ACIL ALLEN CONSULTING

REPORT TO
ENERGY CONSUMERS AUSTRALIA

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MULTIPLE IMPACTS OF HOUSEHOLD ENERGY EFFICIENCY:

AN ASSESSMENT FRAMEWORK

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EXECUTIVE SUMMARY

Traditionally household energy efficiency programs have been assessed on the basis of a reduction in energy usage and thereby a reduction in energy costs. In some cases, reduced greenhouse gas emissions were also considered. As a result, the benefit cost ratio for many household energy efficiency programs has been less than 1.0 and, as a consequence, government-funded household energy efficiency programs have been of a limited scale.

However, there is now a considerable body of evidence that there are multiple impacts (both costs and benefits) associated with energy efficiency – both private and public. In July 2011 the Commonwealth Government announced the Low Income Energy Efficiency Program (LIEEP), a competitive merit-based grant program to trial approaches to improve the energy efficiency of low income households and enable them to better manage their energy use. The final reports on the LIEEP programs refer to co-benefits associated with the projects, but assess these qualitatively rather than quantitatively. However, some of those programs indicated that the non-energy benefits (such as increased home comfort and improved health outcomes) could be of greater value than the energy savings delivered by the interventions.

Despite the considerable body of international evidence on the value of the multiple impacts of energy efficiency, the absence of a holistic framework for applying existing international research on these multiple impacts to the Australian context makes consideration of these impacts contentious, particularly given the wide variation of climatic conditions across Australia.

Against this background, Energy Consumers Australia (ECA) has commissioned ACIL Allen Consulting (ACIL Allen) to develop a policy framework to help identify and measure the multiple impacts of improved household energy efficiency. It is expected that this framework would assist industry and policy-makers to define and quantify these impacts in the Australian context.

Multiple impacts of energy efficiency

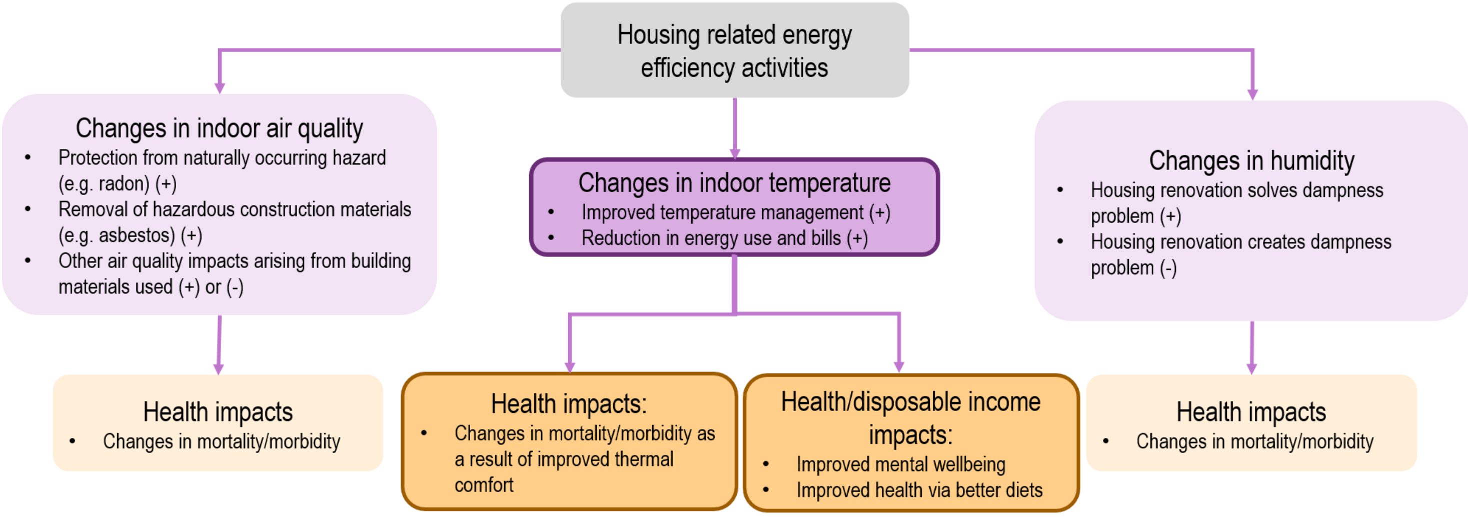
The multiple impacts of energy efficiency include the impacts of energy efficiency on:

— health and wellbeing
— other participant benefits
— the energy system
— the overall economy.

Health and wellbeing

Residential energy efficiency actions can result in a number of health-related impacts in addition to the direct observable energy savings. Figure ES 1 outlines the causal link from housing related energy efficiency measures to the exposure factors critical to improving health and wellbeing, and the potential outcomes that can be expected to materialise. Health and wellbeing impacts can materialise through three different pathways. These are improved thermal quality, improved air indoor quality and resolved issues relating to excess humidity.

FIGURE ES 1 IMPACTS ON HEALTH AND WELLBEING ARISING FROM HOUSING RELATED ENERGY EFFICIENCY ACTIONS



Note: (+) denotes a positive impact; (-) denotes an adverse impact

SOURCE: ADAPTED FROM (COMBI, 2015B; IEA, 2015)

Direct impacts from improved thermal quality

The most significant health and wellbeing effect from energy efficiency relates to improved thermal quality through avoidance of excessively cold or hot indoor temperatures.[1] Better thermal quality in turn reduces mortality from hot and cold extremes, as well as symptoms of a range of diseases such as respiratory and cardiovascular diseases, allergies, arthritis and rheumatism. The strongest evidence to date has been established in relation to temperature-related deaths in cold conditions, as well as reduction in respiratory and cardiovascular diseases (IEA, 2015).

In Australia, extreme heat is a more common concern than extreme cold. A considerable evidence base has demonstrated a link between heat extremes and an increased risk of mortality. Populations at particular risk include the very young, the elderly and people with chronic or underlying medical conditions such as diabetes, mental illness, kidney disease, and respiratory or heart disease. Moreover, heat-related deaths are more likely to occur at home, before the individual has been able to seek medical attention (Williamson, Grant, Hansen, Pisaniello, & Andamon, 2009). While the relationship between energy efficiency measures and reduced heat stress have not been extensively studied, in principle measures that keep heat inside in cold temperatures are likely to keep heat out when outdoor temperatures are high (IEA, 2015).

In addition to improved physical health, evidence linking improved mental health and wellbeing with energy efficiency has emerged during the last decade. Energy efficiency may lead to improved mental health and wellbeing outcomes through reducing financial stress related to high energy bills and fear of falling in debt. Alleviation of chronic thermal discomfort can also contribute to improved mental wellbeing, though this effect has not been extensively studied (IEA, 2015).

Indirect impacts from improved thermal quality

As well as direct impacts on participants' health and wellbeing, energy efficiency measures may result in reduced public health spending as a result of lower mortality and morbidity. In addition, a number of suggested, but not yet well-established participant co-benefits include (IEA, 2015):

[1] The World Health Organisation's range for healthy indoor air temperatures is between 18 and 21 degrees Celsius.

— reduced malnutrition and obesity if funds freed up from lower energy bills are used to purchase better quality food
— lessened family tensions if installation of energy efficiency measures allows more areas of the dwelling to be heated, lessening the need for the family crowd into a single heated room
— reduced social isolation if energy efficiency measures reduce occupants' embarrassment with their uncomfortable conditions
— improved social cohesion and sense of community among residents
— higher rates of school attendance
— healthier lifestyles
— improved access to local services.

Benefits linked to improved indoor air quality and reduced dampness

Improved indoor air quality and reduced dampness are two other possible pathways through which energy efficiency measures may result in reduced mortality and morbidity (COMBI, 2015b; IEA, 2015). Issues that can be addressed through a well-designed housing retrofit program include (COMBI, 2015b):

— indoor air quality issues arising from the presence of naturally occurring pollutants such as radon, and legacy issues arising from dangerous materials such as asbestos
— excess indoor humidity caused by draughts, high air tightness indoors and high humidity outdoors.

Trade-offs between health and mental wellbeing impacts

Energy efficiency improvements can be reaped as 100 per cent improvement in indoor temperature (possibly also increasing the total space heated), as 100 per cent energy bill savings maintaining the indoor temperatures stable or any combination involving a split into indoor temperature rise and energy bill savings (COMBI, 2015b). This split between energy savings and comfort (where improvement in indoor temperature is known as the take-back effect) has been observed in studies documenting so-called easy retrofits—interventions improving one of more elements such as glazing, insulation or draught proofing in a non-systematic way. However, there is no evidence of a split between comfort and energy savings for systematic, deep retrofits (COMBI, 2016).[2]

As outlined in Figure ES 1, the causal pathway from energy efficiency to improved mental health depends on improved thermal comfort, as well as reduced energy consumption leading to reduced bills and greater disposable income. Of these, alleviation of financial stress has been the more commonly observed driver of improved mental health (IEA, 2015). Therefore, to the extent that a take-back effect is present, there is a trade-off between physical and mental health impacts.

Transferability of health and wellbeing impact estimates

A number of factors affect the magnitude of co-benefits, and therefore the transferability of estimates from one context to another. The main factors are discussed below.

— **The extent to which the intervention is targeted:** improved health is most likely to be observed, and the effects will be of greater magnitude, when the program targets vulnerable populations such as groups known to experience particular health conditions, or those with inadequate housing conditions (Thomson, Thomas, Sellstrom, & Petticrew, 2013; IEA, 2015).
— **Climatic conditions:** the causal pathway from energy efficiency to improved health outcomes is somewhat different in hot and cold climates, as is the extent to which extreme weather events cause excess mortality (IEA, 2015).
— **Public health expenditure savings:** estimates of public health spending savings are highly dependent on the health care costs in each country, as well as whether the avoided health costs are publically or privately funded (IEA, 2015).

[2] While the definition of a deep retrofit varies, these are commonly understood to mean renovations that result in at least 50 per cent energy savings, when compared with pre-retrofit usage. The savings are realised through systematic improvements to building shell, space heating/cooling and hot water systems.

- **Program design:** to the extent that the household bears the cost of the intervention (for example through off-set bill savings), this may lead to a reduction in health-related co-benefits, at least until the payback period for the investment is over. During this period, income constrained households will not be able to choose between increased indoor temperatures (potentially leading to greater physical health) and lower energy bills (potentially contributing to reduced stress and improved mental health) (COMBI, 2015b; IEA, 2015).

Other participant benefits

Research from a number of countries, including Australia, indicates that information on the energy performance of a home is reflected in property values through sale prices and rents.

Research drawing on data from the ACT indicates that house prices increase by 1.2 to 1.9 percentage points for each increase of 0.5 stars along the energy efficiency rating scale (ABS, 2008). Research from California and Ireland indicates that homes labelled as 'energy efficient' attract a premium of up to 9 per cent. Moreover, in Ireland, poorly performing homes carry a price penalty of 10 per cent (Kahn & Kok, 2014; Poortinga et al. 2016). The effect, while present, is less pronounced for rental properties.

However, a contrasting result from Japan has found that 'green' buildings are penalised by a price discount of around 5 per cent. This is hypothesised to be the result of perceived higher maintenance costs, and a potential methodological weakness in location being omitted from the set of explanatory variables (Yoshida & Sugiura 2010).

A number of other impacts linked to energy efficiency have been hypothesised, but not yet robustly measured. These include (Kenington, Wood, Reid, & Klein, 2016; GEER Australia, 2017) the following.

- **Self-efficacy (or empowerment):** refers to the ability of individuals to control the use of energy in the home and the empowerment that arises through understanding how energy works, through the use of knowledge, technology or seeking the right assistance. Self-efficacy is also related to confidence to take action and control one's life which is closely linked to wellbeing and to resilience.
- **Community engagement:** refers to the extent to which people are connected to their local community or area, through formal or informal links, and the extent to which they participate in or feel connected to the life of their community. The impact may be present for energy efficiency programs with a community focus.
- **Support for vulnerable people:** refers to the extent to which people are aware of and able to access social support options available to them. An energy efficiency program incorporating information on the broader range of available support options may improve participants' ability to access support and address problems.
- **Level and quality of partnership:** refers to the effectiveness of partnerships emerging from or supported by an energy efficiency program. An energy efficiency intervention may bring together different stakeholder groups, which, as a result, may form partnerships lasting past program completion.
- **New business opportunities:** this impact refers to the extent to which energy efficiency programs can create additional business opportunities through demand for additional energy efficiency and renewable energy.

Energy system impacts

Energy efficiency interventions can lead to tangible benefits along the entire energy supply chain, if this consideration is taken into account during the design stage. The benefits for energy providers include improved system reliability, enhanced capacity adequacy, better ability to manage peak demand, opportunities to defer generation and network infrastructure investments, as well as reduced price volatility in wholesale markets (RAP, 2013; IEA, 2015).

Energy system benefits can be expected to arise from two types of interventions. These are (COMBI, 2015e):

- programs seeking to reduce customer energy use on a permanent basis through installing energy efficient technologies
- load management programs seeking to either curtail or shift demand from high cost, peak demand periods.

Additional benefits specific to programs targeting low income or vulnerable customers include improved ability to manage energy bills, which in turn can lead to reduced arrears, unpaid debts and collection costs for energy utilities. To the extent to which these costs are borne by the utilities, the savings can (in a competitive market) be assumed to ultimately accrue to non-participants in the form of lower utility bills. If hardship or payment assistance programs are funded from general tax revenue, cost savings can be regarded as societal benefits (RAP, 2013).

Macroeconomic impacts of energy efficiency

Macroeconomic impacts of energy efficiency cover effects occurring at national, international and regional levels. Given that the macro-economy, by definition, includes a broad range of sectors, consideration is typically given to energy efficiency policies more broadly, rather than the impact of individual programs or interventions. Analyses generally seek to establish the total effect of energy efficiency policy, including the sum of individual effects as well as the complex interactions throughout the economy (IEA, 2015).

Macroeconomic effects can be framed either through the source of the impact, or the nature of its impact on the economy (COMBI, 2015c).

The IEA views macroeconomic impact through identifying the source of the impact. These can be divided into two classes:

- investment effects arise from increased expenditure on energy efficient goods and services, which leads to higher production in these sectors but lower production in other sectors of the economy
- energy demand reduction effects operate through reduction (cost savings) in relation to energy-related expenditure leading to increased disposable income and higher business profits.

These two effects combined can lead to changes in macroeconomic variables such as Gross Domestic Product (GDP), employment, energy prices and the trade balance (IEA, 2015).

An alternative perspective is put forward by the European Union funded COMBI project, which considers the short-run (business cycle) and long-run (structural) effects of energy efficiency investments (COMBI, 2015c).

The short-run effects of additional investment in energy efficiency include employment, GDP, public budgets and inflation. In an economic downturn, when output is below the economy's potential growth rate, the additional investment can help lessen the severity of the recession. However, in an upswing, additional investment may have a detrimental impact, either crowding out other (more productive) investment, or contributing to an overheating of the economy (COMBI, 2015c).

The long-run impact of energy efficiency investments may be observed as changes in the structure of the economy. Potential effects include improved labour productivity (arising from, for example, health benefits or improved indoor air quality), relative prices (energy intensive products relative to other goods, or imports relative to exports), trade flows and the overall productivity in the economy. These effects can lead to (assumed net positive) changes in employment and the potential growth rate of the economy (COMBI, 2015c).

Where macroeconomic impacts are considered, it is important to consider the net effect on the economy (IEA, 2015).

Energy efficiency impacts logic map

Figure ES 2 presents a logic map for the multiple impacts associated with residential energy efficiency policies and programs. The diagram draws on the relevant Australian and international research.

The logic map is divided into 7 separate levels and 26 individual impacts. Of these, impacts presented in a darker shade are, to date, underpinned by a more substantial evidence base than those in a lighter shade.

Interrelationships between the impacts are indicated by connecting arrows. A solid line indicates that a stronger causal link has been established in the existing literature, while a dashed line symbolises a weaker causal link.

The logic map can be interpreted, from top to bottom, as follows.

1. The **first layer** is the implementation of an energy efficiency policy or program and the associated energy efficiency measures.
2. The **second layer** represents changes in householders' attitudes towards, and knowledge of, energy efficiency.
3. The **third layer** represents household behaviour change as a result of the energy efficiency intervention.
4. The **fourth and fifth layers** represent the first and second round impacts arising from changes in energy consumption and thermal comfort.
5. The **sixth layer** describes the impacts for industry participants.
6. The **final layer** depicts the societal impacts from residential energy efficiency.

Of these, the strongest evidence to date has been established for energy system benefits and reduced public health care expenditure.

Principles for assessing the multiple impacts of energy efficiency

This report assesses each of the multiple impacts of energy efficiency by reference to a set of principles. These principles are summarised in Table ES 1.

TABLE ES 1 PRINCIPLES FOR ASSESSING THE MULTIPLE IMPACTS OF HOUSEHOLD ENERGY EFFICIENCY

Best practice assessment principles	Principles for quantification of impacts
Causality	Individual treatment
Consistency with objectives	Fit for purpose
Comprehensiveness	Robustness
Consistency with existing frameworks	Symmetry
Materiality	Avoid double counting
Quantification	Consider the rebound effect
	Measure marginal, not average, impacts
	Consider the incidence of impacts
	Transparency

SOURCE: ACIL ALLEN CONSULTING

Key findings

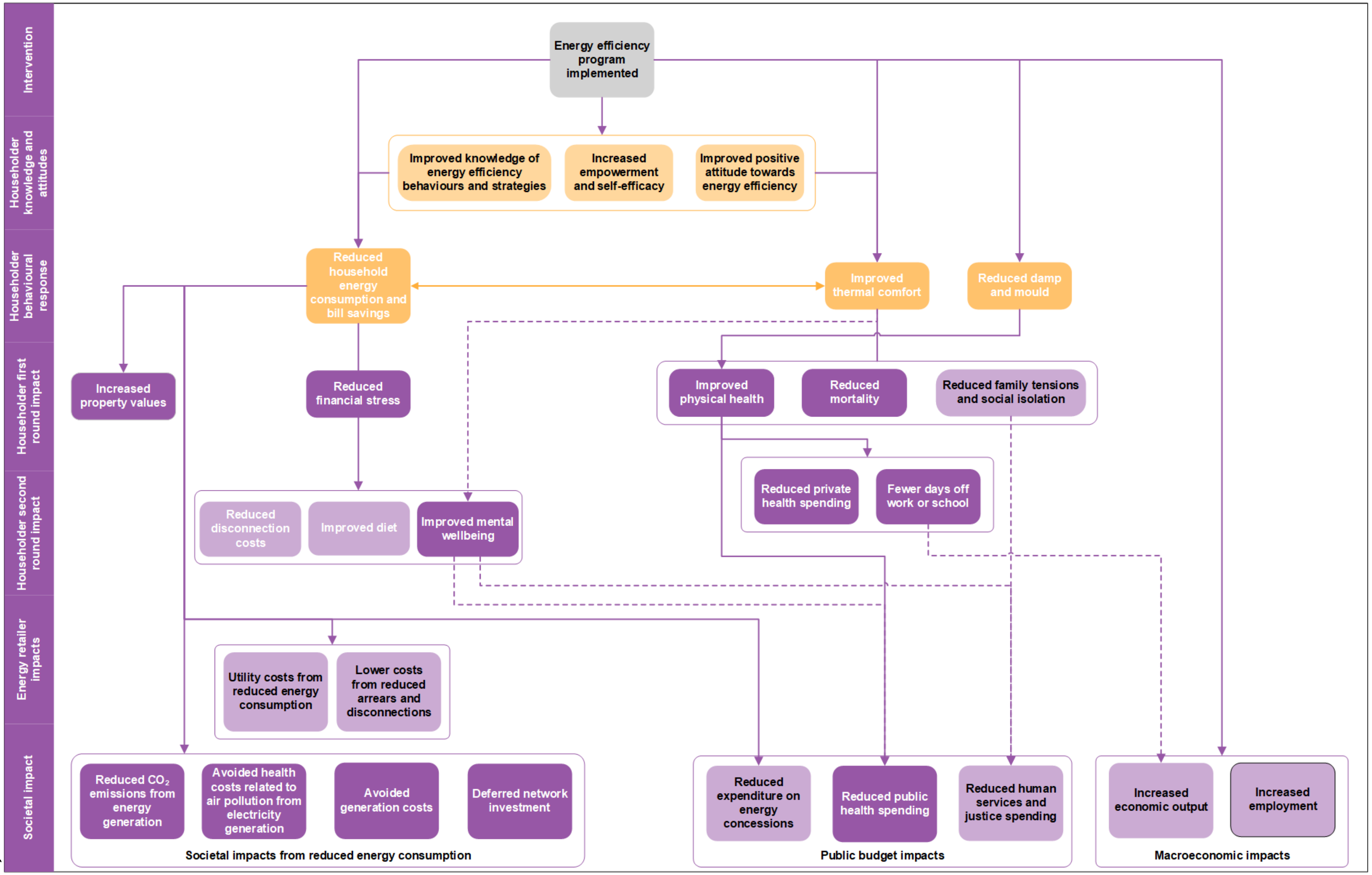
Non- energy benefits of household energy efficiency policies/programs (such as increased home comfort and improved health outcomes) could be of greater value than the energy savings delivered by the interventions.

Despite the considerable body of international evidence on the value of the multiple impacts of energy efficiency, the absence of a holistic framework for applying existing international research on these impacts to the Australian context made consideration of these impacts contentious.

The policy framework for assessing the multiple impacts of energy efficiency, developed in this report, aims to fill this gap.

There are a number of additional areas of research which would help fill the current information gaps and improve the measurement of multiple impacts of household energy efficiency in the Australian context.

FIGURE ES 2 ENERGY EFFICIENCY IMPACTS LOGIC MAP



SOURCE: ACIL ALLEN

1 INTRODUCTION

Traditionally household energy efficiency programs have been assessed on the basis of a reduction in energy usage and thereby a reduction in energy costs. In some cases, reduced greenhouse gas emissions were also considered. As a result, the benefit cost ratio for many household energy efficiency programs has been less than 1.0 and, as a consequence, government-funded household energy efficiency programs have been of a limited scale.

However, there is now a considerable body of evidence that there are multiple impacts (both costs and benefits) associated with energy efficiency – both private and public. For instance, the International Energy Agency (IEA, 2014) has analysed five benefit areas, although not all of these apply to households:

- macroeconomic development – energy efficiency improvements can deliver benefits across the whole economy with direct and indirect impacts on economic activity
- public budgets – public budgets can be impacted by reduced fuel costs for heating, cooling and lighting, reduced unemployment payments, and savings from subsidised energy consumption
- health and well-being – energy efficiency programs can improve physical and mental health, and lead to lower public health spending
- industrial productivity – industrial energy efficiency can enhance competitiveness, profitability, production and product quality, improve the working environment, and reduce costs for operation, maintenance and environmental compliance
- energy delivery – while the direct benefits of energy efficiency to the cost of energy delivery are well recognised, there are also the indirect benefits associated with improved affordability, which can reduce arrears and the associated administrative costs.

Similarly, the European Union's *Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe* (COMBI) project is currently seeking to quantify and monetise the following benefits associated with energy efficiency:

- air pollution, which considers health, eco-system, crops and the built environment
- resources, which considers biotic/abiotic energy resources, and biotic/abiotic non energy resources
- social welfare, which considers disposable income/fuel poverty reduction, improved comfort and health
- commercial productivity, which considers productivity in commercial buildings
- macro-economy, which considers employment, gross domestic product (GDP), and public budgets
- energy system/security, which considers energy system costs and energy security.

In July 2011 the Commonwealth Government announced the Low Income Energy Efficiency Program (LIEEP), a competitive merit-based grant program to trial approaches to improve the energy efficiency of low income households and enable them to better manage their energy use. Twenty projects were funded under the LIEEP, with projects generally undertaken during the 2013-16 period. The projects were conducted:

- using a variety of approaches to improve energy efficiency, including in-home education, home energy assessments, retrofits and upgrades, in home displays, community capacity building, and communication via SMSs and social media
- across different jurisdictions, with projects conducted Australia-wide, in New South Wales, in Queensland, in South Australia, in Tasmania and in Victoria
- across different low income cohorts, including senior citizens, the Indigenous community, refugees, those in caravan parks and residential villages, those in private rental accommodation, young adult renters, those in their own homes, those that receive Home and Community Care Services, and those with chronic or acute health conditions.

The final reports on the LIEEP programs refer to co-benefits associated with the projects, but assess these qualitatively rather than quantitatively. However, some of those programs indicated that the non-energy benefits (such as increased home comfort and improved health outcomes) could be of greater value than the energy savings delivered by the interventions.

Despite the considerable body of international evidence on the value of the multiple impacts of energy efficiency, the absence of a holistic framework for applying existing international research on these multiple impacts to the Australian context makes consideration of these impacts contentious, particularly given the wide variation of climatic conditions across Australia.

1.1 Project objectives and scope

Against the background outlined above, Energy Consumers Australia (ECA) has commissioned ACIL Allen Consulting (ACIL Allen) to develop a policy framework to help identify and measure the multiple impacts of improved household energy efficiency. It is expected that this framework would assist industry and policy-makers to define and quantify these impacts in the Australian context.

The public policy framework was to be developed by drawing on the LIEEP projects and Australian and international research to:

- develop principles and procedures to assist industry and policy-makers in the design and implementation of programs to promote energy efficiency
- where possible, make recommendations to inform Australian policy-makers on how best to define and quantify these impacts.

Developing new methodologies/estimates to measure individual impacts was outside the scope of this report.

1.2 Methodology

ACIL Allen's approach to this study involved:

- undertaking a review of national and international literature on the impacts of household energy efficiency (with a particular focus on impacts beyond energy savings)
- discussions with key stakeholders about the existing body of evidence on the multiple impacts of energy efficiency
- developing a series of core principles for assessing the direct and indirect impacts associated with household energy efficiency
- developing a framework for assessing the multiple impacts of household energy efficiency based on existing national and international research and in-depth research on the LIEEP pilots undertaken by the Group of Energy Efficiency Researchers Australia (GEERA)
- gathering feedback from key stakeholders on the developed principles and framework.

1.3 Report structure

The remainder of this report is structured as follows.

- Chapter 2 summarises the existing national and international evidence on the multiple impacts of energy efficiency.
- Chapter 3 presents a series of core principles for assessing the multiple impacts associated with household energy efficiency.
- Chapter 4 presents a logic map for the impacts associated with residential energy efficiency, discusses the use of multiple impacts assessments and discusses a number of cross-cutting methodological considerations that need to be taken into account when assessing energy efficiency impacts.
- Chapter 5 provides additional details about the definition and measurement of the different multiple impacts of energy efficiency.
- Chapter 6 outlines the key findings of this report, its limitations and topics for further study in the area of the multiple impacts of energy efficiency.

EXISTING EVIDENCE ON THE MULTIPLE IMPACTS OF ENERGY EFFICIENCY

2

This chapter summarises the existing national and international evidence on the multiple impacts of energy efficiency.

2.1 Definition of multiple impacts of energy efficiency

Traditionally, the impacts of energy efficiency have been assessed through the units of electricity or gas saved, or the dollar savings accruing from reduced consumption. However, this perspective significantly undervalues the full suite of impacts (both positive and negative) that may accrue as a result of energy efficiency policies and programs.

The multiple impacts perspective on energy efficiency therefore seeks to capture the many different impacts that may result at various levels of society (including the direct impact of reduced energy demand). Consideration is given to benefits, such as improved health outcomes as the result of healthier indoor air, and also the potential for adverse unintended outcomes. These include, for example, ill-designed energy efficiency interventions that worsen indoor environments and create or exacerbate health problems. Together, these multiple impacts comprise the value of energy efficiency to society and individuals.

The full suite of potential impacts should be considered holistically, rather than focussing only on the traditional energy savings and their dollar value. However, to date, the multiple impacts of energy efficiency have not been systematically assessed; data limitations and the lack of mature methodologies have meant that policy makers have included the broader impacts in decision making only in a qualitative way, if at all (IEA, 2015).

2.2 Studies covered in the literature review

Table 2.1 provides an overview of the key studies covered in the literature review. A full list of references is provided at the end of this report.

TABLE 2.1 STUDIES COVERED IN THE LITERATURE REVIEW

Source	Description
Capturing the multiple benefits of energy efficiency, the IEA	This publication provides a comprehensive literature review of existing research on the multiple impacts of energy efficiency. It examines how methodologies, including those already employed in economic and policy evaluation, can be applied to the multiple impacts of energy efficiency. It aims to strengthen capacity in both the public and private sectors to better assess the full range of outcomes of energy efficiency to improve both the basis for economic analysis of policy options, and the ability to communicate the value that energy efficiency can deliver for the economy and society.

Source	Description
COMBI project, the EU	The project *Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe* (COMBI) aims to develop methodologies for the quantification, monetisation and aggregation of the multiple impacts of energy efficiency. Key tasks for the project are to: – refine existing methods and models, and develop new methods for the quantification and monetisation of the multiple impacts of energy efficiency – apply these methods to derive (ranges of) values for the selected multiple impacts of energy efficiency and incorporate these into decision-support frameworks for policy-making such as cost-benefit analysis, energy efficiency cost curves or multi-criteria analysis – communicate research findings to policy-makers, evaluators and the public through easy-to-use tools, graphs and reports.
LIEEP, Australia	The Australian Government's national Low Income Energy Efficiency Project (LIEEP) provided grants to consortia of government, business and community organisations to trial approaches to improve the energy efficiency of low income households, and enable them to better manage their energy use. Research on the multiple impacts of these interventions provides initial qualitative evidence on the magnitude and significance of these benefits in Australia.
OEH, NSW	Research undertaken by the NSW Office of Environment and Heritage (OEH) on the multiple impacts of the Home Power Savings Program (HPSP) provides an initial understanding of the potential impacts among low income households. OEH has, in addition, developed a preliminary framework for assessing the multiple impacts of energy efficiency of residential and community programs.

2.3 Evidence on the multiple impacts of energy efficiency

The following sections discuss the existing national and international evidence on some of the multiple impacts of energy efficiency. Particularly, these sections discuss the evidence on the impacts of energy efficiency on:

- health and wellbeing
- other participant benefits
- the energy system
- the overall economy.

2.3.1 Health and wellbeing

Residential energy efficiency actions can result in a number of health-related impacts in addition to the direct observable energy savings. Figure 2.1 outlines the causal link from housing related energy efficiency measures to the exposure factors critical to improving health and wellbeing, and the potential outcomes that can be expected to materialise. Health and wellbeing impacts can materialise through three different pathways. These are improved thermal quality, improved air indoor quality and resolved issues relating to excess humidity.

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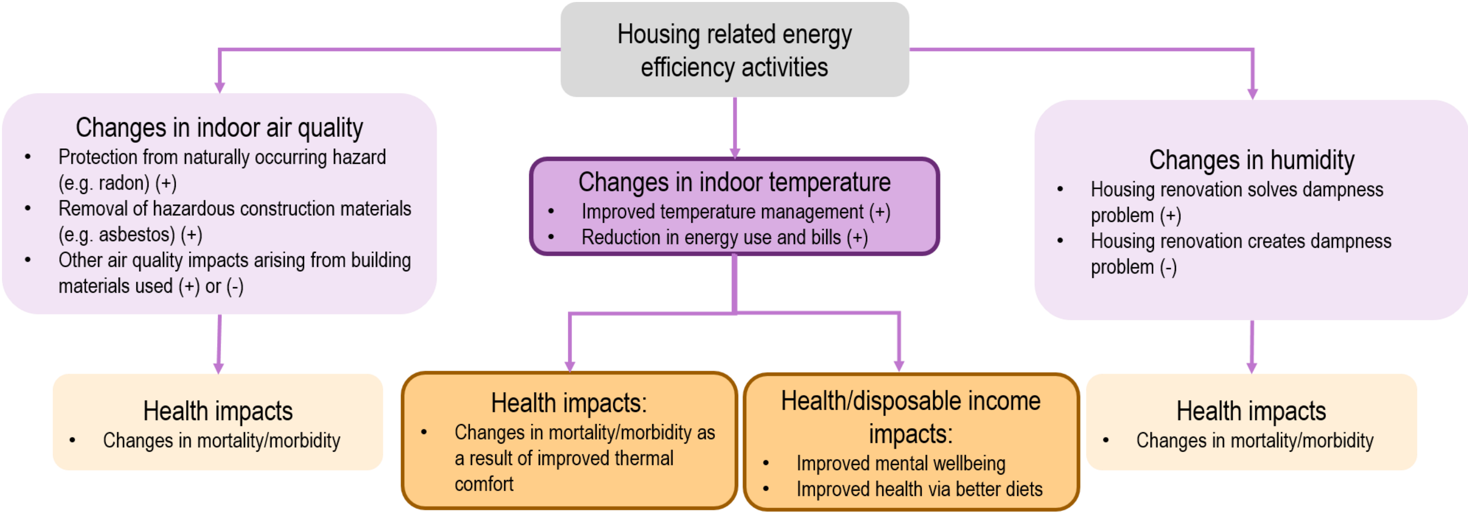

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In Australia, extreme heat is a more common concern than extreme cold. A considerable evidence base has demonstrated a link between heat extremes and an increased risk of mortality. Populations at particular risk include the very young, the elderly and people with chronic or underlying medical conditions such as diabetes, mental illness, kidney disease, and respiratory or heart disease. Moreover, heat-related deaths are more likely to occur at home, before the individual has been able to seek medical attention (Williamson, Grant, Hansen, Pisaniello, & Andamon, 2009). While the relationship between energy efficiency measures and reduced heat stress have not been extensively studied, in principle measures that keep heat inside in cold temperatures are likely to keep heat out when outdoor temperatures are high (IEA, 2015).

In addition to improved physical health, evidence linking improved mental health and wellbeing with energy efficiency has emerged during the last decade. Energy efficiency may lead to improved mental health and wellbeing outcomes through reducing financial stress related to high energy bills and fear of falling in debt. Alleviation of chronic thermal discomfort can also contribute to improved mental wellbeing, though this effect has not been extensively studied (IEA, 2015).

Indirect impacts from improved thermal quality

As well as direct impacts on participants' health and wellbeing, energy efficiency measures may result in reduced public health spending as a result of lower mortality and morbidity. In addition, a number of suggested, but not yet well-established participant co-benefits include (IEA, 2015):

— reduced malnutrition and obesity if funds freed up from lower energy bills are used to purchase better quality food

[3] The World Health Organisation's range for healthy indoor air temperatures is between 18 and 21 degrees Celsius.

— lessened family tensions if installation of energy efficiency measures allows more areas of the dwelling to be heated, lessening the need for the family crowd into a single heated room
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Improved indoor air quality and reduced dampness are two other possible pathways through which energy efficiency measures may result in reduced mortality and morbidity (COMBI, 2015b; IEA, 2015). Issues that can be addressed through a well-designed housing retrofit program include (COMBI, 2015b):

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Energy efficiency improvements can be reaped as 100 per cent improvement in indoor temperature (possibly also increasing the total space heated), as 100 per cent energy bill savings maintaining the indoor temperatures stable or any combination involving a split into indoor temperature rise and energy bill savings (COMBI, 2015b). This split between energy savings and comfort (where improvement in indoor temperature is known as the take-back effect) has been observed in studies documenting so-called easy retrofits—interventions improving one of more elements such as glazing, insulation or draught proofing in a non-systematic way. However, there is no evidence of a split between comfort and energy savings for systematic, deep retrofits (COMBI, 2016).[4]

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A number of factors affect the magnitude of co-benefits, and therefore the transferability of estimates from one context to another. The main factors are discussed below.

— **The extent to which the intervention is targeted:** improved health is most likely to be observed, and the effects will be of greater magnitude, when the program targets vulnerable populations such as groups known to experience particular health conditions, or those with inadequate housing conditions (Thomson, Thomas, Sellstrom, & Petticrew, 2013; IEA, 2015).
— **Climatic conditions:** the causal pathway from energy efficiency to improved health outcomes is somewhat different in hot and cold climates, as is the extent to which extreme weather events cause excess mortality (IEA, 2015).
— **Public health expenditure savings:** estimates of public health spending savings are highly dependent on the health care costs in each country, as well as whether the avoided health costs are publically or privately funded (IEA, 2015).
— **Program design:** to the extent that the household bears the cost of the intervention (for example through off-set bill savings), this may lead to a reduction in health-related co-benefits, at least until the payback period for the investment is over. During this period, income constrained households will not

[4] While the definition of a deep retrofit varies, these are commonly understood to mean renovations that result in at least 50 per cent energy savings, when compared with pre-retrofit usage. The savings are realised through systematic improvements to building shell, space heating/cooling and hot water systems.

be able to choose between increased indoor temperatures (potentially leading to greater physical health) and lower energy bills (potentially contributing to reduced stress and improved mental health) (COMBI, 2015b; IEA, 2015).

Indicators to measure health and wellbeing impacts

Table 2.2 outlines the most common indicators used to quantify health and well-being impacts. To establish a plausible causal link, both exposure and co-benefit indicators should be measured before and after the intervention. Where possible, validated survey instruments from health or psychology professions should be used (IEA, 2015).

TABLE 2.2 COMMON INDICATORS TO MEASURE HEALTH AND WELL-BEING IMPACTS

Exposure indicators	Health and well-being indicators
Average indoor temperature of building	Number of statistical life years lost
Humidity levels inside the building	Rate of excess seasonal mortality
Number of rooms heated and in active use by occupants	Number of visits to the hospital, doctor, pharmacist
Level of particular indoor pollutants	Cost of treatment
Number or percentage of buildings using harmful fuels for heating	Number of accidents or injuries within the building
Number or percentage of occupants reporting improved indoor comfort	Assessed health status (based on existing standardised surveys or self-assessment)
Percentage of monthly budget spent on energy bills	Number of restricted activity days (number of days off work or school)

SOURCE: (IEA, 2015)

2.3.2 Other participant benefits

Research from a number of countries, including Australia, indicates that information on the energy performance of a home is reflected in property values through sale prices and rents.

Research drawing on data from the ACT indicates that house prices increase by 1.2 to 1.9 percentage points for each increase of 0.5 stars along the energy efficiency rating scale (ABS, 2008). Research from California and Ireland indicates that homes labelled as 'energy efficient' attract a premium of up to 9 per cent. Moreover, in Ireland, poorly performing homes carry a price penalty of 10 per cent (Kahn & Kok, 2014; Poortinga et al. 2016). The effect, while present, is less pronounced for rental properties.

However, a contrasting result from Japan has found that 'green' buildings are penalised by a price discount of around 5 per cent. This is hypothesised to be the result of perceived higher maintenance costs, and a potential methodological weakness in location being omitted from the set of explanatory variables (Yoshida & Sugiura 2010).

A number of other impacts linked to energy efficiency have been hypothesised, but not yet robustly measured. These include (Kenington, Wood, Reid, & Klein, 2016; GEER Australia, 2017) the following.

— **Self-efficacy (or empowerment):** refers to the ability of individuals to control the use of energy in the home and the empowerment that arises through understanding how energy works, through the use of knowledge, technology or seeking the right assistance. Self-efficacy is also related to confidence to take action and control one's life which is closely linked to wellbeing and to resilience.

— **Community engagement:** refers to the extent to which people are connected to their local community or area, through formal or informal links, and the extent to which they participate in or feel connected to the life of their community. The impact may be present for energy efficiency programs with a community focus.

— **Support for vulnerable people:** refers to the extent to which people are aware of and able to access social support options available to them. An energy efficiency program incorporating information on the broader range of available support options may improve participants' ability to access support and address problems.

- **Level and quality of partnership:** refers to the effectiveness of partnerships emerging from or supported by an energy efficiency program. An energy efficiency intervention may bring together different stakeholder groups, which, as a result, may form partnerships lasting past program completion.
- **New business opportunities:** this impact refers to the extent to which energy efficiency programs can create additional business opportunities through demand for additional energy efficiency and renewable energy.

2.3.3 Energy system impacts

Energy efficiency interventions can lead to tangible benefits along the entire energy supply chain, if this consideration is taken into account during the design stage. The benefits for energy providers include improved system reliability, enhanced capacity adequacy, better ability to manage peak demand, opportunities to defer generation and network infrastructure investments, as well as reduced price volatility in wholesale markets (RAP, 2013; IEA, 2015).

Energy system benefits can be expected to arise from two types of interventions. These are (COMBI, 2015e):

- programs seeking to reduce customer energy use on a permanent basis through installing energy efficient technologies
- load management programs seeking to either curtail or shift demand from high cost, peak demand periods.

Typically in Australia, relevant system benefits are included in the assessment of energy efficiency programs and policies through dedicated wholesale energy market modelling. The increased use of smart metering will improve the ability to estimate the impact on peak demand.

Additional benefits specific to programs targeting low income or vulnerable customers include improved ability to manage energy bills, which in turn can lead to reduced arrears, unpaid debts and collection costs for energy utilities. To the extent to which these costs are borne by the utilities, the savings can (in a competitive market) be assumed to ultimately accrue to non-participants in the form of lower utility bills. If hardship or payment assistance programs are funded from general tax revenue, cost savings can be regarded as societal benefits (RAP, 2013). Data sources to estimate these benefits include information on changes to arrearage rates from the utilities, combined with customer surveys to assess the impact on payment difficulties and the rate of disconnections (IEA, 2015).

2.3.4 Macroeconomic impacts of energy efficiency

Macroeconomic impacts of energy efficiency cover effects occurring at national, international and regional levels. Given that the macro-economy, by definition, includes a broad range of sectors, consideration is typically given to energy efficiency policies more broadly, rather than the impact of individual programs or interventions. Analyses generally seek to establish the total effect of energy efficiency policy, including the sum of individual effects as well as the complex interactions throughout the economy (IEA, 2015).

Macroeconomic effects can be framed either through the source of the impact, or the nature of its impact on the economy (COMBI, 2015c). These two perspectives are described below.

The IEA views macroeconomic impact through identifying the source of the impact. These can be divided into two classes:

- investment effects arise from increased expenditure on energy efficient goods and services, which leads to higher production in these sectors but lower production in other sectors of the economy
- energy demand reduction effects operate through reduction (cost savings) in relation to energy-related expenditure leading to increased disposable income and higher business profits.

These two effects combined can lead to changes in macroeconomic variables such as Gross Domestic Product (GDP), employment, energy prices and the trade balance (IEA, 2015).

An alternative perspective is put forward by the European Union funded COMBI project, which considers the short-run (business cycle) and long-run (structural) effects of energy efficiency investments (COMBI, 2015c).

The short-run effects of additional investment in energy efficiency include employment, GDP, public budgets and inflation. In an economic downturn, when output is below the economy's potential growth rate, the additional investment can help lessen the severity of the recession. However, in an upswing, additional investment may have a detrimental impact, either crowding out other (more productive) investment, or contributing to an overheating of the economy (COMBI, 2015c).

The long-run impact of energy efficiency investments may be observed as changes in the structure of the economy. Potential effects include improved labour productivity (arising from, for example, health benefits or improved indoor air quality), relative prices (energy intensive products relative to other goods, or imports relative to exports), trade flows and the overall productivity in the economy. These effects can lead to (assumed net positive) changes in employment and the potential growth rate of the economy (COMBI, 2015c).

Given the cross-sectoral nature of macroeconomic impacts, the variables in question are unlikely to be affected by programs that only target one part of the economy, or are small-scale in nature (IEA, 2015). Typically, macroeconomic or computable general equilibrium (CGE) models (possibly in combination with input-output models) are used to estimate the economy-wide effects and interactions (COMBI, 2015c; IEA, 2015).

Where macroeconomic impacts are considered, it is important to consider the net effect on the economy. For example, while an energy program or policy may result in the creation of direct employment (in the installation and manufacturing of energy efficiency equipment) and indirect employment (resulting from changes elsewhere in the supply chain) these gains must be netted off against jobs lost elsewhere in the economy (for example in energy producing sectors) (IEA, 2015).

3 PRINCIPLES FOR ASSESSING THE MULTIPLE IMPACTS OF ENERGY EFFICIENCY

This chapter presents a series of core principles for assessing the direct and indirect impacts associated with household energy efficiency. These principles represent sound economic and regulatory practices and incorporate the input received from a range of stakeholders during the development of this report.

It is recommended that the principles outlined in Table 3.1 are applied when conducting assessments of the multiple impacts of household energy efficiency.

TABLE 3.1 PRINCIPLES FOR ASSESSING THE MULTIPLE IMPACTS OF HOUSEHOLD ENERGY EFFICIENCY

Principle	Description
Best practice assessment principles	
1. Causality	There should be a sound basis for considering the different impacts of an energy efficiency policy or program and a logical pathway through which the energy efficiency measure would result in the impact(s) being considered.
2. Consistency with public and corporate objectives	The multiple energy efficiency impacts being considered should align with broader public policy objectives (when the policy/program is funded by government) or corporate objectives (when the policy/program is funded by industry). For example, the value placed on emissions avoided should be consistent with the value that the particular jurisdiction or business places on emissions avoided.
3. Comprehensiveness	All the multiple impacts associated with the intervention or suite of interventions should be identified when assessing the overall net impact of an energy efficiency policy or program.
4. Consistency with existing frameworks	The approach used to assess the multiple impacts of energy efficiency should be consistent with existing jurisdictional frameworks for assessment of energy efficiency policy/programs, such as The Australian Guide to Regulation, the NSW Guide to Better Regulation, the Victorian Guide to Regulation, and the Queensland Government Guide to Better Regulation.
5. Materiality	While all the multiple impacts associated with energy efficiency should be identified, the effort expended to quantify each of these impacts should be commensurate with their expected materiality.
6. Quantification	To the maximum extent possible, and subject to the materiality assessment, all the multiple impacts associated with the intervention should be quantified. Only where impacts cannot be quantified should they be assessed qualitatively.
Principles for quantification of impacts	
7. Individual treatment	The most appropriate methodology and data should be applied when quantifying each individual impact.
8. Fit for purpose	The robustness of the methodology, estimates and data for quantifying the multiple impacts of energy efficiency should be fit for purpose, taking into consideration the application of the quantification (e.g. an initial estimate, a cost benefit analysis for a Regulatory Impact Statement, a business case or a program evaluation).

<table>
<tr><th>Principle</th><th>Description</th></tr>
<tr><td>9. Robustness</td><td>The most robust methodology and data available should be used to quantify the multiple impacts of energy efficiency. The following hierarchy should be considered when undertaking these assessments.
a) Where robust estimates and data are available for quantifying the multiple impacts under specific circumstances (that is, for that energy efficiency measure in that jurisdiction) those robust estimates and data could be applied.
b) If robust estimates and data have not been developed for the multiple impacts under the specific circumstances, then estimates and data from similar circumstances (same category of energy efficiency measure (deep retrofit, shallow retrofit or behavioural change), similar climate zone and similar socio-demographics) could be conservatively applied.
c) Where estimates of impact are not available for the specific circumstances (that is, for that energy efficiency measure in that jurisdiction), data should be collected to appropriately quantify the different impacts.
d) If quantification of the multiple impacts associated with the intervention is not possible given best-available data and estimates, then qualitative consideration of all the multiple impacts is preferable to assuming those impacts do not exist or have no value.</td></tr>
<tr><td>10. Symmetry</td><td>Assessments of the multiple impacts of an energy efficiency intervention should be symmetrical and include costs, benefits and trade-offs associated with each relevant type of impact so that the net impacts are considered.</td></tr>
<tr><td>11. Avoid double counting</td><td>The multiple impacts of energy efficiency are not always distinct and independent. Double-counting of impacts should be avoided by:
a) avoiding the inclusion of:
i) non-external ancillary benefits, where the impact is already included in a market transaction—for example increased profits for companies providing energy efficiency services
ii) pecuniary externalities, where the energy efficiency measure causes a price effect, but does not have a real resource effect—for example when energy efficiency contributes to increased property values
b) avoiding overlaps or gaps between values obtained through different assessment methods, resulting in an over or underestimation of the total impact
c) considering the interactions between different actions or policy measures tackling the same sector or issue.</td></tr>
<tr><td>12. Consider the rebound effect</td><td>Energy savings from implemented energy efficiency measures may not materialise. This is referred to as the rebound effect and may take three forms:
a) the take-back effect, where energy users increase their consumption of energy using services (e.g. heating)
b) the spending effect, where energy users spend financial savings from energy efficiency on other energy consuming activities
c) the investment effect, where investment in energy efficiency leads to an indirect increase in economic activity and energy consumption.
The rebound effect should be considered in assessing the net impacts of energy efficiency interventions.</td></tr>
<tr><td>13. Measure marginal, not average, impacts</td><td>The marginal impacts associated with an energy efficiency measure should be considered rather than the average impacts. Marginal impacts are specifically associated with the energy efficiency measure, while average impacts are estimated by averaging over a larger population. For example, the marginal benefit of avoided emissions considers only the generators that are displaced as a result of an energy efficiency initiative. The average benefits are estimated using the emissions intensity averaged across a larger group of generators.</td></tr>
<tr><td>14. Consider the incidence of impacts</td><td>The incidence of the costs and benefits associated with an energy efficiency measure should be considered to ensure that there is a net societal benefit associated with that measure rather than a distributional effect, whereby a benefit to one party is a cost to another party.</td></tr>
<tr><td>15. Transparency</td><td>The assessment of impacts should be transparent, with the methodology, source of estimates and source of data clearly identified.</td></tr>
</table>

SOURCE: ACIL ALLEN CONSULTING.

FRAMEWORK FOR ASSESSING THE MULTIPLE IMPACTS OF HOUSEHOLD ENERGY EFFICIENCY

4

This chapter presents a logic map for the impacts associated with residential energy efficiency, discusses the use of multiple impacts assessments and discusses a number of cross-cutting methodological considerations that need to be taken into account when assessing energy efficiency impacts.

4.1 Energy efficiency impacts logic map

Figure 4.1 presents a logic map for the multiple impacts associated with residential energy efficiency policies and programs. The diagram draws on the relevant Australian and international research discussed in the previous chapter.

Darker shaded boxes represent a more substantial evidence base

Solid lines represent a stronger causal link

The logic map is divided into 7 separate levels and 26 individual impacts.

Of these, impacts presented in a darker shade are, to date, underpinned by a more substantial evidence base than those in a lighter shade.

Interrelationships between the impacts are indicated by connecting arrows. A solid line indicates that a stronger causal link has been established in the existing literature, while a dashed line symbolises a weaker causal link.

The logic map can be interpreted, from top to bottom, as follows.

The **first layer** is the implementation of an energy efficiency policy or program and the associated energy efficiency measures. These include the full suite of possible interventions, such as:

— deep, systematic retrofits that aim to achieve large scale reductions in energy consumption
— so-called easy retrofits that improve one or more elements such as glazing or insulation or draught proofing in a non-systematic way
— low cost or no cost energy efficiency actions, such as provision and installation of door snakes and draught strips
— energy saving tips and advice to householders.

The **second layer** in the diagram represents changes in householders' attitudes towards, and knowledge of, energy efficiency. These effects are likely to depend on the nature of the intervention—whether, for example, information provision and advice on energy usage are incorporated as part of the program objectives and delivery.

The **third layer** represents household behaviour change as a result of the energy efficiency intervention—this will be a combination of reduced energy consumption (and associated bill savings) and improved thermal comfort. These are also known as *exposure factors* and primarily depend on the intervention itself, but also changes in householders' attitudes and knowledge affecting energy use. There may be a trade-off between these two impacts, which is discussed in greater detail in the next chapter.

The **fourth and fifth layers** represent the first and second round impacts arising from changes in energy consumption and thermal comfort.

The strongest evidence to date exists for reduced bill pressure and financial stress (potentially in combination with improved thermal comfort) associated with reduced energy consumption, leading to improved mental health. Improved thermal comfort leads to reduced mortality and better physical health. Flow-on impacts of improved health on households may be reduced private health care costs and fewer days off school and work.

Other benefits for which some evidence exists include increased property values, improved diet as a result of greater disposable income, reduced costs associated with disconnections, and lessened family tensions and social isolation as the home is better heated.

The **sixth layer** describes the impacts for industry participants. While from a societal perspective energy efficiency generally speaking incurs benefits, energy utilities experience reduced energy consumption as a decrease in revenue and investment opportunity.

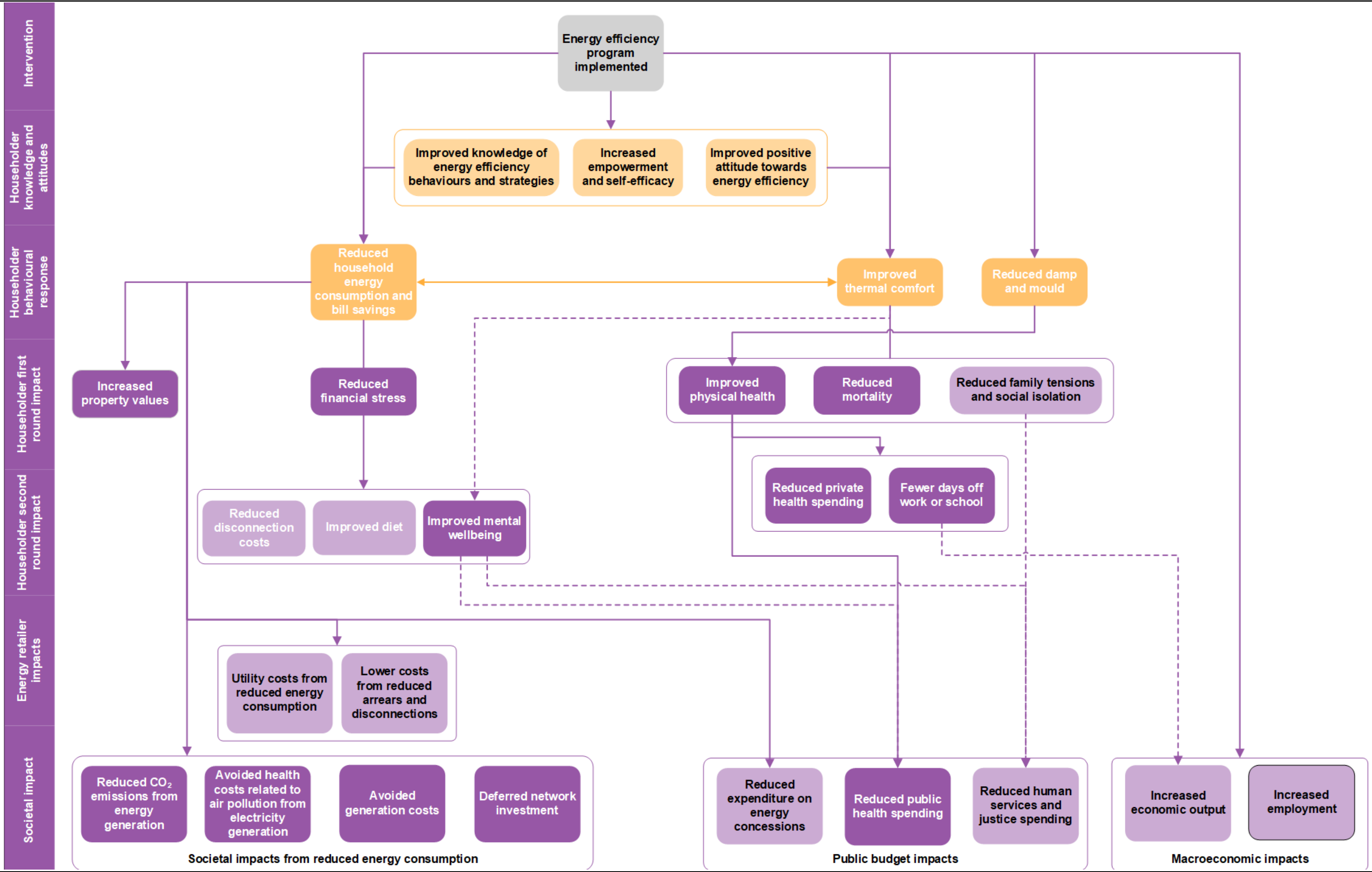
The benefits from energy efficiency for industry participants relate to energy efficiency initiatives targeting low income households, which can lead to reduced expenditure on energy retailers' hardship programs, reduced arrears, and reduced costs associated with collections, disconnections and bad debts. In a competitive market these impacts would be expected to translate to lower prices for consumers, but in the short term the impacts accrue as a benefit for energy retailers. In addition, initiatives aimed at low income consumers may provide a benefit for retailers in the form of improved corporate relations and reputation.

The **final layer** in the diagram depicts the societal impacts from residential energy efficiency. These are benefits accruing to all members of society beyond those directly participating in the energy efficiency program. Societal impacts can be categorised as:

— energy system benefits arising from reduced energy consumption
— public budget impacts due to reduced costs associated with the payment of energy concessions, human services and justice, and public health care costs
— macroeconomic impacts on economic output and employment.

Of these, the strongest evidence to date has been established for energy system benefits and reduced public health care expenditure.

FIGURE 4.1 ENERGY EFFICIENCY IMPACTS LOGIC MAP



SOURCE: ACIL ALLEN

4.2 Use of multiple impacts assessments

Broadly speaking, the multiple impacts of energy efficiency can be assessed for two distinct, but interrelated purposes. Firstly, these impacts may provide a valuable input to cost-benefit analysis as part of the policy development and design process. In this case, the assessment is conducted ex ante using appropriate values from existing studies and literature, if it is thought that these are transferable to the initiative in question.

From a public policy perspective the cost-benefit analysis (whether ex ante or ex post) should consider the societal impacts outlined in Figure 4.1**.** Where these can be robustly quantified and monetised, other impacts such as improved physical health and mental wellbeing, reduced mortality and a reduction in days off school or work may be included. To date, robust methodologies for a number of intangible benefits such as reduced disconnection costs, improved diet or reduced family tensions and social isolation have not yet been established. However, approaches to value these should be pursued, and once a reliable framework has been established, the benefits could be considered for inclusion in a cost-benefit analysis.

From an industry participant perspective, the inclusion of the multiple impacts associated with energy efficiency may bolster the business case for an energy efficiency program being considered. Relevant benefits for inclusion are the energy system impacts associated with reduced energy consumption, and retailer benefits arising from reduced expenditure on hardship programs, reduced arrears and reduced costs associated with collections, disconnections and bad debts. In addition, retailers may wish to include participant benefits in terms of improved health, mortality and well-being outcomes, to the extent that these can be robustly monetised.

Secondly, assessing the multiple impacts associated with energy efficiency may provide a valuable input to program evaluation. They can be used as part of an economic evaluation in the form of an ex-post cost-benefit analysis. This would ideally draw on information about the real outcomes achieved.

In addition, an assessment of the multiple impacts of energy efficiency may provide a valuable input to an evaluation assessing the outcomes achieved by a program. The impacts may be directly linked to the objectives and purpose of the intervention, provide contextual information about the causal pathway from outputs to ultimate outcomes, or explore some of the unintended results achieved. In this case, the impacts considered will largely depend on the program or intervention logic, potentially coupled with some qualitative or exploratory analysis to capture unintended outcomes.

4.3 Cross-cutting methodological considerations

This section provides an overview of social research protocols and methods, approaches for valuing intangible impacts, and common approaches to setting discount rates.

4.3.1 Social research protocols and methods

The multiple impacts of energy efficiency are in most cases dependent on the characteristics of the households receiving the intervention. Program design considerations and geographical factors such as climate zone may also have a significant impact.

When designing and conducting an assessment of the multiple impacts of energy efficiency, care should be taken to consider and document these contextual factors that will potentially affect the prevalence and magnitude of the impact. This will enable other researchers to assess the applicability of the results to their own program.

If using estimates established for one program to assess multiple impacts from another intervention, care should be taken to only use estimates from comparable programs. For example, the improvement in thermal comfort of an intervention targeting dwellings in very poor condition would not be comparable with a broad-based program aimed at all dwellings with some potential for improved energy efficiency.

When undertaking research into the multiple impacts of energy efficiency, best practice social research protocols should be followed. These should be set out before embarking on the research and also clearly outlined in project reports. Key considerations include (WHO, 2017) the following:

- **Rationale and background information**, specifying the reasons for conducting the research and setting out a well-documented statement of the need/problem, the cause of this problem and its possible solutions.
- **Study goals and objectives**, outlining in specific terms what the research hopes to accomplish.
- **Study design**, including information on the type of study, the research population or the sampling frame, study participants and (expected) duration of the study.
- **Methodology**, including detailed information on the interventions, procedures used, measurements taken and observations made.
- **Statistical analysis**, describing statistical methods used, including reasons for the sample size selected, power of the study and level of significance.
- **Outcomes of the study,** including how the results can be utilised and how they may affect program and policy design.

The most robust research methods and evidence possible should be used to assess the multiple impacts of energy efficiency. Box 4.1 discusses the relative strength of different types of evidence.

BOX 4.1 CONSIDERATIONS IN ASSESSING ROBUSTNESS OF EVIDENCE

Evidence hierarchy

1. **A systematic review**

   A systematic review of randomised controlled trials is the strongest source of evidence on the effectiveness (or otherwise) of an intervention. It methodologically identifies, appraises and synthesises evidence from scientific studies, only taking into account findings from studies deemed sufficiently robust.

2. **A randomised controlled trial**

   For single studies, this is the most robust design for demonstrating a causal relationship between the intervention and the observed outcomes. Randomised allocation into treatment and control groups ensures that systematic differences between the two are minimised and that the observed results are not affected by any potential bias associated with the selection process.

3. **A pseudo-randomised controlled trial**

   This design is similar to a randomised controlled trial, with the exception that selection into treatment and control groups is done using a pseudo-random method, such as alternate allocation.

4. **A comparison study with concurrent controls**

   When randomised allocation into treatment and control groups is not feasible, a comparison study design may be employed. A well thought-out, high quality design can demonstrate a causal link between the program activities and outcomes through comparing participants to a non-random control group, a similar comparison group or at different phases of the intervention. Common techniques include:

   a) *non-randomised allocation into treatment and control groups* (for example, based on subject preference or availability)
   b) *cohort studies*, where outcomes for groups of people exposed to the intervention are compared to groups not exposed, defining the groups either prior to commencing the intervention (prospective design) or at point of time in the past and comparing their outcomes (retrospective design)
   c) *case-control study*, where people with the outcome in question (for example a disease) are compared to an appropriate control group without the outcome, and information is obtained on whether the study subject had previous been exposed to the intervention under examination
   d) *interrupted time series with a control group*, where trends in an outcome are measured over multiple time points before and after the intervention is introduced to a group of people, and then compared to the outcomes at the same time points for a group of people that do not receive the intervention.

5. **A comparison study without concurrent controls**

If obtaining a comparison group whose outcomes can be observed concurrently with those of the intervention group is not possible, a study design may use alternative ways of defining a control group. These include:

a) *historical control study*, where outcomes for the treatment group are compared to, for example, the outcomes of a previous study of comparable people undergoing an alternative or control intervention
b) *two or more single arm study*, where the outcomes of a single series of people receiving an intervention from two or more studies are compared
c) *interrupted time series without a parallel control group*, where trends in an outcome are measured over multiple time points before and after the intervention is introduced to a group of people, and compared (as opposed to being compared to an external control group).

6. **Case series with before-and-after or post-test only measures**

The weakest quantitative study design considers only a single group of people exposed to the intervention, and cannot be used for establishing a causal link between the intervention and observed outcomes. Measurements are taken either before and after the intervention has been introduced, or only after the fact. In the latter case, no comparisons can be made.

7. **Qualitative data**

Qualitative data can be used to supplement quantitative measurement of observed outcomes. Although qualitative methods, such as case studies and expert opinion, cannot measure the effectiveness of a program or intervention, robust outcome evaluations often include some qualitative data sources to provide contextual information and a narrative for the quantitative data captured.

Other considerations in determining robustness of evidence

When considering the overall robustness of the findings of a study, the quality of its design is only one consideration. Other factors include quality of how the study was conducted, the consistency of findings with those from other studies, the clinical impact of its results, the generalisability of the results to the population for whom the guideline is intended; and the applicability of the results to the Australian (and/or local) health care setting.

SOURCE: (NHMRC, 2009; DPC, 2016)

4.3.2 Valuing intangible benefits

Cost benefit analysis (CBA) is one of the primary tools used for policy development and decision making. It provides a consistent framework for valuing the different impacts of a policy or program at the societal level, allows various options and initiatives to be ranked, and investments to be prioritised accordingly.

The use of CBA requires that a monetary value be ascribed to each impact included in the calculation. When a market value exists, this is relatively straightforward. However, the valuation of non-market or intangible impacts is more challenging and, as a result, these impacts are often only considered qualitatively, if at all.

However, over the last decade and more, considerable progress has been made in developing consistent approaches and frameworks for the valuation of intangible impacts. In particular, social return on investment (SROI) analysis provides a framework for identifying, evidencing and monetising the full range of economic, social and environmental impacts.

Table 4.1 provides a high-level overview of the standard approaches for valuing intangible impacts.

TABLE 4.1 APPROACHES FOR VALUING INTANGIBLE IMPACTS

Method	Description	Complexity
Revealed preference	Revealed preference techniques infer values from the prices of related market-traded goods. With the underpinning assumption that consumer preferences are revealed by their purchasing decisions, these techniques analyse data on individual transactions to attribute value to non-market goods. Revealed preference techniques are medium to high complexity, requiring good quality data as well as substantial technical expertise.	Medium to high complexity
Stated preference	This method estimates non-market values by asking people what they are willing to pay for a hypothetical good or service, or what they are willing to receive as compensation to tolerate a cost or a loss. This is done by surveying a sample of people considered representative of the wider population. Stated preference techniques require significant resources and expertise in designing appropriate surveys and undertaking fieldwork. Designs based on hypothetical situations can be subject to bias.	Very high complexity
Benefit transfer	When primary studies on stated or revealed preferences are available, these findings can be used as proxies when valuing non-market impacts. Consideration needs to be given to comparability of both the intervention and the target population. This is the most cost-effective of the three methods, as is does not require primary research to be undertaken. However, it relies on the availability of existing studies and may not result in valuations tailored to the initiative under consideration.	Low complexity
Life satisfaction approach	This relatively new approach estimates the value of non-market goods by looking at how they impact on people's reported well-being. Drawing on findings from behavioural economics and psychology, the motivation for the methods stems from doubts over whether the assumption of rationality underpinning preference-based approaches is valid. Using the life satisfaction approach necessitates the collection of primary data from a sample population, requiring significant resources and expertise. Given the relatively untested nature of this method, usage of its results in CBAs is not yet recommended.	High complexity

SOURCE: (INFRASTRUCTURE VICTORIA, 2016; SROI NETWORK, 2012; HM TREASURY, 2011)

4.3.3 Discount rates

There is extensive debate around the basis and selection of an appropriate rate to discount the streams of costs and benefits of energy efficiency policies and programs.[5]

In the United States, the recommended discount rate depends on the evaluation perspective. A low societal discount rate is suggested as the most appropriate when considering costs and benefits from a whole-of-society perspective. This reflects society's tolerance for receiving benefits in the future, better ability to access funds at a lower borrowing cost, and the relatively low risk associated with energy efficiency investments (RAP, 2012).

In the United Kingdom, the recommended discount rate across all government investment decisions is based on social time preference approach. This is defined as the value that society attaches to present, as opposed to future, consumption. For investments with a time horizon of up to 30 years, a rate of 3.5 per cent is recommended. In addition, uncertainty over the future causes declining discount rates over time. A schedule of declining long-term discount rates is therefore applied for costs and benefits accruing more than 30 years into the future (HM Treasury, 2016).

In Australia, the preferred approach is to base the discount rate on market-based interest rates. This is seen to account for the societal opportunity cost of capital and to indicate the value to the current population of future net benefits. The use of benchmarks such as the government long-term bond rates are not seen as appropriate, as the government's ability to borrow at a lower rate than the private sector derives from its taxing powers, which impose welfare losses on the economy (OBPR, 2016; NSW Treasury, 2017).

[5] Throughout this section, real rather than nominal rates are used.

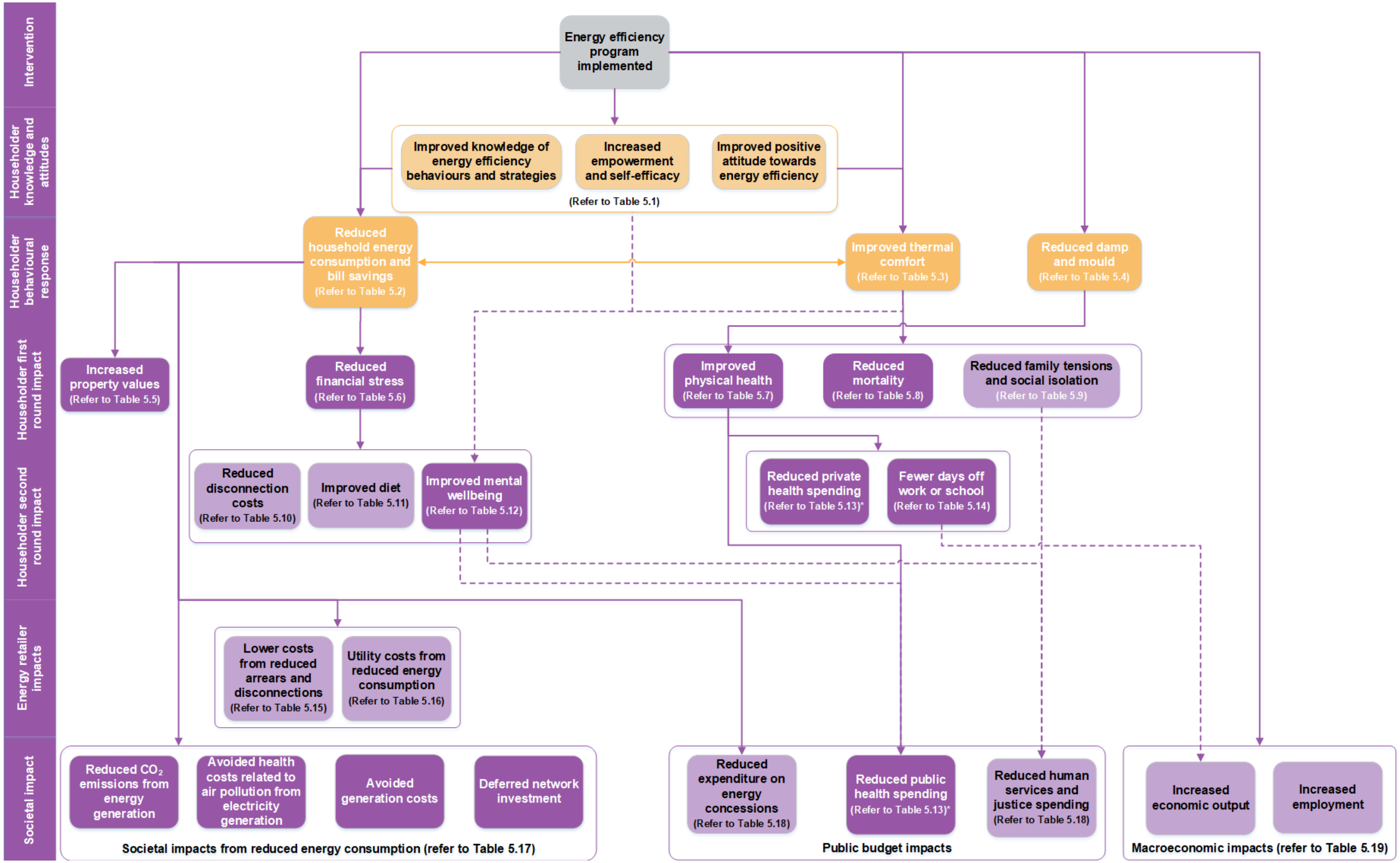
The most commonly used central discount rate is 7 per cent, with sensitivity testing typically undertaken at 10 per cent and 3 or 4 per cent (OBPR, 2016; NSW Treasury, 2017). However, jurisdictional variations exists. For example, the Victorian Government recommends the use of a 4 per cent discount rate for regulatory proposals, when the benefits can be articulated but are not easily translated to monetary terms, or when there is considerable uncertainty about estimated costs and benefits. A rate of 7 per cent should be used when the benefits attributed to the project can easily be monetised (DTF, 2013).

5 MULTIPLE IMPACT FRAMEWORK COMPONENTS

This chapter provides additional details about the definition and measurement of each of the multiple impacts of energy efficiency outlined in Chapter 4.

Figure 5.1 identifies the table in which the details for each multiple impact can be found within this chapter.

FIGURE 5.1 GUIDE TO THE MULTIPLE IMPACTS OF ENERGY EFFICIENCY



SOURCE: ACIL ALLEN

5.1 Householder knowledge, attitudes and behaviour

TABLE 5.1 HOUSEHOLDER KNOWLEDGE, ATTITUDES AND SELF-EFFICACY

Criteria	Findings
Description	As illustrated in Figure 5.1, the implementation of an energy efficiency program may lead to changes in participants' knowledge, attitudes and self-efficacy. These can be defined as follows: – **knowledge** relates to an understanding of energy efficiency behaviours and strategies – **attitudes** measures the extent to which householders regard energy efficiency behaviours and practices positively – **self-efficacy** (also known as empowerment) reflects householders' ability to control the use of energy in the home through a greater understanding of how energy works.
Likely materiality of the impact	The materiality and relevance of this impact depends on the extent to which knowledge, attitudes and behaviours have been incorporated in the program design. If it is a key part of the intervention logic, it should be measured. Research undertaken in Australia provides some evidence that this impact has been achieved among low income households. However, the usefulness of existing studies is limited by methodological constraints such as lack of baseline information and consistency in the measurement framework. Finally, it is unlikely that interventions that do not explicitly include improvement in knowledge, attitudes and self-efficacy will achieve this outcome.
Approaches for quantifying the impact	Changes in knowledge, attitudes and self-efficacy are measured using a household survey. Ideally, this would include before-and-after measurements for both participants and an equivalent control or comparison group. It is not appropriate to monetise this impact.
Indicators and data requirements	The research undertaken for this report has not identified a validated survey instrument for measuring improvements in knowledge, attitudes and self-efficacy. In the absence of a common framework, studies investigating the issue have developed their own indicators, covering issues such as: – understanding of energy use in the home – interest in, and attitudes towards, energy efficiency – confidence in using heating/cooling controls to manage temperature.
Dependencies and trade-offs with other impacts	Improvements in knowledge, attitudes and self-efficacy may amplify the effect of the energy efficiency intervention, resulting in greater energy savings and/or enabling householders to better manage the trade-off between bill savings and thermal comfort. This impact, when present, may therefore contribute to greater downstream impacts such as improved health, reduced bill pressure and improved mental wellbeing.
Contextual factors and considerations	As discussed above, the presence of this impact is highly dependent on program design and implementation. However, in principle it should be available to all household types, regardless of socioeconomic and geographical considerations.
Key studies assessing the impact	Databuild (2014). Evaluation of Non-Energy Benefits for the NSW Home Power Savings Program. Final report to the NSW Office of Environment and Heritage. GEER Australia (2017). Power Shift Project Two Deliverable 1: Overview of Energy Efficiency Co-Benefits. Report to Energy Consumers Australia. James, M., & Ambrose, M. (2017). Retrofit or Behaviour Change? Which has the Greater Impact on Energy Consumption in Low Income Households? *Procedia Engineering*, 180, 1558-1567.
Transferability of existing estimates	Given that this impact is highly dependent on program design and implementation, estimates are not transferable to other interventions.
Next steps	To advance the understanding of how energy efficiency interventions may contribute to improved knowledge, attitudes and self-efficacy, it is important to establish a common framework and survey instrument for measuring change. Linkages to other impacts should be explored further, particularly considering the role program design incorporating knowledge, attitudes and self-efficacy considerations may have on amplifying the impact of any physical energy efficiency measures.

5.2 Reduced household energy consumption and bill savings

TABLE 5.2 REDUCED HOUSEHOLD ENERGY CONSUMPTION AND BILL SAVINGS

Criteria	Findings
Description	A reduction in household energy consumption, resulting in bill savings, is a direct distributional impact of energy efficiency.
Likely materiality of the impact	The potential for energy and bill savings depends on both the nature of the intervention, and the presence of a take-back effect. Exclusion of other impacts has the effect of underestimating the total benefits that can accrue from residential energy efficiency; however, energy and bill savings remain material in most, if not all, interventions.
Approaches for quantifying the impact	The impact of a policy or program is estimated through comparing energy use before and after the intervention. For ex ante analysis, inputs include estimates of potential savings (based on engineering calculations or previous studies) and building stock models, which often incorporate energy consumption data. For ex post analysis, energy savings can be quantified using regression analysis, where non-program effects of weather and household specific differences are controlled for directly. Techniques implicitly controlling for non-program effects, for example through using matched control groups, have also been employed; however, regression analysis is generally preferred since it more readily allows for the estimation of individual program components. The **participant benefit** in terms of bill savings can be expressed as a proportion of household energy consumption, or monetised using retail tariffs, to understand the distributional impact of an energy efficiency initiative. The **societal perspective**, using wholesale energy prices as a proxy, rather than retail energy prices, should be used for policy development and evaluation. Approaches for valuing the societal benefit are discussed in Table 5.17**.**
Indicators and data requirements	Data required to assess the reduction in household energy consumption include: – energy metering data – energy efficiency intervention(s) applied – weather and climate data – household demographics.
Dependencies and trade-offs with other impacts	The benefit of energy efficiency measures can be reaped by households as improvements in thermal comfort, as energy bill savings, or some combination of the two. Prioritisation of improved thermal comfort at the expense of bill savings is known as the take-back effect. This is more likely to be present for so-called 'easy' retrofits (non-systematic improvements to one or more dwelling elements) but has not been documented for systematic, deep retrofits. The presence of a take-back effect may in turn have knock-on effects for other impacts; these will be highlighted in the sections below as appropriate. In addition, program design considerations, such as required co-contribution (offset by bill savings) from participants, may have an impact on households' ability to make a choice between energy savings and thermal comfort.
Contextual factors and considerations	The magnitude of potential energy savings depends on the climate zone in which the intervention is being implemented, dwelling type, household demographics and the energy efficiency measure(s) being applied. In ex-post studies, all relevant factors should be controlled for when estimating the savings, and therefore the potential benefit to the household. In ex-ante studies assessing the feasibility of a particular policy or program, estimates of savings from the measures under consideration are typically applied to households in general. Distributional effects on particular cohorts, such as the impact on low income households, may also be considered (but only the net societal impact measured).
Key studies assessing the impact	Rickwood P., Mohr S., Nguyen M., Milne G. (2012). *Evaluation of the home power savings program–Phase 1*, prepared by the Institute for Sustainable Futures, UTS for the NSW Office of Environment and Heritage, Sydney. Sustainability Victoria (2014). Victorian Households Energy Report.
Transferability of existing estimates	Existing empirical estimates of potential energy savings are frequently used in ex-ante modelling of energy efficiency policies and programs. Issues that should be considered when transferring estimates include nature and scale of the intervention, the population targeted by the intervention and local climate zone.
Next steps	Methodologies for assessing energy savings are well established, and should continue to be followed when evaluating the potential and realised impact of energy efficiency interventions in the residential sector.

5.3 Improved thermal comfort

TABLE 5.3 IMPROVED THERMAL COMFORT

Criteria	Findings
Description	Thermal comfort or quality refers to whether the indoor air temperature is comfortable and healthy, defined by the World Health Organisation as ranging between 18 and 21 degrees Celsius. Energy efficiency measures may lead to changes in indoor temperature toward the healthy range during both hot and cold spells. As outlined in Figure 5.1, improved thermal comfort is the key exposure factor linking energy efficiency to improved health outcomes.
Likely materiality of the impact	Typically, extreme heat is perceived to be a more common concern than extreme cold in Australia. However, evidence from Europe indicates that excess winter mortality (the increased rate of deaths observed in winter compared to summer) is greater in temperate and hot climates than in colder climates. This effect has been linked to inadequate quality of housing and heating systems to cope with periodic colder spells. There is strong evidence internationally linking energy efficiency to improved thermal comfort, particularly in colder climates. However, the magnitude of the impact will depend on contextual factors described below. Given the variability in climate conditions, residential energy efficiency in an Australia context may plausibly lead to improved thermal comfort through tempering the effects of both hot and cold extremes. However, to date, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	Physical measurements and occupant perceptions (outlined below) provide supporting evidence for establishing the causal link between an energy efficiency intervention, improved thermal comfort as the exposure factor, and observed outcomes such as improved health. Improved comfort is often regarded as an important selling point for energy efficiency, and obtaining information on program participant perceptions through surveys can provide valuable information for program design and promotion. However, thermal comfort is typically not valued or monetised. It is generally regarded as a 'softer' benefit for which willingness to pay type approaches are not regarded as robust. While other approaches such as asking households to value the improvement in comfort as a fraction of bill savings have been explored, these are not yet well established or prevalent.
Indicators and data requirements	Possible indicators that can be used to measure improved thermal comfort are: – indoor average temperatures, obtained through physical measurements – number of rooms heated and in active use by occupants, obtained through physical measurements or household surveys – occupants' perceptions of thermal comfort, obtained through household surveys.
Dependencies and trade-offs with other impacts	The benefit of energy efficiency measures can be reaped by households as improvements in thermal comfort, as energy bill savings, or some combination of the two. Prioritisation of improved thermal comfort at the expense of bill savings is known as the take-back effect. This is more likely to be present for so-called 'easy' retrofits (non-systematic improvements to one or more dwelling elements) but has not been documented for systematic, deep retrofits. The presence of a tack-back effect may in turn have knock-on effects for other impacts; these will be highlighted in the sections below as appropriate. In addition, program design considerations, such as required co-contribution (offset by bill savings) from participants, may have an impact on households' ability to make a choice between energy savings and thermal comfort.
Contextual factors and considerations	The pathways through which energy efficiency measures contribute to improved thermal comfort, and ultimately improved health, depend on the climate zone in which the intervention is being implemented. Program specific factors include: – the extent to which the intervention targets vulnerable populations, such as the elderly, individuals with a known health condition (for example respiratory disease or asthma), or dwellings in colder areas and/or with known poor energy efficiency performance – design choices relating to required co-contribution from households: to the extent that participants bear the cost of the intervention through off-set bill savings, they will be unable to independently make the choice between realised energy savings and improved thermal comfort.

Criteria	Findings
Key studies assessing the impact	Skumatz, L., Dickerson, C., and Coates, B. (2000). Non-Energy Benefits in the Residential and Non-Residential Sectors—Innovative Measurements and Results for Participant Benefits, American Council for an Energy Efficient Economy (ACEEE) Conference Proceedings, Asilomar, California. Howden-Chapman, P., Matheson, A., Crane, J., Viggers, H., Cunningham, M., Blakely, T., Cunningham C., Woodward A., Saville-Smith K., O'Dea D. & Kennedy, M. (2007). Effect of insulating existing houses on health inequality: cluster randomised study in the community. *BMJ*, 334(7591), 460. Stoecklein, A., & Skumatz, L. (2007). Zero and Low Energy Homes in New Zealand: The Value of Non-energy Benefits and Their Use in Attracting Homeowners, ACEEE Summer Study. ACEEE, USA. Tetra Tech, Inc. and Massachusetts Program Administrators (MPA) (2011). Massachusetts Special and Cross-sector Studies Area, Residential and Low-income Non-energy Impacts (NEI) Evaluation, final report prepared for MPA, Tetra Tech, Inc., Madison
Transferability of existing estimates	The studies above asked energy efficiency participants in the United States and New Zealand to estimate the value of comfort (and other impacts) relative to energy bill savings obtained through an energy efficiency measure. These estimates are not readily transferable to an Australian context. Key issues include: – The cost of electricity, and hence bill savings, is likely to vary between United States, New Zealand and Australia. As a result, the dollar value for improved comfort estimated relative to bill savings is not comparable between them. – The studies cover a wide range of interventions, and drawing a clear link between the findings to a particular intervention in an Australian context is likely to prove challenging. – Cultural variations may affect the value households associate with improved comfort, and hence any cross-country estimates should be treated with caution.
Next steps	Further research on the impact of energy efficiency on thermal comfort should be conducted in an Australian context. Key actions include: – developing harmonised indicators to measure the improvements in thermal comfort – investigating the nature and extent of the problem in Australia, including variations between climate zone – developing validated survey instruments to measure household perceptions of thermal comfort.

5.4 Reduced damp and mould

TABLE 5.4 REDUCED DAMP AND MOULD

Criteria	Findings
Description	Excess indoor humidity or dampness can generate and aggravate a range of illnesses, including allergies and respiratory diseases such as asthma. In addition, it can lead to mould growth, which has further negative health impacts. Well-designed energy efficiency interventions, especially those including better ventilation systems, can reduce dampness. However, poorly designed interventions increasing air tightness without consideration of air flow in the dwelling may increase dampness and inadvertently create negative health outcomes. As outlined in Figure 5.1, reduced damp and mould is, alongside improved thermal comfort, a key exposure factor linking energy efficiency to improved health outcomes.
Likely materiality of the impact	An estimated 10-50 per cent of building stock in Europe, North America, Australia, India and Japan may suffer from poor indoor air quality as a result of excess dampness. However, the prevalence of the problem varies depending on country, continent and climate zone. Certain areas, such as river valleys and coastal regions, are more susceptible to problems associated with dampness. Evidence from New Zealand and the UK indicates that well-designed energy efficiency measures can improve problems associated with excess indoor dampness. While the studies to date have been conducted in colder climates, it is plausible that an energy efficiency intervention which incorporates air flow considerations could reduce indoor dampness in warm, humid climates. However, to date, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	Physical measurements and occupant perceptions (outlined below) provide supporting evidence for establishing the causal link between the energy efficiency intervention, reduced damp and mould as the exposure factor, and observed outcomes such as improved health. As an exposure factor leading to potential downstream benefits, reduced damp and mould is typically not monetised as an individual impact. However, it is conceivable that improved comfort resulting from a healthier indoor environment could have a value for program participants, apart from and in addition to any potential health benefits. Approaches trialled in the valuation of improved thermal comfort could also be considered in the context of reduced damp and mould, but further work is needed to establish the robustness of these techniques.
Indicators and data requirements	Possible indicators that can be used to measure reduced damp and mould are: – humidity levels inside the building, obtained through physical measurements – prevalence of mould or other problems, obtained through physical measurements or household surveys – occupants' perceptions of indoor dampness and comfort, obtained through household surveys.
Dependencies and trade-offs with other impacts	As discussed above, damp and mould are key exposure factors linking energy efficiency to improved health outcomes. Trade-offs with other impacts have not been discussed in the literature considered for this study. A reduction in damp and mould is likely to be most significant in the context of a well-designed, systematic retrofit rather than a non-systematic intervention. Interventions focussing on improving thermal comfort through providing central heating may also indirectly contribute to reduced damp and mould, since a warmer dwelling is typically also drier than a cold one. However, this type of intervention is unlikely to address the core cause behind the problem, and it is therefore likely that the impact on damp and mould is not substantially affected by the trade-off between bill savings and thermal comfort.
Contextual factors and considerations	The extent to which damp and mould are problems that may be remediated by well-designed energy efficiency actions, or occur as the result of ill-designed interventions, depends on the climate zone and level of humidity of the region in which the intervention is being implemented. In addition, the impact on damp and mould is likely to depend on the nature of the intervention, in particular whether air flow considerations are included in the design. For example, insulation and draught-proofing measures may, in the absence of actions to address ventilation, create or exacerbate dampness and mould. Energy efficiency measures that do not affect the air tightness of the dwelling are unlikely to create or exacerbate problems associated with dampness and mould, although installation of central heating may remediate the problem. Finally, the correct installation of the energy efficiency measure is also important for achieving the intended outcomes and avoiding any unforeseen adverse impacts.

Criteria	Findings
Key studies assessing the impact	Howden-Chapman, P., Matheson, A., Crane, J., Viggers, H., Cunningham, M., Blakely, T., Cunningham C., Woodward A., Saville-Smith K., O'Dea D. & Kennedy, M. (2007). Effect of insulating existing houses on health inequality: cluster randomised study in the community. *BMJ*, 334(7591), 460. Platt, S., Mitchell, R., Petticrew, M., Walker, J., Hopton, J., Martin, C., Corbett, J. & Hope, S. (2007*). The Scottish executive central heating programme: assessing impacts on health*. Scottish Executive. Braubach, M., Heinen, D., Dame, J., & World Health Organization. (2008). Preliminary results of the WHO Frankfurt housing intervention project. Bone, A., Murray, V., Myers, I., Dengel, A., & Crump, D. (2010). Will drivers for home energy efficiency harm occupant health? *Perspectives in public health*, 130(5), 233-238.
Transferability of existing estimates	The estimates of the impact of energy efficiency on reduced damp and mould come primarily from New Zealand, the UK and Germany. Given the difference in climate conditions and the quality of the housing stock between these countries and Australia, the estimates are not readily transferable to an Australia context.
Next steps	Further research on the impact of energy efficiency on damp and mould should be conducted in an Australian context. Key actions include: – developing harmonised indicators to measure the presence and severity of damp and mould – investigating the nature and extent of the problem in Australia, including variations between climate zone – developing validated survey instruments to measure household perceptions of damp and mould, and their impact on comfort.

5.5 Increased property values

TABLE 5.5 INCREASED PROPERTY VALUES

Criteria	Findings
Description	Investment in energy efficiency can increase the value of the dwelling where the measures are installed. This can be reflected in both the sale price and rent of the property.
Likely materiality of the impact	Research from a number of countries, including Australia, indicates that information on the energy performance of a home is reflected in sale prices and rents. This is usually communicated to consumers through energy efficiency or energy performance ratings. Dwellings with higher-than-average performance attract a premium, while dwellings with a lower-than-average rating suffer a penalty. The effect, while present, is typically less pronounced for rental properties.
Approaches for quantifying the impact	The earlier literature on the impact of energy efficiency on property values used willingness-to-pay approaches obtained through household surveys, but more recently hedonic pricing analysis has used market data on sale prices and rents. The latter approach is preferable, in that it provides an actual rather than hypothesised valuation of energy efficiency. The increase in property values represents the present value of the benefits associated with energy efficiency, as assessed by the market. Therefore, including increased property values in a cost-benefit analysis would be double-counting and should not be done. However, it may nonetheless be useful to quantify the impact on property prices and rents, as this is likely to influence property owners' willingness to invest in energy efficiency.
Indicators and data requirements	Data required to assess the impact of energy efficiency on property values include: – information about the energy performance of dwellings (for example through an energy efficiency rating) – information about the energy efficiency characteristics of dwellings (for example through an energy efficiency rating) – information about the other characteristics of the dwelling, such as location and number of bedrooms – sale prices and rents.
Dependencies and trade-offs with other impacts	The increase in property values occurs through the reduction in energy consumption and improved thermal comfort, as well as the downstream participant benefits of these impacts. There are no trade-offs with other impacts.
Contextual factors and considerations	The distributional impact of increasing property prices and rents on vulnerable cohorts such as low income households should be considered.
Key studies assessing the impact	Australian Bureau of Statistics. (2008). *Energy efficiency rating and house price in the ACT*. Canberra: Department of the Environment, Water, Heritage and the Arts Yoshida, J., & Sugiura, A. (2010). *Which "greenness" is valued? Evidence from green condominiums in Tokyo*. Hyland, M., Lyons, R. C., & Lyons, S. (2013). The value of domestic building energy efficiency—evidence from Ireland. *Energy Economics*, 40, 943-952. Kahn, M. E., & Kok, N. (2014). The capitalization of green labels in the California housing market. *Regional Science and Urban Economics*, 47, 25-34.
Transferability of existing estimates	The impact of energy efficiency on property prices varies from country to country. It is therefore not appropriate to transfer international estimates to an Australia context. In Australia, the trends in the property market vary from jurisdiction to jurisdiction depending on local economic trends. However, once a credible estimate has been obtained for a given location or jurisdiction assessing, for example, the price premium gained by each additional point on an energy efficiency scale, this estimate may be applied for a period of time.
Next steps	Further research on the impact of energy efficiency performance and property values, using existing research methodologies, should be conducted in an Australian context.

5.6 Reduced financial stress

TABLE 5.6 REDUCED FINANCIAL STRESS

Criteria	Findings
Description	Reduced spending on energy as a result of an energy efficiency intervention can lead to reduced financial stress among households experiencing energy bill pressure. In the UK, Ireland and New Zealand, the term fuel poverty is commonly used, while in Australia the concept of energy bill pressure is more commonly used.
Likely materiality of the impact	Reducing bill pressure and/or fuel poverty is often a core policy objective of energy efficiency interventions aimed at low income households. While not always explicitly measured, the link between lower bills and reduced financial stress is generally well established.
Approaches for quantifying the impact	A reduction in financial stress is usually considered a contributing factor to other impacts, such as improved mental wellbeing. Measuring improvements in financial stress can be useful for establishing the causal link between energy efficiency and downstream impacts but is typically not monetised for the purposes of a cost-benefit analysis. The most robust evidence for assessing the impact of energy efficiency on reduced financial stress use standardised surveys with demonstrated construct validity. The most rigorous designs include a control or comparison group to establish a causal link between the energy efficiency intervention and observed outcomes.
Indicators and data requirements	Possible indicators for reduced financial stress are: – percentage of monthly budget spent on energy bills – self-reported experience of financial stress and burden associated with energy bills. Changes in financial stress attributable to high energy bills can be assessed objectively, through measuring the proportion of income or monthly budget spent on energy. In addition, financial stress inherently incorporates a subjective element, which can be assessed through household surveys using validated survey instruments. Appropriate control/comparison groups should be used in all cases.
Dependencies and trade-offs with other impacts	Reduction in financial stress is dependent on the extent to which energy savings are realised as a result of the energy efficiency intervention. To the extent that households prioritise thermal comfort over financial savings, there may be a trade-off between improved indoor temperatures and reduced financial stress. In theory, this trade-off is more likely to be present in so-called easy retrofits than for deep, systematic energy efficiency interventions. However, evidence from previous studies indicates that financially vulnerable households continue to under-heat their homes. This can indicate that these householders may in practice prefer bill savings over improved thermal comfort, or that they do not have sufficient knowledge and confidence in their capacity to manage energy use effectively, even given more efficient equipment. Reduction in financial stress can, in principle, result from any type of energy efficiency intervention leading to energy savings. However, there is evidence indicating that interventions which include measures aimed at improving householders' ability to self-manage the trade-off between warmth and bills are the most effective in reducing the experience of financial stress. Reduction in energy-related expenses, and therefore financial stress, can drive further benefits for households. The most substantial of these is improved mental wellbeing (discussed in Table 5.12). Other potential benefits include reduced disconnection costs (Table 5.10) and improved diet among households facing a trade-off between energy bills and other necessities such as food (Table 5.11).
Contextual factors and considerations	An observable reduction in financial stress is most likely to occur among households experiencing bill pressure or fuel poverty. Therefore, the presence of this co-benefit depends on the extent to which the intervention targets vulnerable populations experiencing bill pressure. Other program-specific factors include: – the extent to which the intervention provides guidance and advice on using energy efficiency equipment installed and/or strategies to manage energy bills – design choices relating to required co-contribution from households: to the extent that participants bear the cost of the intervention through off-set bill savings, they will be unable to reap benefits in terms of reduced bill pressure.
Key studies assessing the impact	Gilbertson, J., Grimsley, M., Green, G., & Warm Front Study Group. (2012). Psychosocial routes from housing investment to health: evidence from England's home energy efficiency scheme. Energy Policy, 49, 122-133. Bashir, N., Cronin de Chavez, A., Gilbertson, J., Tod, A., Sanderson, E., & Wilson, I. (2013). An evaluation of the FILT Warm Homes Service. Sheffield: CRESR, Sheffield Hallam University.

Criteria	Findings
Transferability of existing estimates	Improvement in financial stress is highly dependent on both the characteristics of the target group receiving the intervention and program design. International estimates are therefore not readily transferrable to an Australian context.
Next steps	Further research on the impact of energy efficiency on financial stress should be conducted in an Australian context. Key actions include: – defining harmonised metrics for measuring financial stress – developing validated survey instruments to measure household experience of financial stress.

5.7 Improved physical health

TABLE 5.7 IMPROVED PHYSICAL HEALTH

Criteria	Findings
Description	Energy efficiency programs that result in improved thermal comfort in a dwelling (as described above) can lead to improved physical health, including in symptoms for a range of diseases such as respiratory and cardiovascular diseases, allergies, arthritis and rheumatism.
Likely materiality of the impact	Overall, evidence to date indicates that improved physical health, alongside improved mental wellbeing, can be one of the most important non-energy impacts of energy efficiency. A number of randomised controlled trials have reported a statistically significant relationship between energy efficiency and improved physical health. However, some studies have found no significant link between physical health and energy efficiency. It is not yet clear whether this is due to program specific considerations or some other factors. Further, the magnitude of the impact will depend on contextual factors described below. To date, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	The most robust evidence for assessing the impact of energy efficiency on physical health use methodologies set out in epidemiological health studies. These typically include a rigorous study set up including a control or comparison group to establish a causal link between the energy efficiency intervention and observed outcomes.
Indicators and data requirements	Possible indicators for improved physical health are: – number of visits to the hospital or doctor, obtained through health records or household surveys – number and type of prescription medicines, obtained through health records or household surveys – participant reports of health status, obtained through household surveys using validated instruments. Using health records to assess differences in outcomes for participant and control/comparison groups is the most robust source of evidence. However, accessing health records, even in the context of a rigorous, academic study, may be difficult due to data privacy constraints. When accessing health records proves impracticable, participant reports of healthcare visits, prescription medication usage and health status can provide information on the prevalence and magnitude of health impacts. Ideally, existing, validated survey instruments such as the SF-36 Short Form Health Survey and GHQ-12 General Health Questionnaire should be used. Improved physical health may be monetised through converting improved health outcomes to quality adjusted life-years (QALYs), a standardised measure which can be monetised. As discussed in Table 5.13, improved physical health can also be monetised through reduced public and private health spending. When relying on household self-reports, monetisation of impacts should be done conservatively.
Dependencies and trade-offs with other impacts	Improved physical health is dependent on the extent to which the energy efficiency intervention leads to an improvement in thermal comfort, the key exposure factor linking energy efficiency to improved health and well-being outcomes, or to a reduction in damp or mould. To the extent that households experience financial pressure and make the choice to prioritise bill savings over improving the thermal comfort of the dwelling, there is a trade-off between the two. Linked to the take-back effect, this trade-off is more likely to be present in so-called easy retrofits than for deep, systematic energy efficiency interventions where evidence of a take-back effect has not been found. A reduction in damp and mould is likely to be most significant in the context of a well-designed, systematic retrofit rather than a non-systematic intervention.
Contextual factors and considerations	Improved physical health is dependent on an improvement in thermal comfort or a reduction in damp or mould being realised as a result of the energy efficiency intervention. Therefore, the same contextual and program specific factors apply to improved physical health as to improved thermal comfort and to reduced damp or mould. These are: – the nature of the intervention – climate zone – level of humidity – targeting of vulnerable populations – extent to which the intervention requires co-contribution from program participants.

Criteria	Findings
Key studies assessing the impact	Grimes, A., Denne, T., Howden-Chapman, P., Arnold, R., Telfar-Barnard, L., Preval, N., & Young, C. (2012). Cost benefit analysis of the warm up New Zealand: heat smart programme. Wellington: University of Wellington. Chapman, R., Howden-Chapman, P., Viggers, H., O'dea, D., & Kennedy, M. (2009). Retrofitting houses with insulation: a cost–benefit analysis of a randomised community trial. Journal of Epidemiology & Community Health, 63(4), 271-277.
Transferability of existing estimates	The estimates of improved physical health from improved thermal comfort are from the New Zealand housing stock, which has been characterised as 'old and cold'. The Warm Up New Zealand: Heat Smart Programme, provided subsidies for measures such as insulation, draught proofing and clean heating devices in at houses built before 2000. A preceding clinical study assessed the impact of insulation among low income households where at least one person had symptoms of respiratory disease. The reduction in the number of medical and hospital visits may be conservatively applied if the initiative: – is located in a cold climate zone comparable (to a reasonable degree) with New Zeeland – provides insulation to uninsulated dwellings where lack of adequate warmth during cold periods is a substantial issue. In addition, the estimates from the community trial are only applicable in the context of low income households where at least one family member has a pre-existing respiratory health condition.
Next steps	Further research on the impact of energy efficiency on physical health should be conducted in an Australian context. Key actions include: – assessing the range of health conditions that may be improved through energy efficiency in warmer climates – implementing established research protocols to assess the impact of energy efficiency across Australia, including in both colder and warmer climate zones.

5.8 Reduced mortality

TABLE 5.8 REDUCED MORTALITY

Criteria	Findings
Description	Energy efficiency programs that result in improved thermal comfort in a dwelling (as described above) can lead to a reduction in mortality during hot and cold weather spells.
Likely materiality of the impact	There is strong evidence internationally linking energy efficiency to improved thermal comfort and, in turn, to a reduction in temperature-related deaths in cold conditions. While not as extensively studied, energy efficiency measures can, in principle, also improve thermal comfort during hot weather. The magnitude of the impact in both cases will depend on contextual factors described below. To date, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	The most robust evidence for assessing the impact of energy efficiency on mortality use methodologies set out in epidemiological health studies. These typically include a rigorous study set up including a control or comparison group to establish a causal link between the energy efficiency intervention and observed outcomes.
Indicators and data requirements	Possible indicators of reduced mortality are: – mortality outcomes used to calculate number of statistical life years lost – rate of excess seasonal mortality. Assessment of mortality outcomes requires information on recorded deaths for the participant and control or comparison group. Care must be taken to select a control or comparison group with a similar health status (and therefore, other things being equal, similar life expectancy) to the treatment group. Valuation of statistical life years lost should be based on the approach set out in the Australian Government's *Best Practice Regulation Guidance Note: Value of statistical life*. Excess seasonal mortality is compared across large cohorts, for example at national or state levels. It may be caused by a range of factors, only some of them related to poor quality housing amenable to improvement through investments in energy efficiency. Attribution of changes in excess seasonal mortality to energy efficiency improvements is therefore challenging.
Dependencies and trade-offs with other impacts	Reduced mortality is dependent on the extent to which the energy efficiency intervention leads to an improvement in thermal comfort, the key exposure factor linking energy efficiency to improved health and well-being outcomes. To the extent that households experience financial pressure and make the choice to prioritise bill savings over improving the thermal comfort of the dwelling, there is a trade-off between the two. Linked to the take-back effect, this trade-off is more likely to be present in so-called easy retrofits than for deep, systematic energy efficiency interventions where evidence of a take-back effect has not been found.
Contextual factors and considerations	Reduced mortality is dependent on an improvement in thermal comfort being realised as a result of the energy efficiency intervention. Therefore, the same contextual and program specific factors apply to reduced mortality as to improved thermal comfort. These are: – climate zone – targeting of vulnerable populations – extent to which the intervention requires co-contribution from program participants.
Key studies assessing the impact	Grimes, A., Denne, T., Howden-Chapman, P., Arnold, R., Telfar-Barnard, L., Preval, N., & Young, C. (2012). Cost benefit analysis of the Warm Up New Zealand: Heat Smart Programme. Wellington: University of Wellington.
Transferability of existing estimates	The New Zealand housing stock has been characterised as 'old and cold'. The study identified above investigated the Warm Up New Zealand: Heat Smart Programme, providing subsidies for measures such as insulation, draught proofing and clean heating devices in at houses built before 2000. Mortality outcomes were analysed for individuals aged 65 and above who had been hospitalised prior to participating in the program, matched to a similar comparison group. The annual reduction in deaths per 1,000 households may be conservatively applied if the initiative: – is located in a cold climate zone comparable (to a reasonable degree) with New Zeeland

Criteria	Findings
	– provides insulation to uninsulated dwellings where lack of adequate warmth during cold periods is a substantial issue. In addition, the estimate is only transferable to cohorts with pre-existing health conditions likely to be exacerbated (to the point of death) by cold weather and insufficiently warm indoor temperatures.
Next steps	Further research on the impact of energy efficiency on physical health should be conducted in an Australian context. Key actions include: – assessing the extent to which mortality may be reduced as the result of energy efficiency in both warmer and colder climates – implementing established research protocols to assess the impact of energy efficiency across Australia, including in both colder and warmer climate zones.

5.9 Reduced family tensions and social isolation

TABLE 5.9 REDUCED FAMILY TENSIONS AND SOCIAL ISOLATION

Criteria	Findings
Description	Inadequately heated housing can exacerbate family tensions, for example when family members are forced to crowd into a single heated room. In addition, poor quality housing may contribute to increased social isolation if occupants are reluctant or embarrassed to invite other people to their homes. By increasing thermal comfort, energy efficiency interventions improve the liveability of the home and may therefore reduce family tensions and social isolation.
Likely materiality of the impact	This impact has been investigated in only a few studies, and is not yet well established.
Approaches for quantifying the impact	Perceived changes in family tensions and social isolation can be quantified using survey techniques, and qualitative techniques are usually employed to explore the contextual issues not readily captured through structured surveys. As a softer impact, reduced family tensions and social isolation is not readily monetised. However, some of the approaches outlined in Table 4.1 could be drawn on to develop suitable techniques for valuing this impact. When exploring the issue, good social research practices should be employed. Ideally, a control or comparison group should be used. At a minimum, before and after surveys and interviews with program participants should be conducted.
Indicators and data requirements	Possible indicators that can be used to measure a reduction in family tensions and social isolation are: – indoor average temperatures, obtained through physical measurements – number of rooms heated and in active use by occupants, obtained through physical measurements or household surveys – occupants' perceptions of comfort, obtained through household surveys – influence of thermal comfort on activities and mood, obtained through household surveys – influence of thermal comfort on willingness to invite people to the home.
Dependencies and trade-offs with other impacts	Reduced family tensions and social isolation is primarily dependent on improved thermal comfort being achieved. In addition, it may positively contribute to improved mental wellbeing through a reduction in stress.
Contextual factors and considerations	Reduced family tensions and social isolation is dependent on an improvement in thermal comfort being realised as a result of the energy efficiency intervention. Therefore, the same contextual and program specific factors apply to reduced family tensions and social isolation as to improved thermal comfort. These are: – climate zone – targeting of vulnerable populations – extent to which the intervention requires co-contribution from program participants.
Key studies assessing the impact	Basham, M., Shaw, S., Barton, A., & Torbay, H. H. G. (2004). Central heating: uncovering the impact on social relationships and household management. Torbay, UK: Torbay Health Housing Group. Bashir, N., Cronin de Chavez, A., Gilbertson, J., Tod, A., Sanderson, E., & Wilson, I. (2013). An evaluation of the FILT Warm Homes Service. Sheffield: CRESR, Sheffield Hallam University.
Transferability of existing estimates	Only a few studies have investigated the impact of energy efficiency on reduced family tensions and social isolation. In addition, the effect is highly dependent on program participants' socioeconomic characteristics. Transfer of existing estimates to an Australia context is therefore not recommended.
Next steps	Further research on the impact of energy efficiency on reduced family tensions should be conducted in an Australian context. Key actions include: – defining harmonised metrics for measuring a reduction in family tensions and social isolation – developing validated survey instruments to measure household experience of family tensions and social isolation.

5.10 Reduced disconnection costs

TABLE 5.10 REDUCED DISCONNECTION COSTS

Criteria	Findings
Description	Low income households experiencing bill pressure to the point at which their energy service is disconnected may benefit from reduced disconnection costs as the result of energy efficiency measures being implemented in the home. The costs associated with disconnection of service include a monetary fee required for restoration of service (for which social service agencies may provide assistance). Other, more intangible costs include impacts such as food spoilage and adverse health consequences for example from a lack of heating in winter.
Likely materiality of the impact	Studies on energy efficiency programs among low income households in the United States have shown that these programs have significant impacts on reducing arrears and disconnections. However, the full impact, including the more intangible costs related to disconnection of service, has yet to be comprehensively assessed. So far, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	This impact is typically assessed through household surveys, potentially coupled with data on disconnection rates from energy retailers. As a softer impact, a reduction in disconnection costs is not readily monetised. However, some of the approaches outlined in Table 4.1 could be drawn on to develop suitable techniques for valuing this impact. Good social research practices should be employed. Ideally, a control or comparison group should be used. At a minimum, before and after surveys and interviews with program participants should be conducted.
Indicators and data requirements	Possible indicators that can be used to measure the impact of reduced disconnection costs are: – disconnection rates, obtained through household surveys or from energy retailers – financial costs associated with reconnection of service and their incidence (household or social welfare agency) – self-reported experience of intangible or other costs associated with disconnection of service.
Dependencies and trade-offs with other impacts	A reduced cost associated with disconnection of service is dependent on bill savings being achieved by the household. Key dependencies include a trade-off between thermal comfort and bill savings (discussed in Table 5.2 and Table 5.3), and program design choices requiring a co-contribution (offset by bill savings) from participants.
Contextual factors and considerations	The potential to reduce costs associated with disconnection of service can primarily be found in policies and interventions targeting the most vulnerable groups struggling to meet their energy bills. Energy consumption, and therefore the burden energy bills place on the household budget, is dependent on the climate zone in which the intervention is being implemented, dwelling type, household demographics and the energy efficiency measure(s) being applied.
Key studies assessing the impact	Skumatz, L. (2011). Co-benefits of Low-Income Weatherization Programs: Framing the Role of Co-Benefits. presentation at the IEA Fuel Poverty Workshop Drakos, J. (2013). Low-income weatherization benefits for consumers and utilities in Cincinnati, Ohio. Presentation at the IEA Roundtable on Energy Provider and Consumer Benefits Tonn, B. (2013). Making sense of non-energy benefits: Results from the Weatherization Assistance Program. Presentation at the IEA Roundtable on Energy Provider and Consumer Benefits.
Transferability of existing estimates	The potential magnitude of reduced disconnection costs as the result of an energy efficiency intervention is dependent on the pre-existing rate of disconnection and the nature of the intervention. Transfer of existing estimates to an Australia context is therefore not recommended.
Next steps	Further research on the impact of energy efficiency on reduced disconnection costs should be conducted in an Australian context. Key actions include: – defining harmonised metrics for measuring reductions in disconnection costs for program participants – developing validated survey instruments to measure the impact of disconnection on program participants.

5.11 Improved diet

TABLE 5.11 IMPROVED DIET

Criteria	Findings
Description	Low income households experiencing bill pressure may struggle with the "heat or eat" dilemma, a trade-off between paying for energy bills and other necessities such as food. As a result, nutritional problems, including both malnutrition and obesity, may arise.
Likely materiality of the impact	Studies to date have focussed on the impact of reduced fuel poverty through financial assistance on nutritional status. In principle, energy efficiency interventions reducing bill pressure could result in a similar improvement in diets. However, this impact has not yet been robustly examined.
Approaches for quantifying the impact	To date, cross-sectional studies have been employed to assess nutritional risks among children, toddlers and infants. Improvement in diet is not readily monetised. However, some of the approaches outlined in Table 4.1 could be drawn on to develop suitable techniques for valuing this impact.
Indicators and data requirements	Possible indicators that can be used to measure improved diet and its follow-on effects include: – calculation of the amount of household income made available to purchase more nutritious food through a reduction in energy bills – self-reports of ability to purchase more nutritious food, obtained through household surveys – aggregate nutritional risk for growth problems: weight-for-age below the 5th percentile or weight-for-height below the 10th percentile, obtained through clinical measurements – rates of undernutrition and obesity, obtained through clinical measurements.
Dependencies and trade-offs with other impacts	Energy efficiency interventions resulting in improved diet are dependent on the extent to which bill savings are achieved. As discussed in Table 5.2 and Table 5.3, there is a trade-off between thermal comfort and reduced energy bills. While the issue has not yet been extensively examined in the literature, in principle it would appear logical that households that experience the most bill pressure would prioritise bill savings over thermal comfort. Improved diet may also have a second-round impact on improving physical health, particularly among vulnerable groups such as the young and elderly. This causal pathway has not yet been extensively studied in the context of energy efficiency, and is therefore not represented in Figure 5.1.
Contextual factors and considerations	This impact is likely to only be present among the most vulnerable households experiencing the greatest bill pressure. It is likely to be exacerbated in colder climates, where heating-related energy consumption drives up energy costs during winter months, or hotter climates, where cooling-related energy consumption drives up energy costs during summer months. Other program-specific factors include: – the extent to which the intervention provides guidance and advice on using energy efficiency equipment installed and/or strategies to manage energy bills – extent to which the intervention requires co-contribution from program participants.
Key studies assessing the impact	Frank, D. A., Neault, N. B., Skalicky, A., Cook, J. T., Wilson, J. D., Levenson, S. & Black, M. M. (2006). Heat or eat: the Low Income Home Energy Assistance Program and nutritional and health risks among children less than 3 years of age. Pediatrics, 118(5), e1293-e1302. Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., & Berkowitz, C. (2008). A brief indicator of household energy security: associations with food security, child health, and child development in US infants and toddlers. Pediatrics, 122(4), e867-e875.
Transferability of existing estimates	To date, studies have investigated the effect of energy bill assistance on improved diet, but have not assessed the impact of energy efficiency interventions. In addition, the effect is highly dependent on program participants' socioeconomic characteristics. Transfer of existing estimates to an Australia context is therefore not recommended.
Next steps	Further research on the impact of energy efficiency on improved diet should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – developing methodologies (including indicators and survey instruments) for assessing the impact of energy efficiency interventions on improved diet.

5.12 Improved mental wellbeing

TABLE 5.12 IMPROVED MENTAL WELLBEING

Criteria	Findings
Description	Mental wellbeing comprises two related but independent dimensions: mental health and mental disorder. **Mental health** is characterised as: *"a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community."* *WHO (2013), Mental health action plan 2013-2020. (p6)* In contrast, **mental disorder** is defined as: *"a syndrome characterized by clinically significant disturbance in an individual's cognition, emotion regulation, or behaviour that reflects a dysfunction in the psychological, biological, or developmental processes underlying mental functioning."* *Diagnostic and Statistical Manual of Mental Disorders (DSM-V) (p20)* Prolonged stress is a key contributor to poor mental wellbeing (both mental health and mental disorder). Energy efficiency can improve mental health through reducing the experience of stress, primarily through reducing bill pressure but also through improving the thermal comfort of the home.
Likely materiality of the impact	Overall, evidence to date indicates that improved mental wellbeing, alongside improved physical health, can be one of the most important indirect impacts of energy efficiency. A number of randomised controlled trials have reported a statistically significant relationship between energy efficiency and improved mental wellbeing. However, a minority of studies have found no significant link between mental wellbeing and energy efficiency. It is not yet clear whether this is due to program specific considerations or some other factors. Further, the causal pathway demonstrating the link is complex, and more work is required to test the hypothesised logical model. To date, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	The most robust evidence for assessing the impact of energy efficiency on improved mental wellbeing use standardised surveys with demonstrated construct validity. The most rigorous designs include a control or comparison group to establish a causal link between the energy efficiency intervention and observed outcomes. Some studies report on quantified mental wellbeing outcomes only. Other studies convert the improvement in mental health or incidence of mental disorders to QALYs, a standardised measure which can be monetised.
Indicators and data requirements	As discussed above, improved mental wellbeing can be measured through mental health as a positive state, or the absence of mental disorders as a negative state. A number of possible survey instruments exist, including: – SF-36: the Short Form Health Survey – GHQ-12: the General Health Questionnaire – HADS: Hospital Anxiety and Depression Scale – EQ-5D: survey instrument to measure health-related quality of life – WEMWBS: Warwick and Edinburgh Mental Wellbeing Scale. SF-36 is the most prevalent survey instrument; however, there has been little consistency in subscales used in different studies. Reporting of findings is likewise diverse. Some studies have reported odds-ratios (representing the odds of an event occurring in one group against the odds of it occurring in another group), while others have compared the prevalence of stress and/or mental illness in the treatment and control groups. When designing a study measuring improvement in mental wellbeing, the following considerations should be taken into account: – Energy efficiency may have an impact on both the mental health and mental disorder dimensions of wellbeing. To fully capture the effect on mental wellbeing, both dimensions should be measured using appropriate survey instruments. – Many of the instruments include subscales for both mental and physical health. If physical health is also assessed as part of the study, it is preferable to report results for each impact individually.

Criteria	Findings
Dependencies and trade-offs with other impacts	The causal pathway linking energy efficiency and mental wellbeing is complex, and not yet well established. At present, there is evidence showing that improved mental health may occur as a result of both reduced financial stress and improved thermal comfort. In addition, reduced damp or mould may contribute to improved mental wellbeing. Of these, financial stress has to date been demonstrated to have the strongest connection with mental wellbeing; however, further research is needed to fully explore the causal linkages. Finally, improved mental health may lead to savings in both private and public health expenditure.
Contextual factors and considerations	As discussed above, financial stress and poor living conditions (in the form of thermal discomfort and/or damp or mould) are the key risk factors for poor mental wellbeing. Therefore, the prevalence and magnitude of improvements in mental wellbeing depend on the extent to which the intervention targets populations vulnerable to these risks. Other program-specific factors include: – the extent to which the intervention provides guidance and advice on using energy efficiency equipment installed and/or strategies to manage energy bills – design choices relating to required co-contribution from households: to the extent that participants bear the cost of the intervention through off-set bill savings, they will be unable to reap benefits in terms of reduced bill pressure or improved thermal comfort.
Key studies assessing the impact	Liddell, C., Morris, C., & Lagdon, S. (2011). Kirklees Warm Zone: The project and its impacts on well-being. Belfast, University of Ulster. Gilbertson, J., Grimsley, M., Green, G., & Warm Front Study Group. (2012). Psychosocial routes from housing investment to health: evidence from England's home energy efficiency scheme. Energy Policy, 49, 122-133. Liddell, C., & Guiney, C. (2015). Living in a cold and damp home: frameworks for understanding impacts on mental well-being. Public Health, 129(3), 191-199. Poortinga, W., Grey, C., Jiang, S., Rodgers, S. E., Johnson, R. D., Lyons, R. A., & Anderson, P. (2016). Short-term health and social impacts of energy-efficiency investments in low-income communities: a controlled field study. The Lancet, 388, S96.
Transferability of existing estimates	Improvements in mental wellbeing depend on the extent to which the cohort targeted by the intervention is vulnerable to risk factors for poor mental wellbeing, the baseline prevalence of poor mental health and/or disorders, and program design considerations. The most rigorous studies to date have been conducted in the UK, New Zealand and Europe. Given the cultural, climatic and socioeconomic differences between these countries and Australia, it cannot be readily assumed that estimates from previous studies are readily transferable to an Australian context. However, Liddell et al. (2011) provides a model for how existing estimates can conservatively be used in a cost-benefit analysis.
Next steps	Further research on the impact of energy efficiency on improved mental wellbeing should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – implementing established research protocols to assess the impact of energy efficiency initiatives on mental wellbeing across Australia.

5.13 Reduced public and private health spending

TABLE 5.13 REDUCED PUBLIC AND PRIVATE HEALTH SPENDING

Criteria	Findings
Description	Energy efficiency interventions that result in improved physical health and mental wellbeing may also lead to reduced usage of healthcare services, and therefore reduced health system expenditure. Given that health and wellbeing benefits are likely to be most prevalent among low income and other vulnerable cohorts, the majority of savings will be incurred as savings in the public health system. However, to the extent that co-payments for treatment or medication are required, program participants may also incur a private benefit.
Likely materiality of the impact	There is persuasive evidence internationally linking energy efficiency to improved physical health outcomes, with some studies also reporting a flow-on effect in terms of reduced health spending. The magnitude of the impact will depend on contextual factors described below. To date, studies on mental wellbeing have focussed on establishing the link between energy efficiency and improved mental wellbeing; however, it is plausible that health spending savings could also result. So far, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	The most robust evidence for assessing the impact of energy efficiency on health spending builds on epidemiological health studies establishing reduced incidence of health conditions and health service usage. These typically involve a rigorous study set up including a control or comparison group to establish a causal link between the energy efficiency intervention and observed outcomes.
Indicators and data requirements	The main indicators for reduction in health spending relate to the cost of treatment, including: – doctors' visits – hospitalisation – prescription medicines. Typically, the cost estimate is specific to the health conditions for which a reduction in incidence has been established. As discussed in Table 5.7, health records are the most robust source of evidence on changes in health outcomes. However, accessing health records, even in the context of a rigorous, academic study, may be difficult due to data privacy constraints. In these cases, participant self-reporting can provide information on achieved health impacts. However, self-reported data should be treated with caution and monetised conservatively.
Dependencies and trade-offs with other impacts	Reduced health spending is dependent on the extent to which improvements in physical health and (if included in scope) mental wellbeing result in lessened use of health care services. Improvement in physical health is dependent on the extent to which the energy efficiency intervention leads to an improvement in thermal comfort, or a reduction in damp or mould. Improvement in mental wellbeing in turn depends on a reduction in financial stress and (to a lesser degree) improvement in thermal comfort. Improved physical health and mental wellbeing are discussed further in Table 5.7 and Table 5.12, respectively.
Contextual factors and considerations	Program-specific factors to consider for assessing health system savings associated with improved physical health and mental wellbeing include: – extent to which the intervention targets vulnerable populations – extent to which the intervention requires co-contribution from program participants. In addition, climate zone is an important factor when considering improvements in thermal comfort, and the nature of the intervention, climate zone and level of humidity are important factors when considering reductions in damp or mould. Finally, the extent to which the intervention provides guidance and advice on using energy efficiency equipment installed and/or strategies to manage energy bills is a program design consideration likely to affect potential reduction in financial stress, a causal link between energy efficiency and improved mental wellbeing.
Key studies assessing the impact	Grimes, A., Denne, T., Howden-Chapman, P., Arnold, R., Telfar-Barnard, L., Preval, N., & Young, C. (2012). Cost benefit analysis of the warm up New Zealand: heat smart programme. Wellington: University of Wellington. Chapman, R., Howden-Chapman, P., Viggers, H., O'dea, D., & Kennedy, M. (2009). Retrofitting houses with insulation: a cost–benefit analysis of a randomised community trial. Journal of Epidemiology & Community Health, 63(4), 271-277.

Criteria	Findings
Transferability of existing estimates	The New Zealand housing stock has been characterised as 'old and cold'. The Warm Up New Zealand: Heat Smart Programme, provided subsidies for measures such as insulation, draught proofing and clean heating devices in at houses built before 2000. A preceding clinical study assessed the impact of insulation among low income households where at least one person had symptoms of respiratory disease. The reduction in the number of medical and hospital visits may be conservatively applied to Australia if the initiative: – is located in a cold climate zone comparable (to a reasonable degree) with New Zealand – provides insulation to uninsulated dwellings where lack of adequate warmth during cold periods is a substantial issue. In addition, the estimates from the community trial are only applicable in the context of low income households where at least one family member has a pre-existing respiratory health condition. To assess the impact on health system spending, cost estimates for the relevant Australian jurisdiction should be used.
Next steps	Further research on the impact of energy efficiency on public and private health spending should be conducted in an Australian context. Key actions include: – assessing the extent to which health costs may be reduced as the result of energy efficiency in both warmer and colder climates – implementing established research protocols to assess the impact of energy efficiency on public health spending across Australia, including in both colder and warmer climate zones.

5.14 Fewer days off school or work

TABLE 5.14 FEWER DAYS OFF SCHOOL OR WORK

Criteria	Findings
Description	Energy efficiency improvements leading to healthier living environments and improved physical health can lead to reduced absenteeism from school or work.
Likely materiality of the impact	A reduction in the number of days off school has been most strongly established for energy efficiency interventions targeting children with pre-existing respiratory health conditions such as asthma. A number of studies have also reported a reduction in days off work as a result of improved health outcomes among adults. No robust studies have yet been undertaken in Australia.
Approaches for quantifying the impact	The most robust evidence for assessing the impact of energy efficiency on days off school or work builds on epidemiological health studies establishing reduced incidence of health conditions. These typically include a rigorous study set up including a control or comparison group to establish a causal link between the energy efficiency intervention and observed outcomes. The impact of time off school can be monetised through the daily cost of hiring a caregiver for a sick child (usually costed at the minimum wage) or through estimating the impact of reduced educational attainment on future earnings. The former measures the private benefit of reduced days off school, while the latter assesses the societal benefit in terms of workforce productivity. The impact of time off work is monetised as lost productive capacity to the economy, usually as a proportion of average daily wage rates.
Indicators and data requirements	Indicators for fewer days off school or work include: – days off school (school record data) – days off school (self-reported data) – days off work (self-reported data). If available, school record data on absences should be used. Household surveys can be used to obtain self-reported data on school and work absences but should be treated with caution, given the inherent problems associated with self-reports. In addition, wage rates and an estimated impact of reduced educational attainment on future earnings are required if the impact of fewer days off school or work is monetised.
Dependencies and trade-offs with other impacts	A reduction in days off school or work is dependent on the extent to which the energy efficiency intervention results in improvements in physical health, discussed further in Table 5.7. This, in turn, is dependent on the extent to which the energy efficiency intervention leads to an improvement in thermal comfort, or a reduction in damp or mould.
Contextual factors and considerations	As with improvements in thermal comfort and physical health, and reductions in damp or mould, program-specific factors to consider for assessing the impact on days off school or work include: – nature of the intervention – climate zone – level of humidity – extent to the intervention targets of vulnerable populations – extent to which the intervention requires co-contribution from program participants.
Key studies assessing the impact	Chapman, R., Howden-Chapman, P., Viggers, H., O'dea, D., & Kennedy, M. (2009). Retrofitting houses with insulation: a cost–benefit analysis of a randomised community trial. Journal of Epidemiology & Community Health, 63(4), 271-277. Preval, N., Chapman, R., Pierse, N., Howden-Chapman, P., & Housing, T. (2010). Evaluating energy, health and carbon co-benefits from improved domestic space heating: A randomised community trial. Energy Policy, 38(8), 3965-3972. Woodfine, L., Neal, R. D., Bruce, N., Edwards, R. T., Linck, P., Mullock, L., Russell, D., & Russell, I. (2011). Enhancing ventilation in homes of children with asthma: pragmatic randomised controlled trial. Br J Gen Pract, 61(592), e724-e732.

Criteria	Findings
Transferability of existing estimates	Existing studies on the impact of energy efficiency on days off school or work have been conducted in New Zealand and the UK. In addition, studies have often focussed on vulnerable populations with pre-existing conditions such as asthma. Care should be taken when applying estimates from previous studies in an Australian context. Considerations include: – comparability of climate zone and level of humidity – similarity of target population – similarity of intervention. When monetising the impact, cost estimates for the relevant Australian jurisdiction should be used.
Next steps	Further research on the impact of energy efficiency on days off school or work should be conducted in an Australian context. Key actions include implementing established research protocols to assess the impact of energy efficiency on days off school or work across Australia, including in both colder and warmer climate zones.

5.15 Lower energy retailer costs from reduced arrears and disconnections

TABLE 5.15 LOWER ENERGY RETAILER COSTS FROM REDUCED ARREARS AND DISCONNECTIONS

Criteria	Findings
Description	Energy efficiency interventions targeting low income households experiencing bill pressure may lead to benefits for energy retailers in terms of: – reduced arrears, bad debts and collection costs – reduced costs associated with disconnection and reconnection of service – reduced expenditure on retailer hardship programs – improved corporate reputation and customer retention.
Likely materiality of the impact	Studies on energy efficiency programs from the United States have shown energy efficiency interventions to have significant impacts on reducing arrears, disconnections and costs associated with hardship programs. So far, no robust studies have been undertaken in Australia.
Approaches for quantifying the impact	This impact is typically assessed through household surveys, potentially coupled with data on disconnection rates from energy retailers. Good social research practices should be employed. Ideally, a control or comparison group should be used. At a minimum, before and after surveys and interviews with program participants should be conducted.
Indicators and data requirements	Possible indicators that can be used to measure the impact of reduced disconnection costs are: – proportion of households with bills overdue more than a certain number of days (such as 30, 60 or 90 days), obtained through household surveys or from energy retailers – disconnection rates, obtained through household surveys or from energy retailers – energy retailer expenditure associated with arrears, bad debt and disconnections.
Dependencies and trade-offs with other impacts	A decrease in energy retailer costs from reduced arrears and disconnections is dependent on bill savings being achieved by the household. Key dependencies include a trade-off between thermal comfort and bill savings (discussed in Table 5.2 and Table 5.3), and program design choices requiring a co-contribution (offset by bill savings) from participants.
Contextual factors and considerations	The potential to reduce costs associated with arrears and disconnections can primarily be found in policies and interventions targeting the most vulnerable groups struggling to meet their energy bills. The potential for energy savings, and therefore reduced bills, is dependent on the climate zone in which the intervention is being implemented, dwelling type, household demographics and the energy efficiency measure(s) being applied.
Key studies assessing the impact	Skumatz, L. (2011). Co-benefits of Low-Income Weatherization Programs: Framing the Role of Co-Benefits. presentation at the IEA Fuel Poverty Workshop Drakos, J. (2013). Low-income weatherization benefits for consumers and utilities in Cincinnati, Ohio. Presentation at the IEA Roundtable on Energy Provider and Consumer Benefits Tonn, B. (2013). Making sense of non-energy benefits: Results from the Weatherization Assistance Program. Presentation at the IEA Roundtable on Energy Provider and Consumer Benefits.
Transferability of existing estimates	The potential magnitude of reductions in energy retailer costs from reduced arrears and disconnections as the result of an energy efficiency intervention are dependent on the pre-existing rate of disconnection and the nature of the intervention. Transfer of existing estimates to an Australia context is therefore not recommended.
Next steps	Further research on the impact of energy efficiency on retailer costs from arrears and disconnections should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – developing methodologies (including indicators and survey instruments) for assessing the impact of energy efficiency interventions on retailer costs from arrears and disconnections.

5.16 Utility impacts from reduced energy consumption

TABLE 5.16 UTILITY IMPACTS FROM REDUCED ENERGY CONSUMPTION

Criteria	Findings
Description	Energy efficiency interventions that reduce energy consumption will result in lower revenue for utilities that are not subject to a revenue form of price control. This may potentially lower levels of profitability in dollar terms, and where utilities are government-owned, result in lower dividends that are paid to the Government.
Likely materiality of the impact	The materiality of impact will depend on the extent to which the energy efficiency intervention lowers energy consumption, the competitiveness of the energy market, and the frequency with which the relevant prices can be changed in response to the intervention.
Approaches for quantifying the impact	The impact can be quantified by estimating the: – reduction in household energy consumption, as discussed in Table 5.2 – reduction in revenue earned by the utility – reduction in variable costs incurred by the utility.
Indicators and data requirements	Data required to assess the utility impact of reduced energy consumption include: – energy metering data – energy efficiency intervention(s) applied – weather and climate data – household demographics – variable costs incurred by the utility – rate at which profits are paid as a dividend to the Government.
Dependencies and trade-offs with other co-impacts	The impact of energy efficiency on energy utility revenues is determined by the energy savings achieved by households. This is dependent on the trade-off between thermal comfort and bill savings (discussed in Table 5.2 and Table 5.3), and program design choices requiring a co-contribution (offset by bill savings) from participants.
Contextual factors and considerations	The magnitude of potential energy savings, and hence the impact on energy utility revenue, depends on the climate zone in which the intervention is being implemented, dwelling type, household demographics and the energy efficiency measure(s) being applied.
Key studies assessing the impact	Rickwood P., Mohr S., Nguyen M., Milne G. (2012). *Evaluation of the home power savings program–Phase 1*, prepared by the Institute for Sustainable Futures, UTS for the NSW Office of Environment and Heritage, Sydney. Sustainability Victoria (2014). Victorian Households Energy Report.
Transferability of existing estimates	Existing empirical estimates of potential energy savings are frequently used in ex-ante modelling of energy efficiency policies and programs. Issues that should be considered when transferring estimates include nature and scale of the intervention, the population targeted by the intervention and local climate zone.
Next steps	Methodologies for assessing energy savings are well established, and should continue to be followed when evaluating the potential and realised impact of energy efficiency interventions in the residential sector.

5.17 Societal impacts from reduced energy consumption

TABLE 5.17 SOCIETAL IMPACTS FROM REDUCED ENERGY CONSUMPTION

Criteria	Findings
Description	The impacts of reduced energy consumption at the societal level comprise: – in the short run, the avoided fuel and operating costs associated with reduced energy generation – in the long run, avoided costs associated with deferred investment in generation and the network – reduced CO_2 emissions from energy generation – avoided health costs related to air pollution from electricity generation. These impacts accrue on society as a whole, rather than program participants only.
Likely materiality of the impact	The potential for energy savings, and hence the societal impacts from reduced energy consumption, depend on both the nature of the intervention and the presence of a take-back effect. Exclusion of other impacts has the effect of underestimating the total benefits that can accrue from residential energy efficiency; however, energy savings, and hence the societal impacts from reduced energy consumption, remain material in most if not all interventions.
Approaches for quantifying the impact	In the short run, fuel and operating costs are avoided by reduced energy generation. Wholesale energy price projections are used as a proxy representing the marginal cost saving associated with the energy efficiency intervention. In the long run, investment in new generation or network capacity may be deferred or avoided. However, this is only likely to occur if the energy efficiency is very substantial, and is in a location where capacity is constrained. Retail prices incorporate operational costs associated with call centres, billing and revenue collection, customer acquisition and retention, and IT systems. These are driven by the number of customers, not by energy consumption. From the perspective of energy efficiency, these costs are 'fixed' and should not be used to value the societal benefit of energy efficiency. The benefit of avoided CO_2 emissions from energy generation is valued using an appropriate carbon price series and marginal (not average) emissions intensity factors. Air pollution from electricity generation results in health costs to residents in the areas where power stations are located. The main pollutants are sulphur dioxide, particulate matter and oxides of nitrogen. The health impact of avoided electricity generation is valued using a unit cost for health damage for each pollutant, multiplied by the volume of pollution avoided as a result of reduced electricity generation. Health damage costs are usually derived from appropriate literature.
Indicators and data requirements	Data required to assess the societal impacts from reduced energy consumption include: – energy efficiency intervention(s) applied – energy savings, ideally including location and time of day – wholesale energy price projections – in the long run, generation or network investment deferred – marginal emissions intensity factors – unit cost of health damage for pollutants – amount of pollution per unit of electricity generated.
Dependencies and trade-offs with other impacts	The benefit of energy efficiency measures can be reaped by households as improvements in thermal comfort, as energy bill savings, or some combination of the two. As a result, there is a trade-off between societal impacts from reduced energy consumption and household thermal comfort. This effect occurs upstream at the household level and is discussed further in Table 5.3**.**
Contextual factors and considerations	The magnitude of potential energy savings, and hence the societal impact of reduced energy consumption, depends on the climate zone in which the intervention is being implemented, dwelling type, household demographics and the energy efficiency measure(s) being applied.
Key studies assessing the impact	NSW Government (2014). Review of the NSW Energy Savings Scheme—Part 2: Options Paper.

Criteria	Findings
Transferability of existing estimates	The societal impact of reduced energy consumption is frequently estimated in ex-ante modelling of energy efficiency policies and programs. These may draw on the results from previous studies, but due to differences in policy and program settings, usually further work specific to the initiative under consideration is required.
Next steps	Methodologies for assessing the societal impact of reduced energy consumption are well established, and should continue to be followed when evaluating the potential and realised impact of energy efficiency interventions in the residential sector.

5.18 Other public budget impacts of energy efficiency

TABLE 5.18 OTHER PUBLIC BUDGET IMPACTS OF ENERGY EFFICIENCY

Criteria	Findings
Description	Energy efficiency interventions may reduce public spending through reduced expenditure on energy concessions, if households receiving energy concessions reduce their energy consumption. In addition, improved mental wellbeing and reduced family tensions may reduce the demand on human services and even the justice system. (The impact on public health spending is discussed in Table 5.13.)
Likely materiality of the impact	The impact of energy efficiency interventions on energy concessions and reduced human services and justice spending has not yet been quantified. However, it is plausible that programs targeting low income households could prove effective in reducing the need for energy concessions. The potential for reducing human services and justice spending is as of yet unclear.
Approaches for quantifying the impact	No robust methodologies have yet been developed for assessing the impact of energy efficiency interventions on energy concessions and reduced human services and justice spending. Future methodologies could usefully draw on household surveys, coupled with data on energy concession payments and usage of human services and the justice system. Good social research practices should be employed. Ideally, a control or comparison group should be used. At a minimum, before and after observations should be collected. Given the sensitive nature of these topics, data protection concerns should be considered and addressed before embarking on the research.
Indicators and data requirements	Possible indicators that can be used to measure the impact of energy efficiency interventions on energy concessions and reduced human services and justice spending: – energy concession payment rates, and associated costs – human health and justice systems usage rates, and associated costs.
Dependencies and trade-offs with other impacts	A decrease in energy concessions is dependent on bill savings being achieved by the household. Key dependencies include a trade-off between thermal comfort and bill savings, and program design choices requiring a co-contribution (offset by bill savings) from participants. A reduction in the demand for human health and the justice system may occur as a downstream impact of improved mental wellbeing (arising primarily on reduced financial stress, but also potentially from improved thermal comfort). In addition, reduced family tensions (resulting from improved thermal comfort) may contribute. The trade-off between bill savings and thermal comfort is discussed in Table 5.2 and Table 5.3.
Contextual factors and considerations	The potential to reduce costs associated with energy concessions and human services and justice spending is likely to be limited to policies and interventions targeting the most vulnerable groups struggling to meet their energy bills, and those experiencing highly inadequate thermal comfort. The societal benefit of reduced pressure on public budgets will depend on government decisions on how to reallocate the funds. In principle, governments can use the funds to reduce taxes or provide additional services. Each possible action has a different marginal impact of societal welfare. While for taxation decisions this can, in principle, be assessed through analysing the marginal excess burden of taxation, the marginal societal benefit of additional services is unknown.
Key studies assessing the impact	None available.
Transferability of existing estimates	None available.
Next steps	Further research on the impact of energy efficiency on reduced energy concessions and reduced human services and justice spending should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – developing methodologies (including indicators and survey instruments) for assessing the impact of energy efficiency interventions on energy concessions and reduced human services and justice spending.

5.19 Macroeconomic impacts of energy efficiency

TABLE 5.19 MACROECONOMIC IMPACTS OF ENERGY EFFICIENCY

Criteria	Findings
Description	Additional investment in energy efficiency may result in increased economic output as measured by gross domestic product (GDP) or gross state product (GSP), and in increased employment.
Likely materiality of the impact	Macroeconomic variables are, by their nature, cross-sectoral and are unlikely to be affected by policies or programs that only target one part of the economy, or are small-scale in nature. Generally speaking, measurement of the macroeconomic effects of an energy efficiency program or policy should only be considered where the initial, direct effects of the policy can be well specified and the indirect effects are suspected to be quite large (in other words when indirect effects are thought to equal or even outweigh the direct costs of the policy).
Approaches for quantifying the impact	Policies that are expected to have extensive, economy-wide, flow on effects should ideally be evaluated using a Computable General Equilibrium (CGE) model. A CGE model allows the direct changes in a particular sector to be tracked, as well as their indirect effects in related sectors. If the macroeconomic impacts of a policy are not expected to be large, it is advisable to treat them qualitatively only.
Indicators and data requirements	Data and indicators required for CGE modelling include: – assumed or realised energy savings from the energy efficiency measure(s) under consideration – assumed or realised compliance costs of the energy efficiency measure(s) under consideration – assumed or realised incremental capital cost of the energy efficiency measure(s) under consideration – assumed or realised change on electricity prices associated with the energy efficiency measure(s) under consideration.
Dependencies and trade-offs with other impacts	Macroeconomic impacts are primarily dependent on the energy efficiency policy or program being implemented, and operate to a large degree independently from the other impacts discussed. While potential second-round impacts include improvements in health outcomes, and improvements in the productive capacity of the economy arising from fewer days off work or school, these are difficult to estimate and model in practice.
Contextual factors and considerations	As discussed above, the materiality of macroeconomic benefits is dependent on the scale of the intervention under consideration. It is important to consider the net effect on the economy as a whole. For example, job creation in one sector as a result of an energy efficiency intervention may be offset by corresponding job losses in another sector (these job increases and losses are taken into account within the CGE modelling framework). In addition, when economic growth is at or above the potential growth rate, additional investment could crowd out other productive investments.
Key studies assessing the impact	Copenhagen Economics. (2012). *Multiple benefits of investing in energy efficient renovation of buildings: impact on public finances*. Copenhagen: Renovate Europe. EC (European Commission). (2011). Commission Staff Working Paper Impact Assessment, Accompanying the document Directive of the European Parliament and of the Council on Energy Efficiency and amending and subsequently repealing Directives 2004/8/EC and 2006/32/EC. Brussels: EC.
Transferability of existing estimates	Estimates from previous studies are not readily transferable, as the results will depend on the particular energy efficiency policy or program under consideration, the structural characteristics of the economy in which it is being implemented, as well as the prevailing economic trends at the time.
Next steps	Approaches to fully assess the macroeconomic impacts of energy efficiency should continue to be explored, where the net impact is thought to be material.

6 CONCLUSION

6.1 Key findings

Non- energy benefits of household energy efficiency policies/programs (such as increased home comfort and improved health outcomes) could be of greater value than the energy savings delivered by the interventions.

Despite the considerable body of international evidence on the value of the multiple impacts of energy efficiency, the absence of a holistic framework for applying existing international research on these impacts to the Australian context made consideration of these impacts contentious.

The policy framework for assessing the multiple impacts of energy efficiency, developed in this report, aims to fill this gap and provides policy-makers and industry with:

— a series of principles to guide their assessments of the multiple impacts of energy efficiency when designing and implementing policies and programs to promote energy efficiency

— a logic map that identifies the pathway through which an energy efficiency measure would result in the different impacts

— a framework that identifies and defines the different multiple impacts of energy efficiency and provides recommendations on how best to quantify these impacts.

6.2 Limitations and areas for further investigation

This report focused on developing a policy framework to help identify and measure the multiple impacts of improved household energy efficiency based on existing Australian and international research. The extent to which recommendations could be made about estimates and methodologies that could be used to quantify the multiple impacts of energy efficiency was contingent on the existence of relevant literature (developing new methodologies/estimates to measure individual multiple impacts was outside the scope of this report).

There are a number of additional areas of research which would help fill the current information gaps and improve the measurement of multiple impacts of household energy efficiency in the Australian context. These are outlined below.

TABLE 6.1 ADDITIONAL AREAS OF RESEARCH

Multiple impact	Next step
Householder knowledge, attitudes and behaviour	To advance the understanding of how energy efficiency interventions may contribute to improved knowledge, attitudes and self-efficacy, it is important to establish a common framework and survey instrument for measuring change. Linkages to other impacts should be explored further, particularly considering the role program design incorporating knowledge, attitudes and self-efficacy considerations may have on amplifying the impact of any physical energy efficiency measures.
Improved thermal comfort	Further research on the impact of energy efficiency on thermal comfort should be conducted in an Australian context. Key actions include: – developing harmonised indicators to measure the improvements in thermal comfort – investigating the nature and extent of the problem in Australia, including variations between climate zone – developing validated survey instruments to measure household perceptions of thermal comfort.
Reduced damp and mould	Further research on the impact of energy efficiency on damp and mould should be conducted in an Australian context. Key actions include: – developing harmonised indicators to measure the presence and severity of damp and mould – investigating the nature and extent of the problem in Australia, including variations between climate zone – developing validated survey instruments to measure household perceptions of damp and mould, and their impact on comfort.
Increased property values	Further research on the impact of energy efficiency performance and property values, using existing research methodologies, should be conducted in an Australian context.
Reduced financial stress	Further research on the impact of energy efficiency on financial stress should be conducted in an Australian context. Key actions include: – defining harmonised metrics for measuring financial stress – developing validated survey instruments to measure household experience of financial stress.
Improved physical health	Further research on the impact of energy efficiency on physical health should be conducted in an Australian context. Key actions include: – assessing the range of health conditions that may be improved through energy efficiency in warmer climates – implementing established research protocols to assess the impact of energy efficiency across Australia, including in both colder and warmer climate zones.
Reduced mortality	Further research on the impact of energy efficiency on physical health should be conducted in an Australian context. Key actions include: – assessing the extent to which mortality may be reduced as the result of energy efficiency in both warmer and colder climates – implementing established research protocols to assess the impact of energy efficiency across Australia, including in both colder and warmer climate zones.
Reduced family tensions and social isolation	Further research on the impact of energy efficiency on reduced family tensions should be conducted in an Australian context. Key actions include: – defining harmonised metrics for measuring a reduction in family tensions and social isolation – developing validated survey instruments to measure household experience of family tensions and social isolation.

Multiple impact	Next step
Reduced disconnection costs	Further research on the impact of energy efficiency on reduced disconnection costs should be conducted in an Australian context. Key actions include: – defining harmonised metrics for measuring reductions in disconnection costs for program participants – developing validated survey instruments to measure the impact of reduced disconnection costs for program participants.
Improved diet	Further research on the impact of energy efficiency on improved diet should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – developing methodologies (including indicators and survey instruments) for assessing the impact of energy efficiency interventions on improved diet.
Improved mental wellbeing	Further research on the impact of energy efficiency on improved mental wellbeing should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – implementing established research protocols to assess the impact of energy efficiency initiatives on mental wellbeing across Australia.
Reduced public and private health costs	Further research on the impact of energy efficiency on public and private health spending should be conducted in an Australian context. Key actions include: – assessing the extent to which health costs may be reduced as the result of energy efficiency in both warmer and colder climates – implementing established research protocols to assess the impact of energy efficiency on public health spending across Australia, including in both colder and warmer climate zones.
Fewer days off school or work	Further research on the impact of energy efficiency on days off school or work should be conducted in an Australian context. Key actions include implementing established research protocols to assess the impact of energy efficiency on days off school or work across Australia, including in both colder and warmer climate zones.
Lower energy retailer costs from reduced disconnections	Further research on the impact of energy efficiency on retailer costs from arrears and disconnections should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – developing methodologies (including indicators and survey instruments) for assessing the impact of energy efficiency interventions on retailer costs from arrears and disconnections.
Other public budget impacts of energy efficiency	Further research on the impact of energy efficiency on reduced energy concessions and reduced human services and justice spending should be conducted in an Australian context. Key actions include: – assessing the nature and extent of the problem in Australia – developing methodologies (including indicators and survey instruments) for assessing the impact of energy efficiency interventions on energy concessions and reduced human services and justice spending.
Macroeconomic impacts	Approaches to fully assess the macroeconomic impacts of energy efficiency should continue to be explored, where the net impact is thought to be material.

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