TE 101

EVALUATION OF TECHNOLOGIES WITH POTENTIAL FOR IMPROVING THE SUSTAINABILITY OF NEW HOMES IN NEW ZEALAND: INITIAL ASSESSMENT

A REPORT PREPARED FOR
BEACON PATHWAY LIMITED

WRITTEN BY Bryan Walford, Karen Bayne, Albrecht Stoecklein, Roman Jaques and Jorge Salinas

DATE September 2005

The work reported here was funded by Beacon Pathway Limited and the Foundation for Research, Science and Technology

EVALUATION OF TECHNOLOGIES WITH POTENTIAL FOR IMPROVING THE SUSTAINABILITY OF NEW HOMES IN NEW ZEALAND: INITIAL ASSESSMENT

AUTHORS

Bryan Walford, Karen Bayne, Albrecht Stoecklein, Roman Jaques and Jorge Salinas

REFERENCE

Walford, B., Bayne, K., Stoecklein, A., Jaques, R. and Salinas, J. 2005. *Evaluation of Technologies with Potential for Improving the Sustainability of New Homes in New Zealand: Initial Assessment.* Report TE101 for Beacon Pathway Limited prepared by Scion, Rotorua.

RIGHTS

Beacon Pathway Limited reserves all rights in the Report. The Report is entitled to the full protection given by the New Zealand Copyright Act 1994 to Beacon Pathway Limited.

DISCLAIMER

The opinions provided in the Report have been provided in good faith and on the basis that every endeavour has been made to be accurate and not misleading and to exercise reasonable care, skill and judgment in providing such opinions. Neither Beacon Pathway Limited nor any of its employees, subcontractors, agents or other persons acting on its behalf or under its control accept any responsibility or liability in respect of any opinion provided in this Report.

CONTENTS

1	Executive Summary……	5
2	Introduction……..	8
3	Methodology……	9
3.1	Database……..…	9
3.1.1	Diffusion Categories…….....	10
3.1.2	Database Refinement……	10
3.2	Prioritisation Workshop……..……	11
4	Results…….……....	12
5	Technology Evaluations……..…….	12
6	Selected Technology Outlines……..……	16
7	Beacon's Goals……..……...	23
8	Conclusions……..	24

APPENDICES

Appendix 1:	Selected Technology Outlines……..	25
Appendix 2:	Handbook of Technologies for the Workshop…….....	54
Appendix 3:	Further Details on 'Early Adoptable Options'…….	76

TABLES

Table 1: Summary of factors contributing to the 'effort' rating as provided by the expert panel……..…….... 14

Table 2: Summary of information provided in the technology outlines… 17

Table 3: Impact of technologies on BPL's goals…….... 23

FIGURES

Figure 1: Summary matrix indicating the relative ranking of each technology..... 13

1. EXECUTIVE SUMMARY

Previous studies undertaken as part of the Beacon Pathway Ltd (BPL) research programme indicated that there is a mix of both existing technologies, which are not being widely implemented, and new technologies, which are yet to be developed and implemented, that can be used to further improve the sustainability of the residential built environment (RBE). This report provides a high level screen of over 175 identified technology options to assist future development and prioritisation for the technology related research stream. The selection of high priority technologies was based on input from a panel of experts. The outcomes from this project are contributing to the development of more detailed research plans currently being developed for the overall technologies programme.

Technologies, for the purpose of this project, have been interpreted broadly to encompass new products, systems, methods and approaches to building new houses.

Out of the initial list of 175 technologies, eleven were identified by the panel of experts that could impact significantly on the goals of BPL. Six of these technologies were considered to be 'early adoptable options' in that they are systems which already exist in the market but were identified by the expert group as needing to be more actively supported by BPL to directly impact on sustainability within the RBE. Five were technologies that would impact but need further investigative research and/or development. These technologies were rated on a scale of –2 (some negative impact) to +5 (very high impact) by further experts and prioritised against the BPL sustainability objectives as follows:

	Beacon Goal									**Rank**
Technology	**Desirability**	**Landscape**	**Performance**	**Community**	**Future**	**Investment**	**Resource**	**Affordability**	**Health**	
Early Adoptable Options										
Solar water heating	2.8	1.8	3.7	1.2	4.0	4.0	4.7	3.4	1.2	**3**
Rainwater collection	2.2	3.8	2.3	1.8	4.0	3.3	4.7	3.3	0.7	**4**
Multi-pane windows	3.5	2.7	3.8	1.0	4.0	3.8	3.7	2.7	2.7	**2**
Tankless electric hot water	2.0	1.2	1.8	0.8	2.5	2.5	2.8	2.8	1.0	**9**
Wall insulation	3.7	1.2	3.3	1.5	4.3	4.0	3.8	3.0	3.8	**1**
Mini wind turbines	1.8	0.5	2.7	0.8	3.3	3.0	3.2	2.8	0.8	**7**
Technologies for Development										
Framing efficiencies	0.8	0.8	2.0	0.8	2.0	3.0	3.0	2.7	0.8	**11**
Phase change materials	2.7	1.5	2.5	1.0	3.0	2.0	3.0	2.8	2.2	**5**
Biopolymers	2.7	1.2	2.3	0.8	3.0	2.0	2.5	2.5	1.5	**8**
Air – air heat exchangers	2.3	1.0	2.5	0.8	2.8	2.3	2.8	2.2	3.0	**6**
Airtight recessed down lights	2.2	0.8	2.2	0.8	1.8	2.3	2.2	3.0	1.3	**10**
Ranking of impact against goals	**6**	**8**	**5**	**9**	**2**	**3**	**1**	**4**	**7**	

The primary goal addressed by these technologies was resource use; particularly the more efficient use of energy, minimisation of thermal losses, and alternative means of energy production. The effort required to realise these goals ranges from low, where the technology is already in commercial production but the optimum application has not been determined, to high, where a technology is highly desirable but development and invention would be required to achieve the full impact. The specific actions required by BPL to advance the uptake of these technologies and an initial quantified impact assessment is summarised below.

Technology	Proposed Action Required	Quantified impact on NZ housing (1)
Solar water heating	Encourage the uptake of solar water heating by supporting the Solar Industries Association, providing information and identifying sources of additional information.	Possible saving of up to 15% of electricity consumption for hot water in homes
Rainwater collection	Encourage the use of rainwater for non-potable uses and investigate technologies for the treatment of water to potable standard on a household scale.	Possible deferment of city water supply scheme extensions by 10 to 20 years
Multi-pane windows	Encourage the use of multi-pane glazing in all new construction and quantify the benefits possible.	Possible saving of 3% in energy usage in homes
Tankless hot water systems	Provide information on these systems and quantify the possible benefits.	Possible saving of 3% in energy usage in homes
Wall insulation	Determine the most effective and sustainable material for wall insulation, and disseminate this information.	Possible saving of 4.5% in energy usage where the technology can be applied to both new and retrofit situations for homes.
Mini wind turbines	Work with Wind Power Associations to identify barriers to the uptake of this technology at small scale and formulate solutions, particularly the problems of noise and meter operation.	Possible generation of 30% in household energy requirements
Framing efficiencies	Analyse current building systems to determine what material savings are possible, and disseminate that information through building companies.	Possibly 10% less framing material used for residential buildings
Phase change materials	Identify the possibilities and limitations on the use of phase change materials in building products for improved comfort performance of buildings.	Possible saving of 6% in household energy usage base on international experience
Biopolymer materials	Develop new materials into improved building products such as insulating foams, films and resins.	Not yet possible to quantify
Air-air heat exchangers	Develop a proposed system to commercial application stage.	Healthier living conditions
Airtight recessed downlights	Improve existing down-lights so that they can tolerate less ventilation.	Possible saving of 2% in energy usage if widely implemented in homes

(1) Comments on quantified impact are based on high level preliminary information obtained during the study. More specific quantification of impact will be derived during the technology assessments and other phases of the Technologies Research programme.

The recommended actions for the 'early adoptable options' will be an input to the Technologies Research Stream. The action items for the bio-polymer, phase change materials and air-air heat exchangers will be developed into preliminary technology development projects by the Technology Research Stream. Airtight recessed down-lights should be assessed further to determine if there is already an off-the-shelf solution available.

More detailed technology plans are to be developed as part of the Technologies Research programme for phase change systems and biopolymers. These two technology options were identified as high priority for further significant development and through the process used in this study, were considered to offer considerable scope for improving the sustainability of houses within an appropriate time frame.

2. INTRODUCTION

BPL aims to have the vast majority (90%) of New Zealand's housing stock brought up to a high standard of sustainability by 2012. The fundamental objectives of a sustainable home include:

Desirability – quality of life, no compromises

Landscape – solar access, water harvesting, aesthetics, privacy, road noise

Performance – Sound insulation; structurally adequate; low operating costs; durable; weathertight

Community – neighbour-friendly, low emissions, aesthetics, parks and reserves, access to public transport

Future proof – anticipating future trends and needs

Investment – Convenient access, proven technology, reliable utilities, favourable climatic exposure, conservative design

Resource use – 30-40% reduction in energy use, 50% reduction in purchased water, 100% storm water usage, 50% reduction of landfill waste, reduced embodied energy of materials

Affordability – mainstream, location specific, affordable first cost, affordable operating cost, real and total costs

Personal health – warmth, ventilation, privacy, noise reduction, security, low VOCs, good air quality

This study aimed to provide a high level evaluation of new technologies (either existing and not applied or still to be developed) and building systems that could be used in improve the sustainability of new housing. The assessment builds on the work undertaken previously in Project NEW 1 and NOW 1, both of which included evaluations of technologies for improving sustainability in homes. The assessment was undertaken by:

1. Collating information about a wide range of known technologies with potential to improve sustainability in the RBE. This included technologies and systems that were not included in the NOW Home because they were either not available commercially or because they failed to meet affordability criteria.
2. Categorising these technologies according to constraints for wider market application
3. Prioritising these technologies in terms of their potential impact on BPL's goals. This prioritisation was based on the opinions of a group of 'experts' and took into account each technology's potential uptake and the effort required to achieve market penetration
4. Identifying possible high priority technologies. This involved undertaking an initial high-level feasibility assessment for each technology, which will act as an input to further specific technology development plans.

For the purposes of this study, technology has been interpreted broadly to encompass new products, systems, methods and approaches to building new houses. Although the emphasis of this work is on new build technologies (i.e. systems suitable for new homes), much of what has been considered could also have application to retrofit situations.

3. METHODOLOGY

Previous work by BPL (e.g. NEW 1) concluded that many technologies already exist to improve sustainability; however, their uptake is limited. The recommendation was that BPL should focus its efforts on getting existing technologies into the marketplace, rather than developing new technologies and systems from very early beginnings. There was an indication, however, that there might be scope for innovative development of some of the 'existing' technologies such that these could be made more user-friendly, applicable to the current housing sector or new policy developments could be identified that may accelerate their uptake and impact on sustainability.

In the case of NEW 1, around 80 technologies were identified. However, the focus of this study was on a high level overview of new technologies, in order to assess if all the technologies existed to meet sustainability goals by 2012. This contrasts to the current investigation were the priority was on identifying and reporting on as many technologies that could contribute to sustainability and selecting those that would take BPL closer to its goal.

This led to the following hypothesis:

> *"There is the potential for development of innovative technology options and actions by BPL that will enhance and accelerate the sustainability of the new-build residential built environment, and impact on BPL's sustainability goals by 2012."*

The approach adopted for this study was to expand the list provided by the NEW 1 project and not just focus on off-the-shelf options. The study was broken down into three main tasks:

1. The development of a database of technologies
2. A workshop to prioritise and select technologies for further pre-feasibility analysis. This was done in conjunction with BPL.
3. Initial technology assessment to describe high-level issues associated with the prioritised technologies. This assessment took into account technical risk, market potential, economic viability, obvious constraints to uptake and requirements for further research.

3.1 Database

As background material, the team used the database of technologies created during the NEW 1 project and an ideas log recorded during the NOW Home project. From these two sources, an initial list of technologies was compiled. Further technologies were then added using internet-based databases accessible to Scion and BRANZ.

After the initial development of the database, three scientists (Albrecht Stoecklein, Roman Jaques, and Karen Bayne) spent a week populating the database with new information. The information was sorted into 5 categories: descriptive information about the technology, the diffusion category of the technology, its application (new, retrofit, both), the sustainability benefits that the technology could contribute to, and cautionary notes.

It should be noted that the sustainability benefits used were those of NEW 1, rather than the current BPL sustainability objectives. This was due to the database being created and reviewed prior to the BPL decision for all projects to work from the same footprint information.

3.1.1 Diffusion categories

One of the objectives of the study was to determine the level of potential uptake of each technology, and to identify the major constraints to implementation. The different technologies were then grouped according to one of three main constraints on uptake. These were as follows:

- A technology barrier – where the technology was not yet sufficiently proven, or there was no known solution to the idea
- A commercial barrier – where there were known ways to implement the technology, but no company had yet put out a commercial offering, or it was not readily available to people in New Zealand
- A market barrier – where there were commercial options readily available, but no one seemed to be buying the product

3.1.2 Database refinement

The completed database contained 175 technologies and was then regrouped into 10 categories according to their major function or outcome:

- Comfort – technologies for insulation, thermal comfort & ventilation (31 technologies)
- Coatings – films, coatings and chemicals (24 technologies)
- Efficiency – technologies to improve processes (18 technologies)
- Power – technologies to generate energy (14 technologies)
- Heat – technologies to recover heat (16 technologies)
- Materials – emerging building materials and systems (26 technologies)
- Waste – technologies for reducing and recycling resources (7 technologies)
- Water – water conservation and purification technologies (17 technologies)
- Lighting – lighting technologies (12 technologies)
- Smart – smart systems, intelligent and automated devices (5 technologies)

Robin Allison and John Storey then independently reviewed the database. These reviewers were asked:

- To review the accuracy of the diffusion categories, and
- To provide further suggestions of any technologies not already included

This process resulted in a final selection of 164 technologies. These technologies were assigned an A, B or C ranking according to their best fit with achieving BPL goals, and the top ranked technologies further culled to give a set of 64 that would be used for the next phase of the project which was a prioritisation workshop.

3.2 Prioritisation workshop

The aim of the workshop was to review the 64 technologies, and select less than ten to be further considered in terms of suitability and priority for BPL to further develop in order to achieve its goal. The handbook of technologies developed for the workshop is provided in Appendix 2.

Each technology was review by a team of seven experts and rated according to their potential impact on BPL's goals (high, medium or low) and the effort required to get them applied (high, medium or low).

When considering the effort required getting the technologies applied, the team primarily considered:

- Research effort required
- Cost to both install and operate
- Effort to persuade potential users

4. RESULTS

A summary matrix of the ranked technologies is provided in Figure 1 where the A1, A2 etc. notation refers to the listing of the technologies as provided in Appendix 2. Summaries of factors contributing to the effort rating are provided in Table 1.

5. TECHNOLOGY EVALUATIONS

In total of thirty four technologies were in the low to medium effort and high to medium impact part of the matrix and these covered a diverse range of options from under floor heating derived from district heating schemes to fibre optic lighting or diode lighting systems. The panel of experts reviewing the technology list concluded that the high priority options for further investigation should comprise of the following:

1. Solar water heating,
2. Multi-pane windows,
3. Tankless electric hot water systems,
4. Wall insulation,
5. Mini wind turbines,
6. Framing efficiencies.

In addition to the above list five technologies were viewed to potentially have high to medium impact but involved greater effort. These included:

1. Biopolymers for next generation materials,
2. Airtight recessed down lights,
3. Phase change materials,
4. Air – air heat exchangers.

A further technology was added later; that of rainwater collection, since this technology was incorporated into the Beacon NOW Home.

Low toxicity sprays were eliminated from the list as it was considered that BPL could not make a significant contribution in this area.

Home recycling kits were also ranked as high impact and low effort; however, there was little technology development needed, and this was seen as a solely commercial opportunity.

	Low impact	Medium impact	High impact
High effort	A1 Photocatalyst materials A7.1UV proof varnish A10 Coatings that repel dirt B1 Natilin – Flax Fibre Insulation D7l scale CHP (Combined Heat and Power) E7 Hot Water Recirculation Systems F3 Biofibre plastic composites K2 Self-powered sensor activated faucets	A5.2 Auto-detecting polarised glass D1 Solar panel photovoltaics E3 Passive cooling systems G1 Demountable Fastenings G3 Adhesives which are easy to deconstruct buildings with	E1 Underfloor heating from district heating F7 Biopolymers
Medium effort	A5.1 UV proof films A7.2 Natural oils and waxes B7 Trombe Walls B10 Sheep Wool Batts C3 Fusiotherm plumbing C7 Trombe Walls – same as B7 D6 watt stand-by power for home appliances F6 Agricultural residues for fillers in panel materials J4 Daylight harvesting	A2 Phase Change Materials (PCMs) A8 High tech mineral silicate paints B3.1 Air-Air heat exchanger B4 Wide stud spacing C5 One kWh/day refrigerator C9 Solar panels as a roofing system D5 Biogas pits and methane digesters E4 Thermosiphoning solar storage tanks E6 Solar Slates F5 Recycled materials into new products	B3.2 Heat pump C8 Framing efficiencies D2 Mini wind turbine on roof -Rutland windcharger E8 Tankless hot water systems H1 Composting toilet L58 Icynene foam – insulation L69 Wood fibre insulation board B5 Triple-glazed windows
Low effort	A3 Water-based Exterior Masonry paints A4 Green Chemistry/ Ecopaints A9 Non-toxic paint stripper (gel) B8 Solar fan B9 Non-toxic paint stripper (gel) – same as A9 C1 Mounting water pipes on resilient mounts C2 Driven piles C4 Electronic socket timer controls D3 Solar battery chargers D4 Solartwin – solar water heating using a solar powered pump E5 Reduced standing losses – smaller HW delivery pipes at mains pressure F1 High-performance plasterboards F2 Hardened wood F4 Self-consolidating concrete H4 Rainwater tank siphon cleansing system J3 Solar garden lights K1 Smart Cabling	B2 Solar Chimneys B6 Ultimat – insulation made from old fibres C6 Airtight recessed downlights H2 Permeable pavers for driveways, paths etc H3 Handbasin Toilet J1 Light tubes or skylights J2 Fibre-optic lighting J5 Low energy lightbulbs L6 LED Lighting L7 Compact Fluorescent portable plug-in fixtures L9 Diode lighting systems	A6 Low toxicity herbicides and pesticides E2 Solar water heating G2 Home recycling station - kitset of containers and labels

Figure 1. Summary matrix indicating the relative ranking of each technology.
The high shaded areas indicate the technologies that the expert team considered would have most relevance to BPL and impact on the BPL objectives.

Table 1. Summary of factors contributing to the "effort" rating as provided by the expert panel

Technology		Primary reason for effort rating
High impact – low effort		
A6	Low toxicity herbicides and pesticides	▪ Market acceptance
E2	Solar water heating	▪ Technical/Market acceptance – cost/benefit – payback period, trade industry capabilities
G2	Home recycling stations - kitset of containers and labels	▪ Little commercial support
High impact – medium effort		
B3.2	Heat pumps	▪ Technical/Market acceptance – poor efficiency in low temperatures
C8	Framing efficiencies	▪ Technical/Commercial – material savings may be lost in increased labour needed to achieve them.
D2	Mini wind turbines	▪ Market – reluctance of power companies to accept negative meter operation and aesthetic issues
E8	Tankless electric hot water systems	▪ Commercial – proof of cost/benefit needed. ▪ Technology – load on the grid at peak times
H1	Composting toilet	▪ Market acceptance – perception of being smelly
L58	Spray-in foam – insulation	▪ Commercial – cheaper alternatives for large-scale use
L69	Wood fibre insulation board	▪ Market perception – an "old" product
B5	Multiple-glazed windows	▪ Commercial – proof of cost/benefit needed
High impact – high effort		
E1	Underfloor heating from district heating	▪ Market – district heating schemes not considered cost effective in New Zealand
F7	Biopolymers	▪ Technology – Non-oil-based source of polymers needed
Medium impact – low effort		
B2	Solar Chimneys	▪ Lack of awareness by architects and consideration in design
B6	Ultimat – insulation made from old fibres	▪ Commercial – unpredictable raw material supply
C6	Airtight recessed down-lights	▪ Technology – lights that can tolerate less ventilation
H2	Permeable pavers for driveways, paths etc	▪ Market – cost vs ecological benefit
H3	Hand-basin toilet	▪ Market – lack of awareness
J1	Light tubes or skylights	▪ Market – could be installed in more homes to save lighting
J2	Fibre-optic lighting	▪ Market – proof of cost/benefit needed
J5	Low energy light bulbs	▪ Market perception of cost/benefit
L6	LED lighting	▪ Market - proof of cost/benefit needed
L7	Compact fluorescent portable plug-in fixtures	▪ Market - proof of cost/benefit needed
L9	Diode lighting systems	▪ Market - proof of cost/benefit needed
Medium impact – medium effort		
A2	Phase change materials (PCMs)	▪ Technology – variety of operating temperatures and physical forms needed
A8	High tech mineral silicate paints	▪ Market – proof of cost/benefit needed
B3.1	Air-Air heat exchanger	▪ Market – development of unobtrusive systems needed
B4	Wide stud spacing	▪ Technology/commercial – study of savings vs costs needed
C5	One kWh/day refrigerator	▪ Commercial – overseas technology not available in NZ
C9	Solar panels as a roofing system	▪ Technology – develop dual purpose panels for roofing
D5	Biogas pits and methane digestors	▪ Market – Similar objection as to composting toilets.
E4	Thermosiphoning solar storage tanks	▪ Technology/commercial – determine operational limits for this system

E6	Solar slates	▪ Market – too expensive, unfamiliar and there are grid operator issues
F5	Recycled materials into new products	▪ Commercial – usually not viable on a small scale
Medium impact – high effort		
A5.2	Auto-detecting polarised glass	▪ Market – proof of cost/benefit needed
D1	Solar panel photovoltaics	▪ Market – expensive and problem of power companies allowing negative meter operation
E3	Passive cooling systems	▪ Market – proof of cost/benefit needed
G1	Demountable fastenings	▪ Market – little need seen for this facility – usually requires a high degree of modularity
G3	Adhesives which are easy to deconstruct buildings with	▪ Commercial/technical – limited market for demolition/deconstruct materials and such adhesives do not exist
Low impact – low effort		
A3	Water-based exterior masonry paints	▪ Market – proof of improved eco-friendliness needed
A4	Green chemistry/ ecopaints	▪ Market – proof of improved eco-friendliness needed
A9	Non-toxic paint stripper (gel)	▪ Market – proof of improved eco-friendliness needed
B8	Solar fan	▪ Market – proof of cost/benefit needed
B9	Non-toxic paint stripper (gel) – same as A9	▪ Market – proof of improved eco-friendliness needed
C1	Mounting water pipes on resilient mounts	▪ Market – proof of cost/benefit needed
C2	Driven piles	▪ Market – an “old” technology
C4	Electronic socket timer controls	▪ Market – seen as a technology with limited use
D3	Solar battery chargers	▪ Market – they don’t work at night
D4	Solartwin – solar water heating using a solar powered pump	▪ Market – more expensive than mains powered pumps
E5	Reduced standing losses – smaller HW delivery pipes at mains pressure	▪ Market – proof of cost/benefit needed
F1	High-performance plasterboards	▪ Technology – overcome minor difficulty with attachments
F2	Hardened wood	▪ Market – problem of awareness and availability
F4	Self-consolidating concrete	▪ Commercial – needed only for difficult situations
H4	Rainwater tank siphon cleansing system	▪ Market – simple idea that needs advertising
J3	Solar garden lights	▪ Market – a handy gadget but does nothing for BPL
K1	Smart cabling	▪ Commercial – good idea but no or negligible demand
Low impact – medium effort		
A5.1	UV proof films	▪ Market – needs to be convinced of the need for this
A7.2	Natural oils and waxes	▪ Market – requires high maintenance
B7	Trombe Walls	▪ Market – limited market acceptance
B10	Sheep Wool Batts	▪ Technology – tendency to slump
C3	Fusiotherm plumbing	▪ Market – proof of cost/benefit needed
C7	Trombe Walls – same as B7	
D6	1 watt stand-by power for home appliances	▪ Commercial – manufacturers need to see the customer pull
F6	Agricultural residues for fillers in panel materials	
J4	Daylight harvesting	
Low impact – high effort		
A1	Photocatalyst materials	
A7.1	UV proof varnish	
A10	Coatings that repel dirt	
B1	Natilin - Flax Fibre Insulation	
D7	l-scale CHP (Combined Heat and Power)	
E7	Hot Water Recirculation Systems	
F3	Biofibre plastic composites	
K2	Self-powered sensor activated faucets	

6. SELECTED TECHNOLOGY OUTLINES

Assessments of feasibility for each of the technologies identified in Section 5 were developed into technology assessment outlines. The format used to compile information for these outlines is based on that typically used for a technology stage gate process. Such a process forms the initial phase of a technology development plan. The completed templates for each technology are provided in Appendix 1.

A summary of these evaluations is provided in Table 2.

Table 2. Summary of information provided in the technology outlines.

Technology	Short description	Impact	Effort	Outcome and action
Solar water heating	Use of solar collectors connected to a hot water tank (includes all: evacuated, flat plate, pumped, thermo-siphon systems)	High – BPL may impact on the market by actively supporting the programmes of the Solar Industries Association (SIA) and EECA. Support for these programmes, such as promotion via website, installation on NOW & THEN homes and providing stakeholders with information will directly impact on the sustainability of new homes.	Low – ▪ Expand on identifying the opportunity to use solar hot water heating to improve the overall sustainability within the RBE. ▪ Review SIA information on uptake and barriers to uptake. ▪ Define the actions required by BPL to encourage the uptake of solar hot water. ▪ Identify sources of additional information on solar hot water.	By 2012 at least 15% of domestic electricity consumption for hot water heating will be provided sustainably. ▪ Establish web based links from BPL to Solar Industries Association ▪ Place SIA on circulation list for BPL newsletters and keep informed on other relevant information ▪ Work with the SIA on removing barriers to uptake to solar water systems such as availability of skilled installers, capacity to manufacture and distribute product, and assist with their accreditation-training programme. ▪ Link the outcomes from the market transformation research to SIA, which has developed a market growth strategy and implementation programme.
Rainwater collection	Water from the roof is treated to render the water suitable for all uses within that house.	High – BPL may impact the market by actively supporting the programmes of the NZ Water and Waste Association (NZWWA).	Low – Review MoH and NZWWA information on available systems for the collection, storage and treatment of rainwater. Investigate what technologies the government might use in its aim to improve drinking water standards in selected communities.	Upgrading of city water supply systems could be deferred by 10 to 20 years. ▪ Establish web-based links to the NZWWA. ▪ Compile and publicise information on equipment suitable for treatment of household rainwater supplies. ▪ Support cost/benefits analyses on the methods and equipment for collecting, and storing household rainwater for non-potable uses, and the methods, equipment and treatment of water to potable standards.

Table 2 (cont'd).

Technology	Short description	Impact	Effort	Outcome and action
Multi-pane windows	Window systems with two or three glazing layers, and vacuum, air or gas in the cavity. Shutters and lighting can also be incorporated within the cavity.	High – BPL can impact on the market by closer relations with the Window Association of New Zealand (WANZ), and by actively supporting WERS and EECA programmes. Improved systems, and retrofit technologies should be shown to good effect in the Now and Then homes built/ modified. Brochures that demonstrate the benefits of different models from a cost, thermal and acoustic perspective.	Medium – ▪ Expand on identifying the opportunity to use multi-pane window systems to improve the overall sustainability within the RBE. ▪ Provide a brief status on multi-pane window technologies. ▪ Identify the main barriers limiting uptake of multi-pane windows. ▪ Define the actions required by BPL to encourage the uptake of multi-pane windows. ▪ Identify sources of additional information on multi-pane windows. ▪ Quantify the energy savings possible with multi-pane glazing.	A possible saving of 3% of energy usage over that of a well insulated home with single pane glazing. ▪ Establish web-based links from BPL to WANZ/ WERS; and EECA, and work with these groups to raise awareness of both heat losses, and double glazing options available. ▪ Work with the WANZ on removing barriers to uptake such as availability of skilled installers, capacity to manufacture and distribute product. ▪ Undertake an assessment of various multi-pane window systems and their thermal/ acoustic benefits. ▪ Undertake a cost-benefit analysis for various regions of NZ, and determine payback period.

Table 2 (cont'd).

Technology	Short description	Impact	Effort	Outcome and action
Tankless electric water heaters	Water heaters that heat water on demand.	High – Very well-suited to new building, as there is no behavioural change required by the occupant, and the unit is simple to install by a plumber/ builder, perhaps simpler than fixing in a new insulated water tank.	Medium - ▪ Expand on identifying the opportunity to use tankless electric water heating systems. ▪ Provide a brief status on tankless electric water heating systems. ▪ Identify the main barriers limiting uptake of tankless hot water systems. ▪ Define the actions required by BPL to encourage the uptake of tankless electric water heaters. ▪ Identify sources of additional information on tankless electric water heating.	A possible saving of 3% in electricity usage for hot water heating in homes. ▪ Determine the likely performance of tankless hot water systems in New Zealand houses, compared to 'A' grade tank systems. Include the cost/benefit sensitivity of different home designs that have varying pipe –run lengths to outlets. ▪ Conduct stakeholder workshop with agencies, departments, designers and trades-people to identify barriers and opportunities to residential uptake. ▪ Undertake an assessment of various systems and their thermal/cost benefits. ▪ Investigate implications for power suppliers regarding their ability to cope with peak demand.
Wall insulation	Technology for insulating wall cavities in new built framed houses	High – BPL may impact on the market by actively recommending particular products. Support for these programmes, such as promotion via website, installation in Now & Then homes and providing stakeholders with information will directly impact on the sustainability of new homes.	Medium – ▪ Determine the most suitable technology to insulate framed walls in NZ for different construction materials. ▪ Compare the alternative materials for thermal and acoustic insulation effectiveness, slump, susceptibility to moisture, fire, mould, vermin, interaction with other components (e.g., wiring, and plumbing). ▪ Determine the construction limitations of loose fill types, and foamed in place types.	A possible saving of 4.5% in energy usage in homes ▪ Establish links from BPL to the manufacturers of all the available wall insulating materials. ▪ Identify options for evaluating the performance of insulation materials. ▪ Identify strengths and weaknesses of insulation systems and engage with manufacturers to find solutions for the weaknesses. ▪ Identify options for new generation materials that have lower environmental impact, cost less and provide better performance. ▪ Advertise results on the BPL website and implement recommendations in THEN and NOW houses.

Table 2 (cont'd).

Technology	Short description	Impact	Effort	Outcome and action
Mini wind turbines	Use of mini wind turbines to supplement electricity requirements of NZ households	High – BPL may impact on the market by actively disseminating information on the types of wind turbines available and recommending particular devices for particular locations. Support for these programmes, such as promotion via website, installation on NOW & THEN homes.	Medium – ▪ Determine the range of equipment available and their technical requirements/limitations. ▪ Determine what siting/structural/geographic issues are relevant. ▪ Determine their cost/effectiveness and payback period in New Zealand situations. ▪ Identify the barriers limiting uptake of mini wind turbines. ▪ Define the actions required by BPL to encourage the uptake of mini wind turbines. ▪ Determine the willingness of power supply companies to adopt net-metering.	A possible sustainable energy contribution of about 30% of household electricity requirements. ▪ Establish web-based links from BPL to wind power associations. ▪ Place wind power associations on circulation list for BPL newsletters and keep informed on other relevant information. ▪ Work with the wind power associations on removing barriers to uptake to mini wind turbine systems such as availability of skilled installers, and noise abatement/isolation. ▪ Establish links to power generation companies to determine their attitudes regarding meter operation.
Framing efficiency	More efficient use of timber in timber framed housing.	High – BPL may demonstrate where significant savings in timber usage may be made.	Medium – Determine the extent to which the amount of framing used in timber framed houses may be reduced without compromising structural performance.	A possible reduction of 60,000m^3 of framing timber per year or 10% of the amount presently used. ▪ Use the OVE and Pathnet software to analyse a selection of New Zealand house designs. ▪ Identify and quantify where savings in material usage may be made.

Table 2 (cont'd) .

Technology	Short description	Impact	Effort	Outcome and action
Phase change materials	Phase change materials (PCM) are incorporated in building materials to increase their thermal mass	Medium – PCM would have application for both new build and retrofit. For new build situations the development and implementation of new wall cladding products would reduce energy use. Such products could also be used in retrofit situations as well. Other retrofit applications could be the use of PCMs in conjunction with solar panels.	Medium – ▪ Identify the opportunity to use PCM to improve the overall sustainability within the RBE. ▪ Provide a brief status on phase change technologies. ▪ Identify the main barriers limiting uptake of phase change systems. ▪ Identify actions for BPL. ▪ Identify sources of additional information on PCM and solutions.	Improved comfort in homes with a possible saving of 6% in household energy use. ▪ Determine patent restrictions. ▪ Fund research to develop this technology
Bio-polymers	Development of biopolymer formulations for next generation building materials	High – The main impact will be in the replacement of petrochemical plastics with bio-based, sustainable plastics. A secondary benefit may be in the ability to compost the plastic on site to minimise landfill waste. High IP content for BPL.	High – Initially more work will be required to determine the current and potential applications for plastics in the residential built environment. Once defined the performance criteria will need to be specified then formulation undertaken to determine if the bio-based plastics can meet requirements. This work can build upon existing IP in the area of biobased materials, developed in the Biomaterials Engineering (BME) group at Scion.	Development of sustainable materials, such as foams, films, plastics and composites that are from a renewable source and end of life disposal is environmentally friendly. ▪ Using a team with building (BE) and biomaterial (BME) expertise, identify where biomaterials may substitute petrochemical equivalents (or other unsustainable materials) in the residential built environment. This may first require an inventory of materials to be undertaken with an analysis of why a particular material is chosen for particular applications. Potential examples of where biomaterials could be used include: rigid biopolymer foams for insulation; biopolymer films and containers for packaging to allow waste to be composted; and biopolymer adhesives for engineered wood products. ▪ Describe the properties required in quantified terms. ▪ Undertake scoping studies to narrow down the development projects to be undertaken. ▪ Develop formulations to meet material requirements. ▪ With commercial parties build a business case for the introduction of the new materials.

Table 2 (cont'd).

Technology	Short description	Impact	Effort	Outcome and action
Air-air heat exchangers	An opening window is replaced by a permanently closed (bonded) sheet of glass and ventilation provided by a low-cost air-to-air heat exchanger	Medium – Will achieve a small energy saving, and will reduce the need for a dehumidifier, and provide a healthier (drier) environment, and fresh air.	Medium – ▪ Expand on identifying the opportunity for in-wall air-air heat exchangers to improve the overall sustainability within the RBE. ▪ Provide a brief status on in-wall air-air systems ▪ Identify the main barriers limiting uptake of in-wall air-air systems	This technology should contribute to healthier living conditions in homes. ▪ Patent searching ▪ Prototype testing of systems.
Airtight recessed down-lights	Recessed downlights that do not need ventilation	Medium- This technology would reduce heat loss by preventing the forced ventilation of warm air into the roof space that occurs with current technology	Low – The technology partly exists already in the form of fluorescent light bulbs but these still require ventilation.	An improvement in ceiling insulation would be achieved where downlights are installed, giving a possible 2% saving in household energy us. ▪ Determine patent restrictions. ▪ Fund research to develop this technology

Further details of the first six listed technologies are provided in Appendix 3.

7. BEACON'S GOALS

The impact of the selected technologies on BPL's goals was evaluated by Bryan Walford, Albrecht Stoecklein, Roman, Jaques, Roger Buck, Michael Donn, Jeremy Warnes and Karen Bayne. A scale of 1 (very low) to 5 (very high) was used although one reviewer used a scale of –2 to +5 to account for the negative impact of some technologies on some goals. Table 3 provides the average rating assigned by the expert group.

Table 3. Impact of technologies on BPL's goals.

Technology	Goal									Quantified impact on NZ housing
	Desirability	Landscape	Performance	Community	Future	Investment	Resource	Affordability	Health	
Early Adoptable Options										
Solar water heating	2.8	1.8	3.7	1.2	4.0	4.0	4.7	3.4	1.2	Saving 15% of electricity consumption for domestic hot water
Rainwater collection	2.2	3.8	2.3	1.8	4.0	3.3	4.7	3.3	0.7	10 – 20 year deferment of water supply schemes
Multi-pane windows	3.5	2.7	3.8	1.0	4.0	3.8	3.7	2.7	2.7	Possible saving of 3% in energy usage in homes
Tankless electric hot water	2.0	1.2	1.8	0.8	2.5	2.5	2.8	2.8	1.0	Possible saving of 3% in electricity usage in homes
Wall insulation	3.7	1.2	3.3	1.5	4.3	4.0	3.8	3.0	3.8	Possible saving of 4.5% in energy usage in homes
Mini wind turbines	1.8	0.5	2.7	0.8	3.3	3.0	3.2	2.8	0.8	Possible generation of 30% of electricity requirements for homes
Technologies for development										
Framing efficiencies	0.8	0.8	2.0	0.8	2.0	3.0	3.0	2.7	0.8	Possibly 10% less framing used.
Phase change materials	2.7	1.5	2.5	1.0	3.0	2.0	3.0	2.8	2.2	Possible saving of 6% household energy usage in homes
Biopolymers	2.7	1.2	2.3	0.8	3.0	2.0	2.5	2.5	1.5	Not yet possible to quantify
Air – air heat exchangers	2.3	1.0	2.5	0.8	2.8	2.3	2.8	2.2	3.0	Healthier living conditions
Airtight recessed down lights	2.2	0.8	2.2	0.8	1.8	2.3	2.2	3.0	1.3	Possible saving of 2% in energy usage in homes

8. CONCLUSIONS

There are several technologies that are well-developed but under-utilised in New Zealand. BPL could promote these to contribute towards the realisation of its goal of an improvement in sustainable housing. The technology with the greatest potential energy saving and least effort is the installation of solar hot water heaters, because the technology is already being promoted commercially, and the demand for hot water contributes significantly to energy use in homes. Three other technologies (multi-pane windows, tankless hot water systems and wall insulation) also contribute to energy savings but to a lesser extent. Mini wind turbines need work to overcome noise related issues but can also contribute as an alternative source of electricity generation. Rainwater collection has considerable potential to avoid expenditure on large-scale water supply and treatment schemes, as well as reducing peak flows of stormwater runoff. The amount of framing used in houses appears excessive and the team believes that material savings could be achieved. Some building materials can be derived directly from biomaterials, hence reducing the need for oil-based products. Small savings in energy may be possible with downlights that do not need ventilation. Improved occupant health and comfort may be possible from attention to the possibilities of phase change materials and air-air heat exchangers.

More detailed technology plans are to be developed as part of the Technologies Research programme for technologies deploying phase change systems and biopolymers. These two technology options were identified as high priority for further development and through the process used in this study, were considered to offer considerable scope for improving the sustainability of houses within an appropriate time frame.

Appendix 1. Selected Technology Outlines

Technology Title:	**Solar water heating**
Technology Assessment/Development	Assessment

1. Objectives

- Expand on identifying the opportunity to use solar hot water heating to improve the overall sustainability within the RBE.
- Provide a brief status uptake on solar water heating technologies
- Identify the main barriers limiting uptake of solar water heating
- Define the actions required by BPL to encourage the uptake of solar hot water
- Identify sources of additional information on solar hot water.

2. Technology Definition:

- Use of solar collectors connected to a hot water storage tank.

Use of solar collectors connected to a hot water tank (includes all: evacuated, flat plate, pumped, thermo-siphon systems).

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

This technology is commercially mature and readily available from suppliers. Systems typically cost $4,000 - $7,000. Current payback time is expected to be 7-9 years depending on the cost paid for electricity. Solar hot water technologies currently contribute more than 40GWh (0.1% of New Zealand electricity consumption) electricity equivalent per year. They are cost effective in a number of applications at 8-12c/kWh. Installations are around 1200 units per year, mostly in the residential sector, spurred by government co-ordinated energy saving initiatives.

By year 2008 solar hot water could contribute between 80 and 300 GWh per year. By 2012 their wider adoption would replace upwards of 15% of domestic hot water requirements (600 GWh per year or 4.5% of national consumption) and a proportion of commercial and industrial heat requirements.

This could replace fossil thermal electricity generation and create employment for over 400 people. It would mitigate in the order of 270,000 tonnes CO_2 annually from alternative thermal generation.

- *Water:*

- *Waste:*

- *Resources:*

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

Not applicable to BPL. BPL is unlikely to become involved with IP issues for solar water heating as its role is most likely to focus on developing mechanisms to encourage the uptake of existing systems.

5. Technical Success:

- *Complexity:*

Commercially proven technology is currently being deployed in the market. BPL should not need to become involved in technology development

- *Gaps:*

Not applicable. No current technology gaps identified for BPL.

- *Constraints (capability & equipment):*

  Not applicable to BPL.

- *Risks:*

  Not applicable to BPL

6. Reward:

- *Market implementation:*

  The uptake of solar water systems into the New Zealand market is being actively pursued by the Solar Industries Association in conjunction with the Energy Efficiency and Conservation Authority (EECA) though the implementation of a grants scheme. There is virtually no opportunity for BPL to obtain direct reward for assessment and development of this technology.

- *Impact on market:*

  BPL may impact on the market by actively supporting the programmes of the Solar Industries Association and EECA. Support for these programmes, such as promotion via website, installation on NOW & THEN homes and providing stakeholders with information will directly impact on the sustainability of new homes.

7. Business Risk:

- *Time to develop:*

  Not applicable to BPL

- *Business uncertainties/commercial assumptions:*

  Not applicable to BPL

- *Capex:*

  Not applicable to BPL

- *Critical success factors:*

  Not applicable to BPL

8. Comments:

The Solar Association is working closely with government and its member companies to rapidly expand the implementation of solar water heating into the residential built environment. To facilitate this process the Association has developed a "Solar Water Heating and Manufacturing and Installation Code of Practice for New Zealand". Associated with the Code is a "Manual for Structural Assessment for Installation of Solar Water Heating in Domestic Dwellings" available. Work is also underway to establish an accreditation scheme for installers and certifying products as complying with a standard.

An assessment of different solar water systems was reported by the Consumer Institute and reported in Energy Wise in May 2001.

9. Actions:

- Establish web based links from BPL to Solar Industries Association
- Place Solar Industries Association on circulation list for BPL newsletters and keep informed on other relevant information
- Work with the Solar Industries Association on removing barriers to uptake to solar water

systems such as availability of skilled installers, capacity to manufacture and distribute product. ▪ Link the outcomes from the market transformation research to Solar Industries Association, which is currently developing a market growth strategy and implementation programme.
10. Further Information:
http://www.solarindustries.org.nz/info_solar.html
http://www.eeca.govt.nz/uploadedDocuments/Solar%20energy%20use%20and%20potential%20in%20NZ0.pdf
http://www.eeca.govt.nz/uploadedDocuments/SWHSheet0.pdf

Technology Title:	**Rainwater collection**
Technology Assessment/Development	Assessment

1. Objectives

- Determine the relative merits of individual house systems or communal systems.
- Provide information on the available equipment for removing particulate and biological impurities from rainwater – cost, capacity, availability, and operating costs.
- Provide information on the comparative costs of individual household systems and citywide systems.

2. Technology Definition:

- Collection and treatment of rainwater to potable standards for domestic use.

Water collected from the roof of an individual house is treated to remove all particulate and biological contaminants to render the water suitable for all uses within that house.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

  There would be a slight increase in electricity consumption to power pumps.

- *Water:*

  In most parts of New Zealand there is enough rainfall on the roof of a house to supply the needs of the occupants. Water supply requirements for cities could be approximately halved or new supply schemes deferred for 10 to 20 years, assuming a growth rate of 5%

- *Waste:*

  Peak flows of stormwater runoff would be reduced.

- *Resources:*

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

  Not applicable to BPL

  BPL is unlikely to become involved with IP issues for rainwater harvesting as its role is most likely to focus on developing mechanisms to encourage the uptake of existing systems.

5. Technical Success:

- *Complexity:*
  Not applicable to BPL.

  Commercially proven technology is currently being deployed in the market. BPL should not need to become involved in technology development

- *Gaps:*

  Not applicable. No current technology gaps identified for BPL.

- *Constraints (capability & equipment):*

  Not applicable. No current technology constraints identified for BPL.

- *Risks:*

  Not applicable to BPL

6. Reward:

- *Market implementation:*

  The implementation of this technology should be done with the active assistance of local authorities by way of subsidies because of the potential savings in expenditure on water supply systems.

- *Impact on market:*

  BPL may impact on the market by promoting the technology to local authorities.

7. Business Risk:

- *Time to develop:*

  Not applicable to BPL

- *Business uncertainties/commercial assumptions:*

  Not applicable to BPL

- *Capex:*

  Not applicable to BPL

- *Critical success factors:*

  Not applicable to BPL

8. Comments:

Significant savings in water supply requirements can be made even if uses are confined to non-potable uses such as toilets, laundries, baths and hand-basins. The Ministry of Health has forbidden the use of rainwater collected in urban areas because of airborne contaminants that originate principally from roadways. The extra treatment required to bring the rainwater up to potable standards will depend on the locality, i.e. what contaminants need to be removed and the annual rainfall. On the other hand, water supply sources such as the Waikato river also have serious amounts of contaminants but there are economies of scale in dealing with these.

The Government has a budget of $136.9M to help improve drinking water supply standards in new Zealand. While this is aimed at disadvantaged communities, the technology could be a means that the government could use to realise this aim.

9. Actions:

- Establish web-based links to the NZ Water and Waste Association.
- Compile and publicise information on equipment suitable for treatment of household rainwater supplies.
- Commission a research report describing the costs, benefits, methods and equipment for collecting, and storing household rainwater for non-potable uses, and the methods, equipment and treatment of that water to potable standards.

10. Further Information:

www.moh.govt.nz/water - Household Water Supplies, Ministry of Health code 4602

www.nzwwa.org.**nz** (NZ Water and Waste Association)

Technology Title:	**Multi-pane windows**
Technology Assessment/Development	Assessment

1. Objectives

- Expand on identifying the opportunity to use multipane window systems to improve the overall sustainability within the RBE
- Provide a brief status on multipane window technologies
- Identify the main barriers limiting uptake of multipane windows
- Define the actions required by BPL to encourage the uptake of multipane windows
- Identify sources of additional information on multipane windows

2. Technology Definition:

- Window systems with two or three glazing layers, and vacuum, air or gas in the cavity. Shutters and lighting can also be incorporated within the cavity. This technology is applicable to both new and retrofit construction.
- Retrofitting window service using an additional outer pane and spacers.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

  The issue of single pane windows is critical for making substantial improvements to the sustainability of the NZ housing stock, due to thermal losses and condensation/ mould issues. The BRANZ HEEP year 8 report shows that 30% of domestic energy use goes on space heating. If all windows were multi-pane glazed then a reduction of 10% in space heating energy could be made or 3% of national domestic energy consumption.

- *Water:*

- *Waste:*

  Single pane glazing cause high levels of internal condensation and damage to internal fittings and furnishings. This increases the need for maintenance, including additional internal painting of sills and jambs.

- *Resources:*

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

  Additional panes will enable energy savings whilst allowing follow-on benefits such as sound insulation, light shading through polarisation or enclosed shutters and retrofitting using spacers and an additional pane will significantly reduce installation time and cost.

  There is an opportunity for BPL to investigate new systems specifically for New Zealand conditions, taking into account simple installation mechanisms, and implementations in IGUs to control UV light on interiors, as well as improving current systems using aerogels or in-built shutter systems. BPL could work with a local manufacturer in the IP of these technologies, or at the very least conduct a study of overseas technologies in double glazing, and their application to the NZ marketplace, disseminating this knowledge to the WANZ.

  In the retrofit system, BPL could commercialise and contract a retrofitting service that implements the know-how of spacer and additional pane retrofits. (refer http://www.ata.org.au/articles/84doubleglazing.pdf)

- *Barriers identified*
  1 Lack of consumer awareness of the losses that occur through windows
  2 Lack of awareness of the options available
  3 Cost/benefit or payback period is unknown, and how that varies with climate.
  4 Lack of trained installers

5. Technical Success:

- *Complexity:*

  The systems are very simple, and the only complexity involves the arrangement of various components into a system.

- *Gaps:*

  Customisation and uptake of some of the more advanced overseas technologies for NZ conditions

  Need for a retrofit solution that is commercialisable (best bet being a service provision)

- *Constraints (capability & equipment):*

  Need for a commercial partner in Window industry

- *Risks:*

  Very few. Known technology and market.

6. Reward:

- *Market implementation:*

  While 70% of new domestic dwellings in the South Island of NZ are now being double glazed, in 1994 this was only 20%. A large proportion of existing houses (estimated 80%) have single pane glazing, and much of this is with aluminium framing that gives no thermal break. Approximately half the heat lost from a well insulated home with single glazing goes out through the windows. Double-glazing will halve this heat loss. In 1997, there were 99,000m^2 of IGU units in New Zealand homes.

- *Impact on market:*

  BPL can impact on the market by closer relations with the WANZ, and by actively supporting WERS and EECA programmes. Improved systems and retrofit technologies should be shown to good effect in the Now and Then homes built/ modified. Brochures that demonstrate the benefits of different models from a cost, thermal and acoustic perspective, perhaps also in collaboration with Consumer magazine, would also impact on the market uptake.

7. Business Risk:

- *Time to develop:*

  BPL will need to partner with a NZ window manufacturer if wanting to customise overseas technologies.

- *Business uncertainties/commercial assumptions:*

  That the move towards higher sustainability standards combined with climbing home heating bills and a need for acoustic isolation of units will fuel a sufficient market demand for this technology in the retrofit area.

- *Capex:*

  Not applicable

- *Critical success factors:*

  - Partnering
  - Business case for a retrofit service company for existing market.

8. Comments:

The new build market for insulating window systems in the South Island of NZ has risen from 20 to 70% market penetration over the last decade. An additional benefit is the increase in sound insulation. NZS 4218:2004 requires double-glazed windows in new houses in the South Island and North island Central Plateau, leading to the increase. Aluminium frames are now available in thermally-broken or combination form (timber inside, aluminium outside) from some of New Zealand fabricators, and these, along with thermally improved spacers such as Tremco's 'Swiggle Strip' and Edgetech's 'Superspacer' increasingly being used with double glazing units in New Zealand to improve their thermal performance. Energy efficient low-e glazing, and IGUs with gas fills, while available in New Zealand, are not yet manufactured here, although recent advances are making this technology accessible.

BRANZ Ltd has investigated the potential for the renovation of timber single glazing, and has been involved in the development of WERS I to rank and benchmark existing new glazing products. There is a small wall retrofit industry in NZ, predominantly in the cold parts of the country.

It is known that the cost benefit of the system in the South island (particularly Christchurch and Invercargill) is good, however, the relatively low cost of electricity, temperate climate, restrictions in available glazing rebate widths commonly available in the low-volume domestic IGU market are restricting growth in the North Island. Increasing electricity costs, coupled with closer-living neighbours (acoustic issues) will aid this market to grow.

9. Actions:

- Establish web based links from BPL to WANZ/ WERS; and EECA, and work with these groups to raise awareness of both heat losses, and double glazing options available
- Work with the Window Association on removing barriers to uptake such as availability of skilled installers, capacity to manufacture and distribute product.
- Undertake an assessment of various models and their thermal/ acoustic benefits
- Undertake a cost-benefit analysis for various regions of NZ, and determine payback period. Use this and the thermal/ acoustic to produce an article in build and a consumer home renovation magazine.

10. Further Information:

http://www.wanz.org.nz/

http://www.eeca.govt.nz/

http://www.consumer.org.nz/topic.asp?category=Home%20%26%20DIY&subcategory=Heating%20%26%20energy&docid=90&topic=Double%20glazing&title=Introduction&contenttype=summary&bhcp=1

Technology Title:	**Tankless electric water heaters**
Technology Assessment/Development	Assessment

1. Objectives

- Expand on identifying the opportunity to use tankless electric water heating systems to improve the overall sustainability within the RBE
- Provide a brief status on tankless electric water heating systems
- Identify the main barriers limiting uptake of tankless hot water systems
- Define the actions required by BPL to encourage the uptake of tankless electric water heaters
- Identify sources of additional information on tankless electric water heating

2. Technology Definition:

Storage tank-type water heaters raise and maintain the water temperature to the temperature setting on the tank (usually 49° -60° C). The heater will operate periodically to maintain the water temperature, even when no hot water is drawn from the tank. This is due to the heat losses due through the tank walls and pipes (called standby losses). One way to reduce this heat loss is to use a tankless (also called "demand" or "instantaneous") water heater. Tankless electric water heaters have an electric, gas, or propane-heating device that is activated by the flow of water. They are also known as califonts. Once activated, the heater provides a constant supply of hot water. Tankless electric water heaters heat water entirely on demand, only when it is needed. When a hot water faucet is turned on and the water begins to flow, a sensor detects that hot water is being demanded. This sensor effectively turns on the heating elements/heat exchanger and a computer chip selects the correct power output to the elements/heat exchanger based on the heat setting selected by the user, the flow rate, and other parameters. The water flows across the internal heating elements and exits the unit at the desired temperature. The start-up process takes a couple of seconds. The tankless electric water heater will remain on until the hot water faucet is closed. As soon as the flow sensor detects that water has stopped flowing, the power to the unit is turned off completely.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

  Less energy is used, as the energy is used to heat a specific volume of water being drawn, rather than a whole tank. Hot water heating typically makes up around 29% of household energy use (BRANZ HEEP year 8) and 11% of this is due to standing losses. This equates to a possible saving of 3% of national domestic energy usage.

- *Water:*

  As the system requires low-flow rate for adequate heating, then low-flow heads and nozzles are preferred, allowing less use of water.

- *Waste:*

  Less space wasted in a house, as no need for tank, smaller underbench unit fitted. Most tankless electric water heating models have a life expectancy of more than 20 years compared to storage cylinder heaters tank which last 10 to 15 years. Tankless models have easily replaceable parts that allow the life expectancy to be extended further.

- *Resources:*

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

  No IP, a well-known and used system

- *Barriers identified*
  - Awareness of the technology
  - Cost/benefit of the various options, given the various energy source options.
  - Cost of upgrading electrical system
  - Heater reliability and durability

5. Technical Success:

- *Complexity:*

  Simple system, only need for lowflow shower heads and simple plumbing. Can be more complex if fitting to a solar than a gas fitting. No IP for BPL and technically a well-proven system for NZ homes.

- *Gaps:*

  Not applicable

- *Constraints (capability & equipment):*

  Not applicable

- *Risks:*

  Not applicable

6. Reward:

- *Market implementation:*

  BPL could benefit from reduced energy use and water usage due to greater uptake of this technology. Given the high percentage of household energy spent on water heating, and the water reduction benefits, this could have a significant impact on the BPL goal. The acceptability of these systems is very good in institutional facilities, however, Rheem high-pressure systems are very popular due to the 'hotwater on demand' – and lots of it – philosophy. This system offers the first, but requires a lower-flow nozzle to maintain a steady stream of hot water.

- *Impact on market:*

  Very well-suited to new building, as there is no behavioural change required by the occupant, and the unit is simple to install by a plumber/ builder, perhaps simpler than fixing in a new insulated water tank.

7. Business Risk:

- *Time to develop:*

  Not applicable

- *Business uncertainties/commercial assumptions:*

  Not applicable

- *Capex:*

  Not applicable

- *Critical success factors:*

  Not applicable

8. Comments:

The rationale behind this technology is that standing losses are minimised, and that solar water heating systems are used more efficiently - less energy will be dumped in summer conditions if they don't feed into a normal high temperature cylinder, and all storage (boosted or not) can be maintained at relatively low temperatures. The potential research activity should be to determine the costs and benefits of variable energy tankless electric water heating systems used in conjunction with solar water heating systems, and this should take into account all the efficiency benefits. Retrofitting not difficult in timber houses (requires new cabling and dedicated circuit). Plumbing is simplified, and is also not difficult to retrofit (one pipe only required). Works as well with wetback water heating as it does with solar. The primary efficiency lies in the reduction of standing losses from conventional systems (cylinders and pipe runs), and sometimes losses via pressure relief valves. The efficiency of the unit compared to other tanked systems is very dependent on pipe runs – the further an outlet is from the centralised HW tank, the more cause for using an instantaneous heating system. Therefore, designing many water outlets close together and near to a tank; compared to designs which spread them throughout the home, is a large factor in the cost/benefit of such a system.

9. Actions:

- Determine the likely performance of tankless hot water systems in New Zealand houses, compared to 'A' grade tank systems. Include the cost/benefit sensitivity of different home designs that have varying pipe –run lengths to outlets.
- Conduct stakeholder workshop with agencies/departments, designers and tradespeople to identify barriers and opportunities to residential uptake.
- Undertake an assessment of various models and their thermal/ cost benefits.

10. Further Information:

http://www.consumer.org.nz/topic.asp?category=Home%20%26%20DIY&subcategory=Heating%20%26%20energy&docid=485&topic=Water%20heating%20options&title=Introduction&contenttype=summary

Technology Title:	**Wall insulation**
Technology Assessment/Development	Assessment

1. Objectives

- Determine the most suitable technology to insulate framed walls in NZ, whether steel or timber.
- Compare the alternative materials for thermal and acoustic insulation effectiveness, slump, susceptibility to moisture, fire, mould, vermin, interaction with other components (e.g. wiring, plumbing).
- Determine the construction limitations of loose fill types, and foamed in place types.

2. Technology Definition:

- Technology for insulating wall cavities in new built framed structures.

A range of materials is available for insulating walls, including rigid foam, batts, loose fill and foamed in place. Their suitability needs to be assessed considering the permanent effect of gravity and the intermittent effects of heat and moisture.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

  Loss of heat through walls is second to losses through the roof of houses (about 30%). The majority of this is lost through windows but with attention to double glazing, and wall insulation in all houses, this loss could be reduced to about 15%. Home heating accounts for 30% of all energy usage. Hence wall insulation is relevant to 4.5% of household energy usage, representing about 200 GWh per year (1.3% of national consumption) and potentially mitigates about 90,000 t CO_2 annually from alternative thermal generation.

- *Water:*

- *Waste:*

- *Resources:*

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

BPL is unlikely to become involved with IP issues for wall insulation as its role is most likely to focus on encouraging the uptake of whatever materials or systems are found to provide the best performance. BPL could assist in the development of new generation insulation products that have lower embodied energy, can be recycled, or that result in lower waste production. BPL may have a stake in the IP if there are new products.

5. Technical Success:

- *Complexity:*

Commercially proven technology will be evaluated. BPL should not need to become involved in technology development except where it becomes apparent that particular materials could be improved, or new generation insulation materials could be developed.

- *Gaps:*

  No current technology gaps identified for BPL except for improved environmental performance

- *Constraints (capability & equipment):*

Not applicable to BPL.

- *Risks:*

Not applicable to BPL

6. Reward:

- *Market implementation:*

Wall insulation is a requirement under the New Zealand Building Code so the question is which is the best material to use in given constructions and what causes the deficiencies of those materials that have less than optimum performance. There is virtually no opportunity for BPL to obtain direct reward for assessment and development of this technology.

- *Impact on market:*

BPL may impact on the market by actively recommending particular products. Support for these programmes, such as promotion via website, installation in Now & Then homes and providing stakeholders with information will directly impact on the sustainability of new homes.

7. Business Risk:

- *Time to develop:*

Not applicable to BPL

- *Business uncertainties/commercial assumptions:*

Not applicable to BPL

- *Capex:*

Not applicable to BPL

- *Critical success factors:*

Not applicable to BPL

8. Comments:

A report by the Freedonia Group indicates that the global insulation market will approach US$18 billion in 2006. It anticipates that the Asia/Pacific region will be a leader in the insulation market growth, due to the current booming construction industry, and industrialisation. There are also opportunities for the increased use of insulation with climate change and energy pressures. In the UK, it is estimated that only 6 million of the 17.5 million homes have cavity wall insulation. An UK Energy White Paper indicates that insulating 4.5 million homes before 2010 would significantly save carbon emissions. While foamed plastics and mineral wool is thought to continue to be the fastest growing insulation materials, a number of more sustainable (usually bio-based) options are currently being researched, or commercially available. Wool insulation products that are able to reduce slumping through the use of binders (usually PVA, but the industry is investigating non-petroleum-based binders) are currently available. Straw, hemp, jute and sisal are also being researched for improved insulation products, as well as linen straw and cement fibre combinations.

9. Actions:

- Establish links from BPL to the manufacturers of all the available wall insulating materials
- Identify options for evaluating the performance of insulation materials.

- Identify strengths and weaknesses of insulation systems and engage with manufacturers to find solutions for the weaknesses.
- Identify options for new generation materials that have lower environmental impact, cost less and provide better performance.
- Advertise results on the BPL website and implement recommendations in THEN and NOW houses.

10. Further Information:

Technology Title:	Mini wind turbines
Technology Assessment/Development	Assessment

1. Objectives

- Determine the range of equipment available and their technical requirements/limitations.
- Determine what siting/structural/geographic issues are relevant.
- Determine their cost/effectiveness and payback period in the New Zealand context.
- Identify the barriers limiting uptake of mini wind turbines.
- Define the actions required by BPL to encourage the uptake of mini wind turbines.
- Determine the willingness of power supply companies to accommodate negative power meter operation.

2. Technology Definition:

- Use of mini wind turbines to supplement electricity requirements of NZ households.

This technology is commercially mature and readily available from suppliers. Systems typically cost $6/W and range in size up to 100kW although 5kW is likely to be suitable for a single household. Current payback time is expected to be 15 years depending on the cost paid for electricity.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

The average annual electricity consumption per household is 6700 kWh which is a continuous rate of about 750W (BRANZ, 2002). A 1 or 2 kW turbine could provide 30 to 40% of that power. Since households consume 8.6% of the electricity generated, mini wind turbines could provide about 3% of the nation's electricity requirements, if they were installed on every house.

- *Water:*
  N/A

- *Waste:*
  N/A

- *Resources:*
  N/A

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

BPL is unlikely to become involved with IP issues for mini wind turbines as their role is most likely to focus on developing mechanisms to encourage the uptake of existing systems. A possibility for IP may arise if solutions are invented for the problem of noise, and noise/vibration transmission through the structure of a house.

5. Technical Success:

- *Complexity:*

Commercially proven technology is currently being deployed in the market. BPL should not need to become involved in technology development

- *Gaps:*

Probably not applicable as current technology gaps identified for BPL, except for the problem of noise abatement.

- *Constraints (capability & equipment):*

Not applicable to BPL.

- *Risks:*

  Not applicable to BPL

6. Reward:

- *Market implementation:*

BPL does not stand to gain monetary reward from this technology.

- *Impact on market:*

BPL may impact on the market by actively disseminating information on the types of wind turbines available and recommending particular devices for particular locations. Support for these programmes, such as promotion via website, installation on Now & Then homes and providing stakeholders with information will directly impact on the sustainability of new homes.

7. Business Risk:

- *Time to develop:*

  Not applicable to BPL

- *Business uncertainties/commercial assumptions:*

  Not applicable to BPL

- *Capex:*

  Not applicable to BPL

- *Critical success factors:*

  Not applicable to BPL

8. Comments:

America pioneered wind turbine technology in the 1920s and it is the one renewable energy technology that the U.S. still dominates. Small-scale wind turbines were initially developed in California in the early 1980s, and over the past 15 years, the American small wind turbine industry has been growing at an annual pace ranging from 14 to 25 percent. The US has installed nearly 30 MW of small wind turbine capacity over the past 15 years, and small wind turbine companies have set a target of increasing this total to 107 MW by 2010. Currently there is only one major wind turbine manufacturer in the U.S., GE Wind. European wind turbine companies control the global market for large-scale wind plants. Vergnet is a world leader in the market of small wind turbines not connected to the grid.

With an average growth rate of 30% annually over the past five years, wind energy is the world's fastest-growing energy source, although it still accounts for a small portion of world electricity supply. At an average growth rate of 30% annually over the past five years, wind power has been the world's fastest growing electricity source for much of the last decade, with the majority of these wind turbines, often exceeding 1 megawatt (MW or 1,000 kW) in size, now manufactured in Europe. AWEA believes in the US, small wind is not matching the growth of the residential photovoltaic (PV) industry because government support programs usually favour PV over wind.

The American Wind Energy Association (AWEA)'s Small Wind Industry Market Study forecasts sales of nearly 13,000 small wind turbines (up to 100KW) in 2005 for the US market, totalling nearly 14 MW of installed capacity.

Other findings from the market study are:
The small wind turbine industry could reach sales of 75,000 turbines totalling 115 MW of installed capacity in the 2006-2010 timeframe. The industry believes that growth targets of 18-21 percent are possible over the next five years with the right government policies in place to grow the market;
Four U.S. firms supply at least one-third of the global market for small wind turbines, serving as one of the few remaining U.S. based energy export markets;
The average size of small wind turbines has doubled from 500 W in 1990 to 1 kW in 2004 due to an increase in grid-connected on-site distributed applications.
California currently provides a rebate of up to 50% of the purchase price of a small turbine, and that has helped to sharply increase demand for the units in the state.
The UK government is producing a strategy by April 2006 to encourage small-scale wind turbines for housing. Technical issue which need to be addressed include how to connect to the grid, compatibility with building regulations and planning consents and structural integrity of the home (i.e. are modern houses sufficiently strong to take a wind turbine?).

9. Actions:

- Establish web based links from BPL to wind power generation associations
- Place wind power generation associations on circulation list for BPL newsletters and keep informed on other relevant information
- Work with the wind power generation associations on removing barriers to uptake to mini wind turbine systems such as availability of skilled installers, and noise abatement/isolation.
- Establish links to power generation companies to determine their attitudes re meter operation.

10. Further Information:

Technology Title:	**Framing efficiencies**
Technology Assessment/Development	Assessment

1. Objectives

- Determine the extent to which the amount of framing used in timber framed houses may be reduced without compromising its structural performance.

2. Technology Definition:

- More efficient use of timber in timber framed housing.

Timber frame construction is the most widely used form of house building in New Zealand but the amount of timber used appears to be far more than sufficient for the structure to withstand the expected loads.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*
  N/A

- *Water:*
  N/A

- *Waste:*
  A slight reduction in waste generation is envisaged as a result of this work.

- *Resources:*

  Of the timber used in a house, approximately one third goes into the flooring, wall framing and the roofing respectively. The wall framing, which requires about 8 m^3 for an average house, could be reduced by 2 to 3 m^3, or 10% of the total framing used. Over the 25,000 housing starts per year this amounts to a saving of about 60,000 m^3.

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

  BPL is unlikely to become involved with IP issues for timber framing although the work may reveal that new types of fastenings may be needed.

5. Technical Success:

- *Complexity:*

Commercially proven technology is currently being deployed in the market. BPL should not need to become involved in technology development.

- *Gaps:*

Not applicable. No current technology gaps identified for BPL.

- *Constraints (capability & equipment):*

Not applicable to BPL.

- *Risks:*

Not applicable to BPL

6. Reward:

- *Market implementation:*

There are no monetary rewards for BPL implicit in this technology.

- *Impact on market:*

A reduction in the amount of timber used in a house is likely to be viewed with considerable disfavour by timber producers.

7. Business Risk:

- *Time to develop:*

Not applicable to BPL

- *Business uncertainties/commercial assumptions:*

Not applicable to BPL

- *Capex:*

Not applicable to BPL

- *Critical success factors:*

Not applicable to BPL

8. Comments:

The technique currently employed in the (US) market to reduce the amount of timber used in framing, and also to enhance the overall structural and thermal performance of the timber-frame envelope is called Optimum Value Engineering (OVE). OVE refers to framing techniques that reduce the amount of lumber used to build a home while maintaining the structural integrity of the building. This results in lower material and labour costs and improved energy performance for the building. Initial use of these techniques will slow down framing time temporarily, as framers are unfamiliar with the technique, and would require training. There is also more planning required, and the technique would suit off-site prefabrication.

One technique employed is on centre framing, which widens the framing spacing, and optimises the door and window spacing. Pathnet makes recommendations for designs that are built repeatedly and provides wall framing layout drawings that can guide the framing crews.

9. Actions:

- Use the OVE and Pathnet software to analyse a selection of New Zealand house designs.
- Identify and quantify where savings in material usage may be made.
- Discuss these findings with a house building firm such as G J Gardiner, and with precut/pre-nail operations such as Carter Holt Harvey.
- Provide a report to BPL detailing where savings may be made and if special new fastenings are required, a specification of the function of those fasteners.

10. Further Information:

http://www.pathnet.org/sp.asp?id=9028

http://www.housingzone.com/topics/pb/build/pb03ga021a.asp

http://www.taliesinpreservation.org/preservation/pres_related/wood_framing.htm

Technology Title:	**Phase change materials**
Technology Assessment/Development	Development

1. Objectives

- Identify the opportunity to use phase change materials to improve the overall sustainability within the RBE
- Provide a brief status on phase change technologies
- Identify the main barriers limiting uptake of phase change systems
- Identify actions for BPL
- Identify sources of additional information on phase change materials and solutions

2. Technology Definition:

Phase change materials or systems (PCM) can decrease energy consumption by reducing daily room temperature fluctuations by lowering the peak temperatures resulting from higher daytime temperatures. PCMs thereby reduce home heating or cooling loads, produce energy savings for consumers, and potentially reduce the demand for additional electricity generation required to meet daily peak energy loads.

PCMs are solid at room temperature, but when temperature becomes warmer they liquefy, storing or absorbing heat and cooling a house. Conversely, when the temperature drops the material will solidify and give off heat energy, heating the house. By incorporating PCMs in the building envelope they absorb the heat of higher exterior temperature, defer the heating of the interior, cooling the house during the day and warming it at night when they give off heat as the exterior temperature decreases.

This technology is not currently available commercially.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*

  Current indications are that PCMs may save up to 20 percent of house space-conditioning costs, which accounts for 30% of the domestic energy consumption, i.e. 6% of domestic energy usage. One overseas study has indicated that where PCMs were used for attic insulation that it reduced the total heat flow by 22 percent and the peak heat flow was 42 percent lower than an equal thickness of fiberglass insulation. It reduced the air conditioning load by 40 percent and shifted the peak load up to eight hours, depending on climate. PCM insulation is most effective in climates that have sharp variations between day and night temperatures. Adopted in sufficient quantities, the technology could result in reductions of peak-hour energy use.

  Work completed in the UK where PCM were assessed for conditions in New Zealand based on using solar collectors with PCM, could store approximately 20,000 kWh heat energy during the winter season when incorporated within floor construction. This would represent a solar panel area space covering 27 m^2.

- *Water:*

- *Waste:*

- *Resources:*

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*

  A number of materials are currently being evaluated as possible phase change materials. At this stage the status of IP for these materials is unknown and would need to be investigated further if this was a technology area that BPL wished to advance.

  An important technical barrier is the technology used to encapsulate the phase change material if used in a wall system application. Again, a number of technologies are being evaluated in this area

and the IP opportunity for BPL would need to be further explored.

5. Technical Success:

- *Complexity:*

  The technology has a relatively high degree of complexity, as it typically requires the use of paraffin compounds or so-called linear crystalline alkyl hydrocarbons. Such compounds are commercially available from petroleum refining or polymerisation. Manufacturers have demonstrated two processes that successfully incorporate these types of compounds into wallboards. PCM attic insulation comes hermetically sealed for installation between two layers of certain insulation materials such as extruded polystyrene, urethane or cellulose.

- *Gaps:*

  - Development of phase change systems that effectively operate over a range of temperatures rather than quite a narrow or may be a single ideal temperature. Such systems limit the materials' use in climates where both heating and cooling are important.
  - The properties of the PCM remain constant over many cycles
  - Proof of fire safety
  - Perceived comfort factor
  - Economic payback from energy savings.

- *Constraints (capability & equipment):*

  Domestic experience with this technology primarily resides with universities. Coupling this expertise with building systems and other materials knowledge could give rise to next generation technologies and materials.

- *Risks:*

  Medium to high.

To limit fire risk in a plaster board product, it was found that limiting the amount of PCM (paraffin wax) to 5% to 20%, and subsequently treating the plasterboard with an insoluble fire retardant were appropriate options.

6. Reward:

- *Market implementation:*

  BPL could benefit from the development of next generation PCM and applications.

- *Impact on market:*

  PCM would have application for both new build and retrofit. For new build situations the development and implementation of new wall cladding products would reduce energy use. Such products could also be used in retrofit situations as well. Other retrofit applications could be the use of PCMs in conjunction with solar panels.

7. Business Risk:

- *Time to develop:*

  Commercial applications are not currently known to exist so there would be a reasonable lead-time to have a commercial product available. &D has been completed overseas and work is currently being undertaken at Auckland University.

- *Business uncertainties/commercial assumptions:*

No information available

- *Capex:*

  Capital may be required for demonstration facilities. This would depend on the size and complexity of trials required.

- *Critical success factors:*

  - Development of appropriate encapsulation methods
  - Securing supply of PCMs
  - Identifying the applications, which could provide the most effective outcome for BPL.

8. Comments:

Some studies have indicated that the cost of PCM in houses and other buildings can be cost effective taking into account material and installation costs. No specific NZ data on costs were found in the literature. No commercial products currently exist which employ PCM systems for building applications.

This technology warrants further consideration to more clearly identify the barriers to commercial application and options for innovation to accelerate its development and implementation.

9. Actions:

- Obtain further information on the options for deploying PCMs.
- Compile or obtain an up to date literature review.
- Undertake a preliminary cost benefit assessment of PCMs and their application to the New Zealand RBE. A multidisciplinary team comprising of chemical engineers, chemists, building scientists, economists and material specialists should undertake this.

10. Further Information:

Mohammed Farid, University of Auckland

http://freespace.virgin.net/m.eckert/

http://www.sdge.com/construction/Builders%20Resource%20Guide/Phase%20Change%20Materials.htm

Technology Title:	**Biopolymers**
Technology Assessment/Development	Assessment

1. Objectives

- Develop insulating foams, or building wraps and films, or resins for coatings or adhesives from plant-based raw materials, such that they have better properties than existing products.
- Identify where new inventions are required.

2. Technology Definition:

- Development of biopolymers for next generation building materials

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*
  The materials will have less embodied energy than currently available technologies
- *Water:*
  N/A
- *Waste:*
- *Resources:*

  A reduction of volume of imported oil is possible.

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*
  This technology has a high likelihood of IP accruing to BPL

5. Technical Success:

- *Complexity:*

  This technology is likely to be complex, with methods of production yet to be invented
- *Gaps:*

  Gaps will exist where specific technologies require new knowledge
- *Constraints (capability & equipment):*

  Not applicable to BPL.
- *Risks:*

  Not applicable to BPL

6. Reward:

- *Market implementation:*

  There are considerable monetary rewards for BPL implicit in this technology.
- *Impact on market:*

  Provided these technologies can be developed to perform better at lower cost, the impact on the market will be significant, and will displace existing technologies.

7. Business Risk:

- *Time to develop:*

Unknown

- *Business uncertainties/commercial assumptions:*

Scion has developed prototype insulation foams and resins from biomaterials. It is assumed that these can be developed to commercialisation.

- *Capex:*

Not applicable to BPL

- *Critical success factors:*

Not applicable to BPL

8. Comments:

9. Actions:

- Identify where the properties of insulating foams, building wraps and films, and resins for adhesives or coatings could be improved.
- Carry out patent searches
- Quantify the properties required of technologies with improved performance.
- Further develop previously invented materials and invent new ones where the need arises.

10. Further Information:

Technology Title:	**Air – air heat exchangers**
Technology Assessment/Development	Assessment

1. Objectives

- Quantification of the contribution this technology could make to healthier living conditions.
- Description of existing equipment.

2. Technology Definition:

- Air-air heat exchangers

An opening window is replaced by a permanently closed (bonded) sheet of glass and ventilation provided by a low-cost air-to-air heat exchanger that either replaces the glass or is a fitting in the wall.

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*
  This technology will save space-heating costs by reducing heat losses to due to ventilation. Savings are likely to be negligible, as there will be increased ventilation.

- *Water:*
  N/A

- *Waste:*
  N/A

- *Resources:*
  N/A

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*
  This technology has a high likelihood of IP accruing to BPL

5. Technical Success:

- *Complexity:*

  This technology is likely to be complex, some aspects of the technology yet to be invented.

- *Gaps:*

  Gaps will exist where specific technologies require new knowledge

- *Constraints (capability & equipment):*

  Not applicable to BPL.

- *Risks:*

  Not applicable to BPL

6. Reward:

- *Market implementation:*

There is some monetary reward for BPL implicit in this technology.

- *Impact on market:*

Impact on the market will be not be great, but will depend on the perceived health benefits.

7. Business Risk:

- *Time to develop:*

  Unknown

- *Business uncertainties/commercial assumptions:*

  An expert in this field needs to be found.

- *Capex:*

  Not applicable to BPL

- *Critical success factors:*

  Not applicable to BPL

8. Comments:

9. Actions:

- Carry out patent searches
- Commission an evaluation of the prototype system developed at Scion.
- Expand on identifying the opportunity for in-wall air-air heat exchangers to improve the overall sustainability within the RBE
- Provide a brief status on in-wall air-air systems
- Identify the main barriers limiting uptake of in-wall air-air system

10. Further Information:

Technology Title:	Airtight recessed downlights
Technology Assessment/Development	Assessment

1. Objectives

- Develop a downlight that does not need ventilation
- Identify where new inventions are required.

2. Technology Definition:

- Recessed downlights that do not need ventilation

3. Alignment of the Technology with Beacon's Goals:

- *Energy/energy efficiency:*
  This technology will save space-heating costs by reducing heat losses to the ceiling space. Space heating accounts for 30% of national domestic energy usage and 20% of this is lost through the ceiling. This technology could reduce this by 2%, or 0.6% of national domestic usage.

- *Water:*
  N/A

- *Waste:*
  N/A

- *Resources:*
  N/A

4. Competitive Advantage / Business Advantage (Product / Process):

- *IP Assessment:*
  This technology has a high likelihood of IP accruing to BPL

5. Technical Success:

- *Complexity:*

  This technology is likely to be complex, some aspects of the technology yet to be invented.

- *Gaps:*

  Gaps will exist where specific technologies require new knowledge

- *Constraints (capability & equipment):*

  Not applicable to BPL.

- *Risks:*

  Not applicable to BPL

6. Reward:

- *Market implementation:*

  There is some monetary reward for BPL implicit in this technology.

- *Impact on market:*

  Provided these technologies can be developed to perform better at lower cost, the impact on the market will be not be great, but will displace existing technologies.

7. Business Risk:

- *Time to develop:*

Unknown

- *Business uncertainties/commercial assumptions:*

An expert in this field needs to be found.

- *Capex:*

Not applicable to BPL

- *Critical success factors:*

Not applicable to BPL

8. Comments:

9. Actions:

- Carry out patent searches
- Quantify the properties required of technologies with improved performance.

10. Further Information:

Appendix 2 Handbook of Technologies for the Workshop

NOTE: The areas in which benefits are expected to be obtained from each technology are identified by the letter "y" in the tables.

A FILMS, CHEMICALS AND COATINGS

A1 Photocatalyst materials

From: New 1

Is a photocatalyst construction material that can cool houses by absorbing water when exposed to sunlight.

Barrier: Technology

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y		y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
	y	y			

Cautionary notes and comments by John Storey

Technology barrier. Energy benefits

A2 Phase Change Materials (PCMs)

From: New 1

PCMs are solid at room temperature. When the temperature becomes warmer, PCMs liquefy and absorb and store heat, thus cooling the house. Conversely, when the temperature drops, the material will solidify and give off heat, warming the house. In effect, they increase thermal mass

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y	y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Technology barrier. Also for use in floors. Don't they need sunlight exposure to work? A fundamental problem is that some materials have a very narrow temperature range to change phases, or there is an ideal temperature that limits the material's use in climates where both heating and cooling are important. Issues relating to proof of fire safety, perceived comfort levels, and economic payback from energy savings are still to be researched.

A3 Water-based Exterior Masonry paints

From: New 1

New Water based Exterior masonry paint product that is environmentally better and improves performance. Allegedly

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
					y

Cautionary notes and comments by John Storey

Lots of these now and more every year on the market. mineral paints, self coloured mineral plaster systems, low VOC paints/ finishes all relate to this

---

A4 Green Chemistry/ Ecopaints

From: New 1

An article that explains some of the considerable potentials of non petro-chemical based chemicals. Emphasising the importance of developing non-polluting and sustainable chemical industry.

Barrier: Technology, Market, Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y		y	y		y

Cautionary notes and comments by John Storey

Lots of these now and more every year on the market. Mineral paints, self-coloured mineral plaster systems, low VOC paints/ finishes all relate to this. More each year and getting cheaper. Also water-based, "breathable" paints made from natural materials

---

A5 UV proof films/ Auto-detecting polarised glass

From: Now House

Polarising films that prevent UV rays. Window films and window glass for glare resistance. Diode light sensor detection for polarisation. Window glazing with optical/solar properties that varies according to voltage, light or heat. Most research has been conducted on electrochromics, or materials, which change their optical/solar properties upon the application of a small electric potential.

Barrier: Technology, Market, Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y			y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

Don't think they prevent UV rays (?) There are lots of good UV films on the market for glass - what about other surfaces? Possibly barriers are all three types. Auto-detecting glass windows are still in prototype stage for buildings, though auto-manufacturers have produced these for cars. No residential application yet available

---

A6 Low toxicity herbicides and pesticides

From; Now House

Herbicides and pesticides that biodegrade to non-toxic elements, or contain not toxic materials to begin with. Organic sprays.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y						

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Health and water benefits. Possibly also household cleaners fit in this category?

A7.1 UV proof varnish;
A7.2 Natural oils and waxes

From: Now House

Finishing system that protects/ nourishes but does not yellow timber

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
					y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Lots of good oils and hard waxes that do not yellow timber available. Health benefits. Careful - 'Natural' products can contain toxins and VOC's also – just naturally occurring and not synthetically made from fossil fuels.

A8 High tech mineral silicate paints

From: BRANZ

Ecopaint that doesn't form a surface film that can flake off, providing excellent durability/life-expectancy.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
					y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y			y		y

Cautionary notes and comments by John Storey

Also available in NZ. Market barrier. Provides a highly durable, ultra low odour and VOCs, excellent permeability to moisture, natural and non-toxic ingredients, and non-combustible. Not suitable for flexible surfaces - wood and plastics.

A9 Non-toxic paint stripper (gel)

From: BRANZ

Non-toxic, water based paint and varnish remover

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
					y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y			y		y

Cautionary notes and comments by John Storey

Pretty sure widely available. These non-toxic strippers have nothing to do with waste reduction or ventilation benefits. Air quality, yes, but that's different. Where is the resource use benefit?

A10 Coatings that repel dirt

From: John Storey

Self-explanatory. No maintenance requirement to keep clean

Barrier: Technology, Commercial, Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y				y	y

Cautionary notes and comments by John Storey

B COMFORT, VENTILATION, AIR QUALITY

B1 Natilin - Flax Fibre Insulation

From: New 1

Flax fibres bound using a thermoplastic binder and treated with inorganic salts.

Barrier: Commercial

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y		y	y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y		y		y	

Cautionary notes and comments by John Storey

Prolonged water exposure will cause decay.

Benefits:

B2 Solar Chimneys

From: New 1

Generates air movement through buoyancy forces thus drawing air through and out of the building core.

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y			y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y		y			

Cautionary notes and comments by John Storey

Major barrier to uptake is not applicable. It is a design feature. Moisture and energy are also benefits

---

B3 Air-Air heat exchanger/ Heat pump

From: Now House

Warm air heats incoming cool air on exiting house

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y		y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

See Lindas housing in Sweden.

B4 Wide stud spacing

From: Now House

900 mm or 1200 mm, in external walls in conjunction with 140 mm wide studs and other materials and components to suit. Thicker linings, which can span wider stud spacings, are available. Similarly, cladding systems can be made to work with wider stud spacings. E.g. vertical board and batten depends on dwang spacings, not stud spacings.

Barrier: Market,

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y		y	y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

B5 Multiple-glazed windows

From: Now House

Window systems with several glazing layers, and air or gas in cavity. Can also incorporate shutters, and lighting within cavity.

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y	y		y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Why not multi-layer window systems? Add benefits for this - energy, health etc. Thermal and sound also

---

B6 Ultimat

From: FR

Insulation mat from fibres of old clothes

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y	y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y			y	y	y

Cautionary notes and comments by John Storey

Rodents?

B7 Trombe Walls

From: FR

A north-facing masonry wall covered with glass spaced a few inches away. Sunlight passes through the glass and is absorbed and stored by the wall. The glass and airspace keep the heat from radiating back to the outside. Heat is transferred by conduction as the masonry surface warms up, and is slowly delivered to the building some hours later.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y	y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Are made up from standard technology items, so the barrier is non-applicable – design feature.

B8 Solar fan

From: Robin Allison

PV -powered roof-mounted ventilation

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
					y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y		y			

Cautionary notes and comments by John Storey

B9 Non-toxic paint stripper (gel)

From: BRANZ

Non-toxic, water based paint and varnish remover

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
					y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y			y		y

Cautionary notes and comments by John Storey

Pretty sure widely available. These non-toxic strippers have nothing to do with waste reduction or ventilation benefits. Air quality, yes, but that's different. Where is the resource use benefit?

B10 Sheep Wool Batts

From: Now House

Wool bound using polyester fibres and treated with inert mineral. Polyester binder reduces slumping, and allows springback.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y	y	y	y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y				y	y

Cautionary notes and comments by John Storey

Prolonged exposure to water and sunlight will cause decay.
Also performance quality control issues

C PROCESS IMPROVEMENTS/ EFFICIENCIES

C1 Mounting water pipes on resilient mounts

From: Now House

Stops pipe noise through building members

Barrier: Market

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y			y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Benefits:

Cautionary notes and comments by John Storey

Commonly used in construction. Sustainable benefits unclear.

C2 Driven piles

From; FR

A pile application system consisting of a pole digger and ram, to enable easy fitting of piles

Barrier: Commercial/ Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
				y	

Cautionary notes and comments by John Storey

Easily done with existing technology, but need dimensions very precise before making

C3 Fusiotherm plumbing

From: Now House

Heat-fused plastic pipes which reduce leakage

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Cautionary notes and comments by John Storey

Quite frequently used, especially under slabs and has pre-insulated version

		y				
Health	**Weather control**	**Moisture**	**Waste**	**Performance**	**Resources/ materials**	
				y	y	

C4 Electronic socket timer controls

From: FR

Allow electrical appliances to switch on at certain times only

Barrier: Market,

Benefits:

Water	**Construction**	**Energy**	**Thermal**	**Sound**	**Ventilation**	**Light**
		y				
Health	**Weather control**	**Moisture**	**Waste**	**Performance**	**Resources/ materials**	

Cautionary notes and comments by John Storey

C5 One kWh/day refrigerator

From: BRANZ

Highly efficient fridge-freezer, which is about, double the existing efficiency of the standard off-the shelf unit available today.

Barrier: Commercial

Benefits:

Water	**Construction**	**Energy**	**Thermal**	**Sound**	**Ventilation**	**Light**
		y				
Health	**Weather control**	**Moisture**	**Waste**	**Performance**	**Resources/ materials**	
				y		

Cautionary notes and comments by John Storey

This is important due to the sizeable energy intensity refrigeration has as a proportion of all energy end uses. Danish model is the best I think. Commercial barrier also.

C6 Airtight recessed downlights

From: BRANZ

Airtight downlights with modified ballasts which can handle increased temperature build-up

Barrier: Technology

Benefits:

Water	**Construction**	**Energy**	**Thermal**	**Sound**	**Ventilation**	**Light**
		y				y
Health	**Weather control**	**Moisture**	**Waste**	**Performance**	**Resources/ materials**	
				y		

Cautionary notes and comments by John Storey

It's not just fitting build up but gap required around downlights. Needs insulation and dark ceiling (?)

C7 Trombe Walls

From: FR

A north-facing masonry wall covered with glass spaced a few inches away. Sunlight passes through the glass and is absorbed and stored by the wall. The glass and airspace keep the heat from radiating back to the outside. Heat is transferred by conduction as the masonry surface warms up, and is slowly delivered to the building some hours later.

Barrier: Market

Benefits:

Cautionary notes and comments by John Storey

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y	y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Are made up from standard technology items, so the barrier is non applicable – design feature.

C8 Framing efficiencies

From: New 1/ FR

Lots of work done in the 1980's, but was never taken up in the USA - 40% framing savings claimed

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

Need to dust off this work and see if applicable to NZ? Turboweb used in Australia - no angles cut, just rounded ends and nailplates.

C9 Solar panels as a roofing system

From: New 1

With massive deployment of solar panels on the built environment expected in the future, it is anticipated that most of these panels, especially in new buildings, will be incorporated into the roof structure, rather than attached onto the roof, above an already existing conventional skin to protect against the weather. These panels have to fulfil the demand for comfort conditioning and to provide electrical power.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y	y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

This is an idea that is easily done by using simple current technology - provided roof is right slope. Integrated designs often more acceptable than current clutter

---

D ALTERNATIVE POWER GENERATION

D1 Solar panel photovoltaics

From: New 1

A solid-state semi-conductor device. Light shining on a PV cell liberates electrons, which are collected by a wire grid to produce direct current electricity.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

Cost is main barrier

D2 Mini wind turbine on roof -Rutland windcharger

From: FR

Small turbine for providing electricity supply to power a dedicated device. Small wind-powered turbine for charging 12v-24v battery devices

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

Lots of types available in NZ

D3 Solar battery chargers

From: FR

Mobile phone and rechargeable battery chargers using solar PV

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

D4 Solartwin

From FR

Solar hot water heating using a solar powered pump

Barrier: Market

Benefits:

Cautionary notes and comments by John Storey

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

---

D5 Biogas pits and methane digestors

From: FR

Harvesting methane energy from septic tank or biodegradation

Barrier: Commercial/ Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

Technology has been around for 30 yr. at least. Massey University have done a lot of work on this, big potential. Many other countries using besides China. Would state market barrier rather than commercial, also. Biomass could be really big in NZ, plus there is a lot of waste material.

			y		y

D6 1 watt stand-by power for home appliances

From: BRANZ

Incorporating technology in (especially) lower value consumer electronics and appliances to so that standby power reduces by at least 65% of current levels.

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

Efficient, low loss external power supplies often cost manufacturers less than US$1.00, the cost for internal power supplies in some products may be higher.

D7 I-scale CHP (Combined Heat and Power)

From: New 1

Is a combined heat and power generation system with an electrical power less than 200kW.

Barrier: Commercial/ Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

Don't see how these reduce waste and use less resource?

E HEAT RECOVERY

E1 Underfloor heating from district heating

From: FR

Waste hot water and/or steam from nearby industrial plants is supplied to suburbs, for use in underfloor heating pipes in single homes and apartments

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

E2 Solar water heating

From: Now House

A solar water heater typically uses glazed collectors that are roof-mounted and connected to a preheat storage tank. Fluid is pumped to the collectors where it is warmed by the sun and returned to a heat exchanger where heat from the fluid is used to heats the water in a preheat storage tank

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

There are lots, both mains pressure and low pressure.

E3 Passive cooling systems

From: Now House

A system to heat and cool buildings that relies primarily on radiation heat transfer. Typically, heated or chilled water is circulated though floor or ceiling panels to condition the space.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
			y	y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
				y	

Cautionary notes and comments by John Storey

Is it really passive - i.e. relying on solar energy/air temperatures to provide warmth/cooling

---

E4 Thermosiphoning solar storage tanks

From: Now House

A system that uses the principle of thermosiphoning to produce hot water during the day, and coolth during the night, using a solar panel and a hot and cold storage tank

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y			

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

Mike Collins is testing a thermosiphoning system using water for radiant heating/cooling in select locations. Concept testing by FR - needs large tank for cooling - preferably underground

---

E5 Reduced standing losses

From: Now House

Use mains pressure and small 9mm bore pipe to reduce standing losses

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

E6 Solar Slates

From: ZALEH

Solar Slate works by using a small fan, which is driven directly by solar power itself, to suck the solar heated warm, dry, fresh from directly beneath the slates or tiles and to blow it through a flexible duct to a grille, normally mounted in the ceiling of the hallway of the house. This warm, dry, fresh air then percolates into all the rooms leading from the hallway. A small PV solar cell is located on the south-facing slope of the roof and is connected directly to the fan, which is thus powered and controlled by the sun. The Solar Slate system is entirely automatic and consumes no mains electricity at all. A non-return

valve prevents loss of heat at night or when the fan is not running. Noise levels are low.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y	y		y	

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Depends on incoming air source and slate composition whether air quality is 'fresh'. Suitability in high wind areas to be confirmed. Requires concrete tiles or slates

---

E7 Hot Water Recirculation Systems

From: New 1

In this system, a recirculating pump rapidly pulls hot water from a water heater while simultaneously sending cooled-off water from the hot water lines back to the water heater to be reheated. In addition to having the convenience of hot water on-demand, the system conserves water and can save energy.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

Is this just a design idea rather than a proprietary system?

F MATERIALS AND SYSTEMS

F1 High-performance plasterboards

From: Now House

Plasterboards with improved screw-holding abilities – so we don't need rawl plugs

Barrier: Technology

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y	y	

Cautionary notes and comments by John Storey

F2 Hardened wood

From: Now House

Timber modified with starches, chemicals and biopolymers which increases durability, stability, and allows colourisation of the timber

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Health	Weather	Moisture	Waste	Performance	Resources/

Cautionary notes and comments by John Storey

	control				materials
		y		y	

F3 Biofibre plastic composites

From: FR

Combining and forming building products from waste plant fibre resources and plastic pellets. A high strength fibrous material which can be used for both new and strengthening of existing buildings.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y	y	y			y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y	y	y	y	y	y

Cautionary notes and comments by John Storey

F4 Self-consolidating concrete

From: FR

Composed of optimised aggregate, cements, and admixtures, including superplasticizer, which keeps the mix highly fluid during the pouring process without compromising the cured material's ultimate strength. It requires no vibration, and can therefore be used for difficult or constrained pours, such as those involving unusually dense reinforcing steel or narrow channels through which the concrete must flow.

Barrier: Commercial

Benefits:

Cautionary notes and comments by John Storey

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y	y	y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y	y	y

F5 Recycled materials into new products

From: John Storey

Barrier: Technology/ Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

Victoria University Architecture students doing a lot of the preliminary feasibility for these

F6 Agricultural residues

From: BRANZ

Straw Bagasse. Fibrous plant materials. Used as fillers and flours, also joined in binders and using plastics for WPC's

Barrier: Commercial/ Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
			y	y		

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y	y	y	y	y	y

Cautionary notes and comments by John Storey

F7 Biopolymers

From: New 1

Polymers derived from nature, usually plants. Made into resins and plastics. Can be combined with other materials.

Barrier: Technology/Commercial/ Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
			y			y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y	y	y		y	y

Cautionary notes and comments by John Storey

G WASTE REDUCTION/ RECYCLING

G1 Demountable Fastenings

From: Now House

Clips, screws. Camlocks etc -Enables structural and non-structural elements to be removed and rearranged

Barrier: Commercial/Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

G2 Home recycling station - kitset of containers and labels

From: FR

Recycling deposits (kitset of containers and station) for household separation at source. Also community-based recycling deposit containers and stations for apartment buildings/ student accommodation

Barrier: Commercial/Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

Separation at source not wanted by some kerbside collectors

G3 Adhesives which are easy to deconstruct buildings with

From: Now House

Adhesives are used to lay carpet, attach panels to joists, insert fit-out cabinetry, etc - rather than change back to screws and tacks, is there an easy deconstructing adhesive?

Barrier: Technology/Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		y

Cautionary notes and comments by John Storey

H WATER PURIFICATION/ WATER CONSERVATION

H1 Composting toilet

From: BRANZ

Deals with human waste products on-site - not mains connected. Waterless and decomposes waste into compost.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y						

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		

Cautionary notes and comments by John Storey

Have stigma attached.

H2 Permeable pavers for driveways, paths etc.

From: BRANZ/Now House

Interlocking concrete grid porous pavers for use as a replacement for conventional concrete pavers

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y						

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
	y			y	y

Cautionary notes and comments by John Storey

NZ have this already - Firth. Cost greater than standard because of multi-layer construction. Reduces pollution and rainwater (stormwater) runoff, lessening impact on stormwater drains.

H3 Handbasin Toilet

From: Robin Allison

A hand basin and tap are incorporated into the top of the cistern, with the washwater then flushing the toilet.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y						

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y		

Cautionary notes and comments by John Storey

Available commercially in Japan

H4 Rainwater tank siphon cleansing system

From: Robin Allison

Pipe system installed at the bottom of tank linked to siphon discharge pipe, so that when the tank overflows it draws off the dirty water from the bottom of the tank.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y						

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

Simple method of maximising tank water quality, no power required.

J LIGHTING

J1 Light tubes or skylights

From: Now House

Filtering of natural light into central and darker areas

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
						y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
y					

Cautionary notes and comments by John Storey

J2 Fibre-optic lighting

From: FR

Fibre optic lighting utilises light-transmitting cable fed from a light source in a remote location.

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
				y	

Cautionary notes and comments by John Storey

Especially for feature lighting and outdoor landscape lighting. Early illuminators had lower lumen output when compared to traditional light sources and fixtures, and may have perceptual issue on light availability, and cost

J3 Solar garden lights

From: New 1

Small solar panel to power light, no cables, and easy to transport. Stores energy by day and releases light at night

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y	y	

Cautionary notes and comments by John Storey

performance of most systems not great - good for lighting pathways and entrances, but not strong light

J4 Daylight harvesting

From: FR

Light-level sensors detect available daylight and then modulate the output of electric lights to compensate for light coming into an architectural space from the outside

Barrier: Commercial/ Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
				y	y

Cautionary notes and comments by John Storey

Allows constant lighting levels.

J5 Low energy lightbulbs

From: Now House

Long life bulbs that use less power to run

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
		y				y

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y	y	

Cautionary notes and comments by John Storey

K INTELLIGENT SYSTEMS

K1 Smart Cabling

From: FR

A wired circuit (or series of circuits) linked around the home via a hollow dado picture rail or architrave. Autobus using architrave as conduit.

Barrier: Commercial

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
	y					

Health	Weather control	Moisture	Waste	Performance	Resources/ materials
			y	y	

Cautionary notes and comments by John Storey

Facilitates easy change/ alteration

K2 Self-powered sensor activated faucets

From: BRANZ

Selfcharging hydro-powered faucet coupled to lithium battery doesn't require mains powering

Barrier: Market

Benefits:

Water	Construction	Energy	Thermal	Sound	Ventilation	Light
y		y				

Health	Weather control	Moisture	Waste	Performance	Resources/ materials

Cautionary notes and comments by John Storey

Very expensive.

L OTHER LOWER RANKED TECHNOLOGIES:

L1 Theft-protection devices	Microchip linked to telephone network/power meter which allows appliances to only work at that phone number/ GPS location; Uniquely marked house/contents; Wired houses which Link to nearest security firm alarms -sets off alarm either at house or police station when appliance is unplugged
L2 Domotics / Smart housing	Domestic -robotics or 'smart homes' which have automated controllers for consistent environment. Controls lighting, heating, security and entertainment usually via field-bus loops
L3 Hotel/motel key card system	Card to control lighting and HVAC energy usage, where occupancy status is assessed and energy consumption is adjusted accordingly.

L4 HID (High intensity discharge) ballasts	High Intensity Discharge (HID) lamps produce light by striking an electrical arc across tungsten electrodes housed inside a specially designed inner glass tube.
L5 Universal light dimming control	Dims all lighting types, including CFL's, overcoming a major impediment to their uptake. Uses a microprocessor attached to the lighting circuit.
L6 LED Lighting	As drop in replacements for standard lighting, in certain applications, using superb right types, getting better lumen/Watt efficiencies than CFL's
L7 Compact Fluorescent portable plug-in fixtures	Ensuring lamps etc are compatible with CFL technologies, making it easier for consumer change. These are though to account for about 20% of all lighting.
L8 Emergency lighting using any lighting.	Transforms any lighting fixture into an emergency light
L9 Diode lighting systems	Much less power used
L10 Electroluminescent	Stores daylight energy and requires no electrical connections. Safety lamps but also normal lighting available. 15 yr. warranty, but first cost high

L11 Composter for home biodegradable	Deals with vegetative waste products on-site, and provides fertiliser.
L12 Atmospheric Water Vapour Processing (AWVP)	machines that extract water molecules from the atmosphere and cause a phase change from a vapour to a liquid
L13 Membrane bioreactors for the removal of anionic micro L14 pollutants from drinking water	Biological treatment processes allow for the effective elimination of anionic micro pollutants from drinking water. However, special technologies have to be implemented to eliminate the target pollutants without changing water quality, either by adding new pollutants or removing essential water components.
L15 Ground Water Circulation Wells	A new energy efficient method of small-scale single well extraction that does not rely on a pump.
L16 Sprinkler systems connected to rainwater tank or pool.	
L18 a pH or microbial sensor valve for rainwater collection	to stop greeblies and pollutants going into watertank

L19 Deconstructable house frames	Use small frames of 450mm width between each full frame with coach screws for plasterboard. Disconnect cables and pipes at the panels. This allows the wall frames to be rearranged/ resited to another location without destroying the walls.
L20 Paper log makers	A mould that forms fire bricks from used newspapers
L21 Off-cut joining clips	a device to ensure off cuts of interior lining materials that are less than stud-width can be reused
L22 Mulch chipper and shredder	Chips large weeds and small branches and twigs into garden mulch

L23 CHP systems (Combined Heat and Power)	Is a combined heat and power generation system with an electrical power more than 200kW.
L24 Fuel Cell Electrical Generation	Fuel cell technology is under development that could permit a freezer chest-sized fuel cell to power an entire home. Fuel cells have very low emissions and, in residential applications, are expected to compete with current electricity costs depending on the costs of natural gas and electricity in a given region.
L25 Ocean Thermal Energy Conversion	Is a power generation system that uses the cold deep water to generate power, and provide clean water?

L26 Dye Solar Cells- Third Generation Solar Technology.	Dye solar cells (DSC) are the first commercially available third generation solar cell technology. DSC have been subject of increasing laboratory research since first reported by Grätzel in 1991 [Nature 353 (1991) 737].

L27 Electro Osmotic Pulse Technology for Prevention of Water Intrusion in Concrete Structure	ElectroOsmotic Pulse (EOP) technology is based on the concept of electroosmosis; the movement of an electrically charged ion in a liquid under the influence of an external electric field. EOP not only eliminates water-seepage problems from the interior of the structure without excavation, but it further mitigates corrosion damage to mechanical equipment and reduces the interior relative humidity of the basements.
L28 Prefabricated decking	bolted wooden stage sections for deck platforms between 2 houses, so you can remove the platforms easily in future
L29 Earthquake friction dampers	Steel bracing with a friction damper at the connection used in buildings to dissipate kinetic energy caused by seismic activity.
L30 Advanced cold climate heat pump	Refrigeration systems and controls which are optimised for cold climates
L31 Spheral Solar cells	A new form of solar energy technology made up of thousands of tiny silicon spheres bonded in a flexible aluminium foil matrix - referred to as Spheral Solar(TM) power.
L32 Solid state refrigeration technology	Thin, efficient and small thermoelectric cooling devices. Savings are estimated to be 40% of conventional refrigerators.
L33 Long Volume Turbines (LVTs)	Have increased blade height in relation to throat diameter - improves performance.
L34 FS Mounting System (PV)	Is a system for mounting large PV arrays on flat-roof buildings
L35 Injection Moulding for Wind Turbine Blades	New method of producing Wind Turbine Blades that could result in lighter and more efficient generation of power, particularly as small scale residential and commercial.
L36 High performance–low cost seasonal gravel/water storage pit	Utilises new glass insulation technology to improve the performance of gravel/water seasonal solar storage systems.
L37 Non-caustic textured coating stripper	Allows the safe removal of textured coatings, without causing dust from harmful fibres. Water based and solvent free - no added ventilation needed.
L38 Coatings that repel dirt	No maintenance requirement to keep clean
L39 Low VOC/ low solvent paints	More each year and getting cheaper
L40 Eco paints	Water-based, "breathable" paints made from natural materials
L41 Solar Control Film	Thin film coating that reduces heat gain without reducing daylight transmittance proportionally.
L42 Titanium Phosphate Coating	Coating that has antifungal properties and removes odour
L43 Porphyrin dye	Is a semiconductor based dye used in solar cells to convert renewable energy from sun into electricity.
L44 Protective Coatings for ceramic materials	Lowers the surface temperature of a thermal coating and reduces the heat transfer through the surface preventing the degradation of the underlying substrate.
L45 Phase-change wallcoverings	energy saving wall coverings that incorporate phase-change materials as the thermal storage medium
L46 Cool colours	Developed by Yiping Ma and his colleagues at Tongji University in Shanghai, the coating absorbs heat from the Sun when the temperature drops below 20 °C, helping to warm the building. But when the temperature rises above 20 °C the coating automatically starts to reflect sunlight to keep the building cool.
L47 Cool colour roofing paint	High infrared reflectance paint to reduce heat transfer into the roof-space
L48 Non-toxic paint stripper (heat)	Uses an infrared tool to paint strip at very low temperatures, so than minimal VOCs and no dust result
L49 Electrochromic Windows	Electrochromic windows change from transparent to opaque or shaded by an electric signal
L50 Lot's of work being down on glass	prismatic; holograpic; multicoatings; photochromic

L51 Inert gas window fills	The use of a low-conductivity inert gas instead of air in window glazing cavities in order to reduce heat transmission through the window.
L52 Ultimat	Insulation mat from fibres of old clothes
L53 Trombe Walls	A north-facing masonry wall covered with glass spaced a few inches away. Sunlight passes through the glass and is absorbed and stored by the wall. The glass and airspace keep the heat from radiating back to the outside. Heat is transferred by conduction as the masonry surface warms up, and is slowly delivered to the building some hours later.
L54 Air exchanger systems - heat and energy recovery	An Energy Recovery Ventilation system uses fans to maintain a low-velocity flow of fresh outdoor air into the building (incoming air stream) while exhausting out an equal amount of stale indoor air (exhaust air stream). Fresh air is supplied to all levels of the building while stale air is removed from areas with high levels of pollutants and moisture
L55 Vegetation as insulation (including growing grass on the roof)	Vegetation as means of seasonal climate control for exterior shading and wind breaks
L56 Solar fan	PV -powered roof-mounted ventilation
L57 Sheep Wool Batts	Wool bound using polyester fibres and treated with inert mineral.
L58 Icynene	Open-cell, soft foam insulation that expands into cracks, corners and crevices forming an airtight seal.
L59 Large Scale Heat Insulating Elements.	German research concerning the retrofitting of large heat insulating elements.
L60 Vented concrete block for zero cooling energy.	This paper reports on the performance of a new prototype of horizontal hollow concrete block. Its innovation is that it can prevent the sight from outside and inside as well while permitting natural ventilation and increasing day lighting without inducing overheating. Investigation included compressive strength testing, indoor temperature, natural ventilation and daylight contribution. Low Tech.
L61 Aerosol Duct Sealing	Aerosol duct sealing uses vinyl acetate adhesive particles that are forced into heating and cooling duct systems. The adhesive particles are kept suspended by the airflow until they naturally try to exit the duct system through any leaks they encounter. In the process, particles are flung against the holes where they adhere and build up until the leak is closed.
L62 Formaldehyde as a basis for	A proposed method of measuring healthy ventilation rates based on content of formaldehyde.

residential ventilation rates	
L63 Sound insulating ventilation bricks	for mounting in walls (intended for brick walls, but could be adapted)
L64 Fibreglass low-conductivity window frames	Construct the frame from a low-conductivity material such as wood or vinyl. Durability, maintenance and/or fire concerns usually limit the use of these framing materials in commercial buildings. An alternative framing material is fibreglass which s stronger than vinyl and has lower maintenance requirements than wood. The cavities in the fibreglass frame can be filled with foam insulation for even better thermal performance. Because fibreglass is considered a combustible material, there are limits to the size and range of applications in which fibreglass frames may be used.
L65 Breathing Window	Fine-wire heat exchange ventilation system
L66 Aerogels/ Translucent Insulation	Solid silica materials with nanometre scale pores. Due to lattice structure they are very good insulators, and nearly transparent. Can be used between plates of glass as window insulation for thermal and sound. Translucent insulation uses a form of highly porous silica. Characteristics of aerogel (high surface area, large pore volume) set it apart from common silica products. Aerogel is known as the lightest weight and best insulating solid in the world. Nanogel translucent aerogel combines thermal protection with high quality diffused light and sound reduction when incorporated in various fenestration systems in the Day-lighting construction market.
L67 Cromer cycle air conditioners	Combines desiccant and refrigerant cycle components to provide augmented latent heat for humid climates,
L68 Robust Air conditioners and heat pumps	Air conditioners that compensate for charge losses and low airflow, by very good high temperature performance, an adaptive refrigerant metering device and a fan assembly that adapts to the houses duct system.
L69 Wood fibre insulation	During production the wood is pulped into wood fibre. During this pulping process a thermo – mechanical treatment takes place, which changes the properties of the wood fibre with respect to solid wood. Afterwards the pulp stock is processed into wood fibre insulating boards with the use of near-natural additives. All STEICO products therefore only consist of wood materials since the natural wood material is processed into a new material by breaking down its structure.
L70 Blown fibre/foam insulation	Cellulose, fiberglass, or mineral wool (rock wool and slag wool) is sprayed in a moist state into an open stud cavity. Moist cellulose creates its own glue, but some manufacturers add adhesive. Both mineral wool and fiberglass need added adhesive. Properly installed, it completely fills the cavity, suppressing air leakage.
L71 Low -E glass	
L72 Reconstituted XPS	
L73 Passive rotary vent	Roof-mounted rotary vent activated by wind and rising heat, for passive venting of bathroom etc.
L74 Vacuum Insulated Panels (VIP)	New breed of high performance insulation material
L75 Smart vapour retarders	Smart vapour retarders limit the transmission of water vapour from inside the house into the wall cavity. However, when humidity levels within a wall cavity are high, the vapour retarder becomes permeable, and allows drying toward the inside living space of the home.
L76 Airtight drywall approach	Airtight drywall approach (ADA) is the application of a gypsum board barrier to the foundation, roof or wall section of a building. The barrier is detailed to ensure continuity with framing members. Improved airtightness can be achieved through the use of drywall installed over gaskets adhered to building framing members. The drywall is carefully joint-filled to provide continuity between drywall sheets. Attention to detail is necessary during installation of interior walls, window openings, electrical boxes, plumbing and electrical penetrations, around bathtubs, at split-levels and stairs on outside walls. Little training is required to apply ADA successfully. The application can be expected to last the life of the building with adequate maintenance and when dismounted can be recycled into new material.
L77 Vacuum Glazing	The technology uses the insulating principle of the thermos flask. Two sheets of glass are sealed around the edges, and a vacuum is created in the narrow gap between them, eliminating heat flow through gases between the sheets. An array of tiny support pillars maintains the 0.2 mm separation of the sheets. Unlike conventional double-glazing, this technology requires only the same thin window frames that are used for single glazing, making it easy to retrofit windows in countries such as Japan.
L78 Cellulose waste -based insulation	

L79 Biomass Boiler	Is a system including a biomass boiler with built-in heat storage unit to subsequently store heat produced from boiler to heat the building?
L80 Drainwater heat recovery (DHR)	DHR devices fit into existing waste drain lines from showers and bathtubs to capture heat from the drainwater to preheat cold water going to other showers or a water heater.
L81 Solarwall	Perforated metal external wall, which heats air, which is then drawn into the inside. Transpired solar hot air collector saves 55% of heating, with 3.25-year payback period. The system, manufactured by SolarWall (www.solarwall.com), is comprised of a corrugated metal panel that is painted a dark colour and has minute perforations in the surface. In the winter when sunlight hits the metal panels it heats an air space behind the panels and the air convects to the top of the wall where it is collected by a low speed fan and distributed into the vehicle bays. This technology is particularly effective in large volume spaces like a vehicle bay, manufacturing plant, or distribution center where heated air is lost quickly out of garage doors. Often these spaces need a large amount of fresh air due to the equipment and processes within.
L82 Geothermal heating	A water-source heat pump coupled to a septic field heat exchanger provides backup heating in the winter and cooling in the summer. This system can reduce standard heating and cooling costs by 30-60%.
L83 Residential condensing water heaters (addendum to CHP above)	Are able to capture almost all (90%) of the heat value of the condensing flue gases water vapour to liquid, rather than the usual 60%.
L84 Heat pump water heaters	Uses the vapour compression refrigeration cycle, like an air-conditioner, getting efficiencies between 2-3x what a standard electrical resistance HWC would.

L84 Residential gas absorption chiller heat pump	Uses heat released when the ammonia refrigerant is reabsorbed into the water, to significantly increase the efficiency.
L86 Hydronic Radiant Cooling	There are currently three different hydronic radiant cooling systems available. The panel system is the most common radiant system. The panels, usually aluminium, can be surface mounted or embedded on floors, walls or ceilings. The capillary tube system characteristics are small closely spaced tubes that are embedded in plastic, gypsum, or mounted on ceiling panels. The many tubes allow for better heat absorbing distribution and a thinner ceiling. The concrete core conditioning systems with tubes embedded in a concrete slab allows for peak load shifting because of its thermal storage capacity. This could be used also as a wall mass. In each of these systems, the water is mixed in a glycol solution and cooled by an air-to-water heat pump, a cooling tower, a ground-source heat pump, or even well water.
L87 Condensing water and space heating boilers	Fuels: Natural or liquid gas Specification: Permanently condensing gas boiler for low temperature heating and heating of domestic hot water. Room sealed or open versions available (chimney flue or mounted on exterior wall), no need to convert boiler. Unrestricted hot water supply through integrated 230 L stainless steel cylinder. The boiler is suitable for domestic use because of its attractive appearance and absolutely quiet operation. It is possible to integrate a solar heating system in the boiler (HELIOS solar module or integrated smooth pipe heat exchanger). This boiler concept has already received several awards for Innovative Technology.

L88 Pumice-Crete	Pumice-Crete is a low density and resource-efficient concrete consisting of pumice aggregate, Portland cement, and water. It combines structural strength and insulation in one product, and is a durable, fireproof and noise-resistant material, able to be used in a variety of climates.
L89 Plant Fibre Building Panels	Similar to straw and wood-based panels, but using high-performance fibres such as flax, jute, hemp and sisal. These improve internal bonding and stiffness of the panel.
L90 Bamboo flooring	Slicing and weaving bamboo into a panelised form - high strength and lightweight
L91 Structural Material from Waste Plastic	Using of unsorted recycled plastics and sand to produce structural members for construction.
L92 Synthetic Lightweight Aggregate technology (SLA)	Synthetic Lightweight Aggregate technology (SLA) is manufactured from two materials - waste plastics, and fly ash, though disposal facilities. SLA is being developed and evaluated for use in construction applications such as geotechnical lightweight fill, concrete masonry blocks, and lightweight concrete structures.
L93 Cellular PVC Lumber	Cellular PVC is a solid, extruded material that has the working characteristics of wood, and is used for interior trim, exterior trim, and panelling as well as windows and doors, blinds, and furniture.
L94 Removable Gib stop seals	novel fixing arrangement so we don't need to destroy the linings during relocation
L95 Straw Bale	Waste straw is left over from crops such as wheat, oats, barley, rye, rice and flax, after all the food has been extracted. The straw is gathered and baled using a baling machine. The straw is compressed by the baler and tied together with wire or string. A typical 200 square meter house requires about 300 medium sized bales.
L96 Double skin walls (Enertia)	In the Enertia® Building System, solid Energy-Engineered(tm) wood walls replace siding, framing, insulation, and panelling. An airflow and access channel, or Envelope, runs around the building, just inside the walls - creating a miniature biosphere. Here solar heated air circulates, pumping and boosting geothermal energy from beneath the house, storing it in the massive wood walls. Thermal inertia causes the house to "float" between the cycles of night and day and even between the seasons.
L97 mining residues	
L98 Straw-Based Building Panels	Straw, a by-product from crops such as wheat, rye, rice, and flax that is left over after all the food products have been extracted, is gathered, baled, and transported to a factory, where it is transformed into a wood-like product by compressing it under high temperatures that bond the straw fibres to together, sometimes without adhesives.
L99 Green Pipe: Non-fossil fuel Steel product.	An alternative method of producing steel that uses coal from sustainable plantations for both the production energy and primary material for the steel. This steel is used to make pipes.
L100 Sewage Brick	Slightly confusing article which suggests the use of waste products such as sewage, sludge, slag, ash, in the manufacturing of quality brick products. Based on thermal solidification processes.
L101 Bioconcrete	Biomimetic industrial process that mirrors the geo-microbiological calciferous process mastered by bacteria to produce bioconcrete
L102 Insulated Headers	Two OSB webs that enclose a layer of EPS foam insulation. Along with their engineered joist products, the manufacturer is marketing these headers to builders of conventional framed homes as a strong, lightweight, cost-effective alternative to beam headers. They assert that the headers are straighter and more dimensionally stable, less subject to shrinkage and warping that often causes drywall to crack in conventionally framed header areas.

Appendix 3. Further Details on 'Early Adoptable Options'

The information presented in the following appendix is provided to support comments in the technology outlines. This information was collated from various sources during the study with a focus on the six technologies that were considered as "Early Adoptable Options". Parts of this information were sourced from the international literature and may have variable relevance to New Zealand. This information has been included in this report for completeness.

The information was not validated by cross-referencing to other information sources.

A 3.1 Solar water heating

Solar systems fall into two broad categories. Those that heat water using photovoltaic panels, and those using the principles of solar thermal:

> *Photovoltaics* that produce electricity directly from sunlight as solar cells. Cells are made of thin layers of silicon material, usually silicon, which has too many or too few electrons. Light striking a sandwich of the different layers, begins electron flow producing an electrical current.
>
> *The Solar Thermal* process concentrates sunlight to create high temperatures that are used to vaporize fluid and drive a turbine for electric power generation.

This review focuses on solar thermal for hot water.

A3.1.1 Technology Description

A solar water heater typically uses glazed collectors that are roof-mounted and connected to a pre-heat storage tank. Fluid is pumped to the collectors where it is warmed by the sun and returned to a heat exchanger where heat from the fluid is used to heat the water in a pre-heat storage tank. In the simplest systems the storage tank is mounted above the collectors so that a natural thermo-syphon is created, no heat exchanger is used so the water is preheated directly.

Comment

This technology is well established with several competing systems available. Given the market maturity, technology improvements are likely to be incremental; however, economies of scale will allow improvement and reduce the production costs, given a growing global market impetus for these systems. BPL could undertake consumer-type research to rate the systems in terms of their cost/benefit, maintenance, visual impact, and applicability to particular climates. The energy saving may be considerable so that the need for large-scale power generation and reticulation is reduced, with its attendant legal issues associated with resource consents. Scion has investigated a solar panel system involving thermo-siphoning to produce a reserve of both heating and cooling water for low-grade energy uses around the home.

A3.1.2 Barriers

The barriers to uptake of this technology are believed to be:

1 Cost – initial outlay
2 Which is the most cost-effective system?
3 Ongoing maintenance and operation issues
4 Lack of installer expertise

A3.1.3 Market and Economic Considerations

1 The market for solar worldwide is growing rapidly with global growth exceeding 25% a year – and accelerating. Solar technologies are likely to follow similar market penetration commercialisation paths to that of other high technology products such as fax machines, cellular telephones and personal computers.
2 There are now more than 10,000 homes in the United States that are entirely powered by solar energy. In 1996, CADDET estimated there were 5.4 million solar water heaters installed worldwide, at a rate of around 200,000 new units per year, of which 70% were located in Japan, 22% in the US and 6.5% in Australia. EECA estimates there are around 22,000 solar heating units installed in New

Zealand, with 1700 installed during 2004. The analysis excluded Israel, where a significant market exists. Media and policy makers in many countries and at EU level often underestimate solar thermal and other renewables in the heating and cooling sector: roughly 50% of the EU's final energy is consumed for heating purposes, but policies to support renewable energy have so far focused primarily on electricity.

3 Crest indicates that the solar water heating industry could benefit greatly from partnerships with home builders, such that this technology is installed into new housing, rather than as retrofitted units. This is due to the low uptake of solar water heating units in the US presently, at 0.2% of all new homes installing such systems.

Solar water heating in Australia

www.greenhouse.gov.au/markets/mret/pubs/13_solar.pdf

In Australia, solar hot water is a mature technology with a high level of local manufacturing expertise. There are 5 major manufacturers collectively producing about 30,000 units annually. Sales in Australia are about 20,000 units per year with the balance exported, primarily to South East Asia and Western Europe, however, less than 10% of domestic water heating systems produced in Australia are a solar unit. Water heaters have a life expectancy of 7-10 years; therefore, to convert the entire market to solar- water heaters would take a relatively quick timeframe. In Australia, the most common solar heating product is a close coupled thermosyphon system. A typical system will reduce electricity consumption for hot water heating by about 70%, and it is generally accepted that a properly sized solar water-heater can supply between 60% and 90% of the total annual water heating energy requirements of the system it is supplying, depending on location. Australian market studies indicate that most householders are still unaware of the cost effectiveness of solar water heaters and the significant improvements made to them over recent years.

Solar Thermal Market in Europe 2004

http://www.estif.org/220.0.html
June 2005

China dominates the solar thermal market, followed by Europe. The European market is growing rapidly, however. In 2004, the European solar thermal market (EU-25 + Switzerland) grew by 12% compared to 2003. Germany is the market leader for this technology within Europe. Regulatory incentives have proven to work well in the Netherlands, where financial incentives helped to grow the market for solar water heaters from 1989 until 2003. Once these incentives were removed, very few units were installed; however increasingly tight energy efficiency requirements led to a considerable growth in the new-built sector in recent years: 15%-20% of all new buildings in the Netherlands are nowadays being equipped with solar thermal.

The table overleaf indicates the market growth of European solar thermal technology, and is taken from the European Solar Thermal Industry Federation (ESTIF) market statistics report (http://www.estif.org/fileadmin/downloads/Solar_Thermal_Markets_in_Europe_2004.pdf)

Table 1. New solar thermal market size in terms of capacity (kW_{th})[1]

Country			Market (Newly Installed)						
			2002	2003	2004				
	Total Glazed (kW_{th})	Market Share (%)	Total Glazed (kW_{th})	Total Glazed (kW_{th}))	Total Glazed (kW_{th})	Flat Plate (kW_{th})	Vacuum Collectors (kW_{th})	Total Glazed (%)	Total Glazed (kW_{th})
Austria	1,459,842	14.9%	107,135	116,844	127,816	126,000	1,816	9	140,000
Belgium	33,774	0.3%	3,460	6,333	10,290			62	12,600
Cyprus	315,140	3.2%	21,000	21,000	21,000			0	21,000
Czech R.	30,380	0.3%	4,200	4,900	5,950	5,670	280	21	7,000
Denmark	221,011	2.3%	9,100	13,300	14,000	13,300	700	5	15,400
Estonia	399	0.0%	35	105	175			67	210
Finland	8,386	0.1%	777	1,400	1,400			0	1,400
France[3]	191,870	2.0%	18,900	27,230	36,400			34	52,500
Germany	3,922,800	40.1%	378,000	504,000	525,000	472,500	52,500	4	595,000
Greece	1,978,690	20.2%	106,400	112,700	150,500			34	119,000
Hungary	2,975	0.0%	350	700	1,050			50	1,050
Ireland	5,103	0.1%	613	840	1,400	840	560	67	2,100
Italy	311,000	3.2%	31,500	35,000	40,600			16	49,000
Latvia	1,155	0.0%	210	280	350			25	420
Lithuania	1,155	0.0%	210	280	350			25	420
Luxembourg	8,050	0.1%	840	1,050	1,190			13	1,400
Malta	10,752	0.1%	1,750	2,100	2,951	2,858	92	41	3,990
Netherlands	198,456	2.0%	21,000	19,380	18,410			-5	18,900
Poland	71,764	0.7%	12,600	18,354	23,100			26	24,500
Portugal	101,465	1.0%	3,850	4,200	7,000			67	9,450
Slovakia	39,725	0.4%	3,150	3,500	3,850	3,465	385	10	4,200
Slovenia	68,320	0.7%	840	770	1,260			64	1,400
Spain	294,256	3.0%	46,200	49,000	63,000			29	105,000
Sweden	130,038	1.3%	10,682	13,479	14,041	12,249	1,792	4	17,500
Switzerland	246,722	2.5%	18,502	18,774	21,747	20,932	815	16	24,500
United Kingdom	118,944	1.2%	12,250	15,400	17,500			14	21,000
Total	9,772,172	100.0%	813,554	990,919	1,110,330			12	1,248,940

[1] The conversion factor used to calculate the capacity from the collector area has been agreed by experts of the IEA Solar Heating and Cooling Programme and major solar thermal trade associations from Europe and North America. At a meeting in September 2004, a methodology for the conversion was discussed. Based on actual test results and operating conditions specified in the European norm EN 12975-2, the experts from 7 different countries agreed to use a factor of 0,7 kWth/m2 to derive the nominal capacity from the area of installed collectors

[2] "In operation" capacity: it is calculated assuming an average lifetime of 20 years (15 years for systems installed until 1989). Most current systems are designed to work longer, but individual systems can have a shorter lifetime for reasons such as demolition or change of use of the building, poor maintenance.

[3] France: the data refer to metropolitan France only and therefore exclude substantial markets in the Overseas Territories. In 2004, the market in metropolitan France reached the level of the Overseas Territories. For 2005 it is forecasted that, for the first time, the market in metropolitan France will be larger than in the Overseas Territories

A3.1.4 Research and Development Plan

The competing technologies should be compared for their performance in respect of:

1 Collection efficiency – how much energy can be collected at the optimum orientation?

2 Orientation – If the orientation is less than optimum, how does the efficiency change?

3 Losses – Having collected the energy, how much is actually delivered to the storage tank?

4 Cost/benefit – What is the rate of return on investment?

There are wider issues that should be quantified:

1 If a large community is equipped with solar hot water heating, what is the impact on externally–supplied energy on a daily and seasonal basis?

2 How do the costs of solar water heating installations compare with the cost of large-scale power generation and reticulation costs?

There are possible regulatory and/or financial issues:

1 If these systems show significant savings or deferment of large-scale power generation and reticulation, how can these savings be used to provide incentives to homeowners?

2 Are there likely to be resource consent issues with the installation of solar collectors on houses?

A 3.2 Multi-pane Windows

A3.2.1 Technology Description

Window systems with two or three glazing layers, and vacuum, air or gas in the cavity. Shutters and lighting can also be incorporated within the cavity. This technology is applicable to both new and retrofit construction.

Comment

The thermal performance of New Zealand domestic window systems is very low by international standards. While 70% of new domestic dwellings in the South Island of NZ are now being double glazed, in 1994 this was only 20%. A large proportion of existing houses (estimated 80%) have single pane glazing, and much of this is with aluminium frames. Current retrofit programmes involve replacing single glass with double glazing units, or adding an additional plastic pane. These improvements are not always consumer solutions or sustainable. Single pane glazing can cause high levels of internal condensation and damage to internal fittings and furnishings. The issue of single pane windows is therefore critical for making substantial improvements to the sustainability of the NZ housing stock.

In Europe and much of North America double-glazing is normal for new dwellings and the addition of secondary glazing, or renovated glazing is common in the retrofit market. The new build market for insulating window systems in the South Island of NZ has risen from 20 to 70% market penetration over the last decade. An additional benefit is the increase in sound insulation.

BRANZ Ltd has investigated the potential for the renovation of timber single glazing, and has been involved in the development of WERS I to rank and benchmark existing new glazing products. There is a small wall retrofit industry in NZ, predominantly in the cold parts of the country.

A3.2.2 Barriers

1. Lack of awareness of the losses that occur through windows.
2. Lack of awareness of the options available.
3. Cost/benefit or payback period is unknown, and how that varies with climate.
4. Lack of trained installers.

A3.2.3 Market considerations

There are many commercial solutions of double-glazed, triple-glazed and even glazed units incorporating shutters, photovoltaics and polarising compounds.

A search for commercial techniques that allow retrofit double-glazing to existing windows tended towards replacement of the existing window, and refitting with a new, double glazed solution. Three techniques not fully commercialised (i.e. somebody has found a way of doing it, and might be practising as a small business, but the techniques are not well known to industry by any means) which keep the original window, two of which appear simple and cost-effective for homeowners include:

- An article about Michael Gunter who has devised a method to simply and cost effectively double-glaze all his windows by using spacers, an additional pane of glass, and some sealant.
- A method to route in a wider spacing for the panes, and replace the glass panes and tracks, rather than the entire window
- A restoration project that incorporated existing glass into a new, sealed window unit.

A3.2.5 Research and Development Plan

It is suggested that BPL implement a research activity to address this problem. The research objective will be to identify suitable technologies and implementation paths for the glazing systems of New Zealand houses.

Specific issues include:

What is the most suitable technology to insulate existing NZ domestic window systems, or upgrade new systems on offer?

1 Additional glazing

2 Glazing replacement/refurbishment/addition

3 Additional framing

4 Framing replacement/refurbishment/addition

5 Use of new sealed glazing unit

6 Exterior insulation with opaque or transparent permanent or removable shutters

7 Timber frame renovation

8 Quality control of installations (thermal imaging, etc.)

9 Interaction with other components (internal and external furnishings and hardware.)

10 Cost (compared to other options)

How can the interaction of insulation and solar heat gain be measured in existing framing?

1 WERS II

2 On site measurement

What are suitable market rollout mechanisms?

1 Installer training

2 Incentive schemes (interest free loans, subsidies, loan repayment through power account etc.)

3 Quality guarantee schemes.

4 IP management.

Research steps:

1 Compile experiences from overseas approaches.

2 Compile literature research of New Zealand products and scientific evaluations (investigate existing systems).

3 Conduct a stakeholder workshop with agencies/departments, designers and tradespeople to discuss these enhanced products and techniques, and identify barriers and opportunities in the NZ building context.

4 If required commission specific technology research projects.

5 Develop best practice guide specific for NZ.

6 Develop options for market implementation.

7 Monitor outcomes.

A 3.3 Tankless Hot Water Systems

A3.3.1 Technology Description

Storage tank-type water heaters raise and maintain the water temperature setting for the tank (usually 49° -60° C). The heater will operate periodically to maintain the water temperature, even when no hot water is drawn from the tank. This is due to the heat losses due through the tank walls and pipes (called standby losses). One way to reduce this heat loss is to use a tankless (also called "demand" or "instantaneous") water heater. Tankless electric water heaters have an electric, gas, or propane-heating device that is activated by the flow of water. They are also known as califonts. Once activated, the heater provides a constant supply of hot water. Tankless electric water heaters heat water entirely on demand, only when it is needed. When a hot water faucet is turned on and the water begins to flow, a sensor detects that hot water is being demanded. This sensor effectively turns on the heating elements/heat exchanger and a computer chip selects the correct power output to the elements/heat exchanger based on the heat setting selected by the user, the flow rate, and other parameters. The water flows across the internal heating elements and exits the unit at the desired temperature. The start-up process takes a couple of seconds. The tankless electric water heater will remain on until the hot water faucet is closed. As soon as the flow sensor detects that water has stopped flowing, the power to the unit is turned off completely.

Comment

Most of the heaters of this type that are available in New Zealand use flow rate variation to provide user-required water temperatures. However it can be argued that the most efficient use of tankless heaters is achieved by varying the energy inputs and maintaining a constant flow, as described under “Description” (above). This is because this type of water heater has a particular affinity with solar water heaters in that they suit a tempered water supply, provided by a tempering valve set at a comfortable/safe shower and hand washing temperature (the building code sets slightly higher limits). If the water heaters are designed to have a zero input when the incoming supply from the tempered solar system is at the required temperature then the user's hot water is acquired directly from the solar system. The solar store has options: either no boost heater, which means that there will be some occasions when the water in the tank will be at or close to mains water temperatures (perhaps down to 5/6degC); or, with a boost heater set at a low temperature (say, 10+degC). In the former case the tankless electric water heater would need to provide up to around 12kW at these times, in the latter 10kW should be sufficient. Use of a three-phase power supply can even out the loads (and may be required anyway).

The main benefit this technology is that standing losses are minimised, and solar water heating systems are used more efficiently. The potential research activity should be to determine the costs and benefits of variable energy tankless electric water heating systems used in conjunction with solar water heating systems, and this should take into account all the efficiency benefits. [Note by Roger Buck: I use a variable energy input system, with some differences: there is no heater in the solar store; the tankless heater is only 8kW, and it does not drop its input energy completely to zero. Thus, when the solar store is up to temperature (or above) the device is switched off. The flow rate can also be altered (reduced) to raise the water temperature in extreme conditions]. An alternative application of the technology would be use it in conjunction with a low temperature but otherwise normal storage system (i.e. no solar input). Retrofitting not difficult in timber houses (requires new cabling and dedicated circuit). Plumbing is simplified, and is also not difficult to retrofit (one pipe only required). Works as well with wetback water heating as it does with solar. The primary efficiency lies in the reduction of standing losses from conventional systems (cylinders and pipe runs), and sometimes losses via pressure relief valves.

Current electrical hot water cylinders last 25 to 30 years so replacement with a tankless system is an option at that time.

A3.3.2 Barriers

1. Awareness of the technology.
2. Cost/benefit of the various options, given the various energy source options.
3. Cost of upgrading electrical system.
4. Heater reliability and durability.

A3.3.3 Market and economic considerations

Tankless electric water heaters were introduced in America 25 years ago, and are now common in Western nations, especially in institutional and community facilities. These systems are being increasingly use in New Zealand, though they are not common

.

The heaters are limited by the flowrate required to heat the volume of water required. Faster flow rates or cooler inlet temperatures will reduce the water temperature at the most distant faucet. Using low-flow showerheads and water-conserving faucets are therefore recommended with demand water heaters. The appeal of these heaters is in the elimination of the tank standby losses and therefore lower operating costs, and the continuous delivery of hot water.

Most tankless electric water heating models have a life expectancy of more than 20 years compared to storage cylinder heaters tank which last 10 to 15 years. Tankless models have easily replaceable parts that allow the life expectancy to be extended further.

A3.3.4 Research and Development Plan

It is suggested that BPL implement a research activity to address this technology. The research objective will be to determine the likely performance of tankless hot water systems in New Zealand houses.

Specific issues include:

What systems are available?

1 Electricity, gas or other power source.

2 Replacement or addition to existing systems.

3 Cost vs savings.

Ease of retrofitting?

1 Replacement of existing cylinder or better placement elsewhere.

2 What upgrading of electrical system is needed?

3 Installer training.

4 Incentive schemes (interest free loans, subsidies, etc.)

5 Quality guarantee schemes

Research steps:

1. Compile literature research of existing products and scientific evaluations.
2. Identify major barriers as to why these appear to be implemented in commercial rather than residential situations in New Zealand.

3. Conduct a stakeholder workshop with agencies/departments, designers and tradespeople to identify barriers and opportunities to residential uptake.
4. Develop best practice guide specific for NZ for market implementation.

A 3.4 Wall Insulation

A3.4.1 Technology Description

The technology for insulating wall cavities in new built structures is straightforward, and several varieties of rigid foam or soft mat materials are available. Loose fill materials are possible provided there are linings on both sides of the framing to support the fill. (Then there is the problem of how to put the insulation there once the linings are in place so loose fill hardly needs consideration.) There is a large potential for substituting current materials with more sustainable materials, in particular non-toxic and bio-based binders and foams.

Comment

Thermal performance of New Zealand houses is very low by international standards. A large proportion of existing houses (estimated 80%) have no wall insulation. Current retrofit programmes only address roofs and floor insulation. After these improvements approximately 50% of the remaining heat losses are through uninsulated walls. Uninsulated walls also cause discomfort and can lead to condensation/mould problems. The issue of uninsulated walls is therefore critical for making substantial improvements to the sustainability of the NZ housing stock.

Wall cavities of existing (timber presumably) framed buildings is much more difficult but they can be insulated using materials that are injected through small holes and which foam in place, or by blowing or pouring loose insulating material through larger holes, or by placing insulation over the outside of the existing cladding and applying a weatherproof coating over that (e.g. Insulclad). Questions of effectiveness exist, whether such remedies are practical, how any holes may be filled, and whether the cost of installation is reasonable compared to the saving in energy use.

In the UK significant effort is put into insulating of existing walls, predominantly brick structures. This has lead to wall retrofits of about 20% of the existing uninsulated housing stock. Also in the US a market of timber wall insulation retrofit exists. BRANZ has conducted initial tests on moisture performance of retrofit products. There is a small wall retrofit industry in NZ, predominantly in the colder parts of the country.

Scion and the New Zealand biopolymer network are investigating new bio-based foams and the suitability of using various straw based materials for insulation. These would be suitable for substituting for mineral batts in wall insulation, as well as substituting rigid polystyrene and foils in under-floor insulation.

A3.4.2 Barriers

1 Knowledge of the performance of various materials given the effects of gravity and moisture.

2 Cost/effectiveness, particularly for retrofit.

3 Financing options such as repayment through power accounts.

A3.4.3 Market and Economic considerations

A report by the Freedonia Group indicates that the global insulation market will approach US$18 billion in 2006. It anticipates that the Asia/Pacific region will be a leader in the insulation market growth, due to the current booming construction industry, and industrialisation. There are also opportunities for the increased use of insulation with climate change and energy pressures. In the UK, it is estimated that only 6 million of the 17.5 million homes have cavity wall insulation. An UK Energy White Paper indicates that insulating 4.5 million homes before 2010 would significantly save carbon emissions. While foamed plastics and mineral wool is thought to continue to be the fastest growing insulation materials, a number of more sustainable (usually bio-based) options are currently being researched, or commercially available. Wool insulation products that are able to reduce slumping through the use of binders (usually PVA, but the industry is investigating non-petroleum-based binders) are currently available. Straw, hemp, jute and sisal are also being researched for improved insulation products, as well as linen straw and cement fibre combinations. Some of the agri-fibre products to emerge recently include:
:

Soy-based insulation
http://www.matr.net/article-9559.html, 2004

The product is a spray-in-place insulation that combines soybean oil and petroleum components to produce a polyurethane insulation for walls and rafters, as a substitute for fibreglass. It uses an economically viable method to make polyurethane plastic that is 60 percent soybean oil and 40 percent petrochemicals at a cost that is about 10 percent less than that of an all-petrochemical product. The product is more expensive than fibreglass, but it has added benefits. Because the insulation, once dried, is a kind of plastic, it offers no food value for pests and is rated to prevent fires. It also helps control interior wall moisture, seals out noise and reduces dust, which makes it possible for homeowners to use a smaller heating and air conditioning unit. The resultant polyurethane foam ends up being about 25 percent soy-derived and 75 percent petrochemical-derived.

Both HealthySeal 500 from Atlanta and BioBase in Chicago manufacture this product. BioBase Insulation is made by BioBased Systems, based in Spring Valley, Ill. The company achieved more than $1 million in sales in 2003, its first year of operation, but it is aiming at $10 million in 2005.

*Cotton insulation***.**
Two manufacturers make cotton insulation. Bonded Logic, Inc. (Chandler, Ariz.) and Inno-Therm, Inc. (Newton, N.C.) who make batt insulation products from 85 percent pre-consumer recycled denim scrap saturated with borate flame retardants.

A3.4.4 Research and Development Plan

It is suggested that BPL implement a research activity to address this problem. The research objective will be to identify suitable technologies and implementation paths for retrofitting the wall insulation of a majority of New Zealand houses.

Specific issues include:

What is the most suitable technology to insulate existing NZ timber framed constructions?

1 Practicality of installations (drill holes, blowing of gypsum board, access to small cavities around windows, electrical boxes, etc.)

2 In the case of brick veneer is the building paper sufficient to support the injected insulation?

3 Moisture transfer through insulation material.

4 Moisture problems in the event of weather penetration.

5 Fire risk of some insulation materials.

6 Quality control of cavity filling (thermal imaging, etc.).

7 Interaction with other components (electric wiring, plumbing...)

8 Long term settling (adhesive?)

9 Choice of retrofit material (macerated paper, foam, rock wool, glass fibre, recycled polystyrene beads, bio-composite foam).

10 Cost (compared to other options)

What are alternative means to improve thermal wall performances?

1 re-gibing

2 retrofit EPS lining

3 Exterior insulation

Additionally, BPL should liaise with the Biopolymer network in the research being conducted on new, more sustainable materials, suitable for wall insulation products.

What are suitable market rollout mechanisms?

1 Installer training.

2 Incentive schemes (interest free loans, subsidies, etc.).

3 Quality guarantee schemes.

4 IP management.

For this technology stream, which is focussed on new buildings, the research steps to take are:

1 Compile experiences from overseas approaches to novel wall insulation systems.

2 Compile literature research of New Zealand products and scientific evaluations (leverage off Biopolymer Network knowledge).

3 Conduct stakeholder workshop with agencies/departments, designers and tradespeople to identify barriers and opportunities in the NZ context to the uptake and usability of these novel insulation (both commercially available and still being developed).

4 If required commission specific technology research projects.

5 Develop best practice guide specific for NZ.

6 Develop options for market implementation.

7 Monitor outcomes.

A 3.5 Mini Wind Turbines

A3.5.1 Technology Description

Small turbines for providing electricity supply to power a dedicated device or devices. Small Wind Energy Systems for home use are typically between 1 and 10kW, although the technology defined as mini-turbines allows for all systems under 100kW.

Small wind-powered turbines for charging 12v-24v battery devices may find applications in places like the Wairarapa, and also on farms to (say) stir water, milk, or directly to heat water. Need to investigate the effect of net metering on things like power quality.

Comment

These devices should be seen in the same category as photovoltaic generators, in that their output in terms of watts/$ is small compared to large power schemes but have a significant saving in that they do not need additional power reticulation external to the building on which they are installed. They need an energy reservoir such as a battery bank or if they are connected to the grid that can act as the reservoir. They will generate noise, may look objectionable but little different in scale to a satellite dish. The availability of appliances that will run on 12 or 24v DC needs to be investigated, unless the generator is connected to a 250v AC converter and connected to the grid. If the turbine is owned by the householder then any excess power generated needs to be "sold" to the national grid. If the power company owns the turbines then they are likely to prefer larger machines serving whole communities.

A3.5.2 Barriers

1. Awareness that such devices are available.
2. Limited appliances that can operate directly on their output.
3. Willingness of power companies to support these devices and allow negative power metering.
4. Cost/benefit and suitable financing arrangements.

A3.5.3 Market and Economic Considerations

America pioneered wind turbine technology in the 1920s and it is the one renewable energy technology that the U.S. still dominates. Small-scale wind turbines were initially developed in California in the early 1980s, and over the past 15 years, the American small wind turbine industry has been growing at an annual pace ranging from 14 to 25 percent. The US has installed nearly 30 MW of small wind turbine capacity over the past 15 years, and small wind turbine companies have set a target of increasing this total to 107 MW by 2010. Currently there is only one major wind turbine manufacturer in the U.S., GE Wind. European wind turbine companies control the global market for large-scale wind plants. Vergnet is a world leader in the market of small wind turbines not connected to the grid.

With an average growth rate of 30% annually over the past five years, wind energy is the world's fastest-growing energy source, although it still accounts for a small portion of world electricity supply.

At an average growth rate of 30% annually over the past five years, wind power has been the world's fastest growing electricity source for much of the last decade, with the majority of these wind turbines, often exceeding 1 megawatt (MW or 1,000 kW) in size, now manufactured in Europe. AWEA believes

in the US, small wind is not matching the growth of the residential photovoltaic (PV) industry because government support programs usually favour PV over wind.

The American Wind Energy Association (AWEA)'s Small Wind Industry Market Study forecasts sales of nearly 13,000 small wind turbines (up to 100KW) in 2005 for the US market, totaling nearly 14 MW of installed capacity.

Other findings from the market study are:

The small wind turbine industry could reach sales of 75,000 turbines totaling 115 MW of installed capacity in the 2006-2010 timeframe. The industry believes that growth targets of 18-21 percent are possible over the next five years with the right government policies in place to grow the market;

Four U.S. firms supply at least one-third of the global market for small wind turbines, serving as one of the few remaining U.S. based energy export markets;

The average size of small wind turbines has doubled from 500 W in 1990 to 1 kW in 2004 due to an increase in grid-connected on-site distributed applications.

California currently provides a rebate of up to 50% of the purchase price of a small turbine, and that has helped to sharply increase demand for the units in the state.

The UK government is producing a strategy by April 2006 to encourage small-scale wind turbines for housing. Technical issue which need to be addressed include how to connect to the grid, compatibility with building regulations and planning consents and structural integrity of the home (i.e. are modern houses sufficiently strong to take a wind turbine?).

Comparison of home-based renewables

Status of the technology	Small wind	Solar thermal electric	Photovoltaics
Status	Commercial	Demo	Commercial
Installed cost	US$ 4/Watt	US$ 10/Watt	US$ 8/Watt
Payback period	15 years	30+ years	25 years
Cost potential	US$ 1.50/W in 2010	?	US$ 3/W in 2010
Typical site	Rural	-	Suburban
Available resources	Poor-great	Poor-good	Poor-good

(Source: http://awea.org/smallwind/documents/31958.pdf)

What size turbine would I need for my home?
Homes use approximately 9,400 kilowatt-hours (kWh) of electricity per year (about 780 kWh per month). Depending upon the average wind speed in the area, a wind turbine rated in the range of 5 to 15 kilowatts would be required to make a significant contribution to meet this demand.
http://www.awea.org/faq/rsdntqa.html

From an economic point of view, it must be emphasised that no single value can be assigned to the price of wind energy. It is also important to distinguish between the cost of plant (such as wind turbines and wind farms) and the price of the electrical energy, which they produce. Capital costs are primarily a function of the size of the installation.

Energy prices depend on wind speeds and on institutional factors, and have two principal components: -

1 Capital repayments, including interest charges

2 Operating costs

Energy costs for small turbines of $US0.12 to $US0.20 per kWh are still the norm in the U.S. market. The US industry is striving to reduce the cost of electricity generated by small wind turbines. A typical 5- to 15-kW residential wind turbines cost about $US 3,500 per installed kilowatt in 2002 producing an output of 1,200 kWh per year of electricity per kilowatt of capacity in a class 2 wind area. By 2020, the industry aims to have achieved an installed cost of $US 1,200 to $US 1,800 per kilowatt and raised the productivity level to 1,800 kWh per installed kilowatt. This will see the 30-year life cycle cost of energy in the range of $US0.04 to $US0.05/kWh, which is lower than most current US residential electric rates.

Current and emerging markets for wind energy

Environment Driven Markets Mainly OECD countries	**Energy Driven Markets** Mainly Africa, Asia and Latin America
Market characteristic No need for additional capacity. Financially able to invest. Wind energy only contributes a very small part of the total energy supply. Political interest and international obligation to reduce CO_2-emission. Wind energy development is not very sensitive to variations in international fuel prices.	**Market characteristic** Immediate need for additional energy, especially electricity. Capacity shortfall. Dependent on importation of fossil fuels. In best case self-sufficient. Shortage of foreign currency. Moderate to high economic growth (South and East Asia). Higher average increase in population, economic growth and energy consumption than OECD-countries. Need for technology transfer and local production. Very sensitive to variations in international fuel prices.
EU countries: Germany, UK, the Netherlands, Denmark, Italy, Ireland, Greece, Spain , Portugal, Finland, Sweden, Austria, (Norway) **America:** USA, Canada, Caribbean Islands **Pacific area:** Australia, New Zealand Some islands in the Pacific Ocean **Asia:** Japan, Taiwan, Malaysia	**Africa:** Egypt, Cape Verde, Morocco, Libya **Asia:** India, China, North Korea, Indonesia, Thailand, Vietnam **South America:** Argentina, Brazil, Chile, Bolivia **Central America:** Costa Rica, Mexico, Nicaragua

(Source: Wind Energy - Clean Power For Generations, 1999)

A3.5.4 Research and Development Plan

It is suggested that BPL implement a research activity to address this problem. The research objective will be to identify suitable technologies and implementation paths for the installation of small wind turbines on New Zealand houses.

Specific issues include:

What technologies are available?

1 Power and voltage output.

2 AC or DC generation

3 Power storage medium.

4 Range of appliances that can be powered by a wind turbine.

5 Cost vs value of power generated

Siting issues?

1. Regional and seasonal wind patterns.
2. On site measurement.
3. Placement on houses – reinforcement of roof?
4. Resource consent issues.
5. Incentive schemes.
6. Interest free loans and/or repayment through power accounts.
7. Subsidies.
8. Ownership by householder or power company, etc.
9. Quality guarantee schemes – maintenance.
10. National grid.
11. Technical coupling equipment and reliability.
12. Willingness of power suppliers to have locally-owned generation.

Research steps:

1. Compile experiences from overseas approaches.
2. Compile literature research of New Zealand products and scientific evaluations.
3. Conduct stakeholder workshop with agencies/companies to identify barriers and opportunities in the NZ context.
4. If required commission specific technology research projects.
5. Develop best practice guide specific for NZ.
6. Develop options for market implementation.
7. Monitor outcomes.
8. Determine possible impact on BPL goals for energy saving.

A 3.6 Framing Efficiencies

A3.6.1 Technology Description

A holistic review of light framing systems for buildings that may result in improved performance and improved sustainability at reduced cost. Framing is defined as a construction system using discrete members of timber, metal or other structural materials which are connected together to form a framework for supporting covering materials and carrying loads. The covering materials may also contribute to the structural performance of the frame.

Comment

Framed construction systems have a high structural efficiency in terms of performance versus weight and material use. For these reasons they are used in aircraft construction and are common in ship building and building structures. Where the covering material makes a major contribution to the structural performance, the structures may be referred to as "stressed skin" structures. In some structures, such as modern car bodies and parts of aircraft, which have compound curved panels, the framework is reduced to a negligible part of the assembly, and the skin does all or most of the work. These are referred to as "monocoque" (single shell) structures. Framed structures frequently have multiple load paths that share loads between them and are structurally redundant. The loss of a member does not result in the collapse of the structure. This is particularly the case for light framed building construction.

A3.6.2 Barriers

1. Construction industry is cautious about accepting changes to systems and methods that they have refined and are familiar with.
2. The desire for architectural variety means that large material and labour inefficiencies are often tolerated.

A3.6.3 Market considerations

The technique currently employed in the (US) market to reduce the amount of timber used in framing, and also to enhance the overall structural and thermal performance of the timber-frame envelope is called Optimum Value Engineering (OVE). OVE refers to framing techniques that reduce the amount of lumber used to build a home while maintaining the structural integrity of the building. This results in lower material and labour costs and improved energy performance for the building. Initial use of these techniques will slow down framing time temporarily, as framers are un-used to the technique, and require training. There is also more planning required, and the technique would suit off-site prefabrication.

One technique employed is *on centre framing*, which widens the framing spacing, and optimises the door and window spacing. Pathnet recommends for designs that are built repeatedly that wall framing layout drawings are made that can guide the framing crews.

Benefits include:

- Substantial amounts of timber can be removed from the wall and floor framing,
- Wider stud spacing reduces heat loss by reducing wood thermal bridging, and increasing the amount of insulation that can be placed in the wall.
- Framing material cost savings can be maximised

Limitations:

- Although the need for thicker decking, cladding and finish materials may partially reduce the savings.
- Floor joists may need to be deepened on longer spans.
- This technique is more suitable for simpler rather than complex plans
- Floor decking, cladding and interior finish materials need to be sized to span the added dimension without undesirable deflection. Gypsum board is known to deflect over greater spans, so large sheet thicknesses, or wider spanning cladding options may need to be employed.

Modular framing layout ensures that the envelope is made-up of a divisible number of standardised framing modules, i.e. standard wall plans. This reduces the need for framing plans, and saves cutting and waste on sheet materials.

Open corner framing recognises the need for a single double-stud at corner-joints, and that additional framing is needed simply to support the interior and exterior linings (giving something to nail into and a smooth finish). Thus the number of interim studs can be used to optimise the overall frame efficiency, and drywall clips (such as the Dozlock clip) can be used in place of a full stud, where sheets are joined.

Several articles also make mention of techniques such as ladders at T intersections, and optimised header designs:

http://www.pathnet.org/sp.asp?id=9028
http://www.housingzone.com/topics/pb/build/pb03ga021a.asp

Clever and more holistic approaches to the overall structural framing design is shown to be an old technique, and one case study mentioned is that of Frank Lloyd Wright's Spring Creek Wisconsin home Taliesin. The following website link gives the details of how studs transfer loads horizontally rather than vertically, and how the whole is integrated to produce a simplified and efficient structural envelope:

http://www.taliesinpreservation.org/preservation/pres_related/wood_framing.htm

A3.6.5 Research and Development Plan

This research will primarily address light timber frame house construction to NZS 3604. Some of the comments may also relate to commercial and medium rise framed construction and to light steel framed construction. Of the three building components; floors, walls, and roofs; walls offer the greatest opportunity for improvements, with floor systems next.

Ground floors are now mostly concrete slab construction with the remainder pole platform or piled construction. Upper floors are still mostly timber framed although other systems are used. Roof construction is mostly engineered timber trusses with other roofs either skillion roofs, traditional framed roofs or some alternative system of beams and rafters.

Gains may be made in the areas of performance, durability, sustainability and economy. The performance areas of greatest interest are thermal and acoustic performance. Minimum levels of safety determine structural performance and serviceability set by codes. Improved structural efficiency, simply means doing the same job with less materials and labour, so would be reflected in reduced cost.

A conflict usually arises in balancing material efficiency with labour efficiency in that as material usage reduces, the need for strict quality control and labour input rises. Modular systems exist that achieve high structural and material efficiency with low labour input because they are factory-built, but they tend to be very limited architecturally. Systems exist where conventionally framed houses are constructed in a

factory in transportable sections, then assembled on prepared foundations. This minimises on-site work and is reasonable flexible but may have problems of site access.

Research on wall framing

Wall frames fall into exterior or internal wall frame categories. Exterior walls generally have greater structural, thermal and acoustic demands made on them than internal walls. Both exterior and internal walls have openings in them for doors and windows and the way these openings are handled influences wall performance. Wall intersections require a minimum of two studs for code compliance but three are common so as to provide support for linings and claddings.

A review of wall framing would cover the following topics with respect to structural, thermal and acoustic performance.

1. Framing details at wall intersections and openings.
2. Fastening systems for frame members and connections to roof and floor components.
3. Contributions of claddings and linings towards wall performance and composite structural action.
4. Framing member size and spacing.

Research on floor framing

1. Floor framing issues differ for ground floor and upper floors.
2. For both floors there are structural issues of stiffness relating to vibration.
3. For ground floors there are issues relating to the integration of structure and thermal insulation.
4. For upper floors, structure and acoustic insulation performance interact. Achieving acceptable levels of performance in both areas is a challenge.

Research on roof framing

Apart from trusses that are designed and manufactured in a competitive commercial market, there are several popular roof-framing systems based on beams and rafters. Traditional framed roofs and skillion roofs come into this category. A review of these systems may indicate some areas where efficiency can be improved, if not in structure, then perhaps in design and manufacture.

A 3.7 Technology Review and Recommendations

Energy usage in a typical New Zealand household is reported in the BRANZ Study report No. 133. This gave the breakdown of residential energy use, all fuels as:

Water heating	29%
Home heating	30%
Range	6%
Other appliances	35%

Technologies that can reduce energy usage for water heating and space heating are therefore desirable from BPL's point of view. Considering also, that most of the housing that will exist by 2012 has already been built the savings in energy usage need to be achieved by retrofitting.

Solar heating systems clearly have the greatest potential because they can provide savings for both water heating and space heating, although the latter is more difficult. This technology is well established but BPL needs to demonstrate and endorse its application. There appears very little that BPL can do to aid in the technical knowledge of this technology, and instead, effort should be made in understanding the barriers to uptake, and how to overcome these, and implementing a technology assessment, which would greatly benefit EECA and energy groups in enabling these groups to give better information on the most suitable solar options for various situations, and best solar installation practices.

Wall insulation and multi-pane glazing can provide savings in space heating costs and appear to be relatively easy to apply. The opportunity to produce better-performing, more sustainable insulation materials exists, however, much research is already occurring internationally and via the Biopolymer Network to address this issue. It is recommended that BPL places effort in a 'watching brief' assessing the market for developments that could be used to aid the sustainability goal in this area, or sponsors existing research in these areas. A study should be conducted to assess various commercial options for gravity and moisture performance in-situ, and the results used to identify further research needs, as well as communicate these to existing manufacturers. Due to the renewable plantation resource used in wall framing in New Zealand, efficiencies should be focussed differently to those of the Northern Hemisphere. Rather then looking at reducing the overall amount of wood used for framing, effort should instead be focussed on the aspect of waste from offcuts, as these will invariably go to landfill or clean-fill. The Government has a strategy to reduce construction wastes going to landfill significantly, and much of the timber offcuts from framing will be treated, due to the new legislation requiring framing treatments. Developing a modified light-timber framing acceptable solution that allows for wider stud spacings and greater insulation would also be worthwhile, and could include an open corner framing methodology that reduces the need for a third stud. The framing efficiency review addresses other resource uses and the amount of material currently used in houses appears to be excessive compared to that needed for strictly structural reasons. The majority of New Zealand houses are timber framed and timber has low embodied energy and contributes very little to landfill waste, so the research on framing efficiency review might be better done as a comparison between the various house-building systems for their contribution to embodied energy and waste generation. Minimising the amount of *treated* framing lumber that becomes waste is an obvious research goal. The research effort on framing efficiency will be higher than the other technologies and it is not research on a technology as such but on techniques.

Standing losses in water heating were measured at 25 to 30% of total water heating energy. Tankless hot water systems can reduce these losses and therefore deserve consideration. The question must be asked as to why these systems are not installed as a standard feature in residential homes, as many commercial applications exist, and they are being used widely in institutional and commercial facility bathrooms and kitchens. Research is needed to address this issue. There is little BPL can contribute from a technology viewpoint.

Mini wind turbines do not attempt to provide energy saving but provide alternative sources of energy. They should be considered along with any other alternative energy source. Given the amount of effort by EECA and other agencies into promoting and implementing solar energy systems for individual housing units, an investigation into why there is an emphasis on solar over wind, especially for certain regions of the country, and the economic cost benefits from mini-wind turbines versus solar panels for renewable household energy supply would be of use. A technology assessment comparing the technology development of the two renewable options, and what it would take to get a New Zealand mini-wind industry established (similar to the solar industry) could be an option if the cost-benefit analysis is promising.