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Literature Review

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P6: The Intelligent Grid in a New Housing Development

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Disclaimer

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Executive Summary

Growing energy demand in all sectors has resulted in unprecedented reliance on fossil-based non-renewable energy resources with consequent escalation of greenhouse gas emissions. Household energy consumption is predicted to increase by 56% from 299 PJ in 1990 to 467 PJ in 2020. There is considerable reluctance to adopt energy efficiency features and distributed generation in residential buildings due to the lack of hard evidence of the impact of demand side management and distributed generation and a lack of integrated technical and socio-economic evaluations. The University of South Australia (UniSA) Intelligent Grid Project will be investigating the impacts of the introduction of distributed energy on energy use, greenhouse gas emissions and consumer energy awareness. The research also investigates the issues of ownership and control of distributed energy resources (i.e. local generation and loads) in residential houses, occupants' attitude towards this new type of energy generation and how modelled behaviour translates to real behaviour. Research on low energy housing has started to gain momentum worldwide; standard and benchmarks for energy and sustainability have been developed in Australia (NatHERS) and abroad (LEED for Homes, MINERGIE-P®, PassivHaus). Low energy housing projects have been realised in a number of countries such as Austria, Denmark, France, Germany, Sweden and Australia. Research on relationships between energy use and policy and people behaviour has been initiated in many parts of the world albeit in early stages. The report reviews current low energy housing project and impacts of the use of distributed energy on the electrical grid.

Abbreviations

ACTHERS - ACT House Energy Rating Scheme
BASIX – Building Sustainability Index
BCA – Building Code of Australia
CEPHEUS – Cost Efficient Passive House as European Standards
CGW- Concern about global warming
DER- distributed energy resources
ERA – Energy Reference Area
HVAC – Heating, Ventilating and Air Conditioning
LEED – Leadership in Energy and Environmental Design
NatHERS – Nationwide House Energy Rating Scheme
NEP - New Environmental Paradigm
QOL – Quality Of Life
USGBC – US Green Building Council

Key Words

Sustainable housing, green village, energy rating, star rating, greenhouse gas emissions, smart metering, distributed generation, distributed energy resources, grid connected solar

1 Introduction

Growing demand for energy in all sectors of human activity has resulted in unprecedented reliance on fossil-based non-renewable energy resources with consequent production of greenhouse gas emissions. The residential housing sector represents 20% of Australia's greenhouse gas emissions and is largely responsible for the escalating peak electrical demand. A recent study by the Department of Environment, Water, Heritage and Arts - DEWHA (2008) indicates that an increase of 61% of occupied residential household from 6 million to 10 million is expected to occur between 1990 and 2020. Total residential floor area is also expected to increase by 145%, from 685 million m^2 to 1682 million m^2 for the same period. Household energy (electricity, gas, LPG and wood) consumption is predicted to increase by 56% from 299 PJ in 1990 to 467 PJ in 2020.

The study also presents an interesting finding, namely a 6% decline in energy consumption per household in 2020 compared to the 1990 levels. The reason for this, according to the study, is various energy programs directed to increased efficiency of domestic appliances and the building shell.

However there is considerable reluctance in justifying the use of energy efficiency features and distributed generation in residential buildings. This arises because of the lack of hard evidence of the impact of demand side management and distributed generation on energy use and demand pattern and a lack of integrated technical and socio-economic evaluations.

The University of South Australia (UniSA) Intelligent Grid Project aims at investigating the impacts of the introduction of distributed energy on energy use patterns, greenhouse gas emissions, the electrical grid and consumer energy awareness. The research also investigates the issues of ownership and control of distributed energy resources (i.e. local generation and loads) in residential houses, occupants' attitude towards this new type of energy generation and how modelled behaviour translates to real behaviour and under different circumstances.

The focus of the research is The Lochiel Park Green Village, a housing estate developed and managed by the South Australian Land Management Corporation. This is a state of the art sustainable housing development being built with systems to both allow intelligent grid interaction and monitor energy use patterns. The Lochiel Park Green Village comprises 106 homes being built using a range of environmental sustainability features. In the energy area, the Village target is a 66% reduction in energy use and a 74% reduction in consequent greenhouse gas emissions in comparison with the average Adelaide household. The reductions are being achieved through the use of the following features:

- optimising allotment design to maximise benefits from environmental elements
- reducing building energy requirements through passive design (7.5 star rating, minimum)
- specified energy efficient appliances for heating and cooling

- use of renewable energy (1kW photovoltaic system per 100m² of living area)
- installing electricity load limiting devices
- special bundled tariff incorporating green power
- smart metering and energy usage display
- solar hot water systems (gas boosted)

Many other innovations will be utilised in specific homes with some being designed as net zero energy homes.

This report presents an overview of research activities both locally (Australia) and around the world in relation to low energy housing. An overview of a number of existing sustainability rating tools available in various countries and locally with particular reference to energy performance is presented. A number of examples of low energy housing projects or developments around the world are also presented to provide insight into the activities occurring worldwide in this area. Examples of interaction between distributed generation and the electrical grid are also discussed.

2 Low Energy Housing - Definition and Benchmarks

This section reviews the definitions and benchmarks applied to Low Energy Housing adopted in a number of countries. In addition, a number of low energy houses built will be reviewed.

2.1 DEFINITION

Wikipedia defines a low energy house as 'any type of house that uses *less energy* than a regular house'. The energy consumption of 'regular house' in the above definition differ from one location to another and is dependent on the climatic conditions, number of residents and other conditions specific to the location. Previous analysis of the factors affecting them energy consumption of South Australian housing has been performed by UniSA (Oliphant, M, 2003). This section lists some of the energy rating schemes developed in US, Germany, Switzerland and Australia to provide a means for benchmarking.

2.2 BENCHMARKS

2.2.1 LEED, United States

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System was developed by the U.S. Green Building Council (USGBC) to provide a sustainability benchmark for the design, construction and operation of high performance green buildings. LEED Rating systems are available for different types of buildings (homes, existing buildings, schools, retail, health care, etc.). In the LEED scheme, building energy performance is only one of the categories which need rating; others are: innovation and

design process, site sustainability, water efficiency, materials and resources, indoor environment quality and awareness and education (US Green Building Council Website, 2008).

For the energy performance, the LEED® for Homes Rating Systems manual lists some prerequisites and minimum point requirements for homes as shown in Table 1.

Table 1 – Prerequisites and Minimum Requirements for LEED® for the Home Rating System

Credit category	Prerequisites (mandatory measures)	Minimum point requirements	Maximum points available
Innovation & Design process (ID)	3	0	11
Location & Linkages (LL)	0	0	10
Sustainable Sites (SS)	2	5	22
Water Efficiency (WE)	0	3	15
Energy & Atmosphere (EA)	2	0	38
Material & Resources (MR)	3	2	16
Indoor Environment Quality (EQ)	7	6	21
Awareness & Education (AE)	1	0	3
Total	18	16	136

As seen, although the minimum point requirements set for the Energy & Atmosphere (EA) criterion is nil, the prerequisite is 2, which means that certain measures are mandatory. These prerequisites are: basic insulation, reduced envelope leakage, good windows, reduced distribution losses, good HVAC design and installation, ENERGY STAR lights, and refrigerant charge test.

Once scores of each category appearing in Table 1 have been determined, the building performance level is determined from the following 4 certification levels:

Table 2 – *LEED for Home* Certification Levels and Number of Points Required

LEED for Home Certification Levels	Number of *LEED for Home* Points required
Certified	45 – 49
Silver	60 – 74
Gold	75 – 89
Platinum	90 – 136
Total available points	136

2.2.2 PassivHaus, Europe

PassivHaus is an energy benchmark developed by the PassiveHaus Institute Darmstadt, Germany (PaasivHaus website, 2008). The Institute defines the 'Passive House' as: "*a building in which a comfortable interior climate can be maintained without active heating and cooling systems (Adamson 1987 and Feist 1988).*

The PassivHaus concept has now been adopted by 5 European countries (Austria, Denmark, France, Germany, Switzerland) through CEPHEUS (**C**ost **E**fficient **P**assive **H**ouses **E**uropean **S**tandards) – a project involving the construction and scientific evaluation of 250 housing units built to Passive House standards in those countries (CEPHEUS Website, 2008).

In the PassivHaus concept, the house energy consumption is set by following criteria:

- maximum Constant heating load: 10 W/m^2
- maximum space heating requirements: 15 $kWh/(m^2\text{-}a)$
- maximum total amount of active energy input: 42 $kWh/(m^2\text{-}a)$
- maximum total energy requirement for space heating, domestic hot water and household appliances: 120 $kWh/(m^2\text{-}a)$

2.2.3 Minergie, Switzerland

MINERGIE-P® is a low energy label developed in Switzerland in 2002 (Mennel et al., 2007). It entails a massive decrease in heating energy demand (up to 80%) while guaranteeing a high quality of indoor air. MINERGIE-P® essentially adopts the German PassivHaus concept with some adjustment to Swiss conditions.

MINERGIE-P® label requires that the maximum heating demand is 15 kWh/m^2_{ERA} (where ERA is 'energy reference area' or 'conditioned zone'). The second requirement is that the maximum total energy for domestic hot water, auxiliary energy for pumps and ventilation is 30 kWh/m^2_{ERA}. The last requirement is that the outer shell is very airtight (an air change rate less than 0.6/h at 50 Pa pressure difference).

2.2.4 NatHERS, Australia

NatHERS (Nationwide House Energy Rating Scheme) is a scheme for rating the energy performance of houses in Australia. It relies on a computer program which calculates the energy requirement of a house based on its fabric and form alone. It currently does not include the effects of the cooling / heating system performance or other appliances used in the house. This rating system is mandatory for new Australian houses. Currently, NatHERS relies on AccuRate and BERS energy rating software packages developed by CSIRO. The outcome of AccuRate are: (1) a text file containing hourly values of heating and cooling requirements of every zone, and (2) energy rating of the house in terms of number of stars (between 0 – 10) where higher number of stars indicates lower total heating and cooling

requirements for the particular zone (10 star means no external heating or cooling is required).

The star energy rating system has been incorporated into the Building Code of Australia (BCA). From 1 May 2006, all new homes (and alterations to existing homes) in South Australia are required to achieve a 5 star rating. In addition, after 1 July 2006 the following requirement need to be met: (a) 1000 L rainwater tank plumbed to the house, (2) A solar or heat pump water heater or a gas water heater with an Energy Rating label of 2.5 stars or greater. (House Energy Rating website, 2008).

In Victoria, from July 2005, new class 1 buildings are required to achieve a house energy rating (HER) of 5 stars. Furthermore, a solar hot water system producing a minimum energy saving of 50% when installed between 1 July 2004 and 30 June 2005 compared to conventional water heater, and 60% when installed after 1 July 2005 are required (Sustainability Victoria website, 2008).

Australian Capital Territory (ACT) has its own energy rating scheme called: ACT House Energy Rating Scheme (ACTHERS) which conforms to the national benchmark, NatHERS. For Class 1, 2, 3 and 4 buildings (ie Residential – Single detached dwellings and multi-unit developments). The standard required is an ACTHERS 4 star rating (ACT Palling and Land Authority, 2003). ACT has also mandated the disclosure of the house rating when the residence is offered for sale.

According to the House Energy Rating website, all new houses and extensions in Tasmania are required to comply with the 4 star energy rating as calculated by FirstRate, NatHERS, or AccuRate building simulation software. For a building to pass with the local council or certifier, it needs to have either (a) a 4 star certificate from FirstRate or AccuRate; or (b) demonstrated compliance with the BCA 'deemed to satisfy' conditions.

In Western Australia, new houses built after 1 September 2007 must meet minimum standards for energy and water efficiency: 5 Star Plus. This scheme "*builds on the energy efficiencies of 5 Star and adds the benefits of water reduction measures for homes right across the State. 5 Star Plus is based around two new building codes, the Water Use in Houses Code and the Energy Use in Houses Code which help to improve the water and energy efficiency of new homes*." (Department of Housing and Works Website, 2008).

New South Wales has its own sustainability rating tool called BASIX (Building Sustainability Index). The BASIX was introduced "*to ensure that all new homes that are built are more energy efficient and use less water*". BASIX is an online computer software to determine the energy and water performance of buildings. Thermal comfort is also one of BASIX rating elements as shown in Figure 1 (Greenview Consulting Website, 2008).

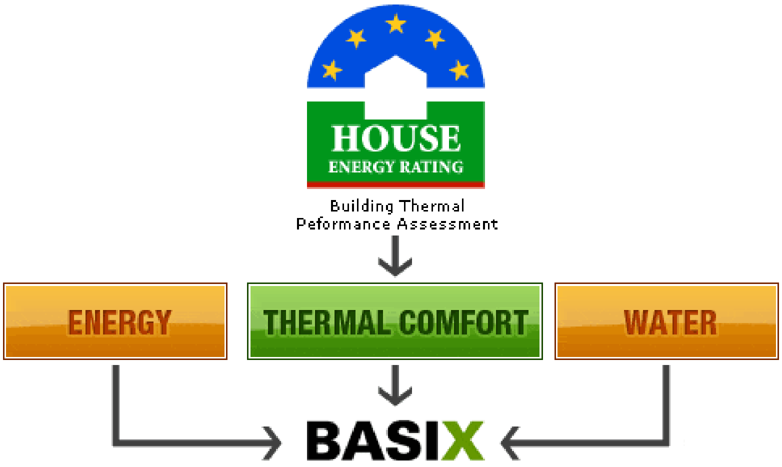

Figure 1 – Elements of BASIX rating

BASIX goes beyond the heating and cooling energy needs. Areas assessed in the Energy Section are: hot water, heating and cooling, ventilation systems, natural lighting, artificial lighting, pool and spa, alternative energy and appliances. In the Water Section, the assessed areas are: landscape, fixtures, rainwater tank, stormwater tank, greywater / wastewater reuse and pool and spa. However, BASIX overall rating is based on subjective weighting factors for various elements involved in the calculation.

2.3 Overview of some Low Energy Housing Projects

Several local governments in a number of countries have been setting energy consumption targets, developing low energy housing estates and / or setting up guidelines for achieving low energy housing. Some examples are described below:

2.3.1 City of Freiburg, Germany

The City Council of Freiburg, Germany, developed the "Low Energy Housing Construction" project in which "new, energy-efficient housing construction standards" are incorporated into all lease and purchase contracts (EAUE Website, 2008). The new policy, which came into effect in June 1992, mandated the reduction of household energy consumption. Specifically the policy sets the maximum heating energy at 65 kWh/m^2-yr. With this, only houses satisfying this requirement can be built in the jurisdiction of Freiburg City Council. This is a considerable reduction, keeping in mind that typical houses in Germany consume 220 kWh/m^2-yr. Freiburg is considering a new law limiting the heating energy requirements to 55, 50 or even 40 kWh (Post Carbon Cities Website, 2008).

The cost associated with achieving this goal is around 3 – 8% of the total construction cost. For a single family house, this translates into an additional construction cost of US$ 12,883. For the same house an estimated annual savings is 19,000 litres of heating oil and reductions

of 6.5 kg SO_2, 3.4 kg nitrogen, 3.1 kg carbon, 0.3 kg hydrocarbon, 0.001 kg dust and 5 tons CO_2.

2.3.2 Vitali-Velti House, Switzerland

Pahud et al (2001, 2002) report on the thermal performance monitoring of two low energy houses built in the village of Monte Carasso, Switzerland, called: "Vitali-Velti" house (Fig. 1). The houses (A and B) have massive construction, with 260 m^2 and 234 m^2 heated floor areas, respectively, and external walls insulated with 15 to 18 cm insulation. Thermal bridges are minimal. They have air controlled ventilation with heat recovery and large windows mounted in south-east façade (Fig. 2).

Figure 2 – South-east and north-west façade of the Vitali-Velti house

The low energy target is achieved through improved building envelopes, installation of heat recovery ventilation units, solar hot water systems and avoidance of installation of conventional heating systems.

The one year monitoring conducted showed that, generally indoor air temperatures are within thermal comfort limits, i.e. below 26.5°C in summer and above 19°C in winter. Indoor air quality measurement (CO2 concentration) also showed that the minimum requirements for hygienic air conditions were achieved.

The heating demand for house A was 56 MJ/m^2-a and 64 MJ/m^2-a for house B. The higher annual heating demand of house B was attributed to lower passive solar gain (due to smaller windows compared to house A which has large window in the south-west facade).

Although the energy performance of house B failed to achieve *PassivHaus* requirement (of 15 kWh/m^2-a = 54 MJ/m^2-a), it is still better than Freiburg city low energy houses (65 MJ/m^2-a).

2.3.3 Terraced Houses, Sweden

Papers by Isaksson & Karlsson (2006) and Karlsson & Moshfegh (2007) report on detailed interdisciplinary investigation on 20 low energy terraced houses constructed south of Gothernburg, Sweden. Each house consists of a kitchen, living room and toilet in the groud floor and three bedrooms and a bathroom on the upper floor. Each house has a total floor area of 120 m^2 including 60 m^2 ground floor area, with ground floor-ceiling height of 2.5 m and upper floor ceiling height ranging from 2.2 – 4.3 m. The low energy target of the houses is achieved through reliance on emission of heat from appliances, occupants' body heat and solar radiation. However, on cold days a 900 W electric heater, integrated into the ventilation system, could be used. In addition, the houses are well insulated and air tight. Domestic hot water is provided by an electric boosted solar system with 5 m^2 collector area. Each house has a skylight which is used for ventilation during summer.

The research found that indoor temperatures in the middle houses were generally within the comfort range compared to those in the gable houses. There were also temperature differences between the floors which were more obvious in gable houses. These resulted in the installation of radiators in each gable house to improve comfort. The occupants' main reliance on local heat sources for heating makes them less affected by power outage. The average annual energy consumption of the middle houses was about 62.5 kWh/m^2 which includes 12.8 kWh/m^2 for comfort heating (without the solar panel, the consumption would increase to about 70.8 kWh/m^2-a). The minimum demand was found to be 49.2 kWh/m^2-a whilst the maximum was 101.7 kWh/m^2-a, reflecting the effects of occupants activities in each house.

2.3.4 CEPHEUS Passive Houses

The CEPHEUS passive houses project aims to construct 250 housing units in five European countries whose energy performances comply with Passive House standards – see Section 2.2.2 (CPHEUS Website, 2008). The project is backed up with scientific evaluation of building operation through systematic measurement programs.

Countries and cities/states involved in this project are Germany (Hannover-Kronsberg and Kassel-Marbachshöhe), Sweden (Göteborg), Austria, France (Rennes Beuregard), and Switzerland (Nebikon/Luzen). General features of the houses constructed under the CEPHEUS projects are listed in Table 3.

Table 3 – General information on the CEPHEUS Passive Houses

	Hannover-Kronsberg	Kassel-Marbachshöhe	Austria	Göteborg	Rennes Beuregard	Nebikon/Luzen
Building type	Terrace house 4 in rows	apartment	Housing units – at 10 sites in 4 Austrian states	Terraced units, 4 + 1 rows	Apartment (2, 3, 4, 6 rooms)	Terraced units
No of buildings	32	2 – total 40 units (23 + 17)	116	20 + 6	40	17
Floor area, m^2	81, 108, 130	23 units: 1662+723 17 units: 1253+164	9200	120/unit	2 rooms: 46 3 rooms: 64 4 rooms: 77 6 rooms: 117	12
No. of storeys	1	3	1	1	6	2
Const. Materials	Dividing walls, floor slabs & building service-cum-staircase core: prefabricated concrete elements. Insulating building envelope: prefabricated lightweight timber elements.	Solid construction (lime-sand bricks with 30 cm thermal insulation), reduced thermal bridging through use of insulating 'Purenit' blocks as first course above floor.	Vary greatly. Solid construction in 3 projects, others: mixed construction with solid load-bearing systems and prefabricated timber walls and roof elements.	Timber, lightweight, super-insulated external walls, partition walls and floors. Timber façade with traditional whitewash	Mixed: concrete skeleton, use of local ecologically sound material	Timber, prefabricated elements with insulation
Green systems	Solar collectors. Climate neutral through Euro 1250 share in wind energy facility integrated in house purchase price.	Not specified	Not specified	Solar hot water, 50% solar fraction. Power connection to wind energy facility in Göteborg.	Solar hot water	Subsoil register, controlled ventilation with heat recovery, heat pump
Heating system, ventilation, Appliances	Supplementary heat supply from local district heat system fed by CHP units.	District heating, ventilation system: 3 – 6 units have joint HX, each unit having separate fans with automatic airflow control.	Not specified	High-efficiency HX in ventilation system	Supplementary heat supply from district heating	Each house has its own, separate ventilation and heat supply system.

2.3.5 Australia

A research report released by the Victorian Building Commission indicates that a direct cost of complying with 5 star standard for new housing in Victoria including both energy efficiency and water conservation measures is only 2% of the total cost (see table 4).

Table 4 – Direct cost of compliance with 5 star standard, Victoria
(Building Commission Website, 2008)

House Type	Average List price $	Direct cost for 5 star compliance ($)
Single storey house: 100 – 160 m^2	118,000	2840
Single storey house: 160 – 250 m^2	150,000	3450
Single storey house: 250 – 380 m^2	209,000	3950
Double storey house: 250 – 380 m^2	311,000	5910

Through NatHERS and its implementation or equivalence in states / territories, existing and especially new houses are being constructed with improved energy performance. The new housing development at Lochiel Park which is the focus of UniSA iGrid Cluster Project is expected to become a "nation's model Green Village incorporating Ecologically Sustainable Development (ESD) Technologies" (Lochiel Park Website, 2008).

The information presented in this Section clearly show that the energy / sustainability benchmarking around the world and locally exist in varying degrees and levels of complexity. The benchmark developed by one jurisdiction cannot be easily adopted by or translated into another in view of the variations in construction methods, local climatic conditions, number of occupants and their behaviour. This fact will be useful in the way the outcome of the current research will be interpreted, inferred and presented.

3 People Awareness, Attitude and Behaviour in Relation to Comfort, Energy Use and Energy Performance of Buildings

It is a common knowledge that people awareness, attitude and behaviour affect the way they consume energy in dwellings. The success of any program aiming at reducing or minimising energy use and the consequent greenhouse gas emissions will depend largely on people's attitude and behaviour. For example, a study by Wilhite & Nakagami (1996) as referenced by Isaksson & Karlsson (2006) compared and analysed how occupants at 16 houses in Japan and 18 houses in Norway use energy for space heating. It was found that "*Japanese households tend to heat only the room they usually occupy, while the Norwegian households heat almost every room in the house*".

The UniSA team conducted a survey on attitude and behavior of owners/occupants of the Mawson Lakes new housing development as part of the main report on the development, implementation and promotion of a greenhouse rating tool (Saman & Mudge, 2003). The main findings of the survey are as follows. The residents' self assessment of their own understanding of the greenhouse effect and energy conservation issues is moderate. They ranked the environment as the third most serious issues after education and health, and more serious than crime, unemployment and poverty. The majority said that their

knowledge of energy conservation information was from media and own personal experience; internet was the least influential (this might have been different had the survey been conducted more recently). Based on the survey, it was also concluded that Mawson Lakes residents have a smaller number of solar hot water systems compared to the overall Australian population. The initial cost of the system was the main cause for this; the significant proportion of residents seemed unaware of the subsidy/rebate schemes offered by the government in this area. Concern over the aesthetic appearance of the house was another reason for some residents deciding not to purchase the system. The situation has changed dramatically at the Mawson Lakes development where solar hot water systems are now mandatory. Differences between attitudes and behaviour were observed by comparing the residents' responses to certain statements and questions in the survey. While the majority of respondents indicated that their decisions to purchase each different type of appliances were influenced by energy-efficiency star ratings, a significant proportion of residents use relatively low energy efficiency appliances.

Occupants behaviour is particularly influenced by information made available in the media and through specific printed and web based resources (e.g. Your Home). The Australian household environmental awareness and actions have improved in the last view years (Ashworth & Gardner, 2006)).

Research carried out by Isaksson & Karlsson (2006) on the Swedish low energy houses (Section 2.3.3) found that the main motives of the house owners to purchase these houses were not the 'low energy profile' of the houses but the *location* and the *house type* (terraced houses) which "*were good value for money*". However, most were positive about the low energy performance of the house. Other findings include the occupants' preferred level of thermal comfort and complaints about low temperatures at certain locations of each house.

Poortinga et al. (2004) investigated the role of values (value dimensions) in the people environmental behaviour in the field of household energy use using the concept of quality of life (QOL). These value dimensions are: *self enhancement*, *environmental quality factor*, *self direction*, *openness to change*, *maturity*, *traditional values* and *achievement*. These value dimensions were regressed against two other variables: the *New Environmental Paradigm* (NEP) as 'world views' and the *Concern about global warming* (CGW) as 'specific beliefs'. The results found that the *environmental quality factor* correlates positively with environmental concern but negatively with the self enhancement value (enjoyment, power and hedonism). On the more practical level, the study found the correlation between the socio-demographic variables (income and household size) with the home and transport energy use.

Ashworth & Gardner (2006) carried out a research to *better understand public perceptions of low emission technologies across New South Wales* and *to explore regional differences that may exist in certain locations*. The research suggests that the public is very much aware of climate change implications to Australia and therefore feel the need to address it. They tend to see the solutions in solar and other renewable energy, although they are also aware of problems currently associated with the resources such as storage, security of supply and affordability.

The public also acknowledge the burning of coal in power stations as the main source of greenhouse emissions. They are not, however, very well informed about technologies that make coal less harmful to environment. They are also eager to adjust their behaviour and they would be prepared to pay higher electricity cost for the sake of the environment. For this, they also expect government to lead by example through government buildings and behaviour.

Japan's Cool Biz initiative, launched on 1 June 2005 demonstrates how a government policy can effectively influence the society's behaviour in relation to energy use. The initiative aims at reducing energy consumption of office air conditioning by encouraging people to wear thin clothes, no tie and no jackets. As a result, temperature set points of offices have increased to up to 28°C with a significant reduction in energy use for air conditioning. The Cool Biz initiative initially created shocks among the Japanese in terms of change of dressing habits and its social implications, people's comfort, work productivity, etc.(National Public Radio Website, 2008). The campaign, however, was eventually accepted by the Japanese society. Since 2006, South Korea and UK have set their own 'Cool Biz' programs (Wikipedia, 2008).

This overview provides us with a number of interesting insights. First, there seems to be a global awareness of the impact of human activities on the environment. However, the people's awareness and attitude towards the global concern does not always translate into their behaviour. The evolutionary (gradual/slow) nature of climate change threat to the environment and humanity makes it harder to push for drastic action. Therefore government initiatives are called upon to influence how people act and behave in regards to energy use. This is being achieved in Australia both through financial inducements and regulation.

4 Interaction with the Grid

The main feature of intelligent grid over the conventional grid is the infusion of the digital intelligence throughout the grid. This infusion is believed to result in improved method of energy delivery and use (Xcel Energy, 2008). Digital intelligence makes it possible to introduce the grid-friendly appliances with the ability to sense grid stress and reduce their power use to prevent grid emergencies (Zheng, 2007). On the other hand, the interaction between the grid and the distributed energy resources (DER) may result in the reduction of the quality of electrical power at the consumer level – in this case the DER (Bollen & Hager, 2005). The power quality in this case means both voltage and current quality which – in the case of deterioration – may lead to reduction in equipment lifetime or damage to the equipment.

An extensive literature search has not found published information on the impacts of interaction between the DER in a housing development and the grid. However, in order to

understand the reasons cited for installation of DER connected with the grid, the results of survey carried out by Poore et al. (2002) are briefly presented. The study surveyed a number of DER plants across the United States and presented 4 case studies of DER plants interconnected with the grid namely: (1) Narrow Coastal Island DER, (2) Magic Valley Foods Cogeneration Plant, (3) Brookfield Zoo Cogeneration and Standby, and (4) Vanderbilt University Power System. The survey noted that the cited reasons for installing DER are: cogeneration, technology demonstration, improved reliability, reduced costs, reduced peak demand, rate structure, price protection, burning of waste product, increased capacity, fuel flexibility, reduced emissions, reduced transmission constraints, market speculation, production of green power and elimination of CFS.

The introduction of distributed generation in The Lochiel Park Green Village will have a direct impact on reducing the housing reliance on energy from the grid and will result in some positive impact on the grid. The reliance on conventional grid will depend on the installed capacity of local energy systems, types and quantity of the loads and the dwelling energy performance. It has been estimated that for a 7.5 star house installed in the Lochiel Park Green Village, the introduction of 3 kWp solar PV system and a correctly sized solar hot water system will create an electrical surplus of 1260 kWh/yr resulting in a negative annual emission of 368 kgCO2-e (Saman, 2008).

Dwellings' reduced reliance on the grid energy is also anticipated to ease the peak demand problems faced by electricity utility in South Australia and therefore help reduce the need for peaking plants. While in the past heat waves like the one experienced by South Australia in March 2008 and January 2009 often resulted in blackouts as the supply coul not cope with the electrical demand. The introduction of distributed generation and particularly solar electricity will in fact ease the peak demand by sending the excess energy to the grid during the peak day time periods.

5 Conclusions

This report aims to establish the foundation for the current research on the effects of the introduction of distributed generation into the new housing development on energy use, greenhouse gas emissions and consumer energy awareness. Information gathered from similar activities around the world and in Australia has been presented. Low energy housing projects have been initiated in many parts of the world together with energy and environmental benchmarking and rating tools. Research on the household attitude and behaviour has provided some insights into the nature of relations between of human activities and environment, in particular with reference to energy use. The impacts of interaction between the distributed energy generation system in the Lochiel Park Green Village with the grid have also been presented. This overview provides the essential information required for the implementation of the current research.

6 References

- ACT Palling and Land Authority, 2003: *ACT House Energy Rating Scheme (ACTHERS) – Guidelines for quality ACT Residences*.
- Ashworth, P. & Gardner, J., 2006: *Understanding and incorporating stakeholder perspectives to low emission technologies in New South Wales*, Centre for Low Emission Technology (cLET).
- Bollen, M.H.J and Hager, M., 2005: *Power quality: Interactions between distributed energy resources, the grid, and other customers*, Electrical Power Quality and Utilisation Magazine, Vol. 1, no. 1.
- Poore, W.P., Stovall, T.K., Kirby, B.J., Rizy, Kueck, J.D., Stovall, J.P., 2002: Connecting distributed energy resources to the grid: their benefits to the DER owner/customer, the utility, and society, Prepared by Oak Ridge National Laboratory for the UU Department of Energy.
- Building Commission Victoria, 2005: *Research report summary on the direct cost of compliance with the 5 Star standard for new housing*, Building Commission Victoria website: http://www.buildingcommission.com.au/resources/documents/5_Star_Report_Summary_final1.pdf - accessed 20 October 2008.
- CEPHEUS Website: http://www.cepheus.de/eng/index.html - accessed 21 October 2008.
- Cool Biz Campaign – Wikipedia, http://en.wikipedia.org/wiki/Cool_Biz_campaign - accessed 22 October 2008.
- House Energy Rating website: http://www.houseenergyrating.com/process/sa - accessed 20 October 2008.
- Isaksson, C. & Karlsson, F., 2006: *Indoor climate in low energy houses – an interdisciplinary investigation* – Building and Environment, vol 41, pp. 1678-1690.
- Karlsson, J.F. & Moshfegh, B., 2007: *A comprehensive investigation of a low-energy building in Sweden*, Renewable Energy, vol. 32, pp. 1983-1841.
- Lochiel Park Webiste: http://www.lochielpark.com.au/lochielpark/home.htm - accessed 22 October 2008.
- Mennel, S., Menti, Urs-Peter, Notter, G., 2007: MINERGIE-P – *A Building Standard of the Future*, Proceedings of Clima 2007 – Wellbeing Indoors, 10-14 June, Helsinki, Finland
- National Public Radio Website: http://www.npr.org/templates/story/story.php?storyId=14024250 – accessed 24 October 2008.
- Oliphant, M, 2003: *South Australian residential sector baseline study of energy consumption*, Final report, Submitted to: State Energy Research Advisory Committee

- Pahud, D., Generelli, M & Velti, A., 2001: *Low Energy Housing in Ticino* – Annual Report 2001: http://www.empa-ren.ch/ren/Projekte_P+D/Pdf_P+D/Housing_in_Ticino_JB2001.pdf - accessed 20 October 2008
- Pahud, D., Generelli, M & Velti, A., 2002: *Low Energy Housing in Ticino* – Rapport Annuel 2002: http://www.bfe.admin.ch/php/modules/enet/streamfile.php?file=000000007892_01.pdf&name=000000230149.pdf – accessed 20 October 2008
- PassivHaus website: http://www.passiv.de/ - accessed 21 October 2008.
- Poortinga, W., Steg, L. & Vlek, C., 2004: *Values, environmental concern, and environmental behavior – A study into household energy use*, Environment and Behaviour, Vol. 36 (1), pp. 70-93.
- Purvis, A., 2008: Energy-efficiency in Freiburg, Germany, Post Carbon Cities Website - http://postcarboncities.net/node/2680 - accessed 20 October 2008.
- Saman, W., 2008: *Intelligent grid in new housing development*, Intelligent Grid Cluster – Adelaide Industry Forum, 5 December, Adelaide.
- Saman, W. & Mudge, L., 2003: *Development, implementation and promotion of a scoresheet for household greenhouse gas reduction in South Australia*, Final Report to Australian Greenhouse Office, Canberra.
- Sustainability Victoria, 2006: *Guidelines for approval of domestic solar water heaters for compliance to the Plumbing (water and energy sasvings) Regulations, July 2004*, Sustainability Victoria website: http://www.sustainability.vic.gov.au/resources/documents/SEAV_PIC_Solar_Hot_Water_Approval_Guidelines.pdf, - accessed 20 October 2008.
- The European Academy of the Urban Environment (EAUE) Website – www. http://www.eaue.de/ - accessed 20 October 2008.
- U.S. Green Building Council, 2008: *LEED® for Homes Rating Systems*.
- U.S. Green Building Council Website - http://www.usgbc.org/leed/ - accesses 20 October 2008.
- Xcel Energy Inc., 2008: *Xcel energy smart grid – A white paper*, http://smartgridcity.xcelenergy.com/
- Zheng, A.Y., 2007: *Smart Grid Environmental Benefits*, Smart Grid Newsletter Website - http://www.smartgridnews.com/artman/publish/article_289.html.