploads/2019/07/MEEA-health-fact-sheet-final.pdf. Accessed 8/5/21

Melles, G., Hulse, K., Podkalicka, A., Milne, E., Winfree, T. (2017) "'Designing in' – media and communications for low carbon home renovation" CRC LCL

Mills, B., & Schleich, J. (2014). Household transitions to energy efficient lighting. *Energy Economics, 46*, 151-160.

Mims, N, Eckman,T and Goldman, C (2017). "Time varying value of electric EE."

Moglia M., Podkalicka A., Marquez, L., Fiess S., McGregor J., Xu C (2018) RP3028: Mapping the adoption processes of energy efficient products in the residential sector, Low Carbon Living CRC

N26 (2021). "Cash in on the 110% Ecobonus for your home renovations" https://n26.com/en-it/blog/110-ecobonus-for-your-home-renovations Accessed 13/7/21

New South Wales Office of Environment and Heritage. (2014). Sustainable Households; Survey of homeowners for the NSW Office of Environment and Heritage, State of NSW

New Zealand Business Council on Sustainable Development (NZBCSD) (2008). "Better Performing homes for New Zealanders."

PACENation Property Assessed Clean Energy Financing (PACE) www.pacenation.org (Accessed Aug 2021)

Park, S., Kim J, and Song D. (2019). "The effect of an energy refurbishment scheme on adequate warmth in low-income dwellings." Sustainability (Switzerland) **11**(9).

Pierse, N., White, M, Ombler, J, Davis. C, Chisholm, E, Baker, M, Howden-Chapman, P. (2020). "Well Homes Initiative: A Home-Based Intervention to Address Housing-Related Ill Health." Health Educ Behav **47**(6): 836-844.

Platform 31 (2017) "Transition Zero." Energiesprong.

Poortinga, W. Jones, N, Lannon, S and Jenkin, H (2017). "Social and health outcomes following upgrades to a national housing standard: A multilevel analysis of a five-wave repeated cross-sectional survey." BMC Public Health **17**(1).

Preval, N, Chapman, R, Pierse, N Howden-Chapman, P (2010) Evaluating energy, health and carbon co-benefits from improved domestic space heating: A randomised community trial, Energy Policy, Volume 38, Issue 8.

Relf Gand Kushler M (2018). "Keeping the Lights On: Energy Efficiency and Electric System Reliability."

Rutovitz, J., Atherton, A. (2009) Energy sector jobs to 2030: a global analysis. Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology Sydney.

SEAI (Sustainable Energy Authority of Ireland) (2015) "Unlocking Energy Efficiency Opportunity"

Sherwani, A., & Usmani, J. (2010). Life cycle assessment of solar PV based electricity generation systems: A review. *Renewable and Sustainable Energy Reviews, 14*(1), 540-544.

Telfar Barnard, L, Preval, N Howden-Chapman, P, Arnold, R, Young C, Denne, T (2011). "The impact of retrofitted insulation and new heaters on health services utilisation and costs, pharmaceutical costs and mortality Evaluation of Warm Up New Zealand: Heat Smart."

Thomson, H., Thomas S, Sellstrom E and Petticrew M (2013). "Housing improvements for health and associated socio-economic outcomes." Cochrane Database of Systematic Reviews **2013**(2).

Thorpe D (2016) Why the UK Green Deal failed and why it needs a replacement https://energypost.eu/uk-green-deal-failed-needs-replacement/ Accessed 17/5/21

Timilsina, G. R., Lefevre, T and Shrestha, S (2000). "Financing solar thermal technologies under DSM programs: An innovative approach to promote renewable energy." International Journal of Energy Research **24**(6): 503-510.

University College London, Sheffield Hallam University, London School of Hygiene and Tropical Medicine (2005). "Health Impact Evaluation of England's Home Energy Efficiency Scheme (Warm Front)."

Vlasova l and Gram-Hanssen, K (2014) Incorporating inhabitants' everyday practices into domestic retrofits, Building Research & Information, 42:4, 512-524

Webber, P., Gouldson A., and Kerr, N. (2015). "The impacts of household retrofit and domestic energy efficiency schemes: A large scale, ex post evaluation." Energy Policy **84**: 35-43.

Willand, N., Gouldson, A., Kerr, N., (2015). "Towards explaining the health impacts of residential energy efficiency interventions - A realist review. Part 1: Pathways." Social Science and Medicine **133**: 191-201.

Wills, A. D., Beausoleil-Morrison, I., & Ugursal, V. I. (2021). A modelling approach and a case study to answer the question: What does it take to retrofit a community to net-zero energy? *Journal of Building Engineering, 40*, 102296.

UK Power (2021) UK Green Deal Scheme. Accessed 17/5/21 https://www.ukpower.co.uk/uk-green-deal-scheme

Yılmaz, E., Arslan, H., & Bideci, A. (2019). Environmental performance analysis of insulated composite facade panels using life cycle assessment (LCA). Construction and Building Materials, 202, 806-813.

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