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Department of Climate Change and Energy Efficiency

Inclusion of Energy Generation in Building Energy Efficiency Standards

Australian Government

Department of Climate Change and Energy Efficiency

Project Details

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Executive Summary

The National Strategy on Energy Efficiency includes the development of a consistent outcomes-based National Building Energy Standard Setting, Assessment and Rating Framework for driving significant improvement in the energy efficiency of Australia's building stock. Development work on the Framework has flagged the possibility that building standards for both new residential and commercial buildings should allow offsets for the energy use of the building by the use of energy generated by zero and low emission energy (ZLEG) systems that supply the building. The study outlined in this Report explores the implications of a policy that would broaden and facilitate the scope to use zero and low emission energy to offset any form of energy use within the building. This is not to say that any proposals to encourage ZLEG systems have been agreed by governments. The mechanism for this policy would be a change in the National Construction Code (also referred to as the Building Code of Australia or BCA).

Definition of Zero or Low Emission Energy Generation

The study proposes that zero or low emission energy generation (ZLEG) is that which offsets any form of energy use within the building it is associated with.

- The generation technology can be on-site or off-site and must be connected to the building by way of a private wire network, or pipes carrying hot or chilled thermal fluid.
- The generation technology must provide a 50% reduction in emissions, consistent with the IPCC target for emissions reduction.

This definition will allow for technologies such as cogeneration and trigeneration to be included provided the associated emissions reductions exceed the reduction target.

Cost Effectiveness

When discussing the issues that may arise due to potential policy change, two broad types of ZLEG were explored. These were scalable, non-dispatchable renewable generation typically for the residential sector (modelled as solar PV) and dispatchable generation, typically for the business sector (modelled as cogeneration). Solar PV and cogeneration were selected after an examination of the cost effectiveness of various ZLEG options. Rapidly falling PV module costs and rising electricity prices will see a rapid improvement in the cost effectiveness of solar PV to the point where take-up may not require any form of incentive. The case of cogeneration and trigeneration is less clear for the residential sector but it is an established technology for the business sector. Results suggest that district level cogeneration/trigeneration is already cost effective but that residential cogeneration/trigeneration will not be cost efficient in the short to medium term.

Existing Standards and Tools

The BCA already sets standards for the energy efficiency of buildings (primarily the thermal efficiency of the building shell). For instance, the BCA requires that new houses achieve a minimum 6 star rating using the accredited NatHERS software tools or elemental (formally deemed to satisfy) standards. However, because the regulations relating to the construction of buildings are specific to individual states and territories, there are different variations of the BCA requirements around Australia. In particular, Queensland allows the use of optional credits for certain design features, including a one star credit towards the 6 star energy requirement where a solar PV system with a capacity larger than 1 kW_p is installed. NSW has its own scheme for rating the performance of buildings, and a BASIX certificate is required for development approval in NSW. BASIX also allows solar PV installations to contribute to the energy performance target but not the thermal comfort performance target. Any changes to the BCA to encourage the take-up of ZLEG would need to be aligned with state and territory planning or building laws. Key issues that may need addressing in the planning or building laws are regulations to ensure the on-going operation of any ZLEG technologies that were needed for a building to comply with BCA targets, the management of the certification of ZLEG technologies, particularly in the residential context, and the modifications to the local building regulations to ensure the ongoing performance of ZLEG systems.

Impacts on Distribution

ZLEG technologies will have an impact on the power networks should the BCA encourage wider deployment of ZLEG in either the residential or the business sector. These impacts are both opportunities and threats. ZLEG, particularly cogeneration and trigeneration, offers a means to defer capital expenditure that would otherwise be used to expand the networks. The situation with solar PV is less clear as the output of solar panels is often quite low at the time of a typical afternoon peak demand for electricity. Certain types of renewable energy generation such as solar PV can also give rise to problems with the quality of electricity on the networks. Further, networks may need to invest in additional power generation systems to backup non-dispatchable renewable generators. Extensive research in Europe and elsewhere has pointed to systems and procedures that can address these problems, although the cost of implementing such procedures in Australian conditions would need further investigation.

Connecting ZLEG systems to the networks is a challenge to the developers of these systems, and is often a major barrier to the implementation of large ZLEG systems. The recommendations regarding improvements to the process for network connections for ZLEG have been made in a number of forums. Should the BCA encourage cogeneration and trigeneration systems to be installed, building owners and developers can reasonably expect that the complexity of network connections is removed, the time to obtain a connection shortened and the costs reduced. The Commonwealth and the states and territories may need to take action to ensure that this happens. The widespread take-up of ZLEG may also see upward pressure placed on retail electricity prices due to the tariff structures that the network service providers use to determine customer charges, and due to market based incentives for these technologies.

Retail Competition

Incentivising ZLEG through the BCA may result in impacts on electricity consumers' competitive energy supply options, and in particular access to best pricing. This may threaten the full retail contestability which is the goal of energy regulation in Australia. Complexity is introduced when a ZLEG system such as cogeneration or trigeneration seeks to supply multiple customers over an "embedded" or "private" network. The study notes that the UK introduced the concept of the virtual private wire network over the local distribution network. Virtual private wire networks provide advantages to the ZLEG owner and customers without the cost of installing a physical network. The study recommends that the Australian Energy Regulator explore the use of virtual private wire networks should the BCA incentivise district level cogeneration and trigeneration.

ZLEG and Energy Efficiency

Finally, the study explored the balance between improvements to energy efficiency and ZLEG as means to reduce a building's operational emissions, and found that evidence from Europe and North America supports improvements in energy efficiency as the preferred method to reduce the building emissions. This was a position that was strongly supported by local stakeholders.

Recommendations

The key recommendations mentioned in this report are:

- A consultation on the most efficient methodology to calculate the savings due to low emissions generation be undertaken.
- Should the BCA be modified to incorporate a method to calculate the impact of a ZLEG, Energetics recommends that the same method be used in all related rating tools such as NatHERS and NABERS.
- A national discussion on changes to the state and territory planning and building laws to better deal with ZLEG in the context of low or zero energy buildings be undertaken.
- Options to extend the output of solar PV panels into the period when the residential peak occurs be explored. These options could include panels that face to the North West or the installation of batteries.
- Any moves to require take-up of ZLEG (and especially cogeneration or trigeneration) through changes in government regulations must be supported by changes to the procedures adopted by the Distribution Network Service Providers to manage connections. The changes must also address the connection of cogeneration systems across multiple sites which are contiguous for instance, a hospital or university.
- Subject to a cost-benefit analysis, the Commonwealth, states and territories explore changes to building regulations to require the installation of smart meters on any new building and any renovation that requires work done by a licensed electrician.
- Current network tariff structures may not be optimal in an environment where there is significant take-up of ZLEG, and any future investigations into network tariffs should explore the role that network tariffs could play in incentivising ZLEG.
- A ZLEG should not be used in preference to improvements in the energy efficiency of the building shell and fixed appliances, unless it can be shown that it offers clear financial benefits.
- A study into the optimum balance between further improvements in the energy performance of the building and take-up of ZLEG be undertaken. This is especially relevant to residential buildings.

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Glossary

ABCB	Australian Building Codes Board
ASBEC	Australian Sustainable Built Environment Council
BASIX	Building Sustainability Index
BAU	Business-as-usual
BCA	Building Code of Australia
DCCEE	Department of Climate Change and Energy Efficiency
DEWHA	Department of the Environment, Water, Heritage and the Arts
DNSP	Distribution Network Service Provider
ECEEE	European Council for an Energy Efficiency Economy
FiT	Feed in tariff
IEA	International Energy Agency
LCOE	Levelised Cost of Electricity
LRET	Large-scale Renewable Energy Target
MEPS	Minimum Energy Performance Standards
MW_e	Megawatt hour electric (measures the electrical rating of a generator)
NABERS	National Australian Built Environment Rating System
NatHERS	Nationwide House Energy Rating Scheme
NCC	National Construction Code
NSEE	National Strategy on Energy Efficiency
ORER	Office of the Renewable Energy Regulator
PJ	Petajoule (equal to one million GJ)
PV	(solar) photovoltaics
REC	Renewable Energy Certificate
SGU	Small Generation Units
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificates
TWh	Terawatt hour (equal to one million MWh)
ZEB	Zero Energy Building
ZLEG	Zero / Low Emissions Generation

Context

1. Background

In July 2009 the Council of Australian Governments agreed to the National Strategy on Energy Efficiency (NSEE), which is designed to substantially improve minimum standards for energy efficiency and accelerate the introduction of new energy efficient technologies. Measure 3.1.1 in the building chapter of the NSEE states that all jurisdictions will work together to develop a consistent outcomes-based National Building Energy Standard Setting, Assessment and Rating Framework for driving significant improvement in the energy efficiency of Australia's building stock.

The key dimensions of the Framework are the development of a pathway for increasing the stringency of the energy efficiency standards for new buildings and major renovations over time, the alignment of measurement metrics and approaches to assessment to enable the consistent application of building ratings to new and existing buildings, and enhancement and co-ordination of governance arrangements for building energy assessments, ratings and standard setting. The NSEE states that this measure will be used to increase the energy efficiency of new residential and commercial buildings with minimum standards to be reviewed and increased periodically. The Framework does not address setting energy efficiency standards for existing buildings, although it does need to cover the assessment and rating of both new and existing buildings and address standards for renovations. Given other NSEE measures relating to mandatory disclosure of building performance at time of sale or lease, there is a need to allow valid and consistent comparisons between all buildings on the market – from buildings just being built to ones built decades ago.

This can be realised both through better approaches to rating the energy performance of buildings and targeted changes to the Building Code of Australia[1] (BCA). The BCA currently provides some scope to use renewable and reclaimed energy to achieve compliance with its performance requirements for hot water and heating and cooling, primarily as an alternative solution for demonstrating compliance rather than as a 'deemed to satisfy' solution. Some states and territories, for example Queensland and NSW, already allow for renewable energy systems in their residential building energy efficiency standards.

Development work on the National Building Energy Standard-Setting, Assessment and Rating Framework has flagged the possibility that building standards for both new residential and commercial buildings should allow offsets for the energy use of the building by the use of energy generated by zero and low emission energy systems that supply the building. The supply of zero or low emission energy could possibly be through a direct connection to the building or through long-term supply arrangements from a distant generator. This approach would contribute to the achievement of zero emission new buildings as a potential longer term strategy.

Governments have not yet made any commitments to including energy generation in building standards beyond what is currently allowed in the BCA, and any future changes to building standards would be subject to policy reviews, consultation and more detailed regulatory impact assessment. To initiate the process, a discussion paper on the National Building Energy Standard-Setting, Assessment and Rating Framework was released in March 2010 which looked at available rating tools and setting future standards.

[1] In May 2011 the BCA became Volume One and Two of the National Construction Code series.

The study undertaken and outlined in this Report, explores some of the issues that the Department of Climate Change and Energy Efficiency (the Department) as part of the Framework, indicated needed further consideration. Specifically, it explores the implications of a policy that broadens and facilitates the use of zero and low emission energy to offset any form of energy use within the building. This Report outlines the issues and practicalities of including low and zero emission energy generation in building energy efficiency standards.

1.1. Objectives

This report was commissioned by the Department to investigate the feasibility and broader policy implications of amending the National Construction Code (NCC)[2] to include more comprehensive provisions for building-connected zero and low emission energy generation to assist in achieving energy efficiency standards for both residential and non-residential buildings.

In this context, the primary goal of building-connected generation is to decrease grid electricity usage by the commercial and residential sectors and to consequently reduce greenhouse emissions.

Reflecting the policy areas to be explored, this report covers the following issues:

- The development of a clear and practical definition of zero and low emission energy generation that is relevant to building energy use, is capable of accommodating new technologies as they come onto the market and that can be applied at different scales. The definition will include energy generation systems that can be fixed to or sited next to the building and supplying energy directly to it, sited close to the building as part of a broader precinct development, or located off-site with the energy purchased through long term supply contracts for use in the building. This will not include short-term products or contracts such as GreenPower.
- Estimates for the projected take-up of zero and low emission energy generation for buildings out to 2020 taking into account the impacts of government regulations and incentives, and changes to the capital costs of the generation equipment.
- Challenges for building energy efficiency standards, verification methods and rating tools in ensuring that the type and expected output of zero and low emission energy generation can be accurately quantified and assessed for compliance, the quality of installation, commissioning and maintenance of systems can be ensured, and the energy supply can be guaranteed to continue for the life of the building independently of the owner or tenant in the building.
- The positive and negative impacts on electricity transmission and distribution infrastructure of the projected take-up of zero and low emission energy generation for buildings, particularly on peak loads, taking into account developments in larger-scale renewable energy supply and infrastructure upgrades, energy demand trends, and new technologies such as smart grids.
- The positive and negative impacts on retail competition, consumer protection, reliability and safety arising from growth in on-site building energy supply.

[2] The report will generally refer to the Building Code of Australia (BCA) rather than the National Construction Code (NCC) as the focus of any revisions to the NCC will be in the first two volumes for the NCC, which encompass the BCA.

- The relative capital and energy supply costs of on-site zero and low emission energy generation systems compared to precinct-scale and more distant off-site energy generation.
- Whether limits should be placed in building energy efficiency standards on the allowable size of zero and low emission energy generation relative to the energy efficiency of the building fabric and fixed appliances and equipment, taking into account the need to ensure the maintenance of building energy performance over its lifetime.

1.2. Stakeholder consultations

Stakeholder consultations were undertaken with a variety of Commonwealth and state agencies as well as relevant technology suppliers, to better understand the policy considerations and current experiences.

2. Zero or Low Emissions Generation and Zero Energy Buildings

Outlined in this section is a clear and practical definition of Zero or Low Emission Generation (ZLEG), supported by a brief overview of the zero emission (renewable) or low emission power generation technologies and a discussion of zero energy buildings.

2.1. Overview of ZLEG technologies and definitions

2.1.1. Technologies

A wide range of power generation technologies do not involve the combustion of a fossil fuel and can therefore be considered zero emission generation technologies[3]. Other technologies deliver electricity at a very much reduced level of greenhouse emissions compared to national average grid power and are therefore considered low emissions technologies. They achieve the emissions reduction through more effective utilisation of the fuel. Renewable generation technologies include technologies such as geothermal, marine power, utility scale wind including off-shore wind, concentrating solar PV and solar thermal power generation. However, these are not suitable as options for on-site generation[4] in buildings as they are best suited to utility scale power generation.

The Australian Building Codes Board (ABCB) has recently published a handbook on renewable energy and energy reclamation (ABCB, 2011), and the document recognises several renewable energy sources. These renewable sources are described in the following table, along with commentary on their suitability as ZLEG technologies.

In addition, the ABCB report recognised cogeneration and trigeneration as technologies that can be effective in reducing greenhouse gas emissions. But importantly, the report did not recognise zero emissions electricity not generated on-site (i.e. Green Power) as renewable energy for the purposes of the BCA.

Table 1: Renewable energy sources[5]

Energy Source	Description (from ABCB, 2011)	Energetics Comment
Solar heater	Solar hot water systems used for heating of domestic hot water supply, swimming pools, spa pools or space heating.	A solar water heater uses solar energy directly to displace water heating technologies that result in the generation of greenhouse emissions. However, it would be difficult to call solar hot water heating a ZLEG technology in terms of generating electricity.
Solid-fuel heater or biofuels	Heaters that burn wood or biomass. Biomass includes any kind of organic matter, e.g. agricultural waste, forestry by-products, etc.	A biomass heater acts to displace space heating technologies that result in the generation of greenhouse emissions. However, it would be difficult to call biomass heater a ZLEG technology.

[3] Strictly speaking, the combustion of biomass results in the formation of nitrous oxide (N_2O) which is a potent greenhouse gas.

[4] Later in the report, the options of precinct level cogeneration and trigeneration and remote wind are discussed.

[5] (ABCB, 2011).

Energy Source	Description (from ABCB, 2011)	Energetics Comment
Solar PV	Solar PV comes in a number of forms, one of which is the typical "solar panel". They convert solar energy directly into electricity.	A zero emissions power generation technology.
Geothermal	Geothermal energy is heat energy derived from the earth's natural (subsurface) heat.	A zero emissions power generation technology. However, geothermal power generation is not cost effective in Australia at small scale. There are also geothermal heat pumps and these can be considered as a more efficient form of space heating and a better described as an energy efficiency measure.
Wind power	Wind power typically uses tower- or roof-mounted turbines to convert the movement of the wind into electricity.	A zero emissions power generation technology.
Other on-site renewable	Any other energy source that is renewable on-site.	These include marine power and solar thermal power, which are best described as 'utility scale' renewable generation technologies. Some bio-energy technologies are suitable for small scale, embedded generation. An example is farm-scale anaerobic digestion/power generation. (IEA, 2005).

One further technology that should be mentioned is solar driven air conditioning (see Appendix B for a description). Solar driven air conditioning cannot be considered a ZLEG because it does not generate any power. However, like trigeneration, it acts to displace the use of electricity in space cooling and heating, and in the context of zero energy (or emission) buildings has the same effect as an embedded renewable power source linked to a mechanical chiller. Solar hot water heating also falls into this category – displacing power demand while not actually generating any power.

On balance, stakeholders consulted during the study favoured a definition that will be capable of dealing with technologies like solar driven absorption chillers which offset power demand rather than generate power.

Two broad types of technology are examined in the context of this study:

- Readily scalable non-dispatchable renewable generation technologies. Being scalable means they are more likely to be cost effective to participants, particularly for participants in the residential sector. And being a renewable technology means they are most likely to be non-dispatchable[6]. The most common example is solar photovoltaics (PV), especially flat panel crystalline panels.
- Dispatchable, low emission, small-scale generation. Cogeneration and trigeneration fall into this category.

For the purpose of simplicity and to assist to clarify points raised in this discussion document, solar PV will be used to illustrate issues with respect to the residential sector, and cogeneration and trigeneration will be discussed in the context of the business sector. This does not mean that the

[6] The term 'non-dispatchable' means that the generator cannot be turned on or off, or can adjust its power output on demand.

issues raised in the discussion paper apply to only those technologies. For instance, micro wind turbines are also suitable for building scale renewable energy.

Additional details of some renewable and low emissions technologies can be found in Appendix A.

2.2. Energy reductions versus emissions reduction - zero energy buildings

ZLEG in buildings is one of a suite of measures that is available to attain zero emissions or zero energy buildings. It is worthwhile then to examine the various questions around definitions of zero emissions or zero energy building as they may provide some guidance as to an appropriate definition for ZLEG.

2.2.1. Four definitions of Zero Energy Buildings

According to Torcellini et al (Torcellini, Pless, Deru, & Crawley, 2006), a net zero-energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies. They then proposed four definitions for ZEB:

- **Net Zero Site Energy**: A site ZEB produces at least as much energy as it uses in a year, when accounted for at the site.
- **Net Zero Source Energy**: A source ZEB produces at least as much energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to generate and deliver the energy to the site. To calculate a building's total source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers.
- **Net Zero Energy Costs**: In a cost ZEB, the amount of money the utility pays the building owner for the energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.
- **Net Zero Energy Emissions**: A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources.

To the above definitions can be added 'Off-the-grid', which describes stand-alone ZEBs that are not connected to an off-site energy utility facility. They require distributed renewable energy generation and energy storage capability.

A limitation with the site ZEB definition is that it does not account for the amount of energy actually expended to deliver energy to the site. Conventional fuel sources are on average 30% efficient due to the heat losses resulting from power generation and then lose a further 15% through transmission and distribution losses. By the time the electricity gets to site it has therefore lost 85% of the initial fuel burnt. A further limitation is that site ZEBs may even encourage the use of electric equipment that is more efficient at the site than its gas counterpart. A good example is hot water heating, where electric storage hot water heaters are more efficient than gas storage hot water heaters from an energy perspective.

A source ZEB produces as much energy as it uses as measured at the source. To calculate a building's total source energy, both imported and exported energy are multiplied by the appropriate site-to-source energy factors. Generally, electricity will have a site-to-source energy factor that is three times larger than the corresponding factor for natural gas. The building's energy balance will be more complex to calculate, and will be influenced by factors beyond the building. However, source ZEBs will result in lower energy/emission outcomes from a societal perspective.

An emissions-based ZEB produces at least as much zero emissions energy as it uses from emissions-producing energy sources. Success in achieving an emissions-based ZEB depends on the generation source of the electricity used, and an emissions-based ZEB importing electricity with a low emissions intensity will have less incentive to implement embedded ZLEG. An emissions-based ZEB will also lead to lower emission outcomes compared to BAU from a societal perspective.

2.2.2. ZEB supply-side options

A renewable energy supply hierarchy was introduced by Torcellini et al. This is outlined in Table 2. The authors acknowledge the importance of reducing the energy demand of the building as the first step to be taken in the path towards a ZEB. This is a key concept, and one that is discussed at length later in this report. The table also presents a hierarchy of supply options, starting with options within the building and progressing to off-site options.

Torcellini et al also flagged the impact that wide spread deployment of ZEBs will have on reliable electricity supply. They noted that trends in other utility sectors, such as water supply, suggest that as buildings become more efficient, and consequently have lower consumptive charges, the costs associated with infrastructure are increased. If significant numbers of buildings achieved a zero energy cost, financial resources would not be available to maintain the infrastructure, and the networks would have to raise the fixed and demand charges. The result will be an increase in power costs for customers who are not able to reduce their energy use. This issue is discussed more in Section 7.

Table 2: ZEB renewable energy supply options[7]

Option	ZEB supply-side options	Examples
0	Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, passive solar building design to improve building thermal performance etc.
On-site supply options		
1	Use renewable energy sources available within the building's footprint	Solar PV, solar hot water, and wind located on the building.
2	Use renewable energy sources available at the site	Solar PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building.
Off-site supply options		
3	Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off site, or waste streams from on-site processes that can be used on-site to generate electricity and heat.
4	Purchase off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options. Hydroelectric is sometimes considered.

[7] From (Torcellini, Pless, Deru, & Crawley, 2006).

The question of a suitable definition for a zero emission building in the Australian context was examined by Riedy et al (Riedy, Lederwasch, & Ison, 2011). This study drew on the literature and stakeholder consultations to reach a common ground on a suitable definition for zero carbon buildings. A zero carbon building is one that has no net annual Scope 1 and 2 emissions from operation of building incorporated services. This definition also required the building to meet any specified standards for energy efficiency and on-site generation, and that compliance is based on modelling or monitoring of greenhouse gas emissions in kg CO_2-e/m^2/yr. Two points recognised by Riedy et al are important in the context of this current report:

- Energy efficiency needs to be considered as well as the net emissions; and
- The calculation of the net emissions must consider emissions at the energy source rather than at the site.

However, the authors focused on zero carbon buildings rather than zero energy buildings. The choice between a focus on energy consumption and a focus on carbon emissions is a key policy issue beyond the scope of this current study, which is to consider energy use.

2.2.3. Consideration of building life cycle

Riedy et al also examined the question of the building life cycle and how it influences interpretation of zero energy and zero emissions. Figure 1 below presents the conceptual framework, and helps to illustrate one particular challenge in developing a robust definition for ZLEG.

The conceptual framework of building life cycle recognises the impact that the boundaries in both space and time can have on the calculation of the energy use or emissions from a building. While noting that there is no ‘one size fits all’ definition, Riedy et al proposed that a zero carbon building is one that has no net annual Scope 1 and 2 emissions from operation of building incorporated services. These are all energy demands or sources that are part of the building fabric at the time of delivery, such as the thermal envelope, water heater, built-in cooking appliances, fixed lighting, shared infrastructure and installed renewable energy generation. Some stakeholders consulted during the preparation of this report did note that any definitions of ZEB should consider only the core building[8] rather than whole building (in the case of a commercial building with multiple tenants), and that it should just focus on the operational energy.

[8] The core or base building usually includes all the common areas such as the lobby and the car park plus central services such as heating, ventilation and air conditioning (HVAC) and lifts. The other component of building energy use is that used by the tenants of the building.

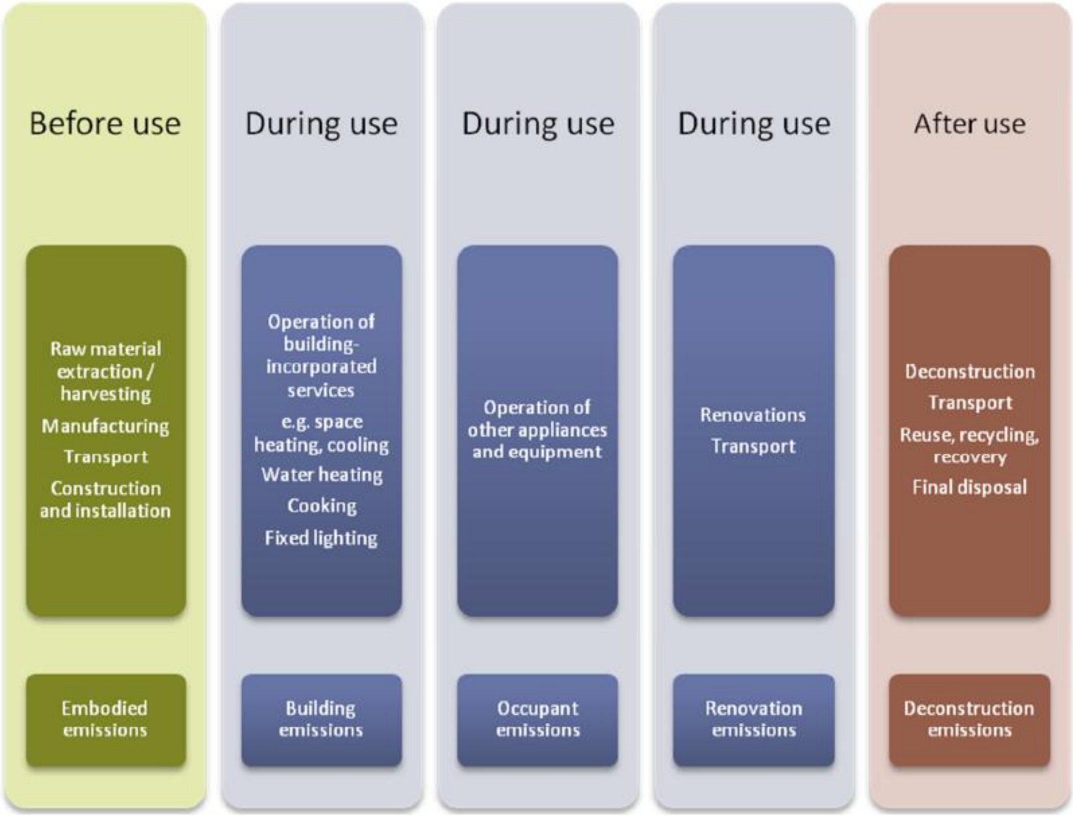

Figure 1: Conceptual framework of building life cycle[9]

2.2.4. Source versus site energy or emissions

In proposing a path to achieving the European Union 2020 target for near zero energy buildings, the European Council for an Energy Efficient Economy (ECEEE, 2011) noted the range of national targets that focus on achieving zero carbon buildings and that necessarily means a consideration of emissions at the source rather than the site. Consistent with this focus on the energy source, the ECEEE's definition of a 'nearly zero energy building' includes the primary energy consumption that is based on national or regional averages for the primary energy factors.

Later in this report, various approaches to achieving zero energy buildings are explored. But, for the moment, the key messages are:

- A definition that considers the energy used at source appears to be favoured. Any definition must recognise the first step towards a zero energy building is reducing the energy demand through energy efficiency.

2.3. Low emissions generation

2.3.1. Existing targets for 'low emission'

The definition for zero emission technology is simple and it means no greenhouse emissions due to the generation of power[10] and includes renewable energy technologies such as solar PV. The issue is

[9] (Riedy, Lederwasch, & Ison, 2011), adapted from the United Nations Environment Programme's Common Carbon Metric.

more complex in the case of low emissions generation. Several criteria are available to inform the debate about the criteria that defines a 'low emissions generation'[11], which are outlined in the table below.

Table 3: Potential ZLEG emissions reduction targets

Source	Reduction target relative to the base case[12]	Basis
Intergovernmental Panel on Climate Change	50% minimum reduction =using past Australian average emissions factors a 50% reduction would result in a target of about 128kgCO2e/GJ	The Intergovernmental Panel on Climate Change (IPCC) reported in the Fourth Assessment Report (Metz, Davidson, Bosch, Dave, & Meyer, 2007), that in modelled scenarios the most stringent emissions stabilisation category (a stabilisation level below 490 ppmv CO2-e), emissions are required to decline before 2015 and are further reduced to less than 50% of 1990 emissions by 2050.
Australian Government	80% minimum reduction=using past Australian average emissions factors a 80% reduction would result in a target of about 52kgCO2e/GJ	The Australian Government has a policy to cut greenhouse emissions by 80% below 2000 levels by 2050, and this would suggest that the definition for low emissions generation is an 80% minimum reduction relative to the 'base case'.
Performance requirement JP3 of the ABCB's guidance on renewable energy and energy reclamation	100 g CO2-e/MJ of thermal energy load[13]. This is equivalent to 100kgCO2e/GJ	Applies to a heating source only. The value has been included as it may provide some guidance in setting a performance benchmark for ZLEG.

2.3.2. Sensibility assessment - apply targets to existing technology examples

It is essential for a policy definition to include a target that not only delivers maximum energy and emissions savings but that is also realistic, pragmatic and appropriate. To do this, the study compared outcomes from existing cogeneration and trigeneration against the targets.

Outcomes from cogeneration in Melbourne and trigeneration in Brisbane were selected as both are desirable examples from a technical perspective. The results are summarised in Table 4. Supporting information can be found in Appendix C.

The analysis shows:

- Trigeneration in Brisbane would only be considered to be a low emissions technology under the IPCC target listed in Table 3.
- Cogeneration in Melbourne would be considered as a low emissions technology except where the requirement is for an 80% reduction relative to grid power.

[10] Note that this definition means that embodied emissions cannot be included as no existing technology has zero lifetime emissions.

[11] It is important to distinguish between the criteria that define a 'low emissions generation' technology and the target for a ZEB.

[12] The obvious base case is conventional grid power.

[13] The figure of 100 g CO_2-e/MJ if applied to grid electricity in Australia is equivalent to 278kg CO2-e/kWh and is substantially lower than current grid intensity factors although only marginally so in the case of Tasmania.

These results indicate that the targets outlined are unlikely to be appropriate for existing 'low emissions' technologies. This is especially when considering that over time, the targets would be increasingly challenging to meet as the emissions intensity of grid power falls due to the impact of other policy measures.

Table 4: Emissions reduction due to cogeneration and trigeneration

Outcome	Reduction relative to current grid emissions intensity	Intensity of electricity generation (g CO_2-e/MJ)
Cogeneration in Melbourne	59%	72
Trigeneration in Brisbane[14]	41%	103

2.3.3. Inclusion of specific technologies

The purpose of setting a target for emissions reduction is to drive emissions reduction without needing to specify appropriate technologies. An alternate approach is to explicitly state the technologies to be included.

This approach has been used by the Queensland Office of Clean Energy (Queensland Office of Clean Energy, 2010) which stated that the opportunities for onsite low emissions energy generation include several renewable energy technologies as well as *natural gas co-generation and trigeneration systems; and electricity generated during required testing of standby generators*.

Solar air conditioning is an example of a technology that may be specifically defined, as it is not technically a ZLEG technology as it does not involve the generation of electricity but is an effective method for reducing the energy demand of a building by displacing some or all of the grid electricity used to drive a mechanical chiller. Given this, it may be considered worthy of inclusion in programs aimed at removing barriers to the deployment of ZLEG in buildings. If the Commonwealth or the states and territories consider it should be included, a method to calculate the emissions reductions associated with solar air conditioning should be outlined to allow the technology to meet the definition of ZLEG.

Energetics has no position on the need to include solar air conditioning in the definition of ZLEG.

2.4. On-site versus off-site

The objectives of the study described in this report require a definition of ZLEG that must be applicable "to energy generation systems that can be fixed to or sited next to the building and supplying energy directly to it, sited close to the building as part of a broader precinct development, or located off-site with the energy purchased through the energy market for use in the building."

The requirement to encompass broader precinct development and off-site generation with the energy purchased through the energy market raises questions relevant to definition as well as a number of policy questions that are discussed in subsequent sections of this report.

[14] The analysis of trigeneration assumed that all heat was used to drive an absorption chiller with a performance level of a 'single effect' chiller. Higher performance is obtained from a 'double effect' absorption chiller. However, these are more complex and require higher temperature waste heat.

2.4.1. Precinct level ZLEG

The key issue is establishing a definition for “building-connected zero and low emissions energy generation”. The benchmark for ‘embedded generation’ is a power generation system that is contained within a building. Obvious examples include cogeneration in a commercial building or solar PV on the roof of a residential building. The benefit of such systems is that they are tightly linked to the building, although Energetics notes that being tightly linked to the building does not guarantee that the ZLEG actually reduces the demand of the building for grid power, as it must also be operated correctly over the life of the building.

Precinct level ZLEG systems such as district heating and cooling systems must be included, and their value for reducing national emissions is clear (IEA, 2011). We suggest that the defining characteristic of precinct level ZLEG in this context is a physical connection between a building and the ZLEG system. This connection can take the form of a private wire network, a “virtual” private wire network (see Section 8.1) or pipes carrying hot or chilled thermal fluid (for instance, water).

Energetics recommends that a definition states that a ZLEG system needs to be connected to the building by way of a private wire network, a “virtual” private wire network or pipes carrying hot or chilled thermal fluid. The ZLEG system itself can be located on-site or off-site.

2.4.2. Offsite ZLEG

Genuine off-site ZLEG, where the only connection is through the electrical transmission and/or distribution networks is more complex. The challenge is to provide a robust legal framework that will ensure that the remote ZLEG system remains linked to the building should the building owner change. It is not clear that future energy users can be forced into long term energy supply contracts at the point of construction of the building.

One approach to ensuring the on-going contribution of off-site ZLEG where supply of power to the building is over the electrical transmission and/or distribution networks is to require the building owner to purchase and immediately acquit sufficient Renewable Energy Certificates (RECs) to cover the projected electricity consumption stemming from the operation of the building over its effective life.

Energetics does not have any specific recommendations in this regard.

2.5. Energy versus emissions

An additional consideration is the different approaches based on ‘emissions’ or ‘energy’, especially in a policy context. Stakeholders noted that ZLEG exists in a policy framework that seeks to reduce greenhouse gas emissions. To this extent, it is important that a definition of ZLEG includes energy use at the source, to account for emission reductions, not merely site energy use.

Since the greenhouse gas intensity from grid power (as published by the Clean Energy Regulator now) varies between states and across time, the definition in terms of actual emission savings will be dynamic. It is therefore possible that technologies that sit near the borderline of the definition may be covered by the definition in one year, but not the next. This will not be the case with a definition in terms of energy.

2.6. ZLEG Definition

In addition to the issues discussed above, we noted a preference from stakeholders for performance requirements, rather than a definition that favours a particular technology, and we generally support this except in the case of absorption refrigeration.

Energetics recommends a definition for low emissions generation to provide for a 50% reduction target compared to grid power with the inclusion of an additional criterion that trigeneration provides a 40% reduction relative to grid power. We recommend that any calculations of the reduction in emissions account for the full fuel cycle (that is both on-site and off-site emissions associated with the use of energy at the site) as supported by Section 2.2

We do not favour the requirement of an 80% reduction as that will effectively exclude both cogeneration and trigeneration from any policy measures that incentivises low emissions generation that are based on this definition.

Energetics proposes the following definition for zero or low emissions technology:

- **Zero or low emissions energy generation is that which offsets any form of energy use within the building it is associated with.**
- **The generation technology can be on-site or off-site and must be connected to the building by way of a private wire network, a "virtual" private wire network, or pipes carrying hot or chilled thermal fluid.**
- **The generation technology must provide no less than a 50% reduction in emissions compared to conventional grid/network supplied energy.**

It should be noted that the 50% target may mean that trigeneration systems and some cogeneration systems in particular locations cannot meet the target.

The proposed definition speaks of "generation", and if this is interpreted to mean generation of useful energy rather than just electricity generation then the definition can encompass technologies such as solar hot water and solar air conditioning.

The methods used to calculate the reduction are discussed in Section 5.4.

Markets, standards and incentives

3. Projected take-up of ZLEG to 2020

This section of the report seeks to establish the magnitude of the impact that ZLEG could have on national energy use and greenhouse emissions. The uptake of zero and low energy generation for buildings to 2020 will be influenced by a range of factors under a business-as-usual (BAU) scenario, even excluding further changes to the building codes and regulations.

Defining a BAU scenario is very difficult, especially with regard to solar PV as the recent rapid take-up of solar PV in the residential sector has been driven by generous government incentive programs, and these programs are now being phased out[15]. However, as these drivers are lost, other drivers are emerging. For instance, solar PV installed 'behind the meter' is soon to be cost effective in its own right, which will help to drive the take-up of solar PV (as outlined further in Section 4).

It is appropriate to consider the estimated take-up of ZLEG to 2020 separately for the residential and commercial sectors. To assist in placing these projections into context, this section begins with a brief outline of energy in Australia.

The analysis that is presented below suggests:

- Residential: the technical potential for Solar PV in the residential sector is in the order of 4.22 GW_p, based on 1.5 kW_p units on all new detached and semi-detached dwellings, and on 2% of all existing dwelling stock each year. Figures expressed as kW_p (or MW_p, GW_p) refer to the installed capacity of embedded generation systems. The accumulated output of the embedded generators is expressed as kWh (or MWh, GWh). The annual rate of installation under this scenario is 470 MW_p/yr. The technical potential is a hypothetical case that shows what could be achieved through a very aggressive policy driver, and needs to be compared with historical and BAU forecast annual installation rates of 110 MW_p per year for the historical take-up in recent years, and 13 MW_p per year for the projected BAU take-up (SKM-MMA, 2010). We also note that the potential for residential wind is minimal and that the potential for other technologies in the residential sector is also limited.
- Commercial: The take-up of ZLEG in the commercial sector is primarily modelled as the deployment of precinct level trigeneration systems and this can provide a total opportunity in Australia of 1.67 GW_e.

The section finishes with a brief overview of current incentive schemes that are driving to take-up of renewable generation and in particular solar PV. This material is added for reference purposes.

[15] For instance, the gradual reduction in the multiplier used in the Solar Credits scheme from five up to 30 June 2011 down to one from 1 July 2013 (See http://www.orer.gov.au/Solar-Panels/Solar-Credits/Solar-Credits). A further example is the closing of the NSW Solar Bonus Scheme from 28 April 2011.

3.1. Energy use in the Australian commercial and residential sectors

In 2009-10, the commercial[16] and residential sectors in Australia consumed 309.1 PJ and 440.1 PJ of energy respectively which represented around 20 per cent of total final energy consumption (ABARES, 2011). Figure 2 shows how the total energy consumption by the commercial and residential sectors compares with the national total.

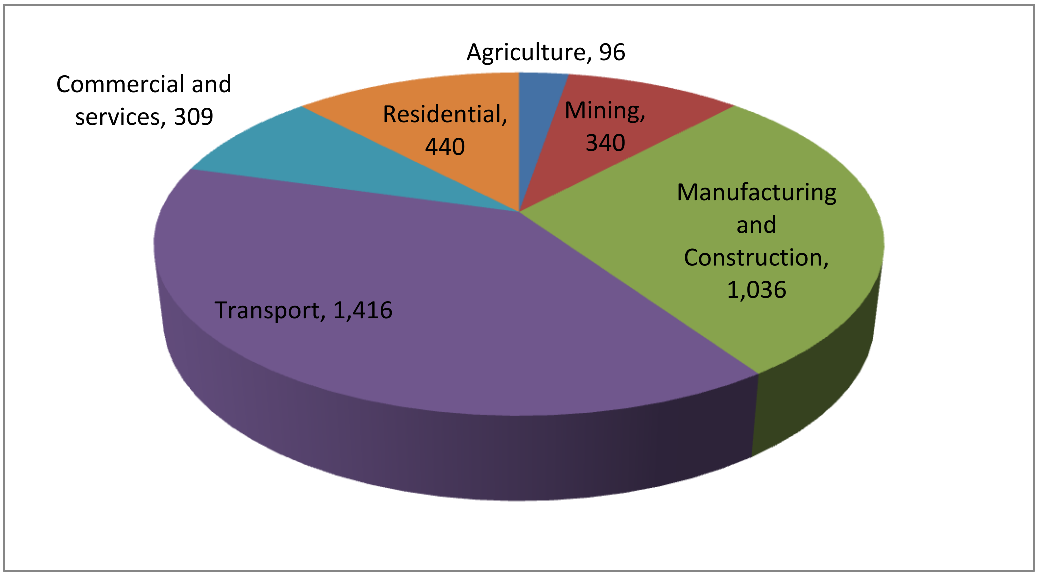

Figure 2: Energy use by sector in 2009-10 (PJ) [17]

Figure 3 below focuses just on electricity consumption, and shows how the commercial and residential sectors use relatively more electricity than the other sectors. The commercial sector consumed 61.5 TWh of electricity in 2009-10 and the residential sector consumed 60.1 TWh.

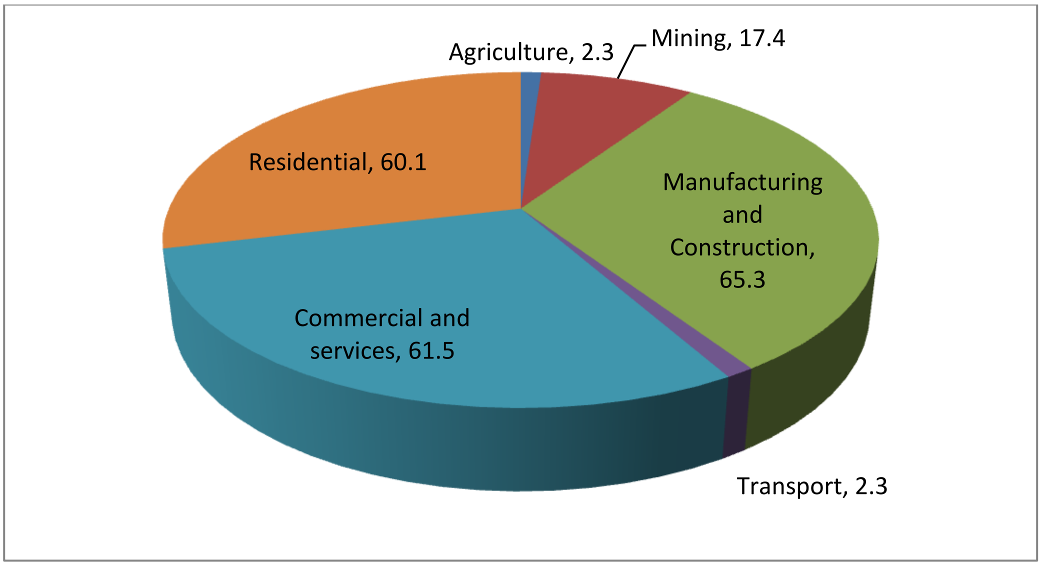

Figure 3: Electricity use by sector in 2009-10 (TWh) [18]

[16] The commercial sector comprises wholesale and retail trade, communications, finance, government, community services and, recreational industries.

[17] (ABARES, 2011). The figures exclude energy consumed or lost in conversion and distribution.

The total national electricity consumption was 209 TWh in 2009/10. The following figure presents the forecasted growth of the national electricity market (NEM)[19] out to 2020, and it shows how the demand for electricity is expected to rise over the next few years.

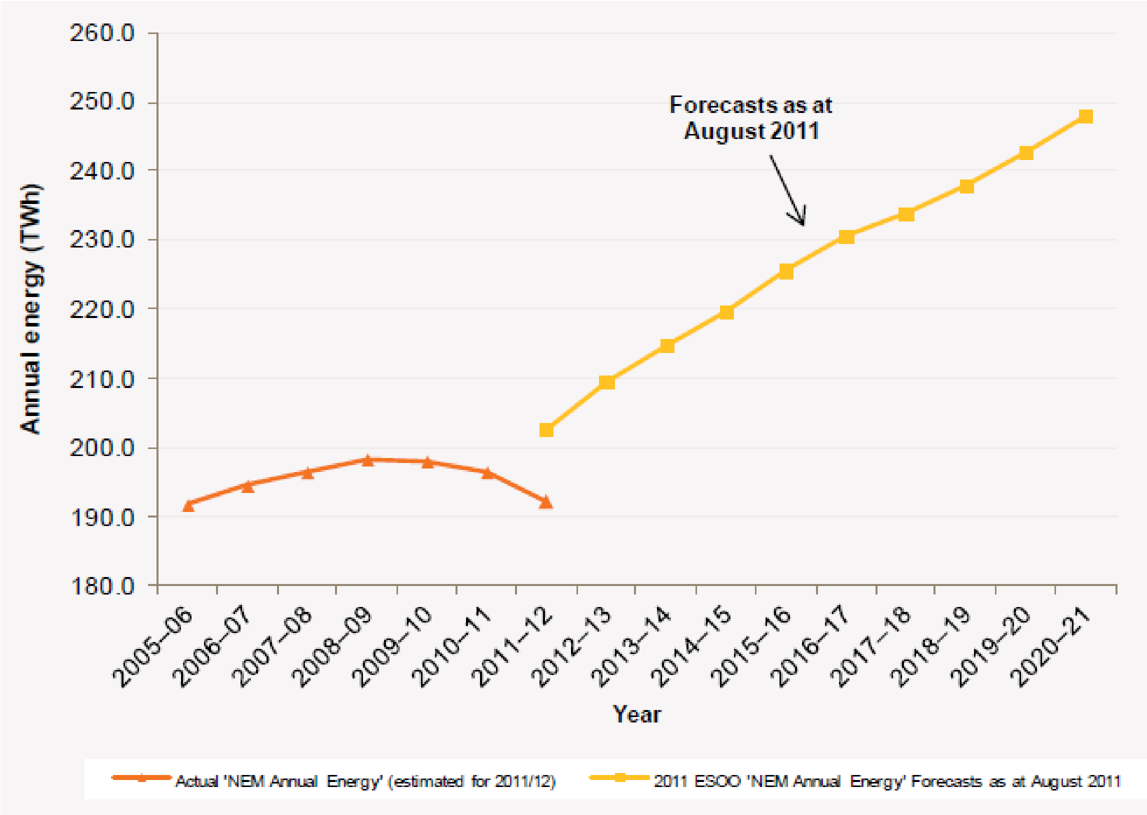

Figure 4: Forecast demand for electricity in the NEM[20]

3.1.1. Technical potential of residential solar PV

In this section, an estimate of the technical potential for residential ZLEG is developed. The technical potential assesses the maximum possible take-up of a technology irrespective of the economics of doing so and assuming that all other market and non-market barriers can be overcome. It provides a useful yardstick to then assess what is feasible under typical business-as-usual scenarios.

The technical potential for ZLEG in the residential sector is assessed in terms of the take-up of solar PV. Solar PV was chosen as it is considered to be the most feasible technology for the residential sector. Small-scale wind has an on-going role and small recorded uptake. Small-scale cogeneration and trigeneration are not economically feasible in the residential sector due to the high cost of natural gas relative to electricity. This last point is explored in Section 4. District level cogeneration and trigeneration, which may include a residential component is included in the estimate of the potential for cogeneration and trigeneration in the commercial sector.

[18] (ABARES, 2011)

[19] Note that the NEM excludes the North and South Western Interconnected Systems as well as various other separated grids in Western Australia, Northern Territory and Queensland.

[20] (AEMO, 2012).

The take-up of solar PV has been modelled for both new and existing dwellings. The following assumptions were used in estimating the technical potential of solar PV to 2020:

- A change in the BCA to drive take-up of solar PV in the residential sector for new dwellings (Table 5) and existing dwellings at time of renovation (Table 6).
- The incentive only applies to new detached or semi-detached residential construction.
- The average solar PV installation on a residence in 1.5 kW_p[21].

Technical Potential of New Dwellings

The most recent comprehensive report on energy use trends in the residential sector is the DEWHA baseline report, prepared by EES (Energy Efficient Strategies, 2008), and released in 2008. The report addressed energy trends in Class 1 and Class 2 buildings. Important aspects in this study, in terms of the potential for distributed generation, lie in the addition of new homes to Australia's housing stock, the types of new properties (and their location), and the expected energy usage characteristics of these homes.

The baseline report gives data on the forecast number of new homes entering the housing stock from 2013 to 2020 inclusive. Approximately 174,000 occupied residential dwellings are added each year. See Appendix D for full details.

New housing can be described as detached (single or 2-storey generally), semi-detached or low and high rise apartments. The baseline report proposed that 67.1% of new residential dwellings will be detached, that 13% will be semi-detached and that the remainder will be apartments.

Table 5: Take-up of solar PV in new dwellings to 2020

Year	New dwellings	New applicable dwelling	New solar PV installations (MW_p)	Capacity factor (%)	Additional capacity (GWh/yr)	Cumulative capacity (GWh/yr)
2012	173200	138730	208	19.3%	352	352
2013	173000	138570	208	20.0%	364	716
2014	173700	139130	209	20.6%	377	1093
2015	175100	140260	210	21.3%	393	1486
2016	174900	140090	210	22.0%	405	1891
2017	174300	139610	209	22.7%	416	2307
2018	172600	138250	207	23.3%	424	2731
2019	172800	138410	208	24.0%	436	3167
2020	172900	138490	208	24.7%	449	3616

[21] For comparison, ORER data show that the average size of PV installations is 1.93 kW_p.

New dwellings that are applicable to our projections are detached and semi-detached dwellings due to their ability to accommodate solar PV on the roof. The capacity factor was derived from Energetics' solar PV model. The forecast potential based on a new solar PV unit on every new detached or semi-detached dwelling is 1.88 GW_p, and with an average capacity factor of 22% is capable of generating 3.6 TWh of electricity. The cumulative solar PV to 2020 should be compared with the estimated electricity demand of new dwellings to 2020 of 8.4 TWh/yr. See Appendix D for the derivation of this latter value.

Technical Potential of Existing Dwellings

The BCA can foster a higher take-up of solar PV potentially through a requirement to include ZLEG as part of major renovations to residential dwellings. In determining the technical potential, we have reasonably assumed that 2% per year of the housing stock that is in existence in 2011 installs a solar PV system. In selecting the figure of 2%, we accounted for the following:

- The rate that home owners undertake renovations. For instance, in 1999, 58% of owner occupiers stated that renovations had been carried out on their current dwelling in the previous 10 years[22]. This is approximately 6% of dwellings being renovated in any one year.
- Constraints due to orientation, size of the renovation and local planning laws limiting the ability to include solar PV in the set of renovation measures.

The residential baseline report estimated the number of dwellings at 8,677,000. Using the assumptions above, we forecast the take-up of solar PV due to major renovations to contribute a total of 4,512 GWh in 2020, with a total capacity of 2.34 GW_p.

Table 6: Take-up of solar PV in existing dwellings to 2020

Year	Renovations	New solar PV installations (MW_p)	PV Capacity factor (%)	Additional capacity (GWh/yr)	Cumulative capacity (GWh/yr)
2012	173540	260	19.3%	440	440
2013	173540	260	20.0%	456	896
2014	173540	260	20.6%	471	1367
2015	173540	260	21.3%	486	1853
2016	173540	260	22.0%	501	2354
2017	173540	260	22.7%	517	2871
2018	173540	260	23.3%	532	3403
2019	173540	260	24.0%	547	3950
2020	173540	260	24.7%	562	4512

Together, the technical potential of generation output from additional solar PV in new and renovated dwellings is estimated at 8,126 GWh or 96% of the forecast growth in electricity consumption of the residential sector.

[22] ABS 4102.0 - Australian Social Trends, 2002.

Historical Take-Up

These projected take-ups of solar PV represent the technical potential for ZLEG in the residential sector, and they should be compared with historical take-up and BAU take-up. The Office of the Renewable Energy Regulator (ORER) has included estimates for the take-up of solar PV, which take into consideration the phasing-out of incentive programs in its recent reports. The following figure is taken from one such report prepared by the ORER. It shows that the take-up of solar PV in Australia peaked at approximately 110 MW of new capacity per year, and with the phase out of several incentive schemes, the take-up will fall to around 13 MW per year. The rapid take-up seen in 2010 and 2011 was due to a combination of the SRECs and the feed-in-tariffs.

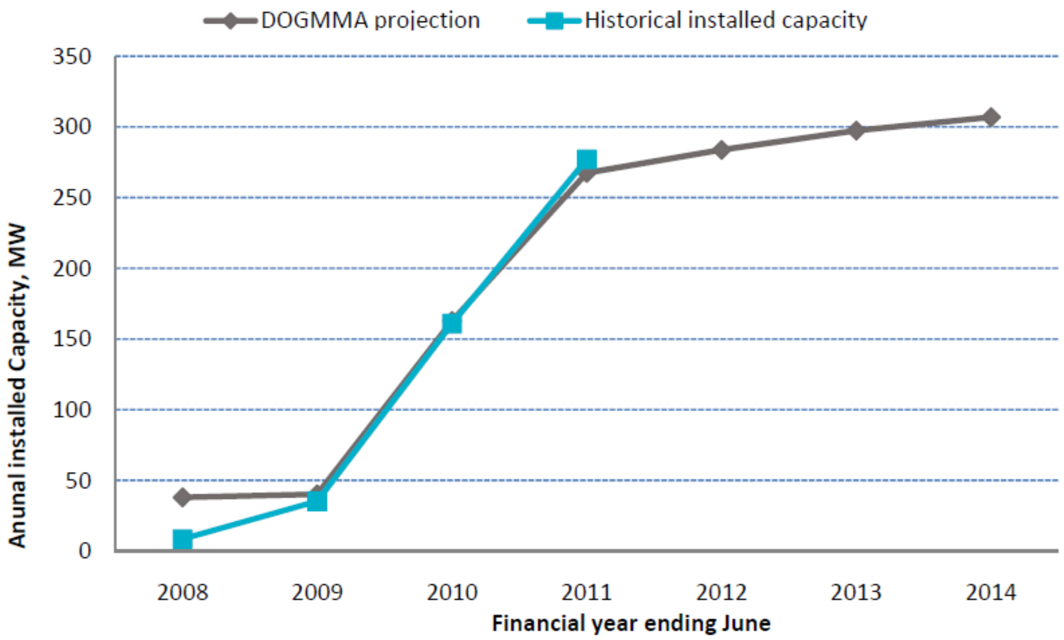

Figure 5: PV uptake capacity for Australia[23]

As outlined, there is great technical potential for solar PV that could be captured through policy incentives by targeting both new residential buildings and major renovations. This potential is significantly larger than the take-up observed over the past few years as a result of several government incentive programs and is an order of magnitude larger than the BAU take-up in the absence of government incentive programs.

3.1.2. Wind turbines

On-site vertical or horizontal wind turbines are constrained by planning laws in urban areas and despite being an eligible generation technology under the Small-scale Renewable Energy Scheme, in the same manner as a solar PV system, the number of current installations only represents a small fraction of the number of PV installations[24]. The variability of wind conditions in urban areas makes them an unreliable and inefficient ZLEG technology with low load factor. For these reasons, small-scale wind turbines in urban areas have not been considered in this analysis of potential impact.

[23] Taken from (SKM-MMA, 2010).

[24] Refer to the 2010 Annual Report of the ORER.

3.1.3. Cogeneration or trigeneration

Cogeneration and trigeneration can be delivered using a fuel cell, a micro-turbine or a conventional internal combustion engine.

The technical potential of residential micro co-generation in single dwellings is limited in Australia due to climatic conditions and overlapping with solar hot water installations. A basic requirement of all generation technologies that rely on waste heat recovery is that there is a use for the recovered heat; in the case of a single dwelling this will be for hot water and space heating/cooling. The absence of predictable, continuous residential thermal loads (heating/cooling) makes cogeneration and trigeneration relatively unattractive at a household level in Australia. In addition, in a single dwelling, cogeneration and solar hot water systems typically overlap in the service they provide. The relatively small footprint of a cogeneration plant may make it more attractive in some cases to solar hot water, conversely adequate roof space may make solar hot water a more economic prospect in other cases.

Cogeneration systems have been widely used in Europe, Japan or South Korea (See Appendix A). There are only a limited number of case studies in Australia and data for the residential sector in Australia suggests that Victoria and the ACT are the most suitable jurisdictions given the relatively high heating energy requirement in these areas, together with southern regions of New South Wales, South and Western Australia. In all jurisdictions (except Tasmania which uses hydro power) solar hot water and gas hot water penetration is high and electric hot water in new homes is rapidly declining, forecast to be between 4-12% of new homes by 2020.

The challenge is to estimate the potential market for micro cogeneration, and some guidance comes from a study by the UK Carbon Trust into field trials of such technology (Carbon Trust, 2011). The study demonstrated that the current payback periods for micro cogeneration units are likely to be well over 20 years. Energetics believes that the technical potential for micro-cogeneration in new homes is limited to around 4-12% of new homes in Victoria, ACT and parts of NSW, WA and SA. A rough estimate suggests around 100,000 homes to be built by 2020 could be suited to micro cogeneration. With a typical average capacity of 1 kW_e these installations will provide a total installed capacity of 100 MW_e. It is noted that for most of these homes, selection of solar hot water and solar PV are alternatives that may prove more attractive, both from a technology availability, maintainability and financial standpoint.

3.2. Technical potential of commercial ZLEG

3.2.1. Solar PV

Our estimate of the potential take-up of solar PV in the commercial sub-sector focuses on the growth in retail and wholesale commercial buildings. We note that buildings in this sector tend to have large roof areas and so are appropriate for solar PV. In Appendix E estimates for the growth in commercial building space are presented. The increase in building area in the retail and wholesale sub-sector is 5,490,000 m^2. For the purpose of this analysis, it is assumed that:

- The average building foot print is 50% of the floor area. This represents a compromise between the typical single level warehouse and a multilevel shopping centre.
- 33% of the building footprint can be devoted to solar PV.

- The average efficiency of the PV cells is 16.4%, and the insolation rate[25] is 5.1 kWh/m^2

After accounting for a 10% loss associated with the solar PV system, the output of solar PV systems associated with new retail and wholesale buildings is 251 GWh/yr.

3.2.2. Cogeneration and trigeneration

The opportunities for cogeneration and trigeneration in Australia are significant, with the technical potential (based on extrapolated Sydney city data) exceeding the forecast growth in the electricity consumption by the commercial sector. The analysis that supports this conclusion is described in the following section.

To assess the potential impact of cogeneration and trigeneration in the commercial sector, we have drawn on the comprehensive study of cogeneration and trigeneration undertaken for the City of Sydney (Kinesis Consortium, 2010). The following figure taken from the study highlights the opportunities for district level cogeneration and trigeneration in the City of Sydney.

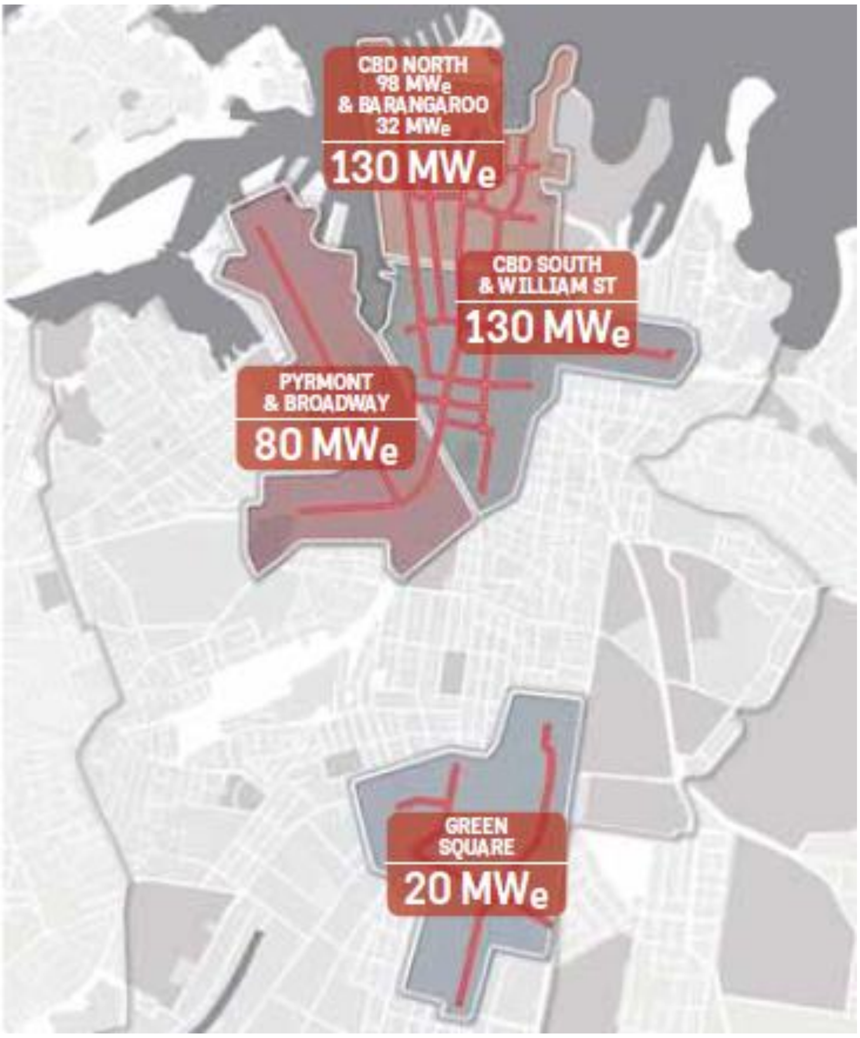

Figure 6: Cogeneration and trigeneration opportunities in the City of Sydney[26]

[25] The insolation rate is a measure of the intensity of sunlight.

[26] Taken from (Kinesis Consortium, 2010)

The study found a total of 360 MWe[27] of cogeneration and trigeneration. The following assumptions were then applied to extrapolate the results of this study to the remainder of Australia:

- A further 180 MWe of precinct level commercial cogeneration and trigeneration is available within greater Sydney.
- Extrapolation to other states and territories is based on population, and so the cogeneration and trigeneration opportunities in NSW represent 32% of national opportunities.
- The average utilisation factor of the cogeneration and trigeneration units is 63%.

Based on these assumptions, the total opportunity in Australia amounts to 1.67 GWe and the amount of electricity that is potentially generated is 9.3 TWh per year.

For comparison, the electricity consumption in the commercial sector is estimated to rise by 6.3 TWh/year in the period from 2013 to 2020 (The basis for this figure is discussed in Appendix E). This indicates that the technical potential of commercial cogeneration and trigeneration can exceed the forecast growth of electricity use.

Note that the calculations of the potential generation capacity of cogeneration and trigeneration have not accounted for the volume of the fuel used to run the cogeneration and trigeneration systems or the electricity used for space heating and cooling that is displaced by the cogeneration and trigeneration system.

3.3. Conclusions

- Understanding the take-up of ZLEG is difficult due to the rapidly changing policy environment, especially with respect to incentive schemes for solar PV.
- The technical potential for both solar PV in the residential sector and cogeneration or trigeneration in the commercial sector is high, and the technical potential of ZLEG is sufficient to meet the demands of new buildings constructed between now and 2020.

Having dealt with the take-up potential, it is now time to consider the cost effectiveness of ZLEG. This will determine if the challenge for governments is to incentive ZLEG through policy instruments to address financial barriers or non-financial barriers, or in fact just manage the business-as-usual take-up of these technologies.

The cost effectiveness of key ZLEG technologies is examined in the next section.

[27] The term MWe refers to the installed capacity of the electricity generator.

4. Cost of ZLEG compared to precinct or remote generation

In this section, the cost of key ZLEG technologies at various scales is examined, and the analysis demonstrates that cogeneration and trigeneration is cost effective at the precinct and commercial scale but not at the residential scale. Solar PV is currently not cost effective at any scale. However, this is expected to change very rapidly and within a few years solar PV at the residential scale is likely to be cost effective even without incentives.

4.1. Cost comparisons

As the installed costs of ZLEG technologies decreases and delivered energy and electricity prices rise, it is anticipated that ZLEG will become more mainstream and be deployed at increasing scale and the cost and technical efficiencies of scale will, to an extent, define the ZLEG technologies which achieve high levels of market penetration.

While larger scale generally means lower cost and higher returns for investors, it is not always the case with energy projects. For example, while residential solar PV is small scale deployment at relatively high cost compared to commercial scale / utility scale solar PV or other renewable energy technologies, the power generated offsets higher residential tariffs which improves the economics greatly. This is a key aspect to the economics of ZLEG which is most cost effective when offsetting the full delivered variable costs of electricity (the rate which retailers charge on their bill). In the current electricity market, the value of ZLEG is greatest when it offsets peak electricity (which can be more than double the off-peak rate) and as such has the highest value. Therefore, technologies that can operate on demand or at peak times (such as solar PV) provide a better investment return for participants who are exposed to peak tariffs.

Across Australia, the electricity tariffs vary considerably ranging between $150-300/MWh for residential consumers and from $90-$220/MWh for commercial consumers[28]. The range is largely due to the cost of transporting electricity, which is passed on to consumers as network costs and for rural and end of grid areas, can be particularly high.

The other aspect to realising the maximum economic value from ZLEG assets is to minimise export to the grid as, from a market perspective, the value of any exported power is small. As an example, a residential consumer with a solar PV system may achieve a saving equivalent to $240/MWh during peak periods but if they were to export surplus electricity, this would only be worth a fraction of this amount, (depending on Feed-in-Tariff arrangements). Therefore, to maximise return on investment, ZLEG should generally be sized to match the baseload demand at a site with any remaining power needs provided by the grid.

For ZLEG technologies, the capital costs vary according to the scale of the installation. At the smallest scale e.g. individual houses, the costs can be up 5-10 times the cost of larger projects per unit of energy generated. For this reason, certain technologies are not currently cost effective at small scale. For example, trigeneration is not generally well suited to individual residential properties due to high capital costs, poor efficiency at small scale and low thermal loads. However, at a commercial scale or multi-unit residential scale, where thermal demand is high for heating and/or cooling, trigeneration can provide a competitive energy supply option.

[28] Internal communication, Energetics, 2012.

For the purposes of this report, the approximate scale of installation has been defined for each technology as shown in Table 7 below. The largest scale considered was district or community scale which for the purposes of this project this was deemed to be sub-utility scale.

Table 7: Technology scale definitions

Technology	Residential scale	Commercial scale	District / Community scale
Solar PV	1 - 5kWe	10-500kWe	>500kWe
Wind	1 - 6kWe	6-2000kWe	>2000kWe
Trigeneration	-	500-3,000kWe	>10,000kWe

The cost of ZLEG technologies is dependent on a number of factors such as location, scale, operating costs, complexity etc, and accordingly, there is a large range in the cost figures published in the public domain. It should be noted that while there are many publicly available figures on technology costs, both capital cost and levelised cost of electricity (LCOE), there is very limited information specifically referencing ZLEG technologies. Most of the cost data is for large scale centralised energy projects comparing costs between wind, coal, nuclear gas etc. For ZLEG technologies where the scale ranges from a 1.5kW solar PV array on a residential dwelling to a 10MW district trigeneration scheme linking commercial buildings, there is a large spread in costs even within each technology type. Another aspect to providing accurate cost information is that the marketplace is moving rapidly. For example, solar PV module prices fell by 50% in 2011 and are 75% lower than in mid 2008[29] but these changes are not necessarily reflected in published figures as yet.

An estimate of capital costs for a range of ZLEG technologies has been provided in Table 8 below, based upon a number of different sources including data compiled as part of the intelligent grid (i-Grid) project and by the NREL[30]. The D-CODE model[31] developed as part of the i-Grid project (CSIRO, 2009) is targeted at distributed generation, is specific to Australia and also has very recent data (November 2011) so probably provides the best and most relevant set of cost data. However, the model does assume larger scale deployment and does not capture the recent changes in solar pricing. The resulting cost figures are indicative and should therefore be treated with some caution. They do however reflect the relative economies of scale achievable.

[29] Bloomberg New Energy Finance, 12th January 2012, http://bnef.com/PressReleases/view/180. Accessed 14th February 2012.

[30] National Renewable Energy Laboratory (NREL), 2012, Distributed Generation Energy Technology Capital Costs, website accessed 14th February 2012, http://www.nrel.gov/analysis/tech_cost_dg.html.

[31] CSIRO, 2011, Intelligent grid website, http://igrid.net.au/resources/downloads/project4/D-CODE.XLSM accessed 16th February 2012.

Table 8: Indicative capital expenditure in $/kWe installed

Technology	Residential scale	Commercial scale	District / Community scale
Solar PV[32]	$6,000-$8,000	$4,000-$5,000	$2,500-$4,000
Wind	$4,000-$6,000	$3,000-$5,000	$2,500-$3,000
Trigeneration	$3,940[33]	$2,300-$3500	$1,900-$3,000

The LCOE is a useful metric to enable comparison of technologies based on their cost of generating energy. For renewable energy projects, which require high capital investment upfront, this is a relatively simple process. For trigeneration it is more difficult as there are higher and more variable operating costs and a need to apply a standard approach to valuing the heating and cooling energy. This is compounded by the fact that electricity and thermal energy cannot easily be compared due to their different thermodynamic quality. Further with many cogeneration or trigeneration projects not all the thermal output is utilised. The figures below in Table 9 are a combination of data from the D-Code model, NREL estimates and other sources.

Table 9: Indicative expenditure in $/kWh

Technology	Residential scale	Commercial scale	District / Community scale
Solar PV	>$300/MWh	$200-$250/MWh	<$200/MWh
Wind	>$200/MWh	$150 -$200/MWh	<150/MWh
Trigeneration[34]	$150-300/MWh	$120-$150/MWh	$120-$150/MWh

The cost effectiveness of trigeneration depends critically upon the relative cost of electricity versus natural gas. The following table (Table 10) lists current and forecast prices for electricity and natural gas in NSW[35]. We assumed a power conversion efficiency of 30% in calculating the volume of electricity generated.

The numbers give a good indication of the relative costs, and show how the cost of the electricity produced by the generator is greater than purchased power. This suggests that cogeneration and trigeneration will struggle to be cost effective in the residential sector. Note that the calculation does not assign any of the cost of the fuel to the chilled water so is not a complete analysis. However, the general observation is still valid.

[32] Costs also referenced to data on February solar PV pricing from Solar Buzz. http://www.solarbuzz.com/facts-and-figures/retail-price-environment/solar-electricity-prices Website accessed 16th February 2012.

[33] Assuming multi-unit residential rather than individual houses.

[34] Assumes that all of the output from the trigeneration system is measured in MWh.

[35] These prices were derived from Energetics energy market model.

Table 10: Cost of power generated from trigeneration system

Sector	Residential		Commercial		Industrial	
Year	2012	2020	2012	2020	2012	2020
Peak Electricity ($/MWh)	306.25	409.89	166.09	224.90	146.51	196.71
Off-peak Electricity ($/MWh)	202.46	270.98	109.80	148.68	98.51	132.26
Natural gas ($/GJ)	26.32	32.45	8.00	11.12	8.00	11.12
Cost of electricity generated ($/MWh)	315.84	389.40	96.00	133.43	96..	133.42

4.2. Trends in solar PV costs

Unlike the other ZLEG technologies discussed above, solar PV technology is rapidly changing[36], and so costs are expected to drop over time. Our forecasts for the levelised cost of solar PV are in Table 11. The following assumptions were used in deriving these results:

- Current year module prices were the average of current firm prices offered by vendors. These prices are exclusive of RECs and so represent the real price in the absence of incentives.
- Module prices were assumed to fall at a rate of 5% per year.
- The current year efficiency was the average of the quoted efficiency of a range of PV modules currently in the market place.
- The average efficiency was assumed to rise at a rate of 0.5 percentage points per year.
- The levelised costs were calculated using the tool provided by the NREL[37].

Table 11: Forecast LCOE for solar PV

Year		2012	2020
Efficiency		14%	18%
Residential	Average module price ($/kW)	$4200	$2800
	Levelised cost of electricity ($/MWh)	$264	$142
	Forecast indicative peak power price ($/MWh)	$306	$410
	Forecast indicative average power price ($/MWh)	$265	$271
Commercial	Average module price ($/kW)	$3600	$2400
	Levelised cost of electricity ($/MWh)	$230	$125

[36] ZLEG systems such as wind power, cogeneration and trigeneration are based on technologies that have been in existence for decades if not centuries and so improvements in performance and reductions in cost tend to be gradual. This is not the case with Solar PV, where rapid improvements in performance (see Figure 11 in Appendix A) and manufacturing techniques (for instance, Twin Creek Technologies proton induced exfoliation) are still the norm.

[37] http://www.nrel.gov/analysis/tech_lcoe.html.

Year		2012	2020
	Forecast indicative peak power price ($/MWh)	$166	$225
	Forecast average power price ($/MWh)	$144	$294
Industrial	Average module price ($/kW)	$2300	$1500
	Levelised cost of electricity ($/MWh)	$153	$85
	Forecast indicative peak power price ($/MWh)	$147	$197
	Forecast indicative average power price ($/MWh)	$123	$165

The analysis is indicating that solar PV will soon be cost effective for all sectors, and particularly the residential sector.

Table 12: Solar PV system components[38]

System component	% of total capital expenditure for system		
	Residential	Commercial	Industrial / Utility
PV Module	35	40	45
Inverter	10	10	8
BoS (other components)	13	15	31
Installation	42	35	16

4.3. Conclusions

- The economics of solar PV are changing rapidly and when coupled with the rising power prices will mean that solar PV will soon be cost effective without the need for incentives. The challenge will be managing the normal take-up rather than driving that take-up.
- Cogeneration and trigeneration struggles to be cost effective in the residential sector. However it remains cost effective in the commercial sector.

[38] Taken from http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/4290-solar-pv-cost-update-report--3-feb-2012-.pdf.

5. Australian standards and rating tools relevant to ZLEG

This section of the report looks at how building energy efficiency standards and rating tools are currently and could be used to support the expansion of ZLEG in Australia.

It begins with a description of the status quo with respect to standards and rating tools in Australia. Special attention is devoted to the state and territory based planning instruments such as BASIX in NSW and the Queensland scheme. The section also discusses wider planning issues such as solar access controls in local government regulations. Finally, rating tools dedicated to assessing ZLEG systems are discussed.

5.1. Government regulation of building energy efficiency

The importance of energy efficiency standards for buildings is not a new concept. In 1961, for example, Denmark introduced energy standards for buildings with positive results (IEA, 2008). The United States adopted residential and commercial building codes with energy components in 1975 (DOE/APEC, 2009).

Various energy efficiency regulations began to be introduced in different Australian jurisdictions in the 1990s. For example, in 1991 Victoria introduced insulation regulations for domestic dwellings, followed by the ACT in the mid 1990s. NSW began its 'Energy Smart Homes' policy in 1997 and has since established BASIX to assess energy and water efficiency and thermal performance of residential buildings.

National energy efficiency provisions for housing in Australia (that is Class 1 and Class 10 buildings) were first introduced into the BCA on 1 January 2003. The provisions varied depending upon the climate zone in which the building was located. To ease adoption, the provisions were initially kept relatively simple and were developed to achieve a nominal level of energy efficiency equivalent to a 3.5 to 4 star rating under the current Nationwide House Energy Rating Scheme (NatHERS) that is described in detail below.

Energy efficiency provisions in the BCA have progressively increased since 2003. In 2005, provisions were introduced for Class 2-4 dwellings (apartments, boarding houses, etc.) for a minimum of 3 stars for all units, an average of 4 stars for units within one building in cool/temperate climates, and an average of 3.5 stars for units within one building for warmer climates.

In 2006 the provisions for Class 1 buildings were upgraded to a minimum of 5 stars or equivalent, and energy efficiency standards were introduced for commercial buildings for the first time. The commercial building requirements represented an important first step for new commercial building work, affecting the thermal performance of external walls and glazing, the efficiency of artificial lighting and the appropriate installation of heating, ventilation and air-conditioning systems. It was recognised at the time of adoption that the stringency of the commercial building requirements could be increased significantly in the future.

On 2 July 2009, as part of the NSEE, the COAG agreed to an increase in the stringency of the energy efficiency requirements for residential buildings from 5 to 6 stars, or equivalent, nationally in the 2010 update of the BCA to be implemented by May 2011, and including new efficiency requirements for hot water systems and lighting (ABCB, 2009). The energy efficiency standards for all classes of commercial buildings were also increased in the 2010 BCA.

The BCA is a national code but states and territories implement the code through their own legislation. Jurisdictional variations to the national code are recorded in the appendices of the BCA. For example, in NSW the Building Sustainability Index (BASIX) replaces the energy efficiency provisions of the BCA for residential buildings[39].

Improvements to existing buildings have been addressed through incentive programs targeting specific elements of a building, such as insulation and hot water heaters. Australian governments have also committed to introducing mandatory disclosure of the energy efficiency of commercial and residential buildings. These schemes aim to improve energy efficiency of existing buildings through publicly disclosing information relating to the energy efficiency of the building.

Appliances sold in Australia, including electric storage water heaters, single phase and three phase air conditioning units and commercial refrigeration, are currently regulated through Minimum Energy Performance Standards (MEPS). Many products also have energy performance labels to help customers choose the most efficient models[40].

The focus of this section of the report is the situation in Australia. To place this discussion in context, a brief outline of the situation elsewhere in the world is warranted. The following is a brief summary of the regulation of building energy efficiency in other jurisdictions. More details are in Appendix F.

- European nations have set targets for zero carbon new buildings to be phased in over the next few years[41].
- National building codes have a strong emphasis on energy efficiency in building design. An example is the Efficient House Plus project in Germany.
- A variety of rating schemes are available e.g. the Code for Sustainable Homes in the UK, Building Research Establishment Environmental Assessment Method (BREEAM) in the UK and elsewhere in Europe and Leadership in Energy and Environmental Buildings (LEED) in North America.
- Nations regularly incorporate codes for energy efficiency in their building regulations. For instance, most states in the USA have implemented regulations based on the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) standards for commercial and larger residential buildings and the International Energy Conservation Code (IECC) codes for small residential buildings.
- The UK has implemented the Merton Rule, which is a planning policy, first introduced by the London Borough of Merton and later implemented in national law. It requires first, the use of energy efficiency measures, and then on-site renewable energy to reduce annual CO_2 emissions.

5.2. Australian building rating schemes

The importance of rating schemes and tools has increased with the introduction of energy efficiency standards in the BCA and increasing public interest in the environmental performance of buildings. There are now a range of tools available which have varying functions and metrics. Most of the

[39] See http://www.nathers.gov.au/about/regulation.html.

[40] Details of appliances covered by MEPS can be found at http://www.energyrating.gov.au.

[41] See Table 20 in Appendix F.

building rating tools allow for renewable or alternate energy sources, or have the capability to incorporate such sources. However, there is currently no allowance for crediting a development which connects to a district or off-site energy source.

The list below summarises the most widely used rating schemes. Other tools are currently being developed within individual jurisdictions and to cater for specific programs, and others are available overseas, but these have not yet gained substantial market traction in Australia.

5.2.1. Nationwide House Energy Rating Scheme

The Nationwide House Energy Rating Scheme (NatHERS) started in 1993 and is now part of the National Framework for Energy Efficiency[42].

The Scheme is administered by the Commonwealth in partnership with the states and territories. NatHERS accredits software tools that rate, using a 10 star band, the potential energy efficiency of the building shell of a home in terms of the heating and cooling energy required per square metre to keep the home at a reasonable level of human comfort. The more stars, the less likely the occupants need to use cooling or heating systems to stay comfortable. The rating takes into account how well the components of the home are suited to the local climate, and include the layout of the home, the construction of its roof, walls, windows and floor; and the orientation of windows and shading to the sun's path and local breezes.

Currently available NatHERS tools do not include the energy use of appliances or the embodied energy of building materials. Individual tool developers have created their own non-regulatory modules to cover other energy impacts such as lighting, hot water, and major fixed appliances; however these are not recognised in building standards.

In the context of this current study, the key features of NatHERS are:

- The rating tool assesses the building shell, with no consideration for renewable energy sources linked to the building.
- Building regulations in all states and territories set minimum standards for energy efficiency in new houses. These are generally related to the NatHERS rating and, for example, the 2010 BCA now requires residential buildings to achieve a 6 star rating[43], with the key exceptions of NSW which uses BASIX and Queensland which allows the use of optional credits, including solar PV systems. Further, the BCA provides elemental (formally deemed-to-satisfy) provisions to provide flexibility to demonstrate compliance with the desired outcomes.

In a recent report prepared for Master Builders Australia (CIE, 2010), it was argued that seeking a residential building performance above 5 stars is not cost effective for the nation. As a corollary, higher energy performance would therefore require the building to be supplied by a ZLEG system. However, this report addressed only energy efficiency measures linked to insulation, weather sealing and shading, and did not address how the use of passive solar design principles can improve the energy efficiency of houses for a lower cost. Some state and territory based stakeholders believe that the BCA could be strengthened to require higher than 6 stars. This issue is discussed further in Section 9.

[42] See http://www.nathers.gov.au for additional details on the NatHERS scheme.

[43] Northern Territory and Tasmania are yet to implement 6 star regulations.

Note that a move to strengthen the energy efficiency requirements of the BCA can be done independently of consideration of ZLEG.

5.2.2. National Australian Built Environment Rating System

The National Australian Built Environment Rating System (NABERS) is a national voluntary environmental rating system for existing commercial and residential buildings administered by the NSW Government and governed by a National Steering Committee comprising representatives from the Commonwealth, state and territory governments and chaired by the Commonwealth[44]. Currently, NABERS provides separate ratings for:

- Office building: this covers the environmental impacts of the activities and services traditionally supplied by, or within the control of, the landlords/operators of office buildings;
- Office tenancy: this covers the environmental impacts of the activities that are under the control of office occupants;
- Hotels: available for AAA-rated business hotels;
- Shopping centres: for centres over 15,000 sqm GLAR;

Ratings are also in development for hospitals, schools and data centres.

The energy component of the NABERS for Office rating tool is used as the assessment method for determining the energy efficiency rating for a building within the Commercial Building Disclosure program, which began in 2010. NABERS for Office ratings are based on greenhouse gas emissions associated with actual annual operational energy use data for the building per unit of function, such as floor area, number of occupants or number of rooms. NABERS ratings are communicated using a 6 star-rating band, with 6 stars set at leading practice and 2.5 to 3 stars being market average.

For new office buildings, NABERS for Office incorporates a ‘commitment agreement’ whereby a building is designed to perform at a 4 star or higher NABERS energy standard and then the building developer (or its subsequent owner) needs to demonstrate that the building meets the claimed energy performance after being occupied.

NABERS for Office ratings can incorporate the following types of on-site energy generation: generation which is connected on the user side of the consumption meter which records the relevant external energy supply to the premises; or generation which is used on site independently of utility-supplied energy required. Externally supplied energy sources (such as gas, fuel oil or electricity used in heat pumps) used to generate on-site energy must be included within the energy assessment.

NABERS for Office ratings can also incorporate the purchase of GreenPower. The purchase of any GreenPower bought separately to offset actual energy consumption must have occurred the date before the date the rating application was submitted and not be greater than the measured energy consumption of the period to which it applies.

Critically in the context of this current report, the proportioning of energy used by cogeneration or trigeneration systems is currently being reviewed for incorporation into the NABERS ratings[45]. One industry stakeholder consulted during the preparation of this report believed that the ability to include

[44] NABERS is described in detail at www.nabers.com.au.

[45] The discussion paper on the NABERS ruling can be found at http://www.nabers.com.au/page.aspx?cid=691&site=2.

power purchased from an off-site cogeneration or trigeneration system in a building's NABERS rating would help drive the take-up of cogeneration or trigeneration.

5.2.3. Green Star

Green Star is a national voluntary environmental rating scheme developed for the property industry by the Green Building Council of Australia. It evaluates the environmental design of new commercial offices, health care buildings, education facilities, industrial facilities and multi-residential unit buildings by determining an overall score across a number of weighted categories. Green Star communicates this score using a star band between 4 and 6 stars for certified ratings, with 6 being international best practice. In the Green Star suite of tools suitable for offices, the NABERS rating tool is embedded as a means to determine greenhouse gas emissions performance. As such and as described in Section 5.2.2, Green Star can incorporate allowances for on-site generation.

5.3. State and territory government building and planning laws

State and territory government planning laws are central to the pursuit of building energy efficiency and the take-up of ZLEG. State and territory governments have carriage of planning and construction of buildings (which may vary between jurisdictions), and so any measures need to be adopted voluntarily by the states and territories. In this section of the report, various issues related to state and territory planning laws are discussed. These include:

- The adoption of the energy efficiency components of the BCA;
- State and territory specific schemes; and
- Planning issues that must be considered in the context of the take-up of ZLEG.

All states and territories set minimum standards for energy efficiency in new houses, and these standards are found in the respective state and territory building and planning regulations. There are similar regulations for apartments (except in the Northern Territory). The regulations for most jurisdictions are found in the BCA or in jurisdictional specific appendices, and it is through enactment in state and territory law that the BCA can drive the take-up of ZLEG in new buildings. Most states and territories have adopted the energy efficiency measures in the BCA, with two important exceptions that are discussed here.

5.3.1. Building Sustainability Index (BASIX)

BASIX[46] was launched by the NSW government in 2004. It established energy, thermal comfort (building shell efficiency) and water reduction targets that need to be met for all new or renovated dwellings in NSW. A BASIX certificate, which is a requirement for building approval, will only be issued if these targets are met. BASIX uses information such as site location, house size, type of building materials and fittings for hot water, cooling and heating. These targets vary according to building type and location. BASIX substitutes for the residential energy efficiency requirements of the BCA in NSW.

BASIX rates buildings by estimating their total household energy and water use as a percentage of a NSW average. BASIX uses a percentage reduction target and reports the results in standard metrics (tonnes of greenhouse gas emissions avoided and gigalitres of water saved).

[46] See www.basix.nsw.gov.au for details of BASIX.

In common with many multiple issue tools, BASIX uses some existing tools such as NatHERS and appliance energy and water ratings as part of the assessment process. For instance, to assess thermal performance compliance, either: the simulated heating and cooling loads predicted by NatHERS software must be provided; or the building fabric must comply with a set of more restrictive 'Deemed to Satisfy' requirements.

The simulation method provides more flexibility in design options. BASIX sets a maximum limit for the cooling load and the heating load separately. The simulation results must be less than these allowable maximums to achieve compliance. BASIX uses the NatHERS assessment to estimate greenhouse gas emission impact based on the thermal loads and the efficiency and type of heating and cooling appliances selected.

Alternative energy sources are accommodated for in BASIX, which presently recognises on-site energy generation (solar PV and cogeneration) that is part of the building footprint or on the land subject to the development consent. Wind power is recognised as an off-line alternative assessment. Other renewable energy/low-carbon sources available in BASIX online include solar hot water and solid-fuel heating (i.e. wood heating).

The inclusion of renewable or low-carbon fuel sources does not impact on the pass mark required for the thermal comfort component of BASIX. The impact of renewable or low carbon fuel sources only impacts the greenhouse gas calculations in the energy section. Currently in BASIX, greenhouse gas emissions avoided from on-site generation can only compensate for the emissions from electricity consumption. Emission from natural gas/LPG combustion cannot be compensated by on-site electricity generation. That means that the score is only impacted to the extent that the renewable generation off-sets demand from grid electricity. In this manner, PV is treated like a 'fuel swap'. Because BASIX is a regulatory tool which mandates demand-side efficiencies and GHG reductions, off-site renewable energy (for example Green Power) are treated as supply side initiatives and thus not included in BASIX calculations.

The NSW Department of Planning and Infrastructure is willing to extend the ZLEG technologies that can be included in a BASIX rating, subject to demand. Further, BASIX presently recognises on-site energy generation that is part of the building footprint or on the land subject to the development consent. Some major developments in NSW such as Barangaroo, CUB and Green Square projects in the City of Sydney will see the deployment of district heating and cooling systems (Kinesis Consortium, 2010), and changes to BASIX to deal with these projects are under consideration.

NSW considers BASIX to be a well tested system that is understood by planners, builders and consent authorities (i.e. local councils) in NSW and feels that a strong case will need to be put to see any move away from BASIX.

5.3.2. Queensland Development Code (QDC)

The QDC requires a minimum 6 star energy equivalence for new houses and townhouses (class 1 buildings) across Queensland. The Code allows the use of optional credits for certain design features that can be used towards achieving the 6 star requirement. The optional credits are provided for a covered outdoor living area (either a one half (no ceiling fan) or a 1 star credit (with ceiling fan)) and a solar PV system (1 star credit) where a minimum 1 kilowatt solar PV system is installed. One or both features can be combined and used as part of compliance with the 6 star requirement, as long as the dwelling's building shell achieves a minimum baseline star rating (which depends on its climate zone and the compliance method used). By ensuring that there is a minimum baseline star rating for the house's design, the Queensland Government is able ensure that sufficient optimisation of the building shell is done before on-site generation is considered. In this way, the building's thermal performance is maintainable over its lifetime. The following points emerged from the stakeholder consultation. First, Queensland remains happy to keep the 1 star optional credit for solar PV with new houses. Budget builders in Queensland tend to select the solar PV option to obtain the 1 star credit, and so it is providing a low cost building option as well as driving the uptake of solar PV. Mid to high range new houses include an outdoor living space and so gain a 1 star credit by that compliance path.

Stakeholders from other states and territories saw some value on the 1 star credit for solar PV provided it did not compromise requirements on the performance of the building shell.

5.3.3. Planning issues to be considered

Several key issues related to the state and territory planning laws emerged during the stakeholder consultation, and they are discussed below. In brief they are:

- The need for regulations to ensure the on-going operation of any ZLEG technologies that were needed for a building to comply with BCA standards.
- Managing the certification of ZLEG technologies, particularly in the residential context.
- Potential modifications to local development control plans to prevent developments at adjacent properties overshadowing a ZLEG system.

These are discussed below.

Ensuring the on-going operation of any ZLEG technologies

The BCA applies to the construction of a building and not the operation of a building. Stakeholders from both the Commonwealth and the states and territories questioned how requirements in the BCA that require the on-going operation of a ZLEG system can be enforced. Some states and territories already have regulations in place that would require the on-going operation of the ZLEG. For instance, the 'conditions of approval' that apply to development consent in NSW provide a consent authority with the ability to serve a compliance order on a building owner should the conditions of consent cease being compiled with. So any requirements to operate a ZLEG could be covered by conditions of approval. The outcome was confirmed in a recent hearing of the NSW Land & Environment Court (NSWLEC 221), which found that the power to impose conditions under the relevant provisions of the NSW Environmental Planning and Assessment Act 1979 extended to include the power to impose conditions to regulate GHG emissions[47]. These also allow NSW to include the performance of appliances such as dishwashers to be included in BASIX.

Other states and territories have mechanisms that could be adapted to cover ZLEG systems. For instance, the states and territories provide a regulatory environment for commercial buildings around maintenance of emergency systems etc. that could be expanded to include generation. It would need to be extended to cover ZLEG and also be extended to the residential sector as well. Several state and territory based stakeholders noted that the regulations around essential services in commercial buildings could be extended to the residential sector, and the challenge is to not compromise the

[47] See "Mining carbon emissions: market mechanisms v regulatory control", Brendan Bateman and Trisha Cashmere. From http://www.claytonutz.com/publications/edition/12_april_2012/20120412/mining_carbon_emissions_market_mechanisms_v_regulatory_control.page (Accessed 6 May, 2011).

regulation of actual essential services in commercial buildings. Regulatory mechanisms through environmental protection legislation may also be possible.

According to some stakeholders, particularly from the Commonwealth, it is important not to underestimate some of the technical challenges in ensuring compliance with requirements for the correct operation and maintenance of ZLEG systems. Examples of the compliance actions that may be appropriate for a large commercial building include:

- inspection of maintenance log books;
- test runs of equipment; and
- inspection of certified records of output from the ZLEG system.

The International Protocol for Measurement and Verification may provide guidance in this regard[48].

Certification of ZLEG technologies

The consultations with stakeholders raised the question of certification of the correct installation of ZLEG systems. This is of particular concern with systems such as cogeneration and trigeneration, which are technically complex. Certainly, equipment suppliers can certify that the system will perform as expected. However, building certifiers who have a background in construction may not be in a position to assess the veracity of such certifications.

Challenges may also arise when compliance to the requirements for ZLEG are achieved through a contract between the owner of a ZLEG system and the owner of an adjacent building seeking to use the output of the ZLEG to meet BCA requirements.

Some stakeholders took the view that solar PV is too complex an issue to be easily incorporated into building design regulations. Complex issues around gross versus net feed-in tariffs, network issues, and renewable energy certificates mean that unintended outcomes may arise.

The protection of ZLEG systems against encroachment

This issue primarily affects solar PV in the residential sector. In a recent article, Kapnoullas (Kapnoullas, 2011) argued that the rights of solar panel owners are not protected under planning law and developments on adjacent properties can result in overshadowing of pre-existing solar PV systems. However, the situation is complex as a need to protect roof spaces in some inner urban areas would essentially prevent any development in those areas[49]. Note that section 3.3.5 of the NSEE includes a measure to support solar access to living areas and importantly roofs but that this has been left to the jurisdictions to implement.

This issue applies equally well to the construction of structures that compromise the wind resource being exploited by a micro wind turbine.

[48] The IPMVP is described at www.evo-world.org.

[49] Internal communication, Leichhardt Council, 2012.

Other issues linked to planning or building regulations

Other planning issues that may need to be addressed include:

- The role and impact of building integrated PV modules (BIPV) into new or existing dwellings. Of particular concern is the incorporation of BIPV modules into the actual building shell and the impact that it could have on the structural and environmental performance of the building.
- Requirements for solar PV installations to meet BCA regulations on dwellings that are either heritage listed or are in heritage conservation zones[50].

5.4. Rating ZLEG systems

Section 2 above proposed a definition for ZLEG that suggested a 50% reduction in emissions relative to grid power. The question of the calculation methodology remained unanswered.

Stakeholders were clear on some of the requirements of the BCA in this regard. They felt that a single nationally consistent method to calculate the emissions associated with a low emission system is desirable. This calculation method needs to account for on-site and off-site ZLEG, and also address the private wire versus network question as it relates to the connection between ZLEG systems and the consumer of power from the system.

Further, the calculation method must be capable of dealing with new technologies, and be independent of scale so it is applicable to the residential, commercial or industrial sectors; across which the type and size of energy generation technologies vary greatly.

Some guidance is provided from the debate on zero emission buildings, where the ZEB concept requires clear and consistent definition and a commonly agreed energy calculation methodology. Several potential methodologies were assessed by A.J. Marszal et al (Marszal A. , 2011). The most important issues that should be given special attention before developing a new ZEB definition are:

- the metric of the balance (e.g., energy at site, energy at source, emissions at source);
- the time period of any calculations;
- the type of energy use included in the balance; and
- the connections to the energy infrastructure.

Some guidance is provided by the draft NABERS ruling that is currently under review. This ruling relates to the export of energy from a cogeneration system, and the proposed method to calculate the emissions associated with exported power is:

- Where electricity is provided to multiple parties from a cogeneration or trigeneration system, the metered output of this generation system can be apportioned to the parties based on their consumption or contractual allocation.
- Waste heat and absorption chilled water output is treated as having no cogeneration or trigeneration energy allocated to it, unless supplementary fuels are used to boost the waste heat or absorption chiller outputs. These supplementary fuels must be separately metered and are directly attributable to the end-users of the thermal energy. This supplementary fuel

[50] Note. One of the authors of this report is a member of Leichhardt Council and so is very familiar with NSW planning law, and issues related to developments in heritage areas.

consumption must be proportioned between the users on the basis of their respective use of this thermal energy and included in the rating calculations.

Should the BCA be modified to incorporate a method to calculate the impact of a ZLEG, Energetics recommends that the same method be used in all related rating tools such as NatHERS and NABERS. Any methodology should also be consistent with the existing NGER determination.

However, Energetics does not have any specific recommends about the calculation technique itself, and we recommend that a separate discussion with stakeholders on the appropriate calculation methodology be considered.

5.5. Conclusions

To address the issues raised by this section to the report, the following changes to the BCA could be considered:

- Develop a robust methodology for calculating the emissions associated with ZLEG systems and the savings relative to grid power due to ZLEG systems.

In addition, the discussion amongst the Commonwealth and states and territories needs to continue regarding several planning questions including:

- the best form of regulation to ensure the on-going contribution of ZLEG to any mandatory building rating; and
- acknowledging the rights of property owners to develop their property while not compromising the performance of ZLEG systems on adjacent properties.

Finally, the role that BASIX may play in any future national scheme needs to be explored.

6. Australian incentive schemes

Although the technical potential of many zero or low emission technologies indicate significant opportunities for reducing building energy use and emissions profile, there are many barriers to uptake that prevent its realisation. Policy, programs and incentives can be used to overcome these barriers and drive uptake and adoption of these technologies. In considering the appropriateness of amendments to the BCA, it is appropriate to consider historical Australian incentive schemes which are outlined in this section.

6.1. Small Scale Renewable Energy Scheme

The Small-scale Renewable Energy Scheme (SRES) forms part of the overall Renewable Energy Target (RET), a mandated scheme to increase the fraction of electricity generated from eligible renewable energy technologies. The SRES encourages the purchase of solar water heaters, heat pumps, and small-scale solar panel, wind and hydro systems (together referred to as Small Generation Units or SGUs) by offering a financial benefit to owners through the assignment and/or sale of Small-scale Technology Certificates (STCs).

Recent increases in the uptake of SGUs have dramatically increased the portion of STCs (historically Renewable Energy Certificates or RECs) from small-scale sources created by SGUs rather than solar hot water heaters. The majority of installed capacity now comes from systems sized between 1.5 and 3 kW.

Table 13: Small generation units installed since 2001[51]

Technology	Installations	STCs created	Capacity installed (kW)
Micro-hydro	14	406	22
Micro-wind	372	18,282	1,233
Solar PV	386,579	45,353,968	746,779

Data source: ORER.

Modelling for the ORER by ACIL Tasman (ACIL Tasman, 2011) suggests that the contribution of SGUs to the overall RET scheme will reduce for 2012 and 2013.

Government assistance in the form of Solar Credits[52] and Feed-in Tariffs, to SGUs has been a crucial driver of the financial attractiveness of these systems to households and businesses.

6.2. National Solar Schools Program

The program offers eligible primary and secondary schools the opportunity to compete for grants of up to $50,000 to install solar and other renewable power systems, solar hot water systems, rainwater tanks and a range of energy efficiency measures. Since the program commenced on 1 July 2008, over

[51] Taken from (ACIL Tasman, 2011).

[52] Solar Credits provide additional support to households, businesses and community groups that install small renewable energy generation units, such as rooftop solar panels, and small-scale wind and hydro electricity systems. Solar Credits work by multiplying the number of STCs that applicable systems would generally be eligible to create under the standard deeming arrangements. The multiplier that applies for eligible system installations up to 30 June 2011 is five. The Solar Credits multiplier reduces over time, reflecting reductions in technology costs. The Government has recently announced changes to the Solar Credits multiplier which will apply from 1 July 2011.

3,800 schools have been awarded a grant, totalling more than $165 million in funding. Over 90% of these projects include solar power systems.

Grant funding totalling $25.04 million is available to schools in 2011-12. As part of the 2011-12 Budget, the Government announced that the program will close on 30 June 2013, and has two remaining funding rounds. Approximately $50 million in funding remains available under the program.

6.3. Feed in tariffs

Several of the states and territories have been encouraging the take-up of ZLEG (particularly residential solar PV) through the use of feed in tariffs (FiT). The next table summarises the current status of the various schemes. As a general rule, the states and territories are winding back the feed in tariffs because of the cost to the state or territory and because of the impact the FiT was having on the cost of power to non-participants, especially less resourced electricity users.

The FiT schemes did drive a rapid rise in the take-up of renewable energy, as seen in the number of SRECs generated over the period. See Figure 5.

Table 14: Status of feed in tariff schemes[53]

State	Status of Feed In Tariff	Maximum Size	Rate/kWh	Technologies
ACT	FIT Closed. Now a 1:1 buyback[54]	30 kW		Any renewable energy
NSW	Net metering is available.	10 kW	Energy Australia offer 6c/kWh	Solar PV and micro-wind
NT	No scheme is in operation.			
Qld.	Currently offering a FiT for systems 5kW	5 kW	44c.	Solar PV
SA	Scheme in operation	10 kW	16c.	Solar PV
Tas.	No FIT Scheme.			
Vic.	A new scheme started on 1 Jan 2012	5 kW	25c.	Solar PV, wind, micro-hydro. biomass
WA	Renewable energy buyback scheme in operation	Up to 10kW, depending on the retailer	Synergy offer 7c/kWh	Solar PV, wind, micro-hydro

6.4. Incentive schemes for large-scale generators

The Large-scale Renewable Energy Target (LRET) supports the deployment of renewable energy projects like wind farms, and commercial solar, geothermal power stations and precinct-scale co-generation and trigeneration technologies. Technologies eligible under the LRET scheme may sell power directly to a facility owner. In this case the ability to create certainty in terms of the continuity of

[53] Clean Energy Council.

[54] 1:1 buybacks offer a price for power sold by a participant that is equal to the average price that the participant pays.

purchased ZLEG power by the facility in the long term is the key issue. The suitability of technologies or the characteristics of energy used in a facility are largely irrelevant.

6.5. Incentives working through NABERS

Recent research (Newell, MacFarlane, & Kok, 2011) undertaken for the Australian Property Institute (API) and the Property Funds Association of Australia (PFA) examined the link between the NABERS rating for a building and the value of the building in the market place. The importance of having the higher NABERS ratings and Green Star rating is clearly shown in the green premiums for office buildings in Australia, with a higher NABERS energy rating leading to higher rents and lower vacancy rates. For instance, a 5 star NABERS energy rating was seen to deliver a 9% premium in value overall.

The relevance of these results is in the effect that cogeneration has on the NABERS rating of a building. Building owners many now see the premium placed on additional NABERS ratings as a further incentive to install ZLEG in their buildings.

Impacts

7. Impacts of ZLEG on Australian electricity and distribution infrastructure

In addition to contributing to a reduction in the emissions intensity of Australia's electricity, zero or low emission generation technologies will have impacts on the existing infrastructure and market for the generation and supply of electricity. There are somewhat conflicting views on whether this is a major technical barrier to the interconnection of embedded generators and this section of the report explores some of the issues, including:

- The management of the electricity market in an environment with large volumes of distributed generation.
- The impact on network investment, and in particular, the scope for deferral of investment.
- Network stability, system impacts and metering requirements.

As the primary building-connected ZLEG technologies that are likely to experience substantial growth are solar PV, cogeneration and trigeneration, these have been the focus of this section. Other technologies such as wind turbines are not typically associated with the built environment and are unlikely to be widely incorporated at a scale that is of relevance to building code amendments. Where technologies such as wind will be deployed at scale in commercial wind farms, planning legislation is the primary control. While incorporating large quantities of intermittent wind energy onto the grid is undoubtedly an issue, it has not been explored in this section as it is not relevant to building regulations and controls.

The remainder of this section will primarily focus on the impacts of solar PV as the impacts of solar PV are very different from the impacts of cogeneration and trigeneration. In particular, solar PV is non-dispatchable generation i.e. its output cannot be controlled. Cogeneration and trigeneration are both examples of dispatchable generation, which can be started and stopped at any time. Further, there are fundamental differences between dispatchable and non-dispatchable generation, and between residential and commercial buildings. In the case of ZLEG, there is a high alignment between non-dispatchable generation and residential buildings.

The impacts of distributed generation in general on networks will also be discussed. This will be followed by a review of connection issues.

7.1. Investment deferral through reducing peak demand

The issues associated with distributed generation and infrastructure costs were recently explored by Zhao & John (Zhao & John, 2010). They found that distributed generation (DG) is rapidly increasing its penetration level in Australia, and is expected to play a more important role in the power industry. On-site ZLEG and precinct level ZLEG are both examples of DG. They acknowledged that an important benefit of DG is its ability to defer transmission investments. Through the use of a simulation model, the Queensland electricity market was studied and results showed that distributed generation does reduce transmission investments. This ability however is greatly influenced by a number of factors, such as the locations of DG, the network topology, and the power system technical constraints.

Choice of DG technology is also important, and the DG must be capable of generating at the time of high demand for power to have an impact on the network.

There has been extensive discussion of the value of distributed generation to reduce the total resource cost of electricity generation and distribution. Much of this discussion in the Australian context was captured in the Intelligent Grid report (CSIRO, 2009). The report provides a detailed analysis of DG across a number of areas including impacts on the distribution network. As part of the CSIRO work, Senergy Econnect were commissioned to model the impact of DG on four real world SP Ausnet feeders. They concluded that DG is of benefit in reducing network losses and improving voltage profiles as well as being of some value in postponing network upgrades. Specifically, the modelling showed a significant reduction in network losses (which are in the order of 11% in Australia) particularly in rural areas. It also concluded that DG is unlikely to cause issues such as voltage flicker, rapid voltage change or phase imbalance. A number of technical grid management issues were investigated and the overall conclusion was that DG, if appropriately designed and managed, does not pose a risk to the distribution network.

The CSIRO also modelled the impact of DG on the transmission network and found that it had a positive impact in terms of relieving congestion and moderating electricity prices but surprisingly, increased transmission losses. This resulted from power being transmitted along a different path that is both longer and using lines of varying characteristics. The summary of the impact of DG on transmission networks was that:

- Adding even small amounts of DG can have dramatic impacts on the power flows and economics of an electricity system;
- The effects of adding DG are not limited to the location in which it is installed. They are felt by pre-existing generation units both near and far and, from a generator's perspective, can be positive or negative;
- The effects of adding DG may depend more upon where the DG is added rather than how much capacity; and
- The effects of adding DG depend quite heavily upon specific characteristics of the target electricity system.

These latter two points are particularly important in the context of ZLEG. When local network service providers seek DG options to relieve a local network constraint they carefully target specific parts of the network topology[55]. Whilst ZLEG can assist in relieving demand constraints, there is no guarantee that it will.

7.1.1. The impact of solar PV on peak loads

The CSIRO study also found clear evidence that a demand side policy, promoting the take-up of solar PV, particularly when combined with a carbon price signal, would have significant benefits. These findings strongly support the installation of significant commercial PV (that is, PV capacity installed on the roofs of commercial premises), in addition to residential-based PV. However, in order to realise the benefits of peak load shaving there needs to be more incentives available for commercial installations. The load shaving from DG through, for example, solar PV or smart metering, has the potential to defer

[55] For instance, at the time that this current report was written, Western Power was undertaking a study into demand response options including DG to address a constraint on the south coast of WA.

transmission investments that are largely driven by peak demand in the middle of the day, or early afternoon. The correlation between commercial peak demand and peak PV output is a significant benefit of broader uptake of distributed solar PV.

The potential peak lopping benefits of distributed commercial solar were explored in a recent study (Western Power, 2011). Western Power assessed the impact of PV generation on individual feeders, total system peak load demand and the annual demand profile. The graph in Figure 7 presents some results from the study. These clearly show that the solar PV systems have not reduced the peak demand. The second graph in Figure 8, models the impact of anticipated PV installations over the next 5 years, assuming the same rate of installation as today. The overall contribution of solar PV to the supply is 9.2% with a 3.5% reduction in peak demand across the entire Western Power Network forecast.

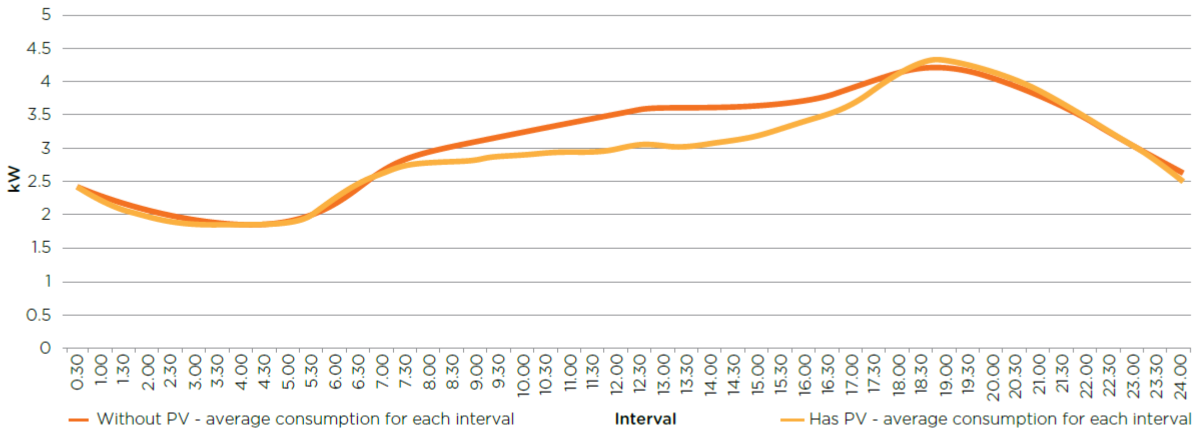

Figure 7: Average electricity demand for solar PV system and non-PV households[56]

[56] From Perth Solar City 2011 Annual Report, December 2011.

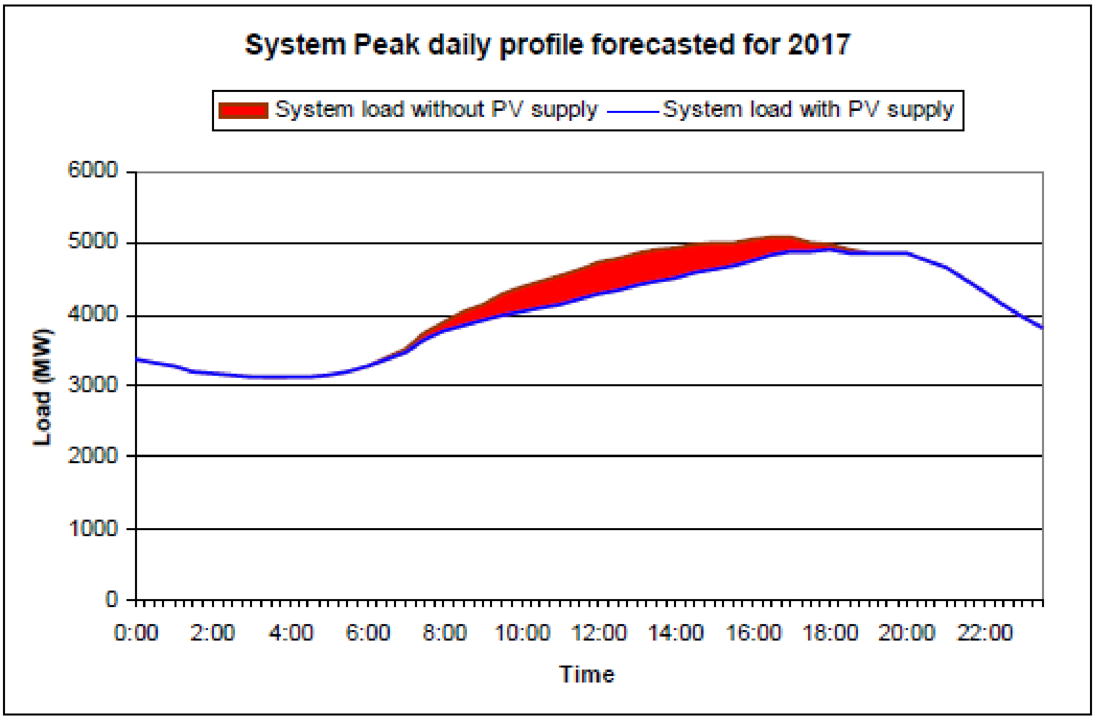

Figure 8: Modelled impact of anticipated PV installations over the next five years

There is much less correlation between residential peak demand and peak solar PV output therefore the potential for peak lopping is reduced. This is discussed in a recent Ausgrid research paper (Ausgrid, 2011) published in October 2011 which assessed the potential for solar PV installations to defer investment in network infrastructure across their network. This is particularly important in the context of this report as distributed solar PV will likely comprise a large proportion of the DG installed in the near future (especially as PV prices continue fall). Peak demand, and therefore the need for network upgrade work, is driven by particularly hot or cold periods when demand for heating and cooling increases the demand for electricity. The peak output of optimally sited solar PV panels is around midday, depending on their orientation, and this peak does not relate particularly well to the residential peak demand which occurs in 3.30pm to 4pm in summer and 6pm to 7pm in winter (after sunset). By this time of the day, the output from PV is dropping thereby reducing the potential impact of PV generation on peak demand.

The Ausgrid study assessed the impact of currently installed PV on summer peak demand in the substation zones with the highest levels of solar PV penetration. It found that at the current low levels of PV penetration, the impact of solar was minimal (max 1.2%). The solar penetration is expected to double by 2011/12 and so it is anticipated that the reduction will double accordingly (max 2.5%). Part of the study assessed 11kV feeders with high levels of solar PV penetration such as Homebush, which includes the Newington Olympic Village site. Here, the demand reduction was 2.9% and so it is clear that when solar penetration levels rise, the impact on peak demand increases. However, this does rely upon good solar conditions at the time of peak demand (although these are often coincident (driven by bright sunny days when PV output is highest).

The next figure shows some results from the Newington Village study (Watt, Passey, Barker, & Rivier, 2006). The output of the solar PV systems does not overlap with the winter peak demand, which occurs after 6pm and in this case was larger than the summer peak. In this case, solar PV will have no impact on the peak demand.

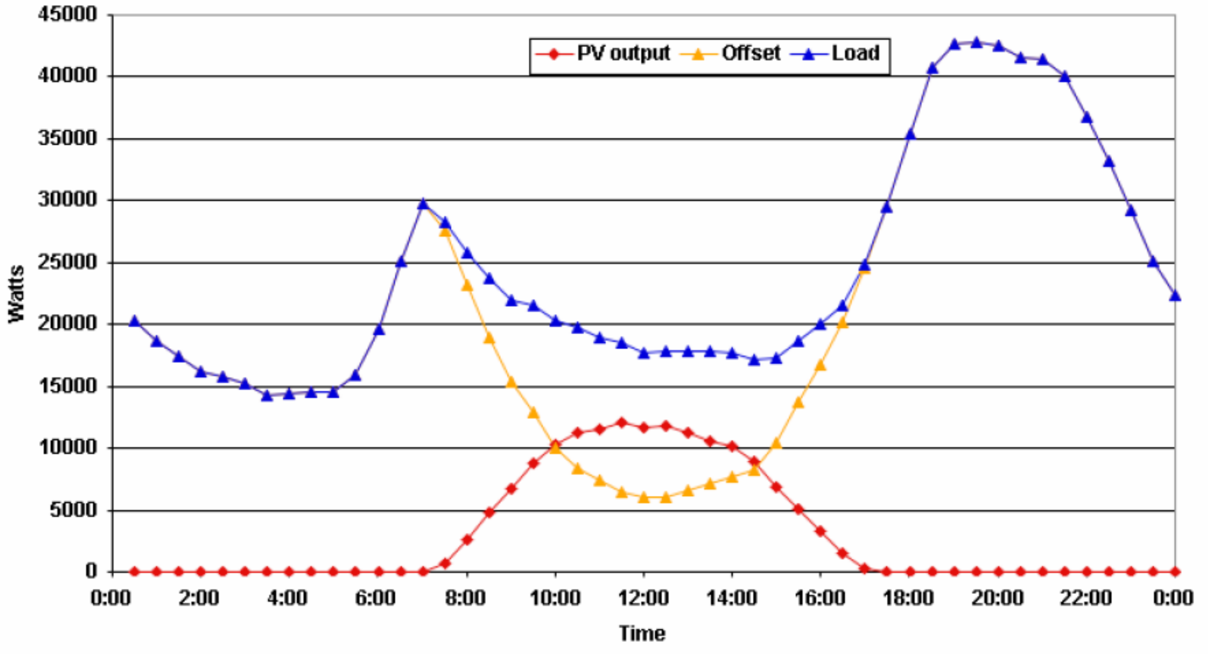

Figure 9: Average winter profile for 30 sites at Newington Village[57]

On deferred network investment, Ausgrid found only a small number of cases across all 204 substation zones, where emerging capacity constraints, rising summer peak demand and high solar PV penetration combined to offer a scenario where solar could defer network investment by more than one year (over the next five years).

This analysis included the rapid growth of PV installations resulting from the NSW Feed-in-Tariff but also reflects that there is limited requirement for network upgrades in the next five years and that solar PV penetration levels are starting from a very low base. Overall, the Ausgrid study concluded that at the current levels of deployment, the potential for solar PV to defer network infrastructure upgrades and expenditure was minimal. The study did however highlight the potential for solar PV to have a meaningful impact on the electricity network and as penetration levels rise, repeating the analysis periodically will inform the case for PV reducing peak demand.

Additional points raised during the consultation with stakeholders were:

- A further weakness of solar PV in addressing the summer peak is the loss of solar PV performance that occurs at high temperatures.
- Various representatives from DSNPs in Queensland expressed their views that PV has no or quite minimal benefit to peak demand.
- Several stakeholders suggested that west or north-west facing panels would move the solar PV peak closer to the power demand peak. However, this would reduce the value of the solar PV installation to the building owner, and some form of incentive may be required to drive this.

Energetics recommends that options to extend the output of solar PV panels into the period when the residential peak occurs be explored. These options could include panels that face North West or the installation of batteries, subject to studies of the cost effectiveness of such options.

[57] From (Watt, Passey, Barker, & Rivier, 2006).

7.1.2. The impact of cogeneration and trigeneration on peak demand

Unlike solar PV, trigeneration or cogeneration is an on-demand distributed generation technology which has considerable potential to reduce electricity demand at peak times because not only is electricity produced, but the waste heat can be used to replace electrical air-conditioning or heating, which are major contributors to peak electricity demand.

A 2010 report (Dunstan & Langham, 2010) by the Institute for Sustainable Futures (ISF) discussed the potential benefits of the City of Sydney's Trigeneration scheme and estimated that the plans could achieve savings in deferred electricity network costs of over $200 million by 2020, or upwards of $1 billion by 2030. When the avoided costs of new fossil fuel power stations of around $0.5 billion of installed capacity are added, the City's proposed 360 MW of trigeneration capacity could potentially avoid in the order of $1.5 billion in electricity generation and networks by 2030.

7.2. Stability and control of the network

The European DISPOWER project (Degner, Schmid, & Strauss, 2006) provides background on the impact on increasing penetration of DG. These impacts are particularly noticeable in Denmark and Germany due to the rapid expansion of wind and cogeneration. It is evident that the grid design and particularly, topology, strongly affect the capacity of distribution networks to integrate DG and intermittent renewables. One of the focuses of the DISPOWER project was to explore the virtues of higher DG penetration levels. The conclusion was that while DG can in some cases be a burden on the network, it can also provide significant value when integrated properly providing benefits in terms of power quality and postponement or avoidance of investments in grid expansion or new construction.

As discussed, distributed generation has been shown to be beneficial to the network in many circumstances, reducing the total resource cost of electricity generation and distribution. DG must, however, be implemented in such a way that safety and reliability is not compromised.

The question of network stability has been studied extensively in Europe. A good summary is provided in a recent IEA report (IEA, 2009). The table below (Table 15) lists a range of control measures available to network operators to deal with problems that could arise due to large take-up of ZLEG. The authors of the report noted that most of the potential problems indicated have yet to become tangible problems at the time the report was written. Furthermore, even the issues with the potential to become problems in the future are generally not serious issues, and can either be dealt with sufficiently with existing technologies or else avoided with proper planning and design.

On this point, one of the state and territory based stakeholders remarked that networks need to demonstrate that their concerns on stability are valid and not just driven by concerns about loss of revenue.

Of the problems studied in the report, dealing with overvoltage concerns is a top priority. Overvoltage incidents are more likely to occur on rural grids in which, generally speaking, the line impedance is higher and the load is relatively low. This network topology is common in Australia and so is an issue that needs to be considered prior to any move to drive the take-up of ZLEG. One DNSP remarked that the main issues are over voltage, reverse power flow, phase imbalance, flicker; and potentially harmonics.

Where inverters are used that reduce outputs of solar PV systems when a certain voltage threshold is exceeded, the problems are more likely to be social (unfairness) in nature than a grid quality issue.

Several of the stakeholders had already flagged this issue. One DNSP expressed interest in having a more restrictive AS 4777 (Grid Connection of Energy Systems) Standard to ensure that the same level of voltage trip-off applies across all homes with PV systems and to better handle the overall system impact and the difficulties to coordinate all of these inverters.

Particular problems are to be expected on sunny weekends when demand is low and output is high. Situations are already arising where people are not being paid for their excess PV generation[58], due to overvoltage problem. ETSA Utilities is also having some problems with areas of high solar PV penetration. For example, there are overvoltage concerns in the Victor Harbour area.

The inclusion of ‘Electric storage devices’ (i.e. batteries) in the range of countermeasures suggests options for dealing with some of the shortcomings of solar PV and other non-dispatchable generation technologies. For instance, the addition of batteries provides a means to extend the output of a solar PV system into the period of the residential peak.

[58] Stakeholder comment.

Table 15: Summary of countermeasures available to distribution network service providers[59]

	Countermeasures		
	Grid side	Demand side	PV side
Overvoltage/ Undervoltage	LDC (Line voltage drop compensator) Shunt capacitor, Shunt reactor SVR (Step voltage regulator) Electric storage devices	Shunt capacitor, Shunt reactor Electric storage devices	Voltage control by PCS Electric storage devices
Instantaneous Voltage Change (Sags/Swells)	TVR SVC STATCOM Electric storage devices	DVR Electric storage devices	Electric storage devices
Voltage Imbalance	STATCOM	DVR	
Harmonics	Shunt capacitor, Shunt reactor STATCOM Passive filter Active filter	Shunt capacitor, Shunt reactor DVR Passive filter Active filter	Advanced PCS
Unintended islanding Protection	Electric storage devices Protective devices Transfer trip equipment	Electric storage devices Protective devices	Electric storage devices Advanced PCS
Short-Circuit Capacity			Advanced PCS
Disconnection Time for Intersystem Fault	Transfer trip equipment		
Increase in DC Offset from PC			Advanced PCS DC offset detector
Frequency Fluctuation	Electric storage devices	Electric storage devices	Electric storage devices
Supply Security	Electric storage devices	Electric storage devices	Electric storage devices
Peak Cut	Electric storage devices	Electric storage devices	Electric storage devices Advanced PCS

7.3. Connection issues

The requirements for connecting an embedded generator to a distribution network represent perhaps the single most important technical and economic challenge in terms of making on-site generation more common in new building construction. For more traditional connections such as standby or cogeneration units, these would typically need to operate in parallel with the distribution network, since supply will usually be augmented from the network on a continuous basis and during periods when the unit is being serviced. In addition to the National Electricity Rules[60] installation will be guided by the

[59] Taken from (IEA, 2009).

[60] National Electricity Rules version 45, Chapter 5 Network Connection, see http://www.aemc.gov.au/Electricity/National-Electricity-Rules/Current-Rules.html.

Distribution Network Service Provider's (DNSP) requirements for connection of embedded generators. These are set out in their Guidelines.

With each DNSP having their own guidelines and requirements, and with the process for and costs associated with connections being unknown and highly variable, there is the necessity for a streamlining of the connection process nationally. This subject was well covered in a recent study by ClimateWorks (ClimateWorks, 2011), and it proposed a number of changes to the market regulations. They found that the process for the connection of a cogeneration system to the electricity distribution grid is an inefficient and costly procedure. The application process involves three steps: a connection enquiry by the cogeneration proponent, the submission of a connection application to the Distribution Network Service Provider (DNSP), and finally, a connection agreement offer from the DNSP. Further, the timeframes and milestones between cogeneration proponents and DNSPs are very different. For instance, one of the DNSPs indicated that for a large project, the connection application process could take up to two and a half years, while for a small project, six to 12 months, but possibly more, was standard.

The connection process is also costly and the costs often remain unknown until significant time and money has been invested in the application process itself. Initially, a cogeneration project owner is responsible for the cost of determining whether there is enough capacity in the local network for them to connect. Determining this can cost hundreds of thousands of dollars in specialist consultants to conduct network studies, design and redesign proposed installations, identify and procure additional equipment to meet DNSP specifications, and to liaise with the DNSP. If the network study finds insufficient capacity in the local network, the DNSP may seek to recover the costs of deep augmentation of the network from the cogeneration project owner. Even shallow augmentation of the network can be costly. Comments during the stakeholder consultation suggested that the DNSPs are required to invest up to $7300 for each kW of distributed generation. The issue of network costs is also discussed below.

An indicative figure of $100 million dollars to deal with DG connections was mentioned by one Queensland DSNP. This is to cover costs for upgrades (transformers, MV network), trials, staffing costs (to deal with complaints especially related to inverter tripping off or light flicking) and metering costs (electronic meters at each site with a PV system). The same stakeholder remarked that overvoltage and flickering will reduce the lifetime on other equipment such as motors connected to the same incoming feeder.

The networks may also be called upon to provide backup generation and spinning reserve to support the intermittent and unreliable nature of the non-dispatchable generation that could be incentivised.

A 2010 study[61] commissioned by Sustainability Victoria, Distributed Generation Experience Analysis surveyed numerous DG project proponents to better understand the issues surrounding implementation and specifically grid connection. The key findings were that in Victoria:

- Connection costs can typically be 50% of the overall project costs;
- Network connection timescales are long;
- There are a limited number of qualified consultants to assist project developers with grid connection issues and liaising with the DNSP; and

[61] Sustainability Victoria, 2010, "Distribution Generation Experiences Analysis – Survey report October 2010".

- A best practice guide and standardisation of the DNSP requirements would assist developers.

Due to the complex and technical nature of grid connecting DG units and the importance of regulating this process, careful management by the network operators is required. There are a number of improvements which could be instigated to reduce costs, speed up connections and smooth the overall grid connection process. However, these aspects, as well as network reliability and safety, are not associated with building regulations. Any amendments of the BCA that impact on the installation and take up of DG, need to be approached in collaboration with network operators and other agencies.

In summary, the main issues around grid connection that will affect greater use of DG are the complexity of the connection process and the lack of a standard approach and requirements from DNSPs, the time required for connections, the cost and the lack of appropriate skills. Note that steps are being taken to address these barriers. An example is the recent request from the Australian Energy Market Operator for a change in the national electricity rule around a “small generation aggregator framework”.

The recommendations regarding improvements to the process for network connections for DG (primarily cogeneration and trigeneration systems) have been made in a number of forums by other authors. To date, the installation of cogeneration and trigeneration systems has been a voluntary activity and so the costs and risks associated with network connections need to be managed by the proponent of the cogeneration and trigeneration project. However, should changes to the BCA result in a greater take-up of cogeneration and trigeneration systems, building owners and developers can reasonably expect that the complexity of network connections is removed, the time to obtain a connection be shortened and the costs reduced.

Energetics recommends that any moves to encourage take-up of ZLEG (and especially cogeneration or trigeneration) through changes in the BCA be supported by changes to the procedures adopted by the DNSPs to manage connections. The changes must also address the connection of cogeneration systems across multiple sites which are contiguous for instance, a hospital or university.

ZLEG and any other form of distributed generation is a threat to the revenue of the DNSPs. Approximately 50% of the cost of delivered electricity is fixed and this is recovered from consumers through tariffs based on consumption. Those consumers that self generate and still require a network connection will not contribute an equitable share of the cost of that network connection. The widespread take-up of ZLEG may result in a significant reduction in the revenue base of the DNSP. That in turn could see upward pressure on network tariffs and rises in power bills for consumers who do not have a ZLEG system installed. This issue is not new, and has been debated by regulators a number of times. An example is the D-factor[62] that can be used by NSW DNSPs to recover the cost of DG.

Any changes to the BCA that drive the take-up of ZLEG will further exacerbate tension between the various participants in the electricity supply chain. Energetics has no specific recommendations around the question of network revenues and tariff structures, although we make these observations:

- The current method where DNSPs charge on the basis of usage of the network (i.e. MWhs) rather than installed capacity may require modification in the case of a large rollout of DG.

[62] See http://www.aer.gov.au/content/index.phtml/itemId/743331.

- Charging models such as the D-factor risk transferring costs from those who can take advantage of ZLEG to those that do not have the opportunity.
- Allowing networks to charge on the basis of the size of the connection to a ZLEG system (i.e. a capacity charge) will increase the cost of the ZLEG system and may therefore act as a barrier to adoption.

7.4. Metering

At a residential level, most existing traditional metering uses an accumulation meter and the need to monitor and record energy generation and export from a DG unit will necessitate the installation of new interval/smart meters should a large expansion in DG occur. An interval meter provides half hourly readings of the electricity consumed and surplus electricity generated. Smart meters are a more advanced type of interval meter which have additional capabilities to facilitate improved energy management. From an energy use and management perspective, the roll out of new metering is a positive byproduct of broader DG uptake. This could enable a smart grid approach to energy provision with numerous economic and environmental benefits.

Energetics recommends that the Commonwealth, states and territories explore mechanisms to drive the installation of smart meters on new buildings and on existing buildings undergoing renovation that requires work to be done by a licensed electrician. Identified mechanisms will need to be assessed through regulatory impact statements.

7.5. Conclusions

This section of the report has explored issues related to the potential impact of network infrastructure.

- On balance, the more widespread take-up of ZLEG is likely to be beneficial to the networks by deferring capital expenditure to expand the networks. This is particularly so in the case of dispatchable local generation (e.g. cogeneration) and non-dispatchable renewable generation whose output matches peak demand (e.g. solar PV in commercial areas)
- The widespread deployment of ZLEG can lead to problems with stability. However, studies from Europe show that these problems are not common and can be managed.
- The major problem is overvoltage and this can be managed through appropriate inverters.
- The costs, delays and complexity associated with network connections are barriers to the deployment of distributed generation, particularly cogeneration and trigeneration. Should government elect to modify the NCC to encourage more deployment of cogeneration and trigeneration, changes to the network connection procedures must be made in parallel.
- Current network tariff structures may not be optimal in an environment where there is significant take-up of ZLEG.
- We also recommend that governments explore mechanisms to drive the installation of smart meters on any new buildings and on existing buildings undergoing renovation that require work done by a licensed electrician.
- Consider providing incentives for householders to install solar PV systems that are orientated to better impact the late afternoon peak. Or better still, conditional on solar PV

proving to be cost effective in its own right, consider incentivising the installation of batteries to support solar PV systems.

In all cases, the cost of both connecting DG systems to the networks and implementing countermeasures to address potential network stability issues need to be balanced against the benefits of the DG systems.

8. Competition, consumer protection and safety

Section 8 of the report looks at two important issues. First, the impact that the incentivising of ZLEG through the BCA could have on customers' choice of retailer and consumer protection is examined. We will introduce the concepts of private wire and virtual private wire networks and emphasise how some possible regulatory changes or tariff initiatives could impact the overall electricity rates. Second, we will discuss questions of safety and system protection.

8.1. Competition and consumer protection

8.1.1. Full retail contestability

Due to the economies-of-scale benefit, an increasing take up of large-scale distribution generators providing energy to a number of customers through an embedded network can be expected. More distributed generation systems are also likely to be included in the development of multi-story buildings, office buildings and shopping centres.

The National Energy Retail Law (Retail Law) prohibits a person from engaging in the sale of energy unless the person has obtained a retailer authorisation or is exempt by the Australian Energy Regulator from the requirements to hold a retailer authorisation. The Australian Energy Regulator's Exempt Selling Guideline[63] provides a framework for retail exemptions. This framework sets AER's guidance on the application of policy principles contained in the Retail Law. One of these principles relates to affording the right to customers of an 'exempt seller' (i.e. the 'exempt customers') the right to a choice of retailer. Section 114(1)(b) of the Retail Law states that 'exempt customers should, as far as practicable, be afforded the right to a choice of retailer in the same way as comparable retail customers in the same jurisdiction have that right'.

For electricity, the most effective way of affording full retail contestability of customers in an embedded network is for each customer to be assigned an appropriate electricity sub-meter with a separate national meter identifier (NMI). The BCA already states that all future multi-unit residential and office building development must have electricity sub-meters installed. In order to assist developers of distributed generation projects who are contemplating an on-selling arrangement, the building regulations could require that individual dwellings in a building and each tenant must have a meter for their own consumption and limit instances where sub-meters are installed for each storey to avoid the risk of the AER not granting a retail exemption.

Rules around full retail contestability place constraints upon the development of district cogeneration and trigeneration systems, and need to be taken into account should Australian governments seek to use the BCA to drive the take-up of ZLEG.

8.1.2. Private network service provider's obligations

Any energy provider supplying electricity to another person over an "embedded" or "private" network is providing an electricity distribution service. Under the Retail Law and the National Electricity Rules, owners/operators of such "private" networks must either be registered with the Australian Energy Market Operator as an electricity distributor or gain an exemption from the requirement to be a registered network service provider from the AER. These regulations would apply to a district cooling

[63] Available on AER's website at www.aer.gov.au.

and heating proponent wishing to develop its own grid that is connected to the rest of the electricity network.

The AER's Electricity Network Service Provider Registration Exemption Guideline[64] details the conditions and the application process to be granted such exemption. Among the conditions applicable to all private networks set by the AER the following elements are worthwhile noting:

- All customers must be individually metered, with metering installations compliant with the requirements of the *National Measurement Act* 1960 (Cth).
- All private networks must, at all times, be installed, operated and maintained in accordance with all applicable requirements for the safety of persons and property, including where relevant an industry Code or Guideline otherwise applicable to a network service provider.
- Any generator located within a "private" network must be designed so that, in the event of a loss of supply from the local network service provider's network, the generator is either shut down or automatically transferred into an islanded operation mode (ability to continue to supply energy in the event of a failure of the main grid to afford local security of supply to customers connected to the island network).

8.1.3. Possible regulatory change towards a "virtual private wire" network

Some stakeholders advocate for changes to the regulatory framework to enable the introduction of "virtual private wire" networks for distributed energy generation systems. Virtual private wire networks allow an embedded generator to supply electricity to local sites and pay network charges that reflect the use of local distribution assets rather than use of the full network and transmission system. Stakeholders emphasise that such a flexible licensing option could allow distributed energy schemes to achieve more economic scales through operating larger energy centres to serve several developments and buildings in an area without building a parallel "private" network, which could represent a cost detrimental to the economic viability of the distributed energy project. The UK's Office of Gas and Electricity Markets (Ofgem) implemented the concept of virtual private wires under the Electricity Supply Licence Modification Statutory Notice on 19 March 2009.

In its submission to the Australian Energy Regulator's "Approach to Retail Exemptions Issues Paper", the City of Sydney (CoS, 2011) noted that the electricity regulatory regime in NSW is not dissimilar to the electricity regulatory regime in the UK. The regulatory barriers to decentralised energy in the UK were overcome initially by class exemptions and private wire networks and later by "virtual private wire networks‟ through the application of a simple supply license modification.

Based on this experience, the conditions that apply to a private wire network or a virtual private wire network are likely to remain i.e. the distributed energy scheme developer or an accredited third party supplier would still have a licence obligation to ensure that:

- It has in place arrangements to facilitate the customer choice of supplier.
- The scheme obtains agreements on the National Energy Retail Law and Rules as part of their supply contract with customers.
- The administration of its metering systems is in accordance with industry procedures.

[64] Available on AER's website at www.aer.gov.au.

8.1.4. Reallocation of costs between embedded generation proponents and customers

Demand side participation programs in the electricity market may reduce energy sales. Reduced energy sales can lower revenues for the retailers and distribution network service providers and put upward pressure on retail rates, with typically an overall negative impact on non-participating ratepayers (rates or bills go up). In the same way, should a change to building regulations encourage a higher take-up of distributed generation, non-participating customers could experience an increase in their electricity rate, providing a negative public policy impact. Two such examples related to the impact of changes to the network connection charges and energy tariffs are detailed below.

In some instances, the transmission or distribution network needs to be augmented upstream of the local point of connection of a distributed generator. Currently, developers of embedded generators often face charges for such augmentations. However proponents of embedded generators are advocating for the application of a “shallow” connection cost regime or at least for the capping of network connection charges at the cost of installing a private wire network (ISF, 2009).

The allocation of costs for any grid reinforcements or line extensions that may be required (for example for transformer or substation upgrades to reduce fault-related issues) is a contentious issue regularly mentioned as a barrier to the take-up of distributed generation. This issue is often presented as the choice between “deep” and “shallow” connection costs for generators. Under a “deep” connection cost regime, the embedded generation applicant is requested to pay up-front the full capital cost of reinforcing the network upstream of the connection point. Under a “shallow” connection arrangement a generator does not pay the cost of the shared network and customers therefore pay it all through their network charges. This issue is also presented as a debate between “Prescribed” and “Negotiated” services (CRA, 2006), i.e. between the parts of the shared network that are necessary to meet prescribed standards of reliability of supply to customers – the Prescribed services – and the costs of direct connection and service required by the embedded generator above that which meets the standards – the Negotiated Services.

Proponents of distributed generation have also mentioned the introduction of regulated Feed-in Tariffs or buy-back tariffs for energy exported into a network. This issue is related to the need to better reflect the avoided network costs for energy exports.

Under the current National Electricity Rules distributed generators selling electricity to a retailer or into the electricity wholesale market typically only attracts the wholesale price, which is 40 to 60 per cent lower than the retail price. Beyond the options mentioned above (i.e. retail licence, private wire network, “virtual private” wire network), a buy-back arrangement tariff would be defined such as the embedded generation operator would get the benefit from network support, network augmentation deferral, and loss reduction.

8.2. Safety and System Protection

With the advent of a larger proportion of distribution energy resources connected to the grid, changes to codes or standards are required to ensure users of electricity and utility workers are not harmed and to protect electric appliances and the equipment of the electricity networks. An example highlighting the need for strict regulations associated with distributed generation is the outcomes of the DCCEE’s inspection of a selection of solar photovoltaic systems funded under the Solar Homes and Communities Plan and National Solar Schools Program.

The inspection program was established to check compliance with program guidelines and Australian Standards. Each system inspected was classified as being either compliant with all program requirements and Australian Standards, non-compliant without the need for a system shutdown, or non-compliant with a safety risk requiring a system shutdown. Note that many of the non-compliances were administrative in nature and so did not reflect a physical defect with the system. The outcomes of the Solar Photovoltaic Inspection Program are summarised below[65].

Classification	National Solar Schools Program	Solar Homes and Communities Plan
Compliant	226 systems (42 per cent)	943 systems (48 per cent)
Non-compliant	266 systems (49 per cent)	910 systems (46 per cent)
Significant defects requiring the system to be shut down	49 systems (9 per cent)	108 systems (6 per cent)

Non-compliant findings that would result in a system being shut down included: system mounting not properly secured, exposed live wiring, loose connections, water ingress, or the system not being properly earthed.

Traditionally, nested protection schemes are implemented with protection equipment required to trip selectively as close as possible to the fault. However this traditional design of power distribution systems does not easily accommodate the two-way flow of power that characterises a network with distributed generators feeding in the distribution grid at many places.

One of the other technical issues created by distributed generation interconnection is related to islanding. Islanding is the situation where the distributed generation installation and a portion of the utility system become isolated from the remainder of the utility system. If this happens, and if voltage and frequency within the island are not maintained within limits, both the utility equipment and customer equipment can be damaged. Note that it can be desirable to permit such islanded operation to increase customer reliability.

Safety of utility personnel and consumers is an important factor considered in the type of hardware and procedures used in the operation of electric distribution systems. Present-day distribution system designs, protection hardware and practices, and personnel safety hardware and procedures have evolved based on centralised generation schemes, and delivery of power over radial feeders that do not have distributed energy resources. When distributed generators are incorporated into the system, procedures must be reviewed and revised.

As embedded generation gains increasing take-up there is likely to be significant changes to interconnection standards and guidelines, protection equipment, control functionality, and communications infrastructure to improve interconnection practices and protection systems.

The safety of network workers is being addressed though the proposed Intergovernmental Agreement on Energy Supply Industry Safety, which among other things will support ongoing governance

[65] The full results are available on DCCEE's website at www.climatechange.gov.au

systems and the formation of the national Energy Supply Industry Safety Committee. Many emergency services agencies have procedures around embedded generation, but these will need to continually evolve.

New interconnection standards are likely to align with the standards developed by the Institute of Electrical and Electronics Engineers[66]. These standards:

- Establish criteria and requirements for interconnection of distributed resources interconnected with electric power systems;
- Specify the type, production and commissioning tests that shall be performed to demonstrate conformance; and
- Provide guidelines for monitoring, information exchange and control for distributed resources interconnected with electric power systems.

8.3. Conclusions

This section of the report has explored issues related to competition, consumer protection and safety. The key points can be summarised as follows:

- Each customer of an embedded generator should be assigned an appropriate electricity sub-meter with a separate national meter identifier (NMI) so that full retail contestability of customers is guaranteed.
- More specifically each individual dwelling in a building and each tenant should have a meter for their own consumption.
- Current network tariff structures may not be optimal in an environment where there is significant take-up of ZLEG.
- Regulatory changes leading to the introduction of the concept of “virtual private wire” networks can greatly assist in overcoming current barriers to cogeneration/tri-generation systems. This concept could be considered when defining ZLEG technologies but it should not impact the BCA if the design and operating conditions that apply to a private network remain applicable to a “virtual private” network.
- Should government regulations require a higher take-up of distributed generation, it should be recognised that non-participating customers could experience an increase in their electricity rate, providing a negative public policy impact. The RIS that would support any such change in regulation should explore this issue.
- Changes to interconnection standards and guidelines, protection equipment, control functionality, and communications infrastructure are likely to be required to ensure users of electricity and utility workers are not harmed and to protect electric appliances and the equipment of the electricity networks.

[66] IEEE 1547 Standard for Interconnecting Distributed Resources With Electric Power Systems

9. Limiting ZLEG relative to energy efficiency

This section addresses the question of whether limits should be placed in the BCA on the relative role that ZLEG energy generation can play in meeting any energy or emissions target relative to the role that improvements in the energy efficiency of the building fabric and fixed appliances and equipment have in meeting the target.

9.1. The pathway to zero energy buildings

With the implementation, both internationally and nationally, of more stringent energy efficiency requirements in building codes and standards, there has been extensive documentation and research surrounding the definition of a 'zero or low emission building'. A building itself may be considered a zero or low emissions building, however this status may be achieved through a combination of better building design, energy efficiency measures and the incorporation of zero and low emission energy generation technologies. See Appendix F for a further discussion of lowering building emissions through the implementation of Zero Emissions Buildings (ZEB).

A key consideration here is the level of abatement that is sought, both in the near term and over the long term. Evidence and analysis underpinning targets in some EU countries suggests that practical limits will exist in terms of building design and energy efficiency so that near-zero or zero emissions generation technologies will be needed for zero energy or similar buildings to be achieved.

Figure 10 shows how the US DOE has mapped out a path to a zero energy building, and how a zero energy home is to be achieved through a 60% to 70% reduction in energy consumption. The balance is made up of a combination of solar PV and solar heating.

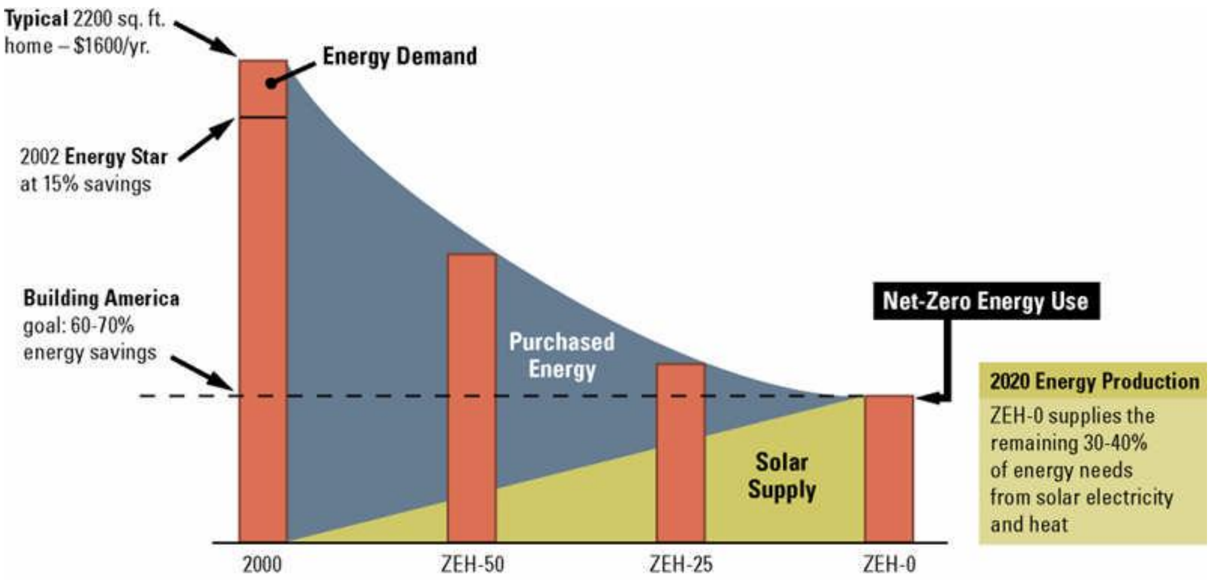

Figure 10: Progression to Full ZEH by 2020[67]

A similar story comes from Germany, where energy efficiency in buildings plays a major role in Germany's Energy Strategy[68]. The target is a primary energy demand reduction of 80% out to 2050.

[67] From "On the Path to Zero Energy Homes, Lew W. Pratsch, Building America Program, August 24, 2006"

[68] "Pilot Project „Efficient Homes", Felicitas Kraus, dena (German Energy Agency), 2011

In 2006 the UK Government's declaration of "a target for all new homes to be zero carbon within a decade" resulted in numerous consultations and task groups which, in 2008, led to a clearer definition of zero carbon homes.

Originally, the proposal was that at least 70% of the target must be achieved in "regulated CO2 emissions". The 'Allowable Solutions' in this case (set out in a Ministerial Statement in July 2009) include: further carbon reductions on site beyond the regulatory standard; energy efficient appliances installed as fittings within the home; advanced building control systems which reduce the level of energy use in the home; exports of low carbon or renewable heat from the development to other developments; investments in low and zero carbon community heat infrastructure; and other allowable solutions remain under consideration.

Embedding a high level of energy efficiency within the UK's 2016 zero carbon homes policy will result in minimising energy demand and ensure that dwellings utilise Low and Zero Carbon (LZC) energy sources in the most efficient way. A similar method could be developed for Australia, by incorporating more stringent and specific energy efficiency requirements into the BCA, and limiting the allowable size of zero and low emission energy generation.

A comprehensive review of the role that energy efficiency standards can and are playing in improving the energy performance of buildings was provided by Laustsen (IEA, 2008).

9.2. Zero or near zero energy buildings

A report commissioned by the Australian Sustainable Built Environment Council (ASBEC), reviewed key considerations for the defining of zero emission buildings and suggested a model for an Australian standard zero carbon definition (Riedy, Lederwasch, & Ison, 2011):

> *"All definitions we examined stress the importance of energy efficient design and construction and prioritise energy efficiency over renewable energy options. According to Marszal et al, 'it is almost always easier to save energy than to produce energy', so prioritising energy savings is a logical approach to zero impact buildings. While energy efficiency is important, it is impossible to achieve zero impact through energy efficiency alone; the remainder of a building's energy needs must be met from zero or low carbon energy sources, either on- or off-site.*
>
> *…the absence of energy efficiency requirements may lead to the installation of oversized renewable energy generation systems which would not have the intended effect of achieving the most cost effective reduction in the environmental impact of the built environment. If Australia was to include an energy efficiency requirement as part of its zero carbon definition, which we recommend, different standards should be set for different building types…"*

Their model of for the emissions reduction model is in Figure 11.

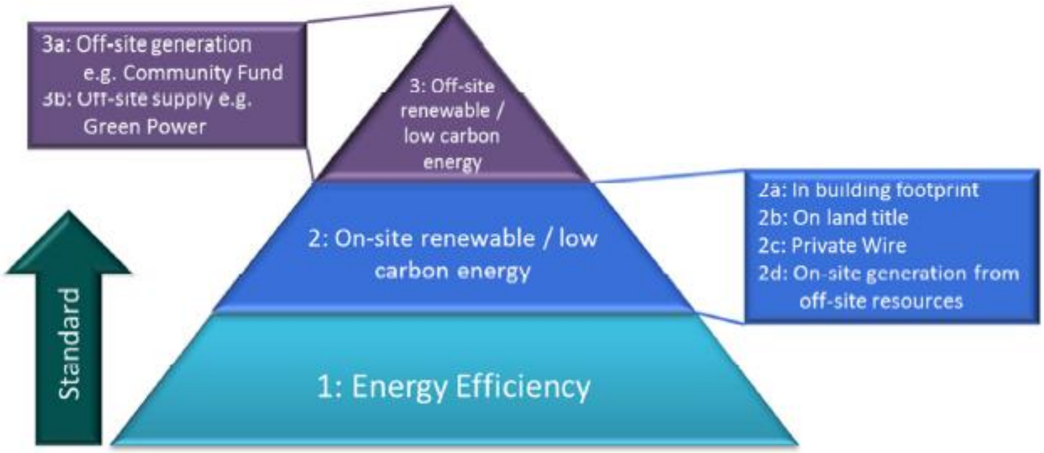

Figure 11: Recommendation for Australian standard zero carbon definition - emission reduction options[69]

The main challenge for off-site emission reduction options is providing some assurance that emission reductions achieved by the energy generation technology will continue to be delivered over time. For example, a building owner could buy Green Power to achieve emissions reductions but this contract could be terminated as soon as new tenants occupy the building. One response, commonly used in voluntary programs, is to require regular evidence (e.g. annual) that emission reductions are still being achieved. Concerns such as these lend weight to the argument that the most reliable component of the measures to achieve a zero energy building is energy efficiency in the design and construction of the building.

From another perspective, the ASBEC Climate Change Taskgroup commissioned a report in 2010 looking at the contribution that energy efficiency in the building sector can make to greenhouse gas emissions abatement[70]. As well as reconfirming both the benefits of energy efficiency in buildings and the potential for savings that still exists, the report discussed how using established technologies to reduce energy demand reduces the risks associated with using less developed technologies such as carbon capture and storage to reduce national emissions.

Cost-effectiveness and consumer protection aspects will presumably also influence what contribution ZLEG technologies could make relative to energy efficiency, and these aspects would also be examined here. As noted by ISF (Riedy, Lederwasch, & Ison, 2011):

> "*issues of economic, technical and environmental efficiency are important to consider when specifying allowable emission reduction options. While energy efficiency may be preferable, setting energy efficiency requirements too high may raise costs if it means more cost-effective clean energy options are displaced. Similarly, off-site renewable energy options at larger scales are typically cheaper than on-site renewable energy options at building scales. Requiring too much on-site renewables may again displace more cost-effective options; requiring too little may lead to minimal uptake of building scale solutions, which would miss opportunities for reducing household energy bills and capturing economies of scale".*

[69] From (Riedy, Lederwasch, & Ison, 2011).

[70] The Second Plank Update: A review of the contribution that energy efficiency in the buildings sector can make to greenhouse gas emissions abatement. Allen Consulting Group, 2010.

9.3. Scope for improvement

The stakeholders consulted during the preparation of this report were clear in their views that improvements to the thermal performance of the building shell and to the energy efficiency of fixed appliances should come before considerations of building-connected generation. The common view amongst stakeholders was that energy efficiency improvements must not be sacrificed by allowing renewable generation to displace energy efficiency when seeking to achieve a performance target. However, the optimal balance between thermal performance, energy efficiency and renewable generation does not appear to have been established. For instance, Hayes et al (Hayles, Horne, Jensen, & Wakefield, 2006) showed how new houses in Australia lag behind other countries in terms of the thermal performance of the building shell. Their results are shown in Table 15.

Table 16: Summary analysis of AccuRate model results

Australian equivalent climate zone	Comparison location	Total number of plans rated	AccuRate Stars Range	AccuRate Stars median	**AccuRate Stars Mean**
Zone 1 Darwin	Florida	6	6-8.5	6.5-7	**7**
Zone 2 Brisbane	Texas	5	4.5-9	5	**6**
Zone 3 Longreach	N. Carolina	5	4.5-6.5	5.5	**5.4**
Zone 4 Dubbo	Arizona	4	6.5-7.5	7	**7**
Zone 5 Perth	California (Bakersfield)	3	7-8	7.5	**7.5**
Zone 6 Melbourne	California (SF Bay)	4	6-9	7.5-8	**7.6**
Zone 7 Hobart	UK: Canada	16	6.5-8.5	8	**7.2**
Zone 8 Thredbo	Pennsylvania: Mass.	8	4.5-9.5	6.5	**6.8**
ALL ZONES	**-**	**51**	**4.5-9.5**	**7.5**	**6.8**

The final RIS for the 2010 revision of the energy efficiency requirements of the BCA demonstrated that the move to 6 stars was justified in particular circumstances. There were some stakeholders who took a different view with work carried out for Master Builders Australia (CIE, 2010) found that it is not cost effective to seek a 6 star rating through modification to the building shell. Several stakeholders were of the opinion that a full analysis of impacts of both energy efficiency improvements and ZLEG options is needed to determine the optimal balance between building energy efficiency and building-connected generation.

9.4. Not a measure of energy efficiency

Energy efficiency should refer exclusively to the amount of energy a building uses compared with another building. The source of energy being used has no bearing on the efficiency rating, only on the emissions profile of that building. So any scheme that encourages the ZLEG must clearly separate the thermal performance/energy efficiency of the building from the application of ZLEG to supply the remaining energy requirements of the building.

This is particularly important in the case of performance ratings, where transparency is essential. For instance, a building with a ZLEG system may get a better 'star rating' than an identical building without the embedded generator. However, maintaining the star rating requires the maintenance of a large and complex piece of equipment.

Allowing an energy efficiency rating to be offset or augmented through the inclusion of on-site or direct link ZLEG options may also encourage the use of less efficient appliances within buildings and promote the sale of such technologies in the Australian market.

There are other strong arguments for good building shells independent of any energy concerns. These include health impacts of heat stress. This is particularly relevant for energy poor households. This opens a new area of debate about appropriate targets for the energy performance of the shell.

Given the support for on-going improvements in energy performance of building, Energetics recommends the following:

- ZLEG should not be used in preference to improvements in the energy efficiency of the building shell and fixed appliances, unless it can be shown that it offers clear financial benefits.
- A study into the optimum balance between further improvements in the energy performance of the building and take-up of ZLEG be undertaken. This is especially true for residential buildings.

10. Recommendations

The key recommendations mentioned in this report are:

- A consultation on the most efficient methodology to calculate the savings due to low emissions generation be undertaken.
- Should the BCA be modified to incorporate a method to calculate the impact of a ZLEG, Energetics recommends that the same method be used in all related rating tools such as NatHERS and NABERS.
- A national discussion on changes to the state and territory planning and building laws to better deal with ZLEG in the context of low or zero energy buildings be undertaken.
- Options to extend the output of solar PV panels into the period when the residential peak occurs be explored. These options could include panels that face to the North West or the installation of batteries.
- Any moves to require take-up of ZLEG (and especially cogeneration or trigeneration) through changes in government regulations must be supported by changes to the procedures adopted by the Distribution Network Service Providers to manage connections. The changes must also address the connection of cogeneration systems across multiple sites which are contiguous for instance, a hospital or university.
- Subject to a cost-benefit analysis, the Commonwealth, states and territories explore changes to building regulations to require the installation of smart meters on any new building and any renovation that requires work done by a licensed electrician.
- Current network tariff structures may not be optimal in an environment where there is significant take-up of ZLEG, and any future investigations into network tariffs should explore the role that network tariffs could play in incentivising ZLEG.
- A ZLEG should not be used in preference to improvements in the energy efficiency of the building shell and fixed appliances, unless it can be shown that it offers clear financial benefits.
- A study into the optimum balance between further improvements in the energy performance of the building and take-up of ZLEG be undertaken. This is especially relevant to residential buildings.

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Appendix A. Some ZLEG Technologies

The following section provides some background on the more important ZLEG technologies in the context of zero or low emissions buildings. The applicability for Australian conditions, state of development, technology roadmap and current economics for all technologies are discussed. Some technologies have different applications and configurations for different scales and therefore, where required, the sections are discussed at a residential, commercial or precinct scale.

Solar PV

Solar PV cells directly convert solar energy to electricity. Figure 11 below shows the evolution of solar cell efficiency over time. Crystalline silicon (c-Si) cells are the most efficient of the 'flat plate' PV technologies and represent 85% to 90% of the global annual market[71]. Crystalline silicon can reach a theoretical efficiency of around 30%; however this is under conditions that will never be found in field deployed systems. Crystalline PV cells are a mature technology and have been commercially available for more than 40 years. There are a large number of manufacturers throughout the world and the market for crystalline PV is competitive. In flat plate arrays, efficiency ranges between 11% and 23%[71], depending on location, orientation, end-use application and weather conditions, amongst other factors.

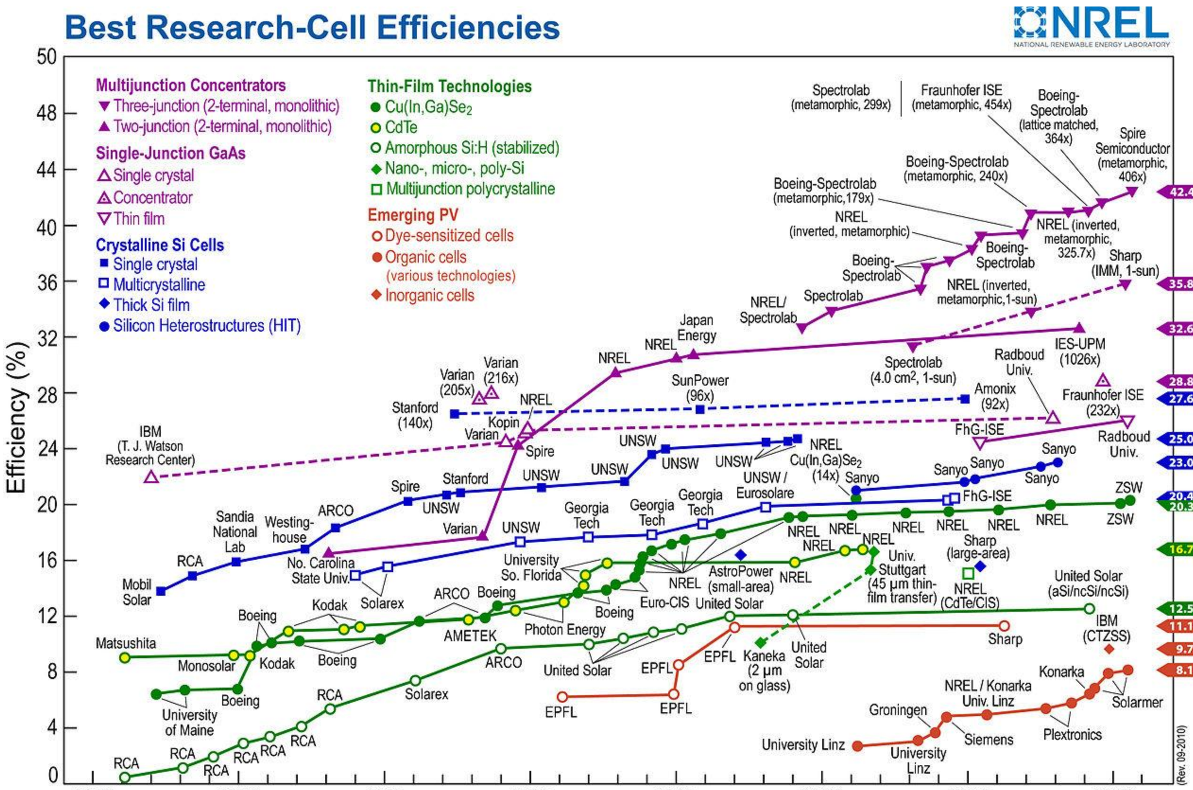
Thin film solar PV accounts for 10% to 15% of global PV sales in 2008[71]. Thin-film PV is still in the earlier stages of the development curve although it has been commercially available for more than 20 years and its market share is growing fast. One of the main advantages over other PV technologies is its lower production costs thanks to automation capabilities in the manufacturing process. Development efforts are focused on increasing efficiency levels.

Organic cells are an advanced PV technology, also referred to as a third generation technology. They can be classified into thin-film organic (OPV) and dye-sensitised cells (DSC). These emerging technologies are currently targeting small niche market applications, however, they show considerable promise if they can be produced at scale through conventional printing processes. OPV forms part of a much larger emerging market, "flexible electronics" with many of the major flat panel manufacturers building research capability. The production of organic-based PV using industrial screen printing has demonstrated the possibility of producing up to 100,000 m^2 on a process line per day while production of the same solar cell area based on silicon typically takes one year[72].

[71] Solar PV Technology Roadmap 2010, International Energy Agency.

[72] Kalowekamo, J., Baker, E., Estimating the manufacturing cost of purely organic solar cells, Sol. Energy (2009), doi:10.1016/j.solener.2009.02.003.

Figure 11: NREL summary of solar cell efficiencies (1975-2009)73



Micro wind turbines

Small-scale wind power refers to wind turbines that could power a house or small business, with a maximum capacity of 100kW, but usually with a capacity of 1 kW to 10 kW. Small-scale turbines are usually mounted on lattice or monopole; guyed or free standing towers between 20 and 40 meters high. As small-scale turbines are frequently used in domestic or built up locations[74] near dwellings, trees and other obstructions, they need to be planned carefully so as to avoid a turbulent wind resource. Turbulence reduces the efficiency and therefore the output of the turbine – sometimes very significantly. The Carbon Trust small wind report[74] also describes the effect of wind quality on the performance of a small wind turbine.

The availability of a wind turbine is the proportion of time that it is ready for use, and provides a useful indication of operation and maintenance requirements, and the reliability of the technology in general.

Cogeneration and trigeneration

Cogeneration is the simultaneous production of two useful forms of energy, such as electricity and useful heat. It is also known as combined heat and power (CHP). Trigeneration uses some of this waste heat in an absorption chiller to produced chilled water. A typical energy balance for a cogeneration or trigeneration is shown below.

[73] NREL National Center for Photovoltaics, (http://www.nrel.gov/ncpv/).

[74] Carbon Trust, 2008, 'Small-scale wind energy – Policy insights and practical guidance'.

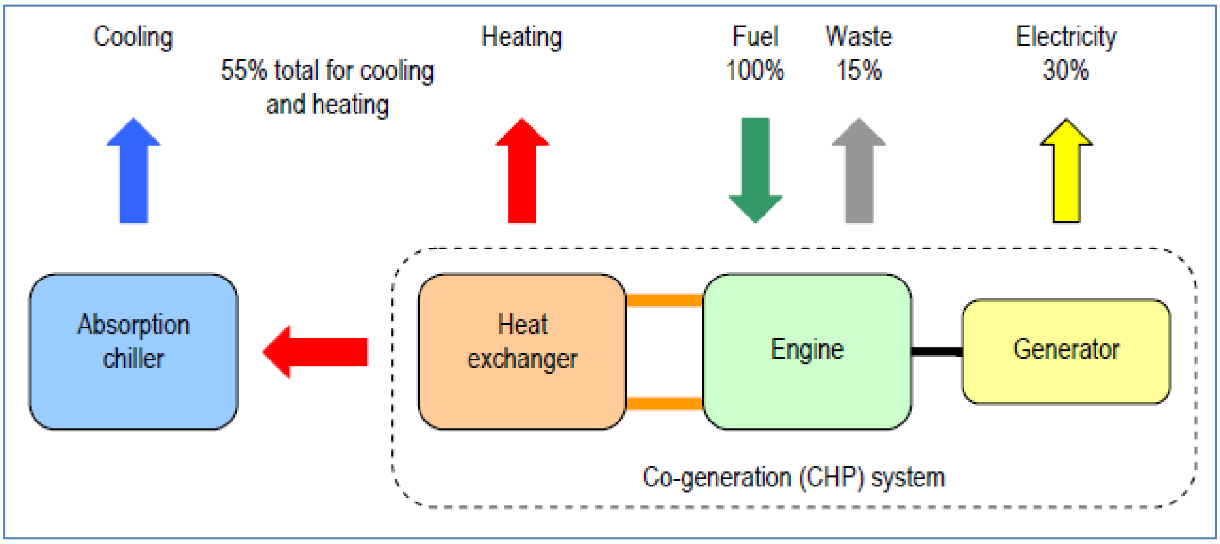


Figure 12: Co-generation and trigeneration system diagram[75]

The ‘engine’ can be one of several possibilities:

- Stirling engines, which operates by the cyclic compression and expansion of air or other gas at different temperatures that sees a net conversion of heat energy to mechanical work. Stirling engines have low electricity generation efficiency (about 12-15%) and consequently high heat output. The high heat output is what makes Stirling engines popular and suited for the cooler European climate, where the heat can be used for water and space heating.
- Conventional internal combustion engines, using natural gas as a fuel. They have relatively high electricity efficiency (up to 45%) and well proven reliability. Emissions of NOx can be a problem with large scale deployments in sensitive airsheds.
- Small, lightweight combustion turbines that typically have power outputs of 30 to 300 kW. A heat exchanger recovers thermal energy from the microturbine exhaust to produce hot water or low-pressure steam.

An alternate approach to cogeneration and trigeneration is the fuel cell. Fuel cells use an electrochemical or battery-like process to convert the chemical energy of hydrogen into water and electricity. The hydrogen can be obtained from processing natural gas, coal, methanol, and other hydrocarbon fuels. The advantages of fuel cells include low emissions and low noise, high power efficiency over a range of load factors, and modular design.

[75] Taken from (ABCB, 2011).

Cogeneration and trigeneration outside of Australia

Commercial cogeneration is similar to residential micro-cogeneration, however is more developed and at a larger scale; gas turbines are also more common in CHP commercial applications.

The status of cogeneration and trigeneration in some international jurisdictions is shown in the next table

Region	Status
Japan	The total cogenerating capacity of public power plants and industrial and commercial cogenerators represents over 1.8 per cent of the total power generation capacity of the country. As of March 1998, there were 1,490 units totalling 789 MW installed for commercial use and 1,051 units totalling 3,507 MW for industrial applications. Gas turbines are popular for bigger capacities, followed by diesel engines, and gas engines are widely applied at sites with very low demand, ranging between 220 and 450 kW[76].
Europe	The EU currently generates 11% of its electricity using cogeneration[77.] However, there is large difference between Member States with variations of the share of cogeneration between 0% and 42. 8%. According to official Eurostat figures from 2007, Denmark has the greatest share of cogeneration in total electricity generation (42%) followed by Latvia (40.9%). In a study to assess the cost of carbon abatement policies in the Netherlands, CHP was identified as one of the least-cost solutions at EUR 25/tonne (t) CO2. This was lower than building insulation, condensing boilers and wind power. [78] The estimated growth potential for cogeneration is a further 110-120 GWe which will lead to an improved environment and greater economic competitiveness in Europe.
North America	The U.S. Department of Energy (DOE) has an aggressive goal of having CHP comprise 20% of the US generation capacity by the year 2030. In order to develop the required technology application knowledge and educational infrastructure necessary to progress CHP technologies, eight Clean Energy Application Centres have been established across the nation with a focus to advance CHP technologies as viable energy options and to reduce any perceived risks associated with their implementation. The Application Centres also provide an outreach and technology deployment program for end users, policy makers, utilities, and industry stakeholders. In 2008, cogeneration accounted for nine percent of total U.S. electricity generating capacity. Nearly three quarters of cogeneration capacity uses natural gas for fuel, and gas-fired combustion turbines and combined cycle systems dominate cogeneration capacity even though nearly half of all cogeneration sites use reciprocating engines. Large cogeneration systems of 100 megawatts or more in capacity accounted for roughly 65 percent of total cogeneration capacity in the U.S in 2008[79.]

[76] A. Ishiyama, "Use of cogeneration system in Japan", 1998.

[77] http://www.cogeneurope.eu/.

[78] Boonekamp, P.G.M. et al. (2004), Milieukosten Energiemaatregelen 1990 – 2010 Energy Centre of the Netherlands (ECN), Petten.

[79] http://www.c2es.org/technology/factsheet/CogenerationCHP.

Case studies of cogeneration and trigeneration in Australia

System	Comments
Coca-Cola Place, North Sydney	Investa installed a trigeneration plant, along with a host of other energy efficient features, at the new 6 star office development in Coca-Cola Place, North Sydney. The system capacity is 774 kW of electrical power generation and 650 kW of absorption chiller capacity.
BASIX Multi-Unit Residential Cogeneration Demonstration Project[80]	The NSW Government's BASIX Multi-Unit Residential Cogeneration Demonstration Project involves partnership with residential development companies Lend Lease GPT and Mirvac. The purpose of the project is to trial and showcase cogeneration technology in a residential setting, with a focus on reducing energy consumption and greenhouse emissions. The project features the installation of small-scale, gas-fuelled generators in a 7-storey Lend Lease development at Rouse Hill in western Sydney, and in Mirvac's 25-storey Cambridge Lane apartment building at Chatswood in northern Sydney. The generators are powered by natural gas with an electrical output of 25 kW. They are able to supply a modest part of the electrical demand of each building, which is used in common area lighting and ventilation. At both developments, the waste heat (47 kW from water jackets and exhaust heat exchangers) is used to provide approximately two thirds of the hot water needed by the residents, saving around 80 tonnes of carbon dioxide per year for each site. Overall expected efficiency is 87%, with 77% achieved in the demonstration phase. The Chatswood generator would pay for itself within 12 years, well within its 25-year expected lifetime. The overall setup cost for the Chatswood development was $185,000
Royal Newcastle Hospital site redevelopment	The former hospital site was redeveloped by Mirvac in the period 2008 to 2010/11, mostly into apartments (146 off) and hotel rooms (89 off). As part of the services a cogeneration plant was designed into the facility, to supply hot water to the hotel and wider site, and wet services to all apartments and hotel rooms. The size of the cogeneration plant was not disclosed in literature that was sighted. However it is expected to save 450 MWh of electricity from the grid, and 350 tonnes of greenhouse gas emissions per year. From this it could be inferred that the unit is likely to be in the range 75kWe to 125 kWe. The project received funding of $320,000 from the NSW government.
Westfield Pitt Street Mall redevelopment[81]	Westfield has substantially completed the redevelopment of the Pitt St Mall site in Sydney, which incorporates a retail centre and two commercial offices, and is one of the largest redevelopment projects undertaken in the Sydney CBD. The development includes a trigeneration plant comprising 3 x 1500 kVA gas fired generators. These supply 25% of the base electrical demand for all three buildings, with waste heat used to meet both heating demand and cooling demand via absorption chillers. This and other measures mean the retail centre is expected to use 25% less energy than typical shopping centres. Both offices have targeted 5 Star NABERS Energy ratings. Expected savings from cogeneration are 7,100 MWh of electricity per year, and 3,010 tonnes of greenhouse gas emissions per year. The project received funding assistance of $2 million from the NSW Government.
Ausgrid 'Smart Grid, Smart City' project	In this project, a family home in Sydney was equipped with a range of new energy technologies, including a BlueGen unit, solar PV and an electric car. The results show that the BlueGen unit generated on average 28 kilowatt hours of electricity per day and the generation from the solar PV system and solar pergola was 4 kilowatt hours per day. Combined, the home generated more electricity than it used. Compared to the average greenhouse emissions from power supplied in NSW, the home saved 1.4 tonnes CO2-e from its solar systems and 6.9 tonnes of CO2-e from the BlueGen unit[82].

[80] https://www.basix.nsw.gov.au/information/common/pdf/CoGen_Fact_Sheet_June_2007.pdf.

[81] http://www.environment.nsw.gov.au/grants/ccfgbp.htm.

[82] http://www.cfcl.com.au/Assets/Files/20120206-Ausgrid-Smart-home-results-Feb2012.pdf Accessed 8/02/2012.

Appendix B. Solar absorption air conditioning

This uses solar thermal collection to provide the heat for an adsorption or absorption chiller. These chillers work by providing heat from high temperature water from solar collectors. Collectors are usually evacuated solar tubes or parabolic troughs. Currently in Australia, absorption chillers driven by solar hot water are often not an attractive option for a building owner looking to reduce their carbon footprint as they are expensive, require large cooling towers and can be difficult to maintain.

Despite a growing interest, the market has nonetheless been slow to develop with accepted figures pointing to German leadership of the European market with close to 40% up until 2004, followed by Spain with more than 27% of the European market. Indeed, by 2008, a total of only 450 to 500 solar cooling systems had been realised worldwide, the vast majority of which are in Europe, where the market has increased in the last five years by 50%–100% annually. Approximately 60% of these systems using absorption chillers, 11% adsorption chillers and 29% open systems (DEC and liquid sorption systems). Even so, the total volume of installations reveals that the solar cooling sector is still a niche market and effectively just emerging.

A recent study[83] of 36 installations showed that the cost of solar cooling installations ranged from $AU2,000 to $AU60,000 per kilowatt of cooling, with a typical value of around 7,000 $/kW. This wide variability is typical of an industry in its early stages and also possesses large cost-reduction potential.

There are limited solar cooling applications in Australia, and those that exist are of commercial or industrial size. One example of absorption solar cooling in Australia is the Ipswich Hospital in Queensland. The parabolic trough collector field installed at Ipswich Hospital includes 43 collectors and has a total output of 225 kilowatt thermal. The field is installed on the roof of the multi-storey carpark and covers an area of about 920 square metres. The hot water produced from the solar collector fields is reticulated to a 300 kilowatt refrigeration double-effect absorption chiller. The system includes a six cubic metre thermal storage tank to extend the operational hours.

The maximum electrical demand for air-conditioning is typically coincident with the maximum availability of solar radiation for solar cooling, particularly in commercial buildings (Figure 14).

[83] Preisler A., "Final Report – Publishable Part", European Project nº TREN/05/FP6EN/SO7.54855/020094, Reduction of costs of Solar Cooling systems, June 2008.

Figure 13: The Ipswich Hospital thermal solar collector field

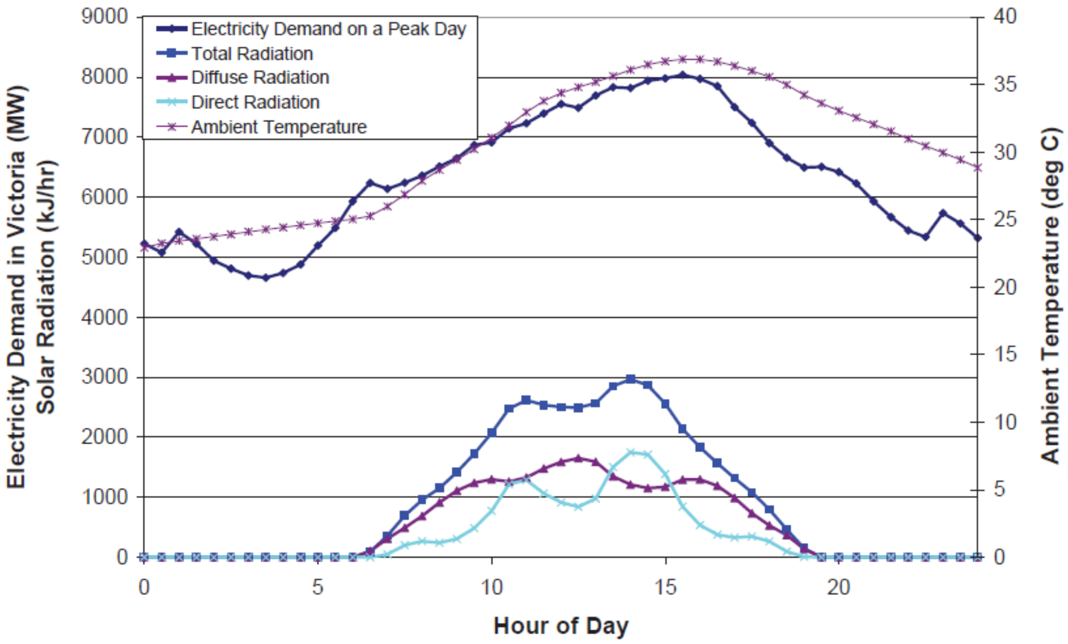


Figure 14: Correlation between cooling demand, solar availability and electricity grid stress[84]

[84] http://ret.gov.au/energy/Documents/cei/acre-sub/054-AustralianSolarCoolingInterestGroup.pdf.

Appendix C. Emissions reduction due to cogenerations and trigeneration

Cogeneration in Melbourne

Emissions	Balance	Base case	Cogen
Fuel	100%		55.3
Waste	15%		
Power	30%	100.9	
Heat	55%	33.8	
Total		**134.7**	**55.3**
Reduction		59%	
Intensity (kg/GJ)		71.69	

Thermal efficiency of the NG heater 90%

The emissions due to the fuel displaced by the waste heat assume that the NG is burnt in a heater with a given thermal efficiency to produce the same amount of heating as the Cogen waste heat stream

The emissions that are assigned to the electricity are the emissions from the Cogen fuel less the emissions due to the avoided gas consumption. Note that this is a different approach than is used for NABERS.

Emissions factors	Scope 1	Scope 2	Scope 3
Natural gas (kg/GJ)	51.3		4
Electricity (kg/kWh)		1.21	
Electricity (kg/GJ)		336.38	

Emissions factors come from the 2011 NGA Factors handbook

Trigeneration in Brisbane

Emissions	Balance	Base case	Cogen
Fuel	100%		59.9
Waste	15%		
Power	30%	73.4	
Heat	55%	29.0	
Total		**102.4**	**59.9**
Reduction		41%	
Intensity (kg/GJ)		103.07	

CoP of the mechanical chiller 3.25

CoP of the absorption chiller 0.70

The emissions due to the electricity displaced by the absorption chiller are equal to the available waste heat times the coefficient of performance (CoP) of the absorption chiller (which gives the cooling duty), divided by the CoP mechanical chiller.

The emissions that are assigned to the electricity are the emissions from the Trigen fuel less the emissions due to the avoided electricity consumption by the mechanical chiller. Note that this is a different approach than is used for NABERS.

Emissions factors	Scope 1	Scope 2	Scope 3
Natural gas (kg/GJ)	51.3		8.6
Electricity (kg/kWh)		0.88	
Electricity (kg/GJ)		244.64	

Emissions factors come from the 2011 NGA Factors handbook

Appendix D. Forecast of energy used by the residential sector in Australia

The most recent comprehensive report on energy use trends in the residential sector is the DEWHA baseline report (Energy Efficient Strategies, 2008) released in 2008 and addressing energy trends in Class 1 and Class 2 buildings. Important aspects in this study, in terms of the potential for distributed generation, lie in the addition of new homes to Australia's housing stock, the types of new properties (and their location), and the expected energy usage characteristics of these homes.

The baseline report gives data on the forecast number of new homes entering the housing stock from 2012 to 2020, as shown below.

Table 17: Occupied housing additions: cumulative new stock by state and territory[85]

Year	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
2012	48400	38000	50000	8800	21500	2700	1400	2300	173200
2013	96400	76100	100200	17600	43100	5300	2800	4600	346200
2014	144500	114300	150800	26300	64800	7900	4200	6900	519900
2015	192900	152600	202200	35000	86700	10500	5700	9200	695000
2016	241200	190800	253900	43500	108600	13000	7100	11500	869900
2017	289200	229000	305700	51900	130400	15400	8500	13700	1044200
2018	336600	266700	357400	60000	152200	17600	9900	15900	1216800
2019	384000	304300	409300	68100	174100	19900	11300	18100	1389600
2020	431300	341900	461500	76100	195900	22100	12700	20300	1562500

New housing can be described as detached (single or 2-storey generally), semi-detached or low and high rise apartments. The baseline report uses the following split of new homes into these three categories to 2020, which was taken as the average in each state and territory between 2001 and 2005.

Table 18: New housing by type – all states and territories 2012 to 2020

Dwelling Type	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Detached	51.9%	72.5%	66.7%	80.6%	82.3%	90.5%	54.8	51.3%	67.1%
Semi-Detached	16.7%	11.9%	12%	13.7%	10.1%	7.5%	16.2	8.4%	13%
Apartment	31.5%	15.6%	21.3%	5.7%	7.6%	2.1%	29%	40.3%	19.9%

[85] (Energy Efficient Strategies, 2008).

This means that by 2020 the numbers of each type of housing built in each state and territory will be approximately as shown below.

From 1990 to 2020 the major trends in energy consumption by end-use can be summarised as follows:

- A significant increase in the share of energy use by electrical appliances (share increase from 24% to 36%).
- A significant increase in the share of energy use for mains gas space heating (share increase from 16% to 25%).
- A significant decrease in the share of energy use for wood space heating (share decrease from 21% to 8%).
- A significant decrease in the share of energy use for electrical water heating (share decrease from 16% to 8%).
- A significant increase in the share of energy use for electrical space cooling (share increase from 1% to 4%).

These trends are illustrated in the graph below, from the DEWHA baseline report.

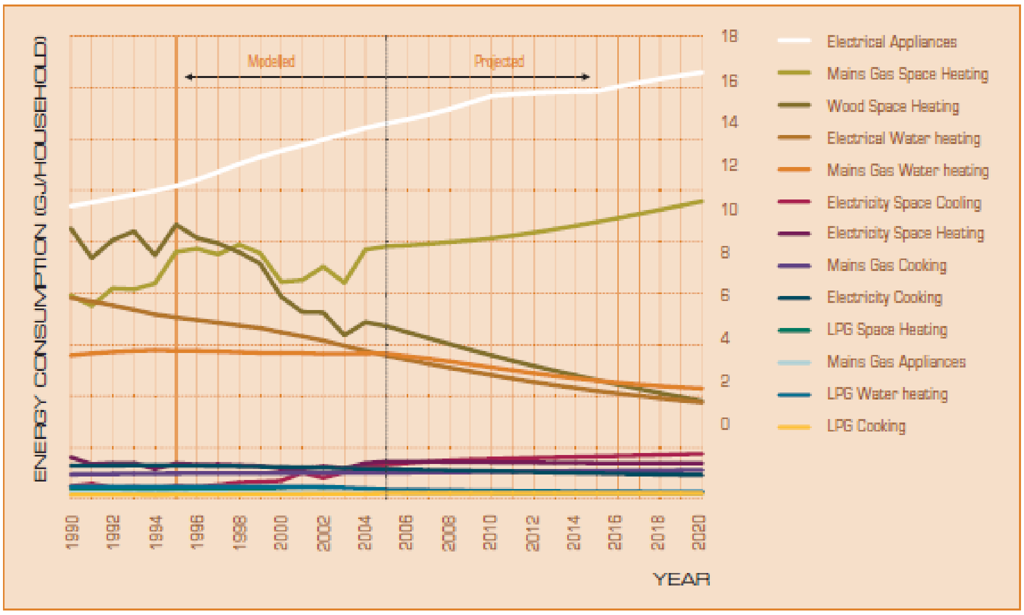


Figure 15: Trends in major end-use energy per household86

Other trends that are useful and apply across the whole of the housing stock include:

- Energy use per household is expected to decline, though energy use per person will increase to 2020. This highlights a rising trend towards fewer occupants per home.
- The overall trend for fossil-fuel driven water heating is downwards, reflecting the rise in solar water heating systems, and this may be particularly the case in new housing developments.

[86] From (Energy Efficient Strategies, 2008).

- Space heating demand growth is occurring in ducted gas systems far ahead of other devices. Along with appliances, gas space heating is the only major category of energy using devices forecast to rise in the period to 2020.
- Overall thermal energy performance is trending downwards, and is expected to reach 150 MJ/m^2 by 2020, from a current level of around 200 MJ/m^2 for the whole stock.
- Electricity use for traditional appliances like freezers, refrigerators, lighting, washing machines, microwaves, dryers and the like is steady or declining, while electricity use by often intermittently-used devices like televisions and computers is rising dramatically.
- Standby power is also forecast to rise dramatically, however MEPS and/or voluntary measures may see both this and television trends reduce somewhat from present forecasts.

Driving some of these trends, continuing changes to the NCC mean that, from May 2011, new homes in most states and territories must meet a minimum 6 star energy rating (or equivalent), and energy efficiency standards will apply to lighting and hot water systems. The take up of the 6 star requirement has happened at various speeds across the states and territories, and as such TAS, NT and NSW have not yet adopted it.

The relevant forecast for the electricity used by the residential sector that was presented in the baseline report is in

Table 19: Forecast electricity demand for the residential sector[87]

Year	Electricity demand (PJ)
2011	216.1
2012	218.8
2013	221.4
2014	224.1
2015	226.6
2016	230.6
2017	234.7
2018	238.6
2019	242.6
2020	246.4

The rise in demand from 2012 to 2020 is 30.3 PJ or 8,400 GWh.

[87] From (Energy Efficient Strategies, 2008).

Appendix E. Forecast of energy used by the commercial sector in Australia

In this section, estimates for the past studies of the commercial sector include a baseline study for the Australian Greenhouse Office (EMET 1999)[88]. This study has been used to inform a range of studies relating to energy policy and efficiency within the commercial sector. It is however, out of date and alternate sources must be used. One such source is a study carried out for DEWHA (CIE, 2009) that forecasts new floor area and energy use in a range of commercial sub-sectors from 2009 out to beyond 2020, with data organised into seven climate zones. The forecast new floor area from 2013-2020 (inclusive) from this model is summarised below.

Commercial Stock	Total additional m^2
Accommodation	7,060,000
Education	4,267,000
Entertainment and recreation	616,000
Health and aged care	2,918,000
Offices	5,346,000
Other commercial	2,052,000
Retail/wholesale trade	5,490,000

This new commercial sector floor area represents a 9.1% increase over the 8-year period. This growth represents a simple growth rate of 1.13% per year. So starting from a reported electricity consumption of 61.5 TWh of electricity in 2009-10 (ABARES, 2011) and assuming that the growth in electricity consumption of the commercial sector is in proportion to the growth in area, then electricity consumption in 2020 will be a further 6.3 TWh/year above the consumption at the start of 2012.

[88] 1999, Australian Greenhouse Office: Baseline Study of Greenhouse Gas Emissions from the Commercial Buildings Sector with Projections to year 2010. Prepared by EMET Consultants Pty Limited and SOLARCH GROUP, May 1999.

Appendix F. International regulations driving ZLEG and zero energy buildings

Europe

European countries have a range of robust policies driving the development of low or net-zero-energy buildings. As reported by the European Council for an Energy Efficient Economy (ECEEE) [89] the EU's 2002 "Energy Performance of Buildings Directive" (EPBD) was updated and adopted in 2010. A highlight includes the strengthening of the energy performance requirements of new buildings across the EU, and specifically by 2020, all new buildings to be "nearly zero energy" (and even sooner for public buildings, by the end of 2018).

Though not quantitatively defined, a qualitative definition for "nearly zero energy building" (or NZEB) is a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby. The approach towards the energy and emissions performance of buildings in Europe at this time is more oriented towards outcomes, e.g. in terms of CO_2 emissions per m^2 of building area, or to zero / net-zero emissions, rather than a focus on specific technologies or supply.

The ECEEE paper[90] looks at how various EU countries, and other jurisdictions outside the EU are progressing towards this directive, or other targets as applicable. For EU countries with commitments or proposals to adopt low / zero energy building codes, their targets are expressed as shown below:

Table 20: Policy standards applicable to new buildings in Europe

Country	Target
Denmark	75% by 2020 (c.f. base year 2006)
Finland	Passive house standards by 2015
France	By 2020 new buildings are energy-positive
Germany	By 2020 buildings should be operating without fossil fuel
Netherlands	Energy-neutral by 2020 (proposed)
Norway	Passive house standards by 2017
UK (England and Wales)	All new houses to be zero carbon as of 2016

The situation in several major European countries is now described, starting with Germany.

[89] 2011, Steering through the maze #2, Nearly zero energy buildings: achieving the EU 2020 target. European Council for an Energy Efficient Economy; updated 8 February 2011.

[90] Ibid.

Germany

Due to its large size and strategic location, Germany has a great impact on energy policy in Europe. In 2010 the German Federal Government announced a “National Renewable Energy Action Plan”, which requires major increases in the share of renewable energy in both the gross final energy consumption (18% by 2020 and 60% by 2050), and in the gross final electricity consumption (35% by 2020 and 80% by 2050)[91]. Germany is also seeking a reduction in primary energy consumption of 20% by 2020 and 50% by 2050 (compared with 2008).

Energy efficiency in buildings plays a major role in German energy strategy and is well integrated into the country’s cultural and economic fabric. In 2011, Germany had roughly 17.8 million buildings, 40% of which were built between 1948 and 1978 and therefore the greatest potential to save energy is offered by existing buildings: The current renovation rate of buildings is 1% per year.

The Deutsche Energie-Agentur GmbH (dena - the German Energy Agency) is the centre of expertise for energy efficiency, renewable energy sources and intelligent energy systems. With its recent ‘Efficient Homes’ project, dena showed how the existing potential for savings can be increased and highly energy-efficient refurbishment carried out, ultimately benefiting owners, tenants and the climate. Since 2003 more than 450 buildings have been refurbished to demonstrate potential energy savings. These buildings use 50 per cent less energy than required by Germany's energy saving regulations (EnEV) applying to comparable new buildings. As of 2011, the Efficient House Plus project[92] will be used to set out the principles for future climate-neutral new build and refurbishment standards. The following targets in the German energy strategy relate to building energy efficiency[93]:

- Building stock shall become nearly climate neutral by 2050;
- Heat demand of buildings shall decrease by 20% by 2020;
- Primary energy demand shall decrease by 80% by 2050;
- Double the renovation rate (from 1% to 2% p.a.); and
- Increase the share of renewable heat significantly.

United Kingdom

In the UK, progress towards targets includes a three-stage hierarchical approach, namely:

1. Ensuring an energy efficient approach to building design;
2. Reducing CO_2 emissions on-site via low/zero carbon technologies and heat networks;
3. Mitigating the remaining carbon emissions with a selection of allowable solutions, which may include:
    - further carbon reductions on site beyond the regulatory standard;
    - energy efficient appliances installed as fittings within the home;

[91] The European Commission’s Renewable energy webpage contains details of the various National Renewable Energy Action Plans. See http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm.

[92] http://www.dena.de/fileadmin/user_upload/Publikationen/Gebaeude/Dokumente/FS_Niedrigenergiehaus_englisch.pdf.

[93] Felicitas Kraus, Head of Division International Cooperation “Pilot Project, Efficient Homes Paris, 02.02.2011.

- advanced building control systems which reduce the level of energy use in the home;
- exports of low carbon or renewable heat from the development to other developments;
- investments in low and zero carbon community heat infrastructure; and
- other allowable solutions remain under consideration.[94]

Quantitative CO_2 targets for new homes generally reflect these, although they have been made slightly less ambitious than was contemplated with the above approach originally (with 70% of target to be met by regulated approaches under 1 and 2 above).

The UK's commitment to heat networks / community heat infrastructure can perhaps be evidenced by the example of the Woking borough near London, as highlighted by the City of Sydney[95]. Woking achieved an 80 per cent reduction in carbon emissions using cogeneration, trigeneration, energy efficiency and renewable energy over 14 years. Also, by 2008 London had installed or given planning consent to more than 600 megawatts of co-generation and trigeneration systems.

Following are a number of polices and initiatives in place in the UK.

- The Merton Rule is a planning policy, introduced by the London Borough of Merton in 2003[96]. It requires first, the use of energy efficiency measures, and then on-site renewable energy to reduce annual CO_2 emissions. Originally the rule required all new buildings to achieve 10% on-site renewable energy for developments of more than 10 dwellings or a building area of more than 1000m^2. In 2008, the UK government published its central planning guidance Planning Policy Statement - Planning and Climate Change - PPS1 that requires all UK local planning authorities to adopt a "Merton rule" policy. The Planning and Energy Act 2008 enables all councils in England and Wales to adopt a Merton Rule as well as specify energy efficiency standards over and above that of building regulations.
- The Code for Sustainable Homes[97] has been developed to promote change in sustainable building practice for new homes. It has been prepared by the UK Government in close working consultation with the Building Research Establishment (BRE) and Construction Industry Research and Information Association (CIRIA), and through consultation with a Senior Steering Group consisting of Government, industry and NGO representatives. The Code is intended as a single national standard to guide industry in the design and construction of sustainable homes. It is a means of driving continuous improvement, greater innovation and exemplary achievement in sustainable home building. The Code uses a sustainability 'star' rating system to communicate the overall sustainability performance of a home. A home can achieve a sustainability rating from 1 to 6 stars depending on the extent to which it has achieved Code standards. 1 star is the entry level, which is above the level of the Building Regulations; and 6 stars is the highest level, reflecting exemplar development in sustainability terms. The Code is mandatory for publicly-funded new homes.

[94] http://www.zerocarbonhub.org/resourcefiles/ZCH-Defining-A-Fabric-Energy-Efficiency-Standard-Task-Group-Recommendations.pdf.

[95] 2010, Green Infrastructure for Sydney, Trigeneration – the International Perspective, www.sydney2030.com.au. This paper also noted that while just 5% of Australia's energy comes from decentralised sources. Corresponding figures are 20% in Germany, 40% in Holland and 55% in Denmark.

[96] See http://www.merton.gov.uk/environment/planning/planningpolicy/mertonrule.htm.

[97] "Code for Sustainable Homes: A step-change in sustainable home building practice" available from www.communities.gov.uk.

- Building Research Establishment Environmental Assessment Method (BREEAM) is a voluntary measurement rating for green buildings that was established in the UK by the Building Research Establishment (BRE). Since its inception it has grown in scope and geographically, being exported in various versions worldwide. In several countries (e.g. UK, Netherlands, Spain) National Scheme Operators operate country specific versions of BREEAM. Where there is no National Scheme Operator, BREEAM Europe Commercial (applicable to retail, office and industrial buildings only) or BREEAM International Bespoke is used. BREEAM uses a straightforward scoring system to evaluate a building's specification, design, construction and use. The measures used represent a broad range of categories and criteria from energy to ecology. They include aspects related to energy and water use, the internal environment (health and well-being), pollution, transport, materials, waste, ecology and management processes.

North America

In both the USA and Canada it is up to the states to set and enforce minimum standards for energy efficiency in buildings. The energy efficiency requirements for buildings vary substantially over the North American continent. Most states have implemented regulations based on the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) standards for commercial and larger residential buildings and the International Energy Conservation Code (IECC) codes for small residential buildings[98].

Many states have chosen levels based on the recent levels in ASHRAE and IECC while other states have based the regulations on older versions of these standards or set standards at a lower level. Some states have chosen to take the energy standards further than the ASHRAE and IECC codes, which is the case for California and Florida where substantial resources have been used to develop individual energy efficiency standards. Both the US and Canada provide web homepages with information on the standards in individual states.

In the USA, the Government's Building America[99] program is focused on research and promotion of the drive towards zero energy buildings. Some states have begun to set out their ambitions towards NZEB: California has committed to achieving zero net energy for all residential construction by 2020, while Massachusetts plans to achieve NZEB for all buildings by 2030.

In the USA and Canada a specific standard Leadership in Energy and Environmental Buildings (LEED) is set up, setting the requirements for the buildings to fulfil. The LEED standard can be obtained on different levels; certified, silver, gold and platinum, with increasing requirements for the different requirements for the building. The LEED standard is set and controlled by the US Green Building Council (USGBC). The LEED standard includes sustainable sites, water efficiency, energy and atmosphere, material resources, indoor climate, innovation and design. Energy and atmosphere is the most important criteria for the buildings. In connection to the LEED buildings ASHRAE is developing a special standard for the design of high-performance buildings (ASHRAE standard 189P) which will lead to further stringency of the LEED requirements in USA.

[98] Details can be found at http://www.energycodes.gov/.

[99] Building America - Resources for Energy Efficient Homes, www1.eere.energy.gov/buildings/building_america.

Japan

The Japanese regulations have lead to very high energy efficiency in appliances and other equipment installed in buildings. As well the building codes, the supporting initiatives promote the development of very efficient installations. In the building regulations the Coefficient of Energy Consumption (CEC) values are set for HVAC systems in general and for the individual parts. Energy efficiency in installed products is also highly promoted through the labelling standards and the top runner schemes, which has lead to highly efficient appliances in general.

China

China has issued a series of national and industrial codes to promote building energy efficiency, including three design standards for residential buildings in different parts of China (published in 1995, 2001 and 2003, respectively) and one design standard for public buildings (2005). In addition, China has developed standards for lighting design in buildings (2004).

Korea

The rapid economic growth associated with industrialisation in the last three decades has resulted in a sharp increase in power and energy demand in Korea. To cope with this, the government has been actively involved in adopting ways and means for using energy more efficiently, conserving energy through recovery of waste energy, supplying reliable energy at low cost, and supplying energy more effectively in a decentralised manner to industrial zones and satellite cities. A major outcome of these efforts has been the widespread development of cogeneration in Korea since the 1980s. This is proven by the fact that the share of power generation of cogenerated plant over the total generating capacity has sharply increased from 4.6 per cent in 1985 to 20 per cent in 1995.

The Ministry of Commerce, Industry and Energy (MOCIE), through Korea Energy Management Corporation (KEMCO), operates three energy efficiency programs to facilitate products embodying low energy input. These three programs are ‘Energy Efficiency Standards and Labelling Program, ‘Certification of High Efficiency Energy-using Appliance Program’, and the ‘Energy-Saving Office Equipment and Home Electronics Program’. The objective of these programs is to stimulate manufacturers to improve their products' efficiency by giving incentives and to induce consumers to purchase more energy efficient products available in the market place.

Considerations for Zero Energy Buildings

In 2008, the International Energy Agency (IEA) detailed the importance of energy efficiency requirements in building codes or standards (Laustsen, 2008). This paper stated that:

"Energy efficiency requirements in building codes can ensure that concern is taken for energy efficiency at the design phase and can help to realise the large potentials for energy efficiency in new buildings... Given the long lifespan of most buildings, the relative energy efficiency of new buildings will influence energy consumption for many years. Construction of buildings offers compelling opportunities for energy efficiency, as decisions made during a building's design phase entail smaller costs with greater potential energy savings relative to later intervention."

With the implementation, both internationally and locally, of more stringent energy efficiency requirements in building codes, standards and regulations, there has been extensive documentation and research surrounding the definition of a 'zero or low emission building'. A building itself may be considered a zero or low emissions building, however this status may be achieved through a combination of building design and the incorporation of zero and low emission energy generation technologies.

The European Council for an Energy Efficiency Economy (ECEEE) provided updated analysis and summary on approaches by EU member states (and non-member states as referenced) towards zero-energy buildings (ECEEE, 2011). The ECEEE study reproduced the pathway towards a Zero Energy Home as envisaged by Building America. This is relevant to the current study as it clearly flags the role of both energy efficiency and zero emissions generation in attaining a zero energy building.

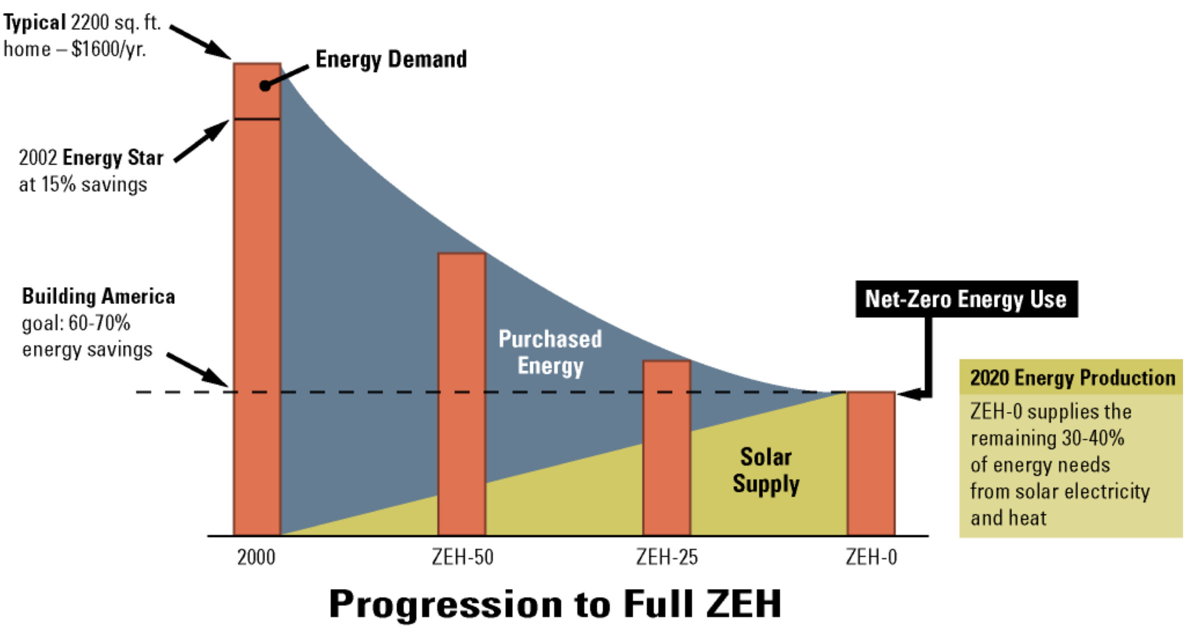


Figure 16: The pathway towards a Zero Energy Home

There are two issues that are relevant to the crafting of a definition of zero / low energy generation. The trajectory proposed in Figure 16 assumes that embedded energy generation is zero emissions, and secondly (and more importantly) that the definition of zero emissions does not consider lifecycle or embedded emissions but only operational emissions. In fact, the definition of a net zero energy building was taken to be:

> *"A net zero energy building is where, as a result of the very high level of energy efficiency of the building, the overall annual primary energy consumption is equal to or less than the energy production from renewable energy sources on site".*

This issue was examined in more detail by the Australian Sustainable Built Environment Council (ASBEC) in a report that examined the definition for a zero emissions building (Riedy, Lederwasch, & Ison, 2011). The ASBEC report sought a common ground on a suitable definition for zero emissions buildings, thus providing a baseline with consistent language to assist stakeholders to progress Australian homes towards zero emissions. The report details types of renewable energy generation which could be included in emissions calculations, both on-site and off-site.

Figure 17 shows the conceptual framework for building emissions. This report will consider emissions during use and in particular the building emissions. Occupant emissions will be considered in the context of any relationships between the building manager and the occupants.

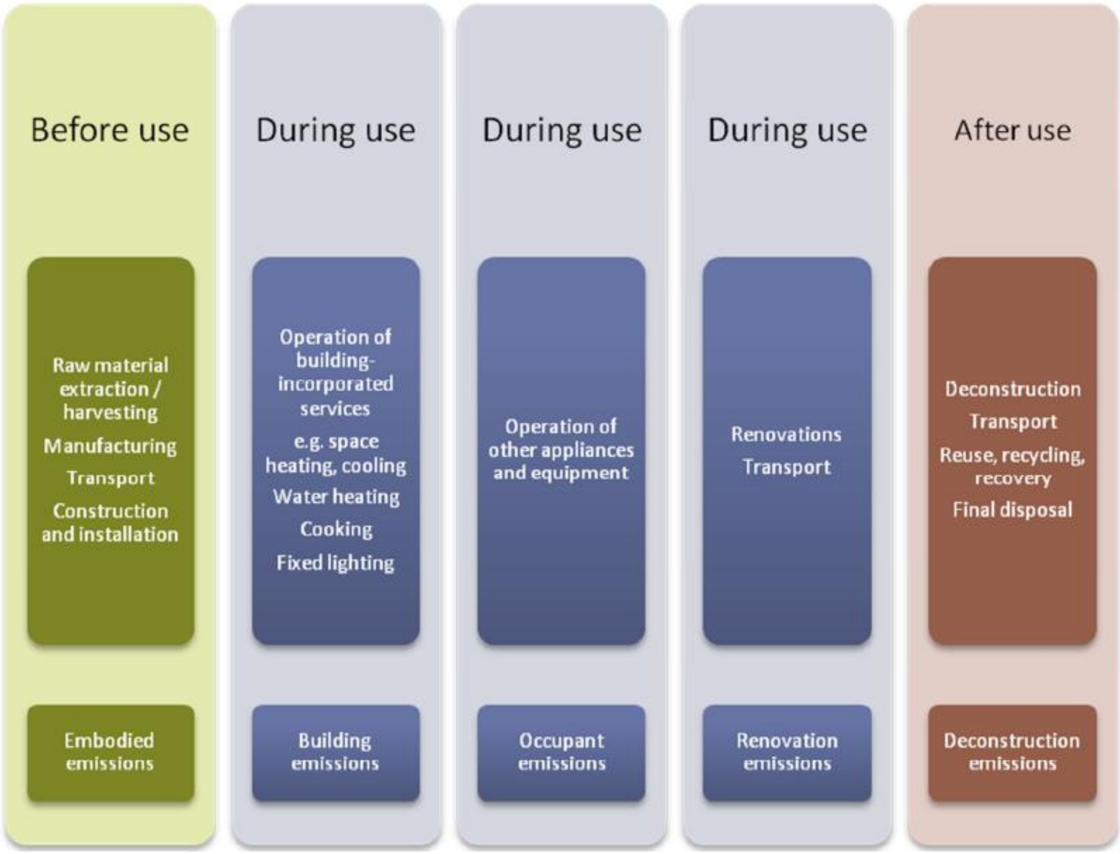


Figure 17: Conceptual framework of building life cycle[100]

[100] (Riedy, Lederwasch, & Ison, 2011), adapted from the United Nations Environment Programme's Common Carbon Metric.

The next question to be considered is the special boundary, and this has been well covered in the literature. Marszal et al (2011) (Marszal, Bourrelle, & Musall, 2010) proposed the following classification for supply options to a zero emission building.

Table 21: On-site energy generation options

On-site Generation Option	Example
Energy generation as part of the building footprint	Solar PV power generation, Solar Hot Water, heat pumps and on-building wind generation
On the land title of the building	Solar PV power generation, Solar Hot Water, low-impact hydro and on-site (but not building) wind power
Energy generation as part of the wider building development, if a building is supplied by a private wire	Solar PV power generation, Solar Hot Water, low-impact hydro and wind
Renewable energy resources produced off site but imported to generate energy onsite	Biomass, wood pellets, ethanol, processed waste and potentially gas (or biomass) fired combined heat and power system

Table 22: Off-site energy generation options

Off-site Generation Option	Example
Investing in renewable energy or low carbon projects through a fund	Investing in a zero or low emissions project and signing a contract for use of that generated energy over a specified time period
Direct purchasing green energy	Green Power Scheme
Market based carbon purchase	Carbon Trading Scheme or accredited carbon offset scheme

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