Report TE106/12

Papakowhai Renovations: Summary of Interim Reporting to inform Home*Smart* Renovations

A report prepared by Beacon Pathway Limited

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1.0 Papakowhai Renovation Project

Beacon Pathway Limited is undertaking a research project to renovate nine homes in Papakowhai, Wellington, with energy, water, waste and indoor environment quality (IEQ) features which will enable the homes to meet a high standard of sustainability. The key focus areas for the retrofits and their evaluation are in the areas of:

- Energy use in the home
- Water use by the household
- Indoor Environment Quality (temperature and humidity)
- Waste (construction waste and waste produced by the households).

1.1 Project Objectives

The project has two key objectives:

1) To identify the best (most cost effective and easy to implement) packages and combinations of retrofit options to significantly improve the standard of sustainability of the homes.

2) To develop the cost benefit analysis at a house level for a range of retrofit technologies in the areas of energy, water, IEQ and waste

The project to date has involved the selection and pre-retrofit monitoring of the nine homes (originally 10, but one dropped out due to a change of ownership), an evaluation of potential retrofit options and implementation of the retrofits. Monitoring has been undertaken throughout the retrofit period and will continue until mid September 2008.

BRANZ Limited have to project managed the research and undertaken the monitoring and analysis and worked with EnergySmart Limited to project manage the physical retrofitting side of the project. The physical work was undertaken by a range of qualified tradespeople, and all consents required were applied for prior to the work being undertaken. Porirua City Council has engaged with the project, both as the Consenting Authority, and in providing financial assistance by waiving the cost of the Building Consent Fees.

2.0 Papakowhai & Beacon Home*Smart* Renovations

One of the most important aspects of the Papakowhai study is its contribution to the development and implementation of the Beacon Home*Smart* Renovations project.

The Beacon Home*Smart* Renovations project is a large scale research and demonstration project with the goal of developing the tools, guidelines and procedures needed to see large scale sustainable home retrofitting. The project envisages the retrofitting 1000 homes around New Zealand to Beacon's HSS High Standard of Sustainability™, a set of performance benchmarks to measure a sustainable home.

A key point of difference to other retrofit programmes is that sustainable home renovation focuses on whole of house solutions extending beyond a package of energy efficiency initiatives (insulation, space heating, lighting, hot water and other appliances), to water (low flow shower heads, dual flush toilets and urban rainwater tanks), waste and indoor environment quality.

This Papakowhai Interim Report has been prepared to inform the Beacon Home*Smart* Renovations project and the development of procedures, tools and guidelines around retrofitting of homes to achieve a HSS High Standard of Sustainability™.

3.0 The Scope and Purpose of this Working Paper

This working paper summarises the Papakowhai Interim Report findings and considers the implications of those findings for the Beacon Home*Smart* Renovations project. The working paper is particularly concerned to identify learnings from Papakowhai by considering the Papakowhai findings in relation to a series of Beacon research reports including:

- A range of BRANZ reports on the project to Beacon as follows:
  - Sustainability Options for Retrofitting New Zealand Homes – Energy (August 2006)
  - Sustainability Options for Retrofitting New Zealand Homes – Theoretical Cost Benefit (April 2007)
  - Beacon Renovation Project – Stage 1 Report (April 2007)
  - Learnings from the Beacon Papakowhai Renovation Project (March 2008)
  - Interim Performance Monitoring from the Beacon Papakowhai Renovation Project (March 2008)
  - HERS Assessment.
- A background report 'Sustainability Options for Retrofitting New Zealand Homes – Water" (Birchfield, 2006).
- Working papers on energy retrofits and recent mover and high energy households emerging from Beacon's Energy Research (Saville Smith, 2008).

The remainder of the working paper is structured as follows:

- Section 4 summarises the preliminary findings from the Papakowhai monitoring data.
- Section 5 summarises the findings from a set of householder interviews undertaken with householders early in 2008.
- Section 6 sets out the learnings from Papakowhai and places those in the context of other research findings.
- Section 7 sets out the implications for Home*Smart* Renovations and the progress in that project.

4.0 Preliminary Findings of the Papakowhai Monitoring

4.1 Research Methodology

The research methodology involved attempting to standardise some of the factors to enable robust outcomes from the research. Specifically the houses were all located in the same climate zone and indeed the same, middle income suburb. This eliminates climactic differences from influencing the data collected and to some extent also income. There was an attempt to control for household composition. Indeed, participants were selected on the basis of household composition but this control could not be achieved because all households changed composition over the period of study.

Because the focus of the selection was on households, not the dwellings themselves, there was considerable variability in the dwelling typology. The suburb was largely developed over a 15 year period and it was expected that this would remove variability from the housing typology. It was recognised that the typology (60s-70s) and the topography of the suburb were factors which were expected to make the retrofits more difficult.

The intention had been to base the retrofits on a series of thermal envelope packages as follows:

- High Thermal (heavy insulation of ceiling, underfloor, insulation of walls, double glazing)
- Standard Thermal (heavy ceiling and underfloor insulation)
- Basic Thermal (a "typical" thermal retrofit as was funded by EECA at the time).

In addition a range of hot water, heating, water efficiency and IEQ improvements were also trialled in different houses.

When the packages were applied to the different houses a number of factors presented difficulties as follows:

- Aspirations of the home owners differed from the proposed methodology [for example recent redecoration meant a reluctance in some cases for wall insulation and different interventions were sought rather than those proposed – partly as a result of expectations being raised early in the project]
- Difficulties arose with defining the thermal envelope to insulate [this was a particular difficulty with the households – four of the dwellings had householders doing some work from home]
- Cost escalations resulting in cut backs to the packages
- Time delays with the consenting process and getting suitable tradespeople meaning that some interventions were not included
- One of the houses was sold and the new owners declined to participate in the project
- Wall insulation was discovered in homes where it was not expected

All of these difficulties could be expected to be encountered in many sustainable home retrofits, and therefore are issues which need to be explicitly identified and managed in future projects.

4.3 Actual Retrofits Undertaken

The actual retrofits undertaken differed from the original intent of the project as is demonstrated in the following table.

Table 1 Retrofit Packages Undertaken as Part of the Papakowhai Renovations

Original Proposed Intervention Packages		Actual Interventions
P01	High Thermal + Pellet Burner	*Standard Thermal + Pellet Burner +* Heavy ceiling insulation and R2 underfloor Pellet Burner + Heat Transfer Kit, Worm Farm, Energy Efficient Lighting + HW Cylinder Wrap.
P02	ECAN/MFE + Waste + IEQ	*Better than Basic but not Standard Thermal* HW Cylinder Wrap, R2 underfloor, Ceiling insulation topup, Heat transfer kit, worm farm
P03	High Thermal + Solar Hot Water + solid fuel	*High thermal +solar hot water + solid fuel* Wall insulation , Heavy ceiling & underfloor insulation, new Al frames & double glazing, solar hot water, low emission wood burner, wormfarm, rangehood, dual flush toilets, low flow shower head
P04	SOLD	No intervention
P05	Standard Thermal + Gas Hot Water	*Standard Thermal _gas hot water* Ceiling insulation topup, underfloor insulation, heat transfer system, bathroom extractor fan, instant gas hot water, low flow shower head, worm farm, energy efficient lighting
P06	No Interventions	*Basic* Ceiling insulation topup
P07	High Thermal	*High insulation* Ceiling insulation topup, wall insulation, underfloor insulation, hw cylinder wrap, bathroom ventilation, wormfarm
P08	High Thermal + Solar Hot Water	*High thermal + solar hot water* Ceiling, wall, underfloor insulation, double glazed window panes, solar hot water, showerdome, wormfarm
P09	Standard Thermal	*High Thermal + heatpump* Heavy ceiling, underfloor, midfloor insulation, wall insulation, showerdome, heatpump, HW cylinder wrap, wormfarm, energy efficient lighting
P10	High Thermal + Solar + Solid Fuel + Wetback	*High thermal + solar + solid fuel + wetback* Ceiling, underfloor, wall insulation, double glazing in new AL windows, solar hot water, low emission wood burner with wetback, bathroom ventilation, wormfarm, energy efficient lighting

4.4 Efficacy of the Retrofits

The most significant results have been the reduction in reticulated energy requirements for water heating due to the solar water heating systems.

The best energy and comfort improvements came from the houses with the most extensive interventions, (Beacon High interventions) including full insulation of the thermal envelope, solar water heating, and new solid fuel burning appliances, although all homes have improved thermal comfort levels, and usually also increased temperatures.

While it is difficult to draw concrete conclusions based on the very short period of monitoring data it appears that the following retrofits in particular were most effective from a resource efficiency and improved indoor environment quality perspective:

- Solar hot water systems – in all of the homes the solar hot water systems have performed well, with significant reticulated energy savings. This is particularly encouraging as the monitoring period was over the winter months (May-September) and indicates that the panels were well oriented for winter sun. It is important to note however that the installations were of a high specification – with panels twice the size of an installation undertaken under the EECA subsidy scheme, and therefore not a common practice installation.
- Heat transfer systems – where heating was undertaken these seemed to make a particular difference to bedroom temperatures, and humidity levels

4.5 Individual Interventions

Numerous different interventions were applied to the Beacon Papakowhai Renovation Project houses. The interventions were designed to generate improvements in four areas, indoor environmental quality (IEQ), energy, water and waste.

The energy savings and temperature differences in the houses with only floor and ceiling insulation are far exceeded by the two houses (P03 and P10) where walls were insulated, and the one house where a lower level of wall insulation already existed (P09). Two of the three of these homes also had double glazing installed. This indicates that the insulation of the full envelope is a synergy that transfers significant benefits. It is expected that these results will be verified by the 2008 analysis, showing higher temperatures, lower humidity, and some energy savings, although it is possible that these will be reduced by comfort take-back as people may use the reduction in power bills to pay for additional heating.

However there is no way to extract the effect of individual interventions from the complete package of ‘Basic’, ‘Standard’ and ‘High’ as multiple interventions interact to alter energy consumption profiles. The intervention packages installed to P03 and P10 in this work were designed to meet a high level of sustainability, cost a significant amount and are unlikely to be able to provide a realistic economic payback period, however the companion report (Saville-Smith, 2008) indicates that the householders were more interested in the comfort and environmental advances.

4.6 HERS Assessments

The nine homes were evaluated using the recently released New Zealand Home Energy Rating Scheme (HERS) using the AccuRate tool. Both a pre-retrofit evaluation and a post-retrofit evaluation were undertaken. At this stage the HERS evaluation only rates the thermal envelope of the home, however it is proposed to be expanded to include hot water and fixed heating in the future.

Table 1 shows the pre and post retrofit results of the HERS Rating. As can be seen from Table 1 there is no apparent relationship between the investment in thermal envelope improvements and the increased star rating under the HERS scheme. In particular it is worth noting that where partial (but inadequate) insulation exists, "topping up" appears to have a low effect on the star rating.

Table 2 Interventions and Effect on HERS Rating

House ID	Thermal Envelope Intervention	Approx Market Value of Retrofit	HERS Star Rating Before Retrofit	HERS Star Rating After Retrofit
P01	Skillion ceiling lowered in 40% of upper level, and R-3.6 insulation installed to achieve R-3.6. R-2 insulation installed underfloor (excluding midfloor) Heavy draught stopping –garage door Polythene laid on ground	$15 900	1	1.5
P02	Relaid and topped up existing R-2.6 ceiling insulation to achieve R-2.6. R-2 insulation installed underfloor Cat door replacement (draughts)	$1 450	2.5	2.5
P03	Insulated walls with R-2.4 insulation Skillion ceiling lowered, (in 40% of upper level) and R-3.6 insulation installed, below existing R-1 layer to achieve R-4.6. Original R-2.6 relaid, extra R-2.6 laid over ceiling joists in cavity ceiling to achieve R-5. Old aluminium windows replaced with clear double glazed units in 16 new frames R-2 insulation installed underfloor Polythene laid on ground	$62 300	2.5	5
P05	R-1.8 blanket laid over existing R-1.5 insulation to achieve R-3.2. R-2 insulation installed underfloor Polythene laid on ground	$4 270	2.5	3.5
P06	Ceiling insulation top-up to achieve R-2.6	$1 380	1.5	1.5

P07	Ceiling insulation topped up over existing macerated paper insulation to R-3.6 in half the ceiling area; top up with R-2.4 over other half bringing insulation to R-5 R-2.4 insulation installed in bedroom walls R-2 insulation installed underfloor Polythene laid on ground	$6 130	2	3
P08	Existing ceiling insulation topped-up to R-2.6, additional layer of R-2.6 put over ceiling joists to achieve R-5. R-2.4 insulation added to rear wall of bedroom R-1.2 masonry insulation added to rear wall of gym R-2 insulation installed to 75% of suspended floor R-1.3 to rest. Polythene laid on ground Clear double glazing units inserted into 16 existing aluminium frames.	$14 190	2	3
P09	Layer of R-2.6 put over existing insulation and ceiling joists to achieve R-4.2. R-2 insulation installed underfloor Polythene laid on ground R-3.6 insulation installed to ceiling/floor of garage/main bedroom. R-2.4 wall insulation installed into internal garage wall to stairwell, and on underfloor side of rumpus. Sliding door to garage draughtstopped	$4 010	4.5	5
P10	R-2.6 insulation laid over existing ceiling insulation, then additional layer of R2.6 put over ceiling joists to achieve R-5. R-2 insulation installed underfloor Polythene laid on ground in subfloor Flat roof of foyer insulated with R-3.6 insulation R-2.4 wall insulation to all walls except 1ower bedroom Clear double glazing units in 25 new window frames installed throughout house.	$59 060	1.5	4.5

5.0 Household Interviews

The occupants of the homes were interviewed following the retrofits. Key conclusions drawn from analysing the interview data in the context of the dwelling performance monitoring data are as follows:

- None of the dwellings showed performance levels unequivocally consistent with the HSS High Standard of Sustainability™ (HSS).
- The level of renovation (basic, low, medium and high) is not clearly related to:
  - the cost of the renovation, nor
  - the dwelling performance subsequent to renovation.

5.1 Householders Get Benefits

What is clear from the research is that, irrespective of the nature of the renovation itself, householders do recognise dwelling performance benefits from retrofitting. Indeed, some householders actively change their behavioural patterns because of those perceived benefits. The most typical changes in behaviour are increased hot water use, and changes in heating patterns. Increased winter warmth and the reduction of damp were consistently identified by householders as expected and important benefits.

Unexpected benefits identified by a number of householders included:

- noise reduction associated by householders with double glazing and/or increased insulation, and
- reduced household stress associated with warmer winter indoor environments and, for those with solar water heating, increased access to hot water.

Three consistent conclusions can be drawn from the analysis of the monitoring data in the context of the householder interviews. They are that the:

- Householders feel changes in indoor comfort even when changes are relatively small.
- Householders do change their behaviours when previous constraints are released. This is most noticeable among those households that have expanded their supply of hot water through solar hot water and instant gas hot water heating. It is not clear whether this generates total increases in water use.
- Changes in performance may be under- or over-stated where changes in occupancy are not taken account. Consequently, physical monitoring data in itself is not enough to evaluate the impact of renovation packages.

5.2 Householder Motivations

Notably renovation was not motivated primarily by ideas around capital gain or even reduced operating costs, although the latter were appreciated by some householders when they emerged. The attraction of the renovation programme lay in householders' desire to:

- improve the performance of their homes in terms of comfort and health
- upgrade their homes for future use, and
- get access to expert advice as well as funding for renovation.

5.3 The Renovation Packages, Value and Willingness to Pay

It is difficult to identify from the monitoring data what packages are the most cost-effective. However, the householder interviews do provide some learnings that impact on package design, and package installation.

There is considerable variability around the willingness to pay for retrofit. Householders in the case studies ranged from around $3,000 to around $30,000. There is, however, less variation

about the priorities of householders. Those may be summarised as winter warmth and the reduction of damp.

Operating cost reduction is also valued, but in an unsystematic way. That is, there is no evidence that return on investment in classical economic terms represents the value householders put on certain amenities or performance improvements. Solar water heating is an obvious example of this. Those householders who had solar water heating installed were aware that reductions in energy costs gave relatively low returns on investment. However, those householders valued it so highly that they would prioritise solar water heating immediately after underfloor and ceiling insulation and effective heating. The non-monetary value of solar hot water heating lay in improved availability as well as affordability of hot water, satisfaction with using the sun's energy, and a sense of independence and certainty around energy supply.

In short, the issue of affordability is important to householders but the rate of return appears to be less of a consideration. The language of 'return on investment' and 'pay-off periods' when householders do refer to them, appear to be simply a superficial adoption of the language and pre-occupations of public policy and investment decision-makers.

However, householders do want to ensure that they make the 'right' decisions. They want to know what is most effective in relation to the performance outcomes they value. They want to ensure that limited disposable income is used to make the most effective choices. There are three aspects of this that have emerged from the householder interviews:

- Firstly, householders want advice on effective investment at different price levels.
- Secondly, householders want advice on how to assess their needs and the sequencing of product/package installation. That is, given that affordability issues might mean that retrofit/renovation is likely to take place over time, they want to know what is the most cost-effective approach to achieving improved dwelling performance.
- Finally, they want to be assured that necessary standards of workmanship are being adhered to.

Ovarall the renovation components that tended to be consistently valued were:

- under floor insulation
- ceiling insulation, and
- efficient wood burners or pellet burners.

Alternative hot water heating, either through wet backs or solar water heating, were valued. Householders' views of double-glazing were more ambivalent. While those that had double-glazing installed appreciated its benefits, double-glazing was not seen as a renovation priority for those householders compared to other retrofit components including solar water heating. Notably, however, those householders that felt that they had 'missed out' on double-glazing tended to see it as a key pathway to improved house performance.

For Beacon the data on willingness to pay, affordability and value means that:

- Packages need to be developed to meet affordability limits. This implies a mix of 'single-point' packages and 'over-time' packages.
- The rationale for packages and package installation processes must be transparent.
- Beacon can support the industry to provide credible assessment and product/package installation processes.

Those findings are consistent with the surveys of householders undertaken in the Energy Research. They are also consistent with the background report on energy and water use. Birchfield (2008) concluded in the latter that:

- Current low standard packages do not achieve sustainable outcomes – need to do more to get energy efficiency AND improved comfort and health [this has now been picked up in EECA programmes]
- Strong link between heating source and insulation – better energy and comfort outcomes result when these are combined [this has also been picked up in EECA programmes]
- Simple water retrofit options (low flow devices, dripping taps) are fairly cheap and easy to install, but not promoted or subsidised in most locations.

The first of these conclusions, however, in the light of the Papakowhai research should not be assumed to suggest that higher expenditure will automatically generate better performance outcomes.

7.0 Implications for Home*Smart* Renovations

There are three sets of implications for Home*Smart* Renovations that can be drawn from Papakowhai. There are implications for:

- research methodology
- retrofit packages
- management of package installation.

7.1 Research Method

One of the major learnings from Papakowhai in relation to method is the importance of differentiating between surveying and case studies. The number of houses involved in the retrofit meant that the dwellings needed to be treated as a set of case studies. Case studies required careful control of some critical parameters to ensure that a robust evaluation of interventions can be made. In hindsight, it would have been useful to specifically select similar houses, as all the houses were very different, and featured a wide range of complex and individual responses to the topography, views and environment.

In addition, while the pre-retrofit monitoring indicated that the 9 homes are relatively ordinary as examples of performance of New Zealand housing stock – that is to say, they are relatively cold, at the upper end of ideal humidity conditions, are energy and water inefficient and do not perform well against high sustainability benchmarks – the homes were chosen on the basis of household makeup, and as a result (and partly because of the topography of the Papakowhai

area) the homes are not particularly representative of the range of New Zealand or Porirua's housing stock. All but one of the homes are split level/ 2 storey homes (the single level home has a sunken lounge), and constructed in the period of 1965 – 1979. As such they both represent relatively difficult subjects for standard energy efficiency retrofits, and were expected to be lacking in insulation in the original constructed dwelling.

This has been recognised in Home*Smart* Renovations and will be addressed by:

- Ensuring that monitoring data is sufficient to generate statistically robust analysis.
- Establishing a sample frame that captures the critical primary variables that require control. Those are:
  - climate zone
  - household income
  - market context.

Getting a sample size that allows for statistical tests of significance against the various factors likely to determine outcomes as well as establish performance outcomes means maximising the size of the sample participating in the research. We propose that all dwellings and households participating in the research be subject to some data collection. That is, the full 1000 dwellings. Data collection will be limited to the:

- critical performance outcomes sought by the HSS, and
- key variables affecting performance:
  - package type
  - take-up pattern
  - household characteristics
  - installation quality.

With regard to the latter, it is well worth taking detailed photographic records of the retrofits –in terms of demonstrating the quality of retrofit of features such as insulation, for training purposes and also a record of pre-retrofit state of the home.

7.2 Retrofit Intervention Development

Papakowhai demonstrated that some packages are easier than others to install and this varies according to both the package and the dwelling itself. This has both cost implications and may affect householder take up.

In terms of physically doing the job, the following retrofits can be regarded as being straightforward **to a competent and suitably qualified tradesperson who has had experience with installing this type of feature**:

- Ceiling insulation in a cavity ceiling
- Skillion ceiling lowering and insulating
- Underfloor insulation
- Wall insulation and replacement of internal linings

- Midfloor insulation
- Replacement of non CA rated downlights with CA rated lights
- Installation of low flow devices (shower head, cistern, taps)
- Installation of bathroom and kitchen ventilation systems (vented to the outside)
- Replacement of solid fuel heating devices
- Installation of pellet burners
- Installation of heat pumps
- Installation of heat transfer systems
- Replacement of single glazing with IGUs in existing, modern, aluminium frames
- Worm farms/compost bins/washing lines/recycle bins/Compact Fluorescents/Draught stopping/Showerdomes and other minor interventions
- Rainwater tanks for outdoor use
- Installing water meters
- Solar hot water system

In all these instances the correct specification of the system for a sustainable outcome is still required – under sizing/under specifying seems to be a common theme in almost all instances, with over sizing a common problem with solid fuel burners.

Papakowhai also showed that there are slightly trickier retrofits. Those require a specialised installer who is familiar with the system. They are also slightly trickier because they require several trades to be involved in the installation.

- replacing windows with Double Glazed IGUs and frames
- rainwater tank plumbed to toilet/washing machine
- greywater systems.

For Home*Smart* Renovations consideration must be given to simpler options such as:

- secondary glazing
- passive vents in windows
- solar tube type systems
- heat pump hot water systems.

In terms of package development, both Papakowhai and the energy surveys show that household take-up is likely to be constrained by both willingness to pay and affordability. Consequently, Home*Smart* Renovations will develop a set of interventions that allow households to manage renovations over a period of time and/or to choose what they will take up within the set of options that Beacon would identify as leading to a dwelling performing at a HSS™.

The idea of renovating for HSS™ over an extended period will also allow householders to consider the 'natural order' of retrofitting. There is a natural order of retrofits to some extent, in that if plumbing and electrical work is being undertaken in ceilings/underfloor, then this should be done *prior* to insulation installation, otherwise tradespeople are likely to damage the installed

insulation. In particular plumbing (eg rainwater tank plumbed to toilet/washing machine), heat pump, wetback and solar hot water systems should be installed prior to insulation.

7.3 Management of Package Installation

The Papakowhai research found that all the householders that participated in the interviews appreciated the opportunity to be involved in the retrofit project. Most householders identified a number of problems associated with participation, however. The most important of those were:

- uncertainty, and in some case unmet expectations, regarding the nature of the package installed
- poor specification and sequencing of installation leading to:
  - extended disruption of the household
  - unexpected requirements to provide a 'sweat' contribution, and
  - difficulties around managing the quality of work.

In addition there were a number of implementation problems that arose in Papakowhai. Prior to interventions being undertaken all the homes were the subject of a detailed BRANZ House Condition Survey and detailed drawings undertaken in order to provide information for modelling the expected performance of the homes.

These pre-retrofit evaluations identified that the homes were of varying levels of maintenance – with some homes needing urgent maintenance to items such as roofs and windows. In some cases full replacement of rotting materials was required. In addition, it became clear that some of the homes had probably been the subject of unauthorised building work undertaken in the past, by previous owners. In all cases Council plans were inaccurate and incomplete, when the actual built form of the homes was examined. One house had part of the home a mirror image of the plan, and other houses had missing elements (including whole floors) in the plans or in the construction. This is not an uncommon feature in New Zealand's housing stock, with a large proportion of older homes having both poor Council documentation and work not authorised under the Building Code.

While these unauthorised building retrofits (many of which were undertaken prior to the current compliance framework) were not the subject of the Papakowhai Renovation Project, they created difficulties for the project when it came to applying for Building Consent for the proposed retrofits. At one point in time it appeared that the Council was considering requiring BRANZ and Beacon to retrospectively consent/legalise all unauthorised building work on the homes (a requirement which would have quickly resulted in the project being cancelled), rather than just the retrofits proposed as part of the project.

Good management of consenting issues and local authorities, then, are critical to implementing Home*Smart* Renovations. Several of the sub-industries routinely avoid building consents through claiming like-for-like replacements, maintenance or simply ignoring the requirement.

This is not condoned by Beacon. Generally the following installations will require a building consent:

- window installation
- solar hot water installation
- solid fuel burners
- skylight and roof window industries

Building consent issues are particularly problematic for retrofitting double glazing. New Zealand homes all have different window typology – there is no standard window size in New Zealand. Therefore replacing frames and/or glass requires one - off products to be made, adding significantly to the cost. Multi level buildings require scaffolding in order to replace windows and it is generally a time consuming and expensive business. There is no Acceptable Solution for replacing windows – therefore compliance issues can arise. It is not a common retrofit, so getting suitably experienced tradespeople is also difficult.

8.0 Conclusions

This report has been prepared to summarise the key points in the series of reports developed as part of the Papakowhai Renovation Project. There are a number of significant learnings to be pulled through into the wider Home*Smart* Renovations project currently planned. These learnings relate to:

- Methodology for the Research
- Methodology for Decision Making around Retrofit Options
- Marketing of Sustainable Home Retrofit to Consumers
- Project Management of the Retrofits
- Physical Installation of the Retrofits, including Sequencing