A CRITICAL ANALYSIS OF SUSTAINABLE DEVELOPMENT: BUILDINGS AND NEIGHBOURHOODS IN NEW ZEALAND.

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DATE:  15 September 2006
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EXECUTIVE SUMMARY

Over the last decade there has been much debate in New Zealand regarding the merits of high versus low density settlement forms, accompanied by many central and local government initiatives focusing on the need for more sustainable buildings. However, there has been little discernable impact on building practice in our towns and cities. Sustainability in this short review paper is considered specifically in terms of self-reliant, resilient and resource efficient housing. In real terms this means houses in residential neighbourhoods that have zero non-renewable energy consumption; housing that is “future proofed” from global, national or regional uncertainties through localised independent on-site infrastructure and essential services, regardless of whether it is located in high or low density developments. Numerous convincing examples of self–sufficient housing developments exist overseas, but there are very few on the ground in New Zealand. The few examples that do exist in New Zealand result from individual initiatives rather than through the assistance of local or central government strategies or incentives. Most attempts are “hybrids” with some of the key elements of sustainable housing, such as partial stormwater management on-site or modest reductions in energy use. None have achieved anything like the completeness to be seen in overseas examples. These developments in New Zealand can be perceived as stepping stones in the right direction, but often lack impact in any meaningful practical sense, and as a consequence do not stimulate great interest as exemplars. Using exemplars cited as “sustainable” or “green” buildings that are in reality “false positives” will cause confusion rather than encourage consumer interest. New Zealand has, on the whole, continued into the 21st Century on the old path of resource inefficient housing stock, and recent improvements in housing are already out of date by international standards. Current plans for improvements in town planning, urban design, style and aesthetics are unfortunately not linked in any way to sustainable housing.

Ironically, there are constant examples of the folly of centralised systems dependency, illustrated by the recent power failure over the whole of Auckland in June 2006, caused by a fault at a single sub-station. Unfortunately technical failures in conventional infrastructure systems are quickly forgotten, as are the concerns over fluctuating global oil supply and price aggravated by international conflicts, or concerns over global warming and climate change. Furthermore, the acumen to make the links between these events and the need for more sustainable housing seems to be lacking; and the opportunities these incidents present for reinforcing the need for a significant shift towards sustainable localised infrastructure are also largely ignored. The debate in New Zealand over the last decade has produced some more enlightened urban professionals capable of combining “Curitiba and Dongtan thinking” at the city scale with sustainable housing, but there has been limited evidence of any tangible change. Internationally, advances are exemplified in the UK by the Hockerton project and BedZED, and in Germany by the solar settlement “Am Schlierberg” in Freiburg. It should be pointed out that these European examples are in locations that are considerably colder and less sunny than New Zealand locations where the need for change is even more obvious. Sustainable housing can be advanced in New Zealand, but it needs to move beyond words, and the raft of brochures, rhetoric and “best practice” manuals.. There is an opportunity for New Zealand to invest in and provide a lead in sustainable building and self-reliant cities and towns. Once impediments to change are understood, a greater sense of urgency is needed, and practical incentives must be provided for home owners and the building industry. These have been proven
to work overseas. We also need to move beyond the debate surrounding high versus low density (frequently referred to as sprawl), and implement new buildings and neighbourhoods with zero-non-renewable energy consumption to suit a range of tastes and incomes. At present leadership comes from individual consumers, community groups, Maori and developers with an affinity for or commercial interest in this area. On its own this is unlikely to be enough to bring about the change that is needed.

BACKGROUND AND SITUATION ANALYSES
The purpose of this review is to analyse our progress towards sustainable development in terms of buildings and neighbourhoods in New Zealand. It is intended as a “think-piece” to challenge and stimulate. Initially we review the current state of play and analyse a selection of case study developments. We conclude by outlining what we believe has been the platform for past and current successes. Although there is in New Zealand a need to develop approaches that suit local conditions there is also a need to catch up with the housing standards already achieved overseas in the 1990s. New Zealand housing should emulate some of the practical rather than theoretical visions and ambition being demonstrated internationally where sustainable building at local scale is already being mainstreamed to the city scales. Making up for lost time and catching up is essential before we can excel.

In the context of this short article there is a need to review briefly terms such as Sustainable Development and what is understood by Sustainable Buildings and Neighbourhoods. In order to do this effectively we must first remind ourselves what the key issues of sustainability are. “Sustainable Development” is often used as a cliché by those who wish to put a green gloss on new buildings, housing styles, and neighbourhoods. We challenge those who misuse the word to start to address the real problems. The well-known Brundtland Report describes Sustainable Development as development that meets the needs of the present without compromising the ability of future generations to meet their needs. The report is a useful platform and producing more with less impact and waste is of fundamental importance. However, whilst conservation and recycling are necessary and valuable contributions to sustainability in any community, they will be insufficient on their own and are in effect only scratching the surface of the problems we face.

UNEP and IUCN describe sustainable development as “Improving the quality of human life while living within the carrying capacity of supporting ecosystems”. “Living within the carrying capacity of supporting ecosystems” is the key constraint. This in turn can be combined with concepts such as self-reliance, resilience, insurance against natural disasters (local or global), and meeting people’s needs for energy efficiency and low running costs. Without that requirement being met, “improving the quality of human life...” will not be possible for long. In other words we require sustainability first and housing development only within that constraint. Therefore, we need to consider Sustainable Buildings and Neighbourhoods in term of self-reliance, resilience and resource efficient housing. We need to look beyond but include designing buildings to capture and retain free energy from the sun to provide warmth and reduce the need for electricity. These features are described more fully in “The New Autonomous House” (Vale and Vale 2002). In real terms this means construction of new buildings and residential neighbourhoods that have zero non-renewable energy consumption and are “future proofed” from global or national
uncertainties, regardless of whether they are high or low density developments. It also means acting with urgency on the retrofitting of the existing building stock in order to reduce its demand for non-renewable resources.

In 1998 the Parliamentary Commissioner for the Environment published “The Cities and Their People – New Zealand’s Urban Environment”. Now eight years on it is timely to reflect on progress. In the 1998 report it was concluded that “with a few notable local exceptions, the concept of sustainable urban development is largely ignored in New Zealand,” and “there is a need to decouple increases in quality of life from resource consumption” (PCE 1998). It is disappointing to report that in 2006 there is no evidence of any discernible change in building practice. It is also unfortunate that reported improvements in urban design style (MfE 20051&2) are not linked in any way to sustainable housing. Rural to urban migration continues to stimulate urban growth (MfE, 2000) and resource inefficient housing in new developments has continued to increase demands on conventional infrastructure (e.g. stormwater piping and electricity supply) (Eason et al, 2004). The costs of maintaining existing and new stormwater and sewerage systems and electricity supply continue to escalate and there are daily examples both nationally and internationally of the vulnerability of centralised systems dependency. This was again highlighted in June 2006 by the power failure throughout Auckland resulting from a failure at one substation, costing the economy $50-100M in a single day (NZ Herald, June 2006.) Few remember or link this event to the inner city blackouts in Auckland in 1998 which produced similar mayhem over an extended period. Also quickly forgotten are concerns over the fluctuating cost and availability of oil, aggravated by international conflicts, technical failures and natural disasters. After decades of debate over the need for improved energy supply and water infrastructure (fresh, waste and stormwater), these remain unresolved priorities (MfE, 2002; PCE, 20021&2; PCE, 2005). Moreover, more sustainable infrastructure should be dealt with in a broader context of more sustainable housing and the use of ecosystem services (van Roon and Knight 2004: van Roon 2005; Eason et al 2006). There is a need to reverse the trend of resource inefficient housing stock which is particularly prevalent in New Zealand with house sizes increasing while the number of residents per household decreases. (Lui et al 2003).

Hence, despite potential benefits in terms of self-reliance, resilience, the attraction of “the house with no bills” and “future proofing” (Vale and Vale 2002), and despite innovative fledgling developments in New Zealand first being attempted by Maori over 20 years ago (Morgan, 2006) further uptake of meaningful sustainable housing approaches is negligible. This should be recognised as folly. To quote from Kunstler (2005), we are: “nearing the end of the cheap-oil age having invested wealth in living arrangements – which have no future”. It is apparent that current approaches in urban design, development and infrastructure continue to assume that future life will be like the past. Much built environment and infrastructure has a life of at least 50 and often 100 years. We are not yet building or planning now for a future that is not like life in the past. The reality may be oil shortages in 20 years time, and the potential of decentralised infrastructure including energy supply, water and alternative transport systems needs to be recognised now in order to give time for appropriate measures to be put in place.
The Ministry of the Environment’s Urban Design Protocol has successfully raised the profile of good town planning having focused on seven essential design qualities: context, character, choice, connections, creativity, custodianship and collaboration. (MfE 2005\(^2\)), but none of these are strongly linked with a view of the future or with sustainable housing, though some are linked to important aspects of improved infrastructure, such as partial or comprehensive stormwater management on site (MfE 2005\(^1\)). Ironically, at the neighbourhood and the building scale, technology exists already to build low or zero-emission dwellings that use no non-renewable energy, that collect their water supplies, treat their sewage and produce much of their food needs (see, for example: www.hockerton.demon.co.uk). In New Zealand we are falling behind as others forge ahead. For example the German “Thousand Roofs Programme” to encourage the uptake of solar microgeneration systems on domestic roofs began in 1990. (Heilscher and Kiefer, 1994). The Australian government’s Photovoltaic Rebate Programme began in 2000 and provides “cash rebates...to householders, owners of community use buildings, display home builders and housing estate developers who install grid-connected or stand-alone photovoltaic systems”. The programme is still in operation as of August 2006. (http://www.greenhouse.gov.au/renewable/pv/index.html viewed Aug 6 2006). Currently Iceland is pioneering hydrogen-power and Shanghai is subsidising the installation of 100,000 roof top solar panels (New Scientist June 2006).

**CASE STUDIES: OVERSEAS AND NEW ZEALAND EXAMPLES**

We have summarised examples of developments in Appendix Table 1 and 2. This section is where selected overseas examples and some examples that exist in NZ are cited.

**Overseas examples** (see Appendix Table 1)

Hockerton, BedZED and the Solar Settlement “Am Schlierberg” encompass very significant sustainability features. All these developments have minimal running costs and were cost-efficient to design and build. For example the Hockerton Housing Project in Nottinghamshire UK cost the same as a conventional complex and yet through smart design unheated indoor temperatures average 18°C in winter and residents’ bills are negligible. The development was completed in 1998, and is a group of five houses, built using off-the-shelf materials and technologies. The houses not only have energy consumption which is 25% of that of a conventional modern house in the UK, but they generate all their energy needs from on-site microgeneration, using wind and solar electricity linked to the National Grid. The houses were comparable in cost to conventional houses, and a UK government report recommended that developers should copy the design. A development company is advancing new developments in the UK based on these designs. Significantly the Hockerton development and copies in construction now in the UK do not just focus on one aspect of sustainability, but integrate zero non-renewable energy with stormwater, sewage and waste water management on site. Until recently sceptics might have argued that these developments are small scale but as sustainable houses and solar panels and other energy-saving features are becoming more popular around the world we witness more ambitious practices. A recent UK government report has stated that solar panels and wind turbines on individual homes, similar to the systems used at Hockerton, could be producing 40% of the country’s electricity demand by 2050. (DTI 2006)
BedZED is a mixed development in the London Borough of Sutton, which was completed in 2001 at a cost of £15.7M. It reconciles high-density three storey city blocks with high residential and workplace amenities. A combination of superinsulation and wind driven ventilation systems, incorporating heat recovery and passive solar gain, aided by thermally massive floors and walls, reduces the need for electricity and heat to a point where a 135kW wood fuelled power plant meets the energy needs of 240 residents. Water saving systems include use of rainwater and grey water recycling and, as at Hockerton, there is on site treatment of waste. (BRECSU, 2002). The “Solar Settlement” in Freiberg also fully exploits the sun’s energy. Buildings are orientated towards the sun and all roof surfaces with solar orientation are formed of photovoltaic panels for producing solar energy. All walls and ceilings have air/vapour barriers to avoid uncontrolled heat loss via air circulation and a simple heat recovery system reduces heating requirements to a minimum. (Made In Germany, 2004). At a much larger scale of development the plans for Dongtan City near Shanghai, population 500,000 (New Scientist 2006), with self sufficiency in energy and food supply, are an indicator of the potential for sustainable buildings and neighbourhoods at a city scale.

New Zealand Examples (see Appendix Tables 2a and 2b)
A sustainable housing sub-division in New Zealand would look remarkably like a conventional one. However most windows would face north and houses would feature excellent insulation. Solar panels or other visible means of providing renewable electricity would be evident. Raintanks would re-use water and waste and stormwater would be substantially managed on site or within treatment systems designed to operate at the neighbourhood scale. For the purposes of this review we have classified New Zealand examples under three headings, as false positives, stepping stones and hybrids, and significant advances.

False positives
The website of the New Zealand “Zero and Low Energy House” (ZALEH) project lists seventeen “zero and low energy” houses presented as case studies. Only one of the houses (DN1, in Otago) is described as having zero total annual energy consumption, but this dwelling makes use of an LPG heater and a log burner with wetback water heating to back up a solar hot water system. This means that this house will be consuming both wood (in the log burner and wetback) and LPG, so it cannot be described as a zero energy house. Of the total of seventeen houses in the survey, only about a third have energy consumption lower than the New Zealand domestic average.

The average end energy use in NZ households is 11,060 kWh for all fuels used, the majority being electricity. (BRANZ, 2004) This is broken down as follows.

Table 1: Average Energy Use in New Zealand Houses

<table>
<thead>
<tr>
<th>Home heating</th>
<th>30%</th>
<th>3318 kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stove</td>
<td>6%</td>
<td>664 kWh</td>
</tr>
<tr>
<td>Water heating</td>
<td>29%</td>
<td>3207 kWh</td>
</tr>
<tr>
<td>Other appliances including lights</td>
<td>35%</td>
<td>3871 kWh</td>
</tr>
</tbody>
</table>
In the ZALEH project database there is only one house (DN1, see above) with a reported annual energy consumption that is less than half the current NZ average. More than half of these “zero and low energy” houses use at least twice the average NZ domestic energy consumption. One house (CH5 in Lyttelton) is shown on the graph as having total annual energy consumption of about 58,000 kWh, yet is described as “a conventional looking home with low running costs.” (BRANZ 2006)

To describe these buildings as “zero and low energy” could be considered as unhelpful in the quest for more sustainable housing.

Stepping stones and hybrids
Beacon Pathway Limited is a consortium formed by BRANZ Ltd., Scion, Waitakere City Council and Winstone Wallboards. The consortium received research funding for a programme, one of the aims of which was to build what is called the NOW Home. “The NOW Home is designed to be as sustainable as possible using the best products, services and design available at the time. This means building a house that uses fewer resources, is energy and water efficient, generates as little waste as possible, is comfortable and healthy to live in, and costs less.”
http://www.nowhome.co.nz/the+criteria.aspx

A Beacon media release dated 1 April 2006 states “Data collected in the past four months suggest that each year the three bedroom home will use about 30% less energy and 25% less water than similar-sized homes in the area.”
http://www.nowhome.co.nz/media+releases.aspx The house that was built to demonstrate the aims of the Beacon project successfully meets the design criteria, but these criteria are not as ambitious as, or comparable with, international examples. The Hockerton Housing Project in the UK, referred to above, was completed in 1998. These houses not only have energy consumption which is 25% of that of a conventional house, but they generate all their energy needs from on-site renewables. The Beacon programme is now planning incremental improvement towards these international standards.

Harbour View in Waitakere and Styx Mill in Christchurch are advances in terms of urban design, low impact design and ecologically responsive approaches. (MfE 2005¹). The preservation of wetlands and use of natural systems particularly at Styx Mill allows some on-site handling of stormwater combined with native vegetation and amenities. However, these are “hybrids” in terms of sustainable neighbourhoods, as are the developments at Tiritiri Road and Verbena Road on Auckland’s North Shore where there is extensive use of raintanks and raingardens. These houses have none of the sustainable features needed to reduce energy use or provide significant self-reliance (Pandey et al 2005).

Further examples of “partial sustainability” and “stepping-stones” are summarised in Table 2a and 2b.
Significant Advances

In New Zealand there are also good examples of much better building performance in both commercial and domestic buildings. In the domestic field, for example, the house at 2 Hauraki Road, Waiheke Island was built as an entirely conventional house about 20 years ago, and has been upgraded recently to incorporate the following features:

- R 5 insulation in roof and underfloor
- Double low-emissivity glazing to north-facing windows
- Solar water heating with relay-switched electric back-up
- Energy-efficient refrigerator
- Low-energy lights

The house is all-electric, and the main living areas are heated electrically to approx 22°C in the morning and evening. The result of the measures to improve energy performance has been annual electricity consumption for the year 2005 of 3,200 kWh. This represents a reduction of 70% of the average NZ domestic energy consumption in a house with a floor area of nearly 200 m². It is worth noting that this is in a converted house, not a purpose designed new house, and no new or unconventional technology is employed (Vale and Vale 2006).

In terms of commercial buildings a good example is the award winning Manaaki Whenua Landcare Research building at Tamaki. This complex building comprising laboratories, offices, archival collection vaults and research greenhouses has an energy consumption around 50% lower than that of a conventional building containing the same functions, and mains water consumption which is 87% lower than that of a standard office building. The building uses a mixture of simple energy techniques such as north orientation, high thermal mass and additional insulation, combined with advanced heat recovery from fume cupboards and refrigeration compressors. All the rain that falls on the roof is collected for re-use, and the toilets on the two upper floors are waterless, turning wastes into compost that can be re-used on the external landscape (Vale 2005; Vale et al. 2006).

RATING SYSTEMS

Internationally, rating systems to assess the sustainability of different building designs have been used with the intention of improving building performance. However there has been confusion in the use of loosely defined terms such as green buildings, eco-friendly buildings and sustainable buildings. Unfortunately there are now a plethora of “environmental” building rating systems that despite initial good intentions have been largely used to justify mediocrity. To date there has been very limited use of rating systems in N.Z but increased interest (Frame and Vale 2006). Just as we can learn from positive overseas examples of sustainable housing that are cited above we can also learn from the use and extensive misuse of green building rating systems and preempt their mis-use in New Zealand. The systems have been used overseas to perpetuate “false positives” rather than buildings and housing that perform significantly differently from conventional buildings. For example, in discussing the US LEED rating system, Gabe concludes “There is also evidence that society is not using LEED as a guideline to reduce ecological impact, but rather as an asset for positive publicity” (Gabe 2005).
The majority of rating systems measure the intention of designers rather than the performance of buildings. At this early stage in the development of resource efficient housing there is little evidence of the correct use or misuse of these systems in New Zealand. In this instance we can learn from overseas mistakes and examples. Many designers of commercial buildings around the world are attempting to address the problem of sustainability. A recent high-profile example of such attempts is Portcullis House, a new building providing facilities for Members of Parliament in London. The building was clearly seen as a sustainable building, as it was nominated for the RIBA Journal Sustainability Award, and achieved a rating of “Excellent” in the BREEAM (Building Research Establishment Environmental Assessment Method) environmental rating system (National Audit Office 2002, p. 39). The energy consumption of the building in use has turned out to be not only over four times what was predicted, but almost twice that of a conventional air conditioned building (National Audit Office 2002, p 37). Had the building been seen as a model for future buildings, the result could have been a decrease in the environmental sustainability of the building stock, owing to the increase in non-renewable energy consumption.

It is clear that a reliable method is needed to provide a reasonably accurate assessment of a building’s overall environmental impact. Without such a method the necessary progress toward greater sustainability will be based on guesswork and good intentions, and it can be seen from the example of Portcullis House that good intentions can be insufficient to achieve good building performance in practice. Currently, much of the published material on buildings that are designed to be more environmentally sustainable is based on assertions by the designers of these buildings. Similarly, many of the existing environmental rating systems for buildings do not measure performance, but only intentions at the design stage. It should be argued that the environmental impact of a building is assessed by what it does in practice, not on how well-intentioned its designers were.

INCENTIVES AND FRAMEWORKS
The PCE report Future Currents (PCE 2005) highlights the need for incentives to advance change. Examples from overseas include the German government providing strong support for energy efficiency. Germany is now the world’s leading producer of wind–power, with strong community involvement. Germany also has one of the fastest growing markets for photovoltaics, stimulated by tax free loans that began with the Thousand Roofs Programme in 1990 (see above). More recently the UK government has been offering “Clear Skies” grants for householders to install small scale renewable energy systems on their homes, now superseded by the Low Carbon Building Programme (http://www.clear-skies.org/ accessed v14 Aug 2006. DTI 2006). As mentioned earlier, in China subsidies already exist in some cities and there is considerable interest from consumers and the business community. Similar serious investment is occurring around the globe in renewable energy. For example General Electric in the US, which has made wind turbines since 2002, plans to triple its renewable energy fund to US$3 billion by 2008 (The Business, 2006). In New Zealand incentive schemes are emerging, but they are rare and not substantial. For example Waitakere City Council is encouraging rain-tank use with a subsidy of $500 for those fitting raintanks for rainwater reuse. Preference is given to installations being retrofitted to existing houses and those in problem catchments where tanks will help reduce stormwater run-off (http://www.waitakere.govt.nz in relation to rainwater use in an urban setting, accessed 20 August 2006).
As a way of improving sustainability outcomes in new urban developments, Sustainable Development Frameworks (SDF) embracing four “spheres” of sustainability: environmental, economic, social and cultural have been used overseas and in New Zealand as a catalyst to draw in communities and professionals with a range of interests. This kind of wide-ranging SDF thinking has underpinned all the successful sustainable developments cited in this review.

A recent local example of SDF in action comes from the Interim Urban Design for Hobsonville. A multi-disciplinary team led by Boffa Miskell, and including Geoffrey Walker Urban Design, Architectus, Landcare Research, Market Economics, Flow Transportation Specialists, Salmond Reed Architects and Fraser Thomas, was selected in late 2005 to complete initial urban design concepts for the Hobsonville Land Company (HLC).

The Hobsonville SDF Framework, in common with successful overseas examples, began with a strong vision of the outcomes that HLC is seeking from this development. The SDF then ‘filters’ the vision through a step-by-step process that gains greater specificity at each step. The first step is to define sustainability through a simple **statement of principle** for each of the four spheres. Each sphere is then dissected into its different **dimensions** that reflect the vision. Under the environment sphere, natural habitat, water, waste and energy have been identified as key priorities. Each dimension is further refined into a set of **objectives** that are unique to the site. As much as possible, **measurable targets** are set so that the intention can be substantiated (Eason et al. 2006).

For each objective, **benchmarks** have been identified which either (a) improve upon the existing condition or (b) match or exceed best practice in New Zealand or abroad. These initial targets should be regarded as an illustration of what can be achieved using innovative technologies and design strategies proven to be reliable and cost-effective in other settings. They can be modified in future stages of the design to ensure that the total concept can be delivered. A **set of indicators** is identified as measurement tools for each objective against a set of key criteria. These indicators were selected to be relevant, easy to understand, reliable and derived from accessible data. A distinction has been made between design (or input) indicators and performance (outcome) indicators. Performance-based indicators are based on the long-term performance of the operational design. These sorts of inclusive frameworks are useful as they help move thinking beyond “hybrid” developments where only one or two aspects of sustainability are dealt with. (see Table 3 adapted from Eason et al. 2006).

We believe that frameworks such as these, if followed through, will go a long way to helping facilitate sustainable housing at the single unit, neighbourhood and city scale if they are used alongside appropriate incentives.
CONCLUSIONS

In conclusion, sustainable building practices in New Zealand, where they exist at all, are often piecemeal or based on concepts which were conceived over 10–20 years ago.

There has been little discernable uptake of self-reliant, resource efficient housing in New Zealand, we have continued into the 21st Century on the old path of resource inefficient housing stock.

There is opportunity for New Zealand to invest in and take leadership in this field, but we need to catch up first.

Sustainable Building not only makes sense for its own sake but is empathic with our global marketing position as “clean and green” and “nuclear free”.

A sustainable housing sub-division in New Zealand is not beyond our capability. It would look remarkably like a conventional one, but it would be far more robust and its overall impact on the environment, and its running costs for residents, would be greatly reduced.

A sense of urgency is needed to advance new sustainable housing development and retrofit the existing housing stock, learning from international initiatives.

ACKNOWLEDGMENTS

The authors would like to acknowledge Professor Jenny Dixon and Viv Heslop for comments on earlier drafts of this review and to Candy Eason for editorial advice and comments.

REFERENCES


23. New Zealand Herald, 14 June 2006, Businesses to get power cut insurance shock


### APPENDIX

**Table 1:** Overseas Neighbourhood and City Scale Exemplars. Significantly Self-Reliant, Resilient and Resource Efficient Housing

<table>
<thead>
<tr>
<th>Name, Location, Date</th>
<th>Residential Units</th>
<th>Sustainability Features</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hockerton, UK 1998</td>
<td>5</td>
<td>“Houses with no bills” using superinsulation and triple glazing. All energy supplied from on-site photovoltaics and wind power; rain water as sole supply. Storm and wastewater and sewage managed on site. Food growing areas included. Cost the same as conventional housing.</td>
<td><a href="http://www.hockerton.demon.co.uk">www.hockerton.demon.co.uk</a></td>
</tr>
</tbody>
</table>

**Table 2a:** New Zealand Examples “Stepping Stones” towards Self-Reliant and Resource Efficient Single Housing or Commercial Buildings

<table>
<thead>
<tr>
<th>Name, Location, Date</th>
<th>Residential Units</th>
<th>Sustainability Features</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOW House (Auckland)</td>
<td>1</td>
<td>Insulation, solar water heater, rain-tank, energy reduction</td>
<td><a href="http://www.beaconpathway.co.nz">www.beaconpathway.co.nz</a> <a href="http://www.nowhouse.co.nz">www.nowhouse.co.nz</a></td>
</tr>
<tr>
<td>Vale house Waiheke (Auckland)</td>
<td>1</td>
<td>Minimal electricity use, rain tank, thermal insulation, double glazing, low energy lights and appliances</td>
<td>Vale and Vale, 2006</td>
</tr>
<tr>
<td>Tamaki Building (Auckland)</td>
<td>1 Commercial</td>
<td>Water re-use, stormwater management on site, composting toilets, energy saving, thermal mass</td>
<td><a href="http://www.landcareresearch.co.nz">www.landcareresearch.co.nz</a></td>
</tr>
</tbody>
</table>
Table 2b: New Zealand Examples "Stepping Stones" towards Self-Reliant and Resource Efficient Neighbourhoods

<table>
<thead>
<tr>
<th>Name, Location, Date</th>
<th>Residential Units</th>
<th>Sustainability Features</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haumingi, Rotorua</td>
<td>10</td>
<td>Intelligent 1980 design to allow for solar harvesting. Water collection management and conservation</td>
<td>Morgan 2006</td>
</tr>
<tr>
<td>Earthsong, Ranui, Waitakere, Auckland</td>
<td>32</td>
<td>Stormwater treatment/infiltration, water harvesting, solar hot water, permaculture vegetable gardens</td>
<td><a href="http://www.earthsong.org.nz">www.earthsong.org.nz</a></td>
</tr>
<tr>
<td>Tui, Abel Tasman</td>
<td>20 approx</td>
<td>Solar harvesting, local food production</td>
<td><a href="http://www.tuitrust.org.nz">www.tuitrust.org.nz</a></td>
</tr>
</tbody>
</table>
### Table 3
Modified from the Sustainable Development Framework in Eason et al 2006. Note the four spheres include environmental, economic, social and cultural dimensions

<table>
<thead>
<tr>
<th>SPHERE</th>
<th>DIMENSION</th>
<th>OBJECTIVES</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Ecology</td>
<td>• Create an integrated natural habitat</td>
<td>% open space in natural habitat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increase indigenous biodiversity</td>
<td>Native birds/invertebrates counts</td>
</tr>
<tr>
<td></td>
<td>Energy</td>
<td>• Reduced non-renewable energy use</td>
<td>Energy consumption per kWh/household per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Produce renewable energy</td>
<td>Energy use in kWh/person/year</td>
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<td></td>
<td>Water</td>
<td>• Improve water quality</td>
<td>% stormwater treated through stormwater quality chain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduce water consumption</td>
<td>Concentration of heavy metals</td>
</tr>
<tr>
<td></td>
<td>Social</td>
<td>• Create opportunities for all sectors of society to live at Hobsonville</td>
<td>Housing type availability and affordability by sector</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Maximise opportunities for community participation</td>
<td>No. of community facilities (type and uses)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Promote a healthy and safe living environment</td>
<td>% of households participating in community activity</td>
</tr>
<tr>
<td></td>
<td>Quality of Life</td>
<td>• Maxime opportunities for community participation</td>
<td>Occupancy ‘crowding index’</td>
</tr>
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<td></td>
<td></td>
<td>• Promote a healthy and safe living environment</td>
<td>Internal air quality standards</td>
</tr>
<tr>
<td></td>
<td>Economic</td>
<td>• Maxime contribution to Auckland’s economic growth</td>
<td>Safety measures (CPTED) reflected in the design</td>
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<tr>
<td></td>
<td>Growth</td>
<td>• Maximise opportunities for Hobsonville to become a learning community</td>
<td>Local business numbers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Maximise local independence</td>
<td>Contribution to GDP</td>
</tr>
<tr>
<td></td>
<td>Viability</td>
<td>• Generate a commercially accepted return on investment</td>
<td>Proportion of household income spent locally</td>
</tr>
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<td></td>
<td>• Demonstrate the overall economic benefit of a sustainable urban development approach</td>
<td>Agreed investment parameters</td>
</tr>
<tr>
<td>Cultural</td>
<td>Sense of place ‘Turangawaewae’</td>
<td>• Create a distinctive identity for Hobsonville</td>
<td>Use of unique and authentic urban design and architecture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extent of prominent landscape features and views preserved</td>
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<tr>
<td></td>
<td></td>
<td>• Extent to which existing recognised buildings are retained and integrated</td>
<td>Use of signage, public art and materials to identify neighbourhoods, including place names drawn from local associations</td>
</tr>
<tr>
<td></td>
<td>Custodianship ‘Kaitiakitanga’</td>
<td>• Acknowledge The Haukainga (home people) of the area</td>
<td>Participation/consultation during design and ongoing community affairs</td>
</tr>
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<td>• Promote participation and community representation of Hobsonville within Waitakere City</td>
<td>Levels of participation/representation in community management bodies</td>
</tr>
<tr>
<td></td>
<td>Heritage</td>
<td>• Ensure that Hobsonville’s future reflects its past</td>
<td>Extent to which Hobsonville’s earlier history (esp. military and aviation history) is interpreted and celebrated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extent to which existing recognised buildings are retained and integrated</td>
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</tr>
</tbody>
</table>