HN2800/3

NOW100 Project Monitoring and Evaluation

Final

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About This Report

Title

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Abstract

This working paper outlines the research methodology, low cost monitoring protocol and research and evaluation framework for the NOW100 Project. It outlines the process of engagement with key industry stakeholders and definition of how Home*Smar*t Homes are able to be put in place using a mass market approach.

Reference

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1 Executive Summary

The NOW100 Project aims to create clear documentation and tools – Home*Smart* Home Procedures (formerly known as NOW Home® Procedures[1]) which codify the approach, specification and methodology for designing and constructing Home*Smart* Homes on a large scale. These Procedures are intended to be able to be used by the industry to produce Home*Smart* Homes and therefore part of the NOW100 Project involves the Piloting of the Procedures in the construction of 100 Home*Smart* Homes across the country, to be undertaken by developer and builder partners. The project also aims to ensure the integrity of the Procedures and their application by developing a simple, low cost monitoring methodology which will enable the verification of the performance of the mass-produced NOW Homes® to the HSS High Standard of Sustainability®.

The research hypothesis for the work in this report is:

- *That **HomeSmart Home Procedures** can be developed, which, when used by stakeholders in the new homes value chain, will enable the development of new HomeSmart Homes which meet Beacon's HSS High Standard of Sustainability®.*
- *That a low cost monitoring procedure can be delivered which can be used to monitor a large number of homes, cheaply, against Beacon's HSS High Standard of Sustainability®.*

This working paper outlines the research methodology, evaluation and for the NOW100 Project. It also provides preliminary information on the methodology for the piloting of the Procedures through the recruitment of developer and builder partners who will be designing and constructing the pilot 100 Home*Smart* Homes.

As part of the pre-work for the NOW100 Project, a research evaluation framework, selection criteria for partners and a case frame for the monitoring and evaluation of the Home*Smart* Homes built has been developed. This will ensure a robust research framework for the NOW100 Project and enable a wide range of useful data to be obtained from the project.

A low cost monitoring procedure has been developed which differs from previous monitoring methodologies used by Beacon and other research organisations who have looked at house performance in New Zealand in that it adapts some elements from commercial building monitoring – most notably, the use of Stream Smart Meters and commercial data collection organizations. While the project aimed to put in place a system with a $500 start up cost, the proposal is for a $1070 system, however a higher detail of information than initially anticipated is able to be provided.

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[1] ***During the development of the Procedures, feedback from industry partners showed that the NOW Home® brand was not considered strong and a new branding exercise led to the creation of HomeSmart Homes (see Development of the HomeSmart Home Procedures, HN2800/2)***

Preliminary engagement with building and development partners for the NOW100 Project has been undertaken and a number of partners are on board with the project. The slowdown of the housing market however means that the project has reached a point where review of the piloting methodology and development of a revised project plan is required, as it may not be possible to get 100 homes built within the timeframe required for the project.

1.1.1 Definitions

Within the context of this report and wider Sustainable Homes Research the following definitions are used:

Home: The physical house with people in it: interacting with the systems of the house, and influencing its performance.

Procedures: These are codified knowledge around how to build or renovate homes to achieve the HSS High Standard of Sustainability®. They are targeted to the particular user (eg developer, home owner, designer, builder, plumber) and will be in different formats depending on the target audience. They include: protocols, guidelines, specifications, plans, checklists, detailed design methodologies, reports, spreadsheets, models, training materials, powerpoint presentations or any other way of presenting codified knowledge appropriate to the particular user.

2 Introduction

Beacon Pathway Limited (Beacon) has developed two prototype NOW Homes® in Waitakere and Rotorua and these have been comprehensively monitored by BRANZ to verify their performance (Jaques et al. 2007, Jaques et al. 2007a, Pollard et al. 2008). To date, it appears that the NOW Home® hypothesis is correct: that it is possible, with current knowledge and technology, and for a price which is affordable to most New Zealanders, to build homes which are substantially more sustainable than standard new homes. Given this, Beacon's aim is to see the NOW Home® model taken up by the mass market, and used to build new homes. It should be acknowledged however that in some areas better performing systems are still needed, and this is the focus of other research by Beacon.

The experience of building and operating the two prototype NOW Homes® has shown that there are a number of key requirements and high performance systems which are needed within the homes in order for them to perform to a HSS High Standard of Sustainability® (HSS®). It has also shown that there are many barriers to the successful implementation of mass market NOW Homes®, now called Home*Smart* Homes. This project aims to remove many of these barriers and create clear documentation and tools (the Home*Smart* Home Procedures) which, when used by the industry, across the value chain, will result in the ability to mass produce Home*Smart* Homes.

In addition, this project aims to ensure the integrity of the procedures and their application by developing a simple, low cost monitoring procedure which will enable the verification of the performance of the mass produced Home*Smart* Homes to the HSS High Standard of Sustainability® and that they are, in actuality, Home*Smart* Homes.

The research hypothesis for the work in this report is:

- *That* Home*Smart* Home ***Procedures*** *can be developed, which, when used by stakeholders in the new homes value chain, will enable the development of new* Home*Smart* Homes *which meet Beacon's HSS High Standard of Sustainability®.*
- *That a low cost monitoring procedure can be delivered which can be used to monitor a large number of homes, cheaply, against Beacon's HSS High Standard of Sustainability®.*

Overall the project has four objectives. To:

1) establish the credibility and robustness of the Home*Smart* Home by broadening the baseline numbers of monitored stock and the typology of stock meeting Home*Smart* Home standards
2) develop a robust set of procedures that Beacon can commercialise and which will allow builders to build homes that meet Beacon's HSS High Standard of Sustainability®
3) demonstrate that Home*Smart* Homes can be shifted from a prototype to a leading product in the new-build market which people associate with comfortable, quality living at an affordable price

4) act as a catalyst for market transformation and the wider uptake of building new homes to achieve the HSS High Standard of Sustainability® using a range of available products.

It is intended that the project as a whole will demonstrate, (from the learnings based on robust research outputs from previous Beacon projects), that New Zealand homes can be built using current building solutions to deliver warmer, healthier homes which are more comfortable, more affordable to run and have lower demand on our nation's resource supplies. The NOW100 project is also intended to engage with a number of key organisations, (some of whom have already successfully partnered in Beacon projects), which have a large vested interest in the residential built environment. These include product manufacturers / suppliers, local authorities, industry organisations and energy / water utilities.

The project commenced in September 2007 and has reached the end of the first stages – the development of the Home*Smart* Home Procedures and the low cost monitoring protocol. This working paper is a companion to the report into the Procedures and provides an overview of the research and project development to date. The next stage of the project is the piloting of the Home*Smart* Home Procedures and the low cost monitoring protocol through the design, construction and monitoring of the 100 Home*Smart* Homes.

3 Project Implementation: Research & Evaluation Framework

The research and evaluation framework for the NOW100 Project and efficacy of the Home*Smart* Home Procedures is being developed to ensure that the Project addresses the following four questions.

1) Do the Home*Smart* Homes perform to a HSS®?
2) To what extent is the performance of Home*Smart* Homes determined by occupant characteristics and behaviours rather than the design and construction of the dwelling?
3) How have the procedures, process plans and specifications provided for the Home*Smart* Homes assisted or presented barriers to participants (including developers, builders, suppliers and regulators)?
4) To what extent is the Home*Smart* Home likely to contribute to market transformation? With particular consideration of:

- consumer traction measured by:
  - household satisfaction
  - affordability
  - cost, price and affordability
- developer and builder traction
  - impact on design and build of other products among participants
  - impact on non-participant perceptions and activities for sustainable dwellings
  - margins and pricing
  - skills and capability challenges

The project team has established that three sets of data will be collected to answer those four key questions. Those are:

- house performance and performance attribution data
- programme and procedure efficacy, and
- market response data .

Table 1 sets out the alignment between those data sets and the key research questions for the NOW100 Project.

Table 1: Key Research Questions for NOW100 Project and Critical Data Sets

Key Questions	Data Sets
Do Home*Smart* Homes perform to a HSS®? To what extend is the performance of Home*Smart* Homes determined by occupant characteristics and behaviours rather than the desire and construction of the dwelling?	House Performance and Performance Attribution Data
How have the procedures, process, plans and specifications provided for the Home*Smart* Homes assisted or presented barriers to industry participants (including developers, builders, suppliers and regulators)?	Programme and Procedure Efficacy Data
To what extend is the Home*Smart* Home likely to contribute to market transformation?	Market Response Data

The analytic robustness of the data in those three data sets is partly dependent on the instrumentation developed to collect data in each set. It is also, however, depends on the sampling strategy and/or case frame strategy which governs the location of Home*Smart* Homes and the number of Home*Smart* Homes and stakeholders involved in the data collection process. Section 4.1 sets out the specification of the House Performance and Performance Attribution Data Set and progress on the instrumentation for data collection. Section 4.2 sets out the specification for the programme and procedure efficacy data set. Section 4.3 sets out the specification for the market response data. Finally, Section 4.4 sets out the considerations and framework governing the locational distribution of the Home*Smart* Homes.

3.2 House Performance and Performance Attribution Data

This data set is directed to establishing the:

- level of house performance, and
- extent to which house performance can be attributed to the design and construction of the dwelling or to other factors.

In relation to dwelling performance, the critical measures of performance are contained in the HSS®. The HSS® measures outlined in Table 2 consist of:

- direct measures:
  - indoor temperatures
  - indoor humidity
  - indoor ventilation rates
  - reticulated energy use
  - reticulated water use
  - volume of construction waste
- indirect measures (checklists):
  - indoor pollutants
  - household waste
  - materials.

House performance data provides a measure of dwelling performance but does not allow for that performance to be explained. The hypothesis that underpins the Home*Smart* Home is:

"That with appropriate design and build HomeSmart Homes provides households with the opportunity to meet the HSS High Standard of Sustainability®."

The specification of this data set recognises three factors may have significant impacts on the performance of a dwelling built as a Home*Smart* Home over the research period. Those are:

- *Environmental Conditions*. Dwellings are fundamentally designed to mediate the impact of the natural environment on people. Dwellings should be able to manage their performance in relation to the HSS® across typical seasonal and diurnal fluctuations. However, it can be equally expected that where the natural environment is atypical (such as sustained high or lower than typical humidity and temperatures), that dwellings that would ordinarily function appropriately may struggle to do so. Consequently, direct measurement of indoor performance must be analysed in relation to likely outdoor environmental conditions - particularly humidity and temperature. In addition because of the use of rainwater and solar in the Home*Smart* Homes the actual and expected rainfall and sunshine over the monitoring period.
- *Departure from Design.* For evaluative purposes, it is critical to know whether there has been design fidelity. Performance measures of the Home*Smart* Home assume that the houses are built as designed. If there are variations from agreed specification these must be understood and accounted for in relation to each dwelling. It must be recognised that departures from specification may not simply lead to poor performance. Departures may also boost performance or contribute to the dwelling meeting performance. Data around fidelity will be collected throughout the building process.
- *Household characteristics and behaviours*. It is clear from the Household Energy End Use Project (HEEP) (Isaacs et al, 2006) that household size and occupancy are important determinant of energy use. Household size and occupancy can also be expected to impact on water consumption. In addition, the resource consumption patterns of households may also be defined by an intermediary factor – that is, the number and type of appliances acquired and used by the household. Appliance use generates a good deal of complexity, but is clear that house performance can not be assessed without controlling for appliance use. Data around those issues will be collected through both observation and household interviews.

Table 2: Data for House Performance and Performance Attribution

Data Parameter	Source
House performance	
Indoor temperature (seasonal + diurnal)	Performance monitoring
Outdoor temperature (seasonal + diurnal)	NIWA
Indoor humidity (seasonal + diurnal)	Performance monitoring
Outdoor humidity (seasonal + diurnal)	Performance monitoring
Rainfall	NIWA
Sunshine hours	NIWA
Reticulated energy use (seasonal + diurnal)	NIWA
Reticulated water use	Performance monitoring
	Performance monitoring
House performance attribution	
Design and build fidelity	Design and house inspection
House performance attribution	
Household size and occupancy	Exception surveying-monitored households
Appliances	Baseline household survey of monitored households
Pre-entry consumption energy profile	

Development of the low cost monitoring protocol

The brief for the development of the low cost monitoring protocol recognised that the monitoring methodologies used in both the Waitakere and Rotorua NOW Homes® were not applicable in a large scale research context. The capital cost of the technology included in the two existing NOW Homes® is in the order of tens of thousands of dollars. Much of the data collected in these programmes is also not required to answer the key question of whether the homes perform to a HSS®.

The NOW100 project sought to monitor a statistically representative sample of the homes cheaply – with a target budget of $500 per house for the initial set up. This created major constraint when considering possible monitoring strategies available, and the extent to which the houses are monitored.

The extent of monitoring required depends on the research questions to be answered. In this case the primary research question is whether or not the Home*Smart* Homes meet the required HSS® targets.

In determining the appropriate monitoring methodology to achieve the research objective, a review of the existing Beacon and BRANZ monitoring programmes and methodology was undertaken. This included:

- Waitakere NOW Home®
- Rotorua NOW Home®
- Papakowhai Renovations
- BRANZ HEEP Project
- BRANZ WEEP Project

This review was then followed by a "technology scan" of available monitoring technologies which, while applied to different circumstances (e.g. commercial buildings) may be easily picked up and used in the performance monitoring of Home*Smart* Homes.

Technologies evaluated as part of this second stage process included:

- Smart electricity meters
- Water meters
- Temperature/humidity sensors

While the focus of the evaluation was whether the technologies enabled easy assessment of performance of the home against the HSS®, it was recognised that these were research sub questions of interest to Beacon also. It was identified that ideally there would still be the capability to separate the energy consumed for end-uses which are affected by the building design and construction (such as space and water heating and lighting), from the energy consumed for more occupant related end-uses such as appliances used for entertainment or hobbies. This is only likely to affect electricity rather than water and other sources of energy, which only tend to be used for one or two end-uses.

It was also recognised that the NOW100 project could supply useful data on the effect of some of the houses' sustainable features; such as the contributions of the rainwater tank and the solar hot water unit (if fitted). While these features may not appear on every house it would still be beneficial to gain some understanding of their value and how this can be maximised. Reviewers note that if we are not monitoring the solar contribution it will be difficult to understand how to maximise features, careful investigation of installation would be needed. It was noted that even with intensive monitoring of solar units results are variable. Therefore this aspect is not expected to be included – discussion kept for completeness.

Two Tier Monitoring Protocol

As a result of the analysis, a two-tier monitoring protocol is proposed for the performance monitoring of the NOW100 project homes. This is outlined in Table 3 below:

Table 3: Proposed levels of monitoring, and comparison with other household monitoring projects

Field	Energy	Water	Temperature / Humidity	Ventilation Rate	External
NOW Home® (existing, Beacon)	8 channels at meterboard, at 10 second intervals	Meters on every end-use, recording at 10 minute intervals	10 minute intervals in bedroom and living area (plus CO_2)	Not measured	10 minute intervals
HEEP (intensive, BRANZ)	Up to 8 channels at meterboard, plus two appliances per month, all at 10 minute intervals	-	10 minute intervals at three points; bedroom, high and low level living. (temperature only)	Not measured	10 minute intervals (temperature only) and NIWA data
WEEP (BRANZ)	-	WEEP use high resolution main meter and disaggregating software	-	-	-
NOW100 Cut-Down Monitoring (sample) (Beacon)	Electricity at 30 minute intervals with remote access, 3 channels: Stream meter Gas mains meter Wood & pellets– to be determined (fire diaries didn't work well in HEEP	Street meter plus NIWA data	30 minute intervals in bedroom and living area: iButton	Blower door test, ventilation not measured.	NIWA data (free to download)
NOW100 All other houses (Beacon)	Electricity & gas mains meter (invoices)	Street meter (invoices, if any)	-	-	-

Energy

Clearly there are many possible sources of energy to a house; however, there is only an HSS® for reticulated energy – i.e. grid sourced electricity and gas. This makes monitoring of electricity consumption a primary goal in the NOW100 project. Other energy sources such as bottle gas or wood for heating cannot be ignored however as they give an indication of the performance of the home thermally.

Electricity

Current smart metering technology allows the electricity usage of a building to be tracked and monitored over time at almost any given interval, though at present this technology is only used in large commercial or industrial sites. However, there is no reason why this technology could not be used in a residential application.

Energy Intellect provides metering technology and technical support to Stream Metering, a service used by many commercial clients to track electricity use. As part of their standard package a customer's electricity use is read half-hourly and downloaded from the meter every day. The data is available to the customer via a secure website where they can view their overall consumption, peak demand and daily load profiles. Raw data is able to be downloaded from the site in text format.

The same service would be used for monitoring the NOW 100. After discussion with Energy Intellect they have confirmed that there is no issue with scaling down the service for a residential application. Furthermore, Stream's meters are designed to measure power consumption over three phases, a residential house however, only receives single phase power. The three phases of the meter could therefore be used to measure three single phase end uses (provided they are circuited separately at the meterboard). This would allow monitoring of electric hot water cylinder boost, fixed electric heating and 'the rest' from the one meter.

Again, individual occupants of each house would be able to view their electricity use (up to midnight the previous day) online and gain a greater understanding of their consumption patterns. The NOW100 research team would also have remote access to the consumption data for every house in the monitoring programme. Because the data is remotely available and in a format which is easily imported into Excel (the data requires no normalisation or calibration) there are significant time savings for the monitoring team when analysing data and producing reports. Energy Intellect will provide summaries online for each occupant.

The costs associated with this monitoring are an initial installation cost, and an ongoing monthly service fee for the data download and web access. The most cost effective strategy appears to be to purchase the metering equipment from Energy Intellect and have the site electrician install the equipment alongside (i.e. in series with) the tariff meter. The metering equipment is estimated to cost $750 to purchase. The ongoing cost of data retrieval and web service would then be around $30/month ($10 of this fee is the cost of an account fee with a mobile network (i.e. Vodafone). This technology is used reliably by commercial clients for energy monitoring and in some cases demand response purposes. With regards to the pilot project this acts as a selection criteria for the candidate houses, as the house must have cell-phone coverage.

While the initial costs are higher than the budget for the monitoring programme, it is felt the ready access to good data, along with the high reliability of the system, justifies the additional cost. When considering the savings in data processing time when compared with similar monitoring programmes this strategy pays for itself several times over. Reviewers noted that

data checking, especially at the start, is very important as electricians can (and do) get it wrong. One solution is to "fly in" electricians who are experienced in installing monitoring – with large cost implications and do need local electricians to improve capacity and provide on-call support. The programme will require good systems and procedures to manage this risk.

The alternative is for Energy Intellect to retain ownership of the meters, and add a leasing fee onto the monthly cost. The installation costs are then slightly reduced, although Beacon would not have to pay the purchase cost of the metering equipment. Energy Intellect would install the meters themselves and charge an associated cost. They have indicated that this installation cost may not be significantly lower than purchasing the meters and using the site electrician. The monthly fee increases to around $75/month when including the leasing costs of the meter –this is based on a minimum contract term of five years, costs would be higher given this monitoring programme is only for one year.

Energy Intellect is able to supply installation guidelines and specifications for use in Home*Smart* Home construction. There is a requirement that the meterboard can fit the additional meter, which may necessitate a slightly larger than usual meterbox.

Solar Hot Water

Assuming the solar hot water system has an electrical or reticulated gas back-up element, the reticulated energy consumed by this element is easily accounted for in the way described above.

Solid Fuel

There will be some Home*Smart* Homes which use solid fuel, particularly for heating. The Home*Smart* Home specification cites MfE approved wood burners and pellet fires as acceptable heating solutions. The HEEP study had the occupants self report their firewood usage in a 'fire dairy'. A typical 'basket' of firewood was weighed and the occupants recorded how many baskets of firewood they used at what time, however feedback from the HEEP team at BRANZ stated that this method was unreliable as occupants were not very good at maintaining the diary. The best solution may be to have occupants record (or report) firewood purchases, however this is complicated by the fact that firewood is often purchased in irregular quantities (e.g. a 'trailer') or some houses may have access to free waste wood. Wood pellets are simpler to measure as they are purchased by the kilogram and any residual at the end of the heating season could be weighed on a set of bathroom scales. There is also reasonably accurate data on wood pellet calorific and CO_2 conversion factors per kilogram.

Gas

Reticulated natural gas is available throughout most of the North Island with other parts of the country using bottled LPG – either large HomeGas bottles (45kg) or the smaller LPG bottles. Gas is typically consumed for three different end-uses: hot water heating, space heating and cooking. A house may use gas for one, two or all three of these end-uses; however, the water and space heating are end-uses which can be reduced by good design, and cooking is an essential end-use which is likely to have a relatively low consumption.

HEEP recorded gas energy usage at ten minute intervals by installing a gas meter for each end use at the main meter in order to investigate the gas usage at the house (Isaacs et al, 2006). Considering the cost restraints on this monitoring programme it is felt that this is not achievable in this case. Given the likely end-uses gas serves, the monthly invoices will provide adequate information to determine the amount of energy used by the house. There may be some houses which use the HomeGas 45 kg bottles or the smaller nine kilogram LPG bottles, in these cases the occupants would have to keep a record of how often they have the bottle filled over the monitoring period.

Note that in a house which uses natural gas as its energy supply for hot water say, a channel on the electricity smart meter would be free to measure another end-use, such as the range or the lights.

Water

The HSS® for water sets benchmarks in relation to water provided from the reticulated mains supply. In addition to the primary research goal of assessing the house's consumption against the HSS® the monitoring needs to take account of the rainwater tank's contribution to the household usage.

Mains Supply

BRANZ has recently carried out a study of water usage in houses, called WEEP (Water Efficiency End-use Project) using high resolution water meters and disaggregating software. From a monitoring perspective this would be the ideal case, as it allows all water end-uses to be monitored at one point from outside the house. Unfortunately the cost is relatively high with the meters BRANZ selecting costing $560 and the logging equipment anywhere from $100-3,000. The disaggregating software costs $1,495 USD, though only one license would need to be purchased to process the data from all the houses.

Data retrieval would also create a large cost, data loggers would need to store a significant amount of data to fit in with the three-monthly visit, increasing the cost. Cheaper loggers require more visits from download staff. There is the ability to send data via cellular link as used by the proposed electricity monitoring strategy, though it is unknown if both the electricity and water meters could use the one transponder. There is also a large time factor in processing the data once retrieved, the disaggregation software can process a weeks worth of data in an hour. With a sample of 20-40 houses this leads to a significant amount of processing time over a year-long study.

It has been decided to read water consumption from a typical domestic meter. This would be read three-monthly by the download staff when they visit the house. For houses in areas where water consumption is billed invoices could also be used instead of / or as a back-up to manual readings. From this data the house's water consumption in terms of litres/person/day can be calculated and compared with Beacon's HSS® for water.

Where councils do charge for water consumption, the council will only allow a certain type of meter to be used – which they then supply. It should be noted that, although only a few councils have compulsory water metering, most councils do allow for a metering option, and may therefore also have prescribed metering equipment which must be used. In non-metered areas, or those without specific council requirements as standard Class C (accuracy of ±2.5%) water meter should be fitted. It is proposed to use a Hydroflow 20mm Gamma meter, which is an inexpensive, easy to read 'grenade' style meter. The 20mm size is the standard connection size from the mains to the street for new houses.

In the Home*Smart* Renovation (Renovate1000) project it is likely that the installation team will encounter several mains sizes, some possibly non-standard. The Gamma meters mentioned above can be supplied in sizes of 15 and 20mm and other meters can be sourced in differing sizes, though there is a risk that some rework may be required to fit a water meter into an existing house. The most likely scenario is having to fit a metric sized meter to an imperial gauge mains pipe.

Rainwater Tank

Additional data collection is required in order to determine the contribution from the rainwater tank. The ideal case would be to install a second flow meter on the rainwater tank's supply to the house. However, in practice, rainwater tanks do not provide enough head to generate adequate water pressure for the water meter to read accurately, especially given that they have to be sited below the level of the roof.

The alternative is to estimate the rainwater tank's contribution from rainfall data taken for the local region. This is the approach used in the Waitakere NOW Home® (Pollard et al, 2008). NIWA's cliflo database of historical weather data has recently been made public access, this allows daily rainfall data to be downloaded for free via the internet for the nearest weather station to the NOW100 sites. The estimate of a rainwater tank's contribution would take the amount of rainfall, and then make adjustments for times when the tank was full (and any additional rainfall went straight to the overflow), and any diverting of initial rainfall (rainwater systems divert an amount of water to prevent detritus from the roof and gutters clogging the system). Such a system has been developed and is used to size rainwater tanks for their commercial projects.

If the nearest NIWA weather station is deemed to be inadequate or non-representative then a simple rainwater meter could be mounted in the garden. This would then be read (and emptied) during the monthly site visits and used to normalise the data from the cliflo database. This method makes the assumption that times of rainfall at the Home*Smart* Home would be similar to that of the NIWA station, though the actual quantities may differ.

Indoor Environmental Quality

The internal environmental quality is also crucial in providing a healthy, comfortable home. Beacon has HSS® requirements for temperature, humidity and ventilation. The monitoring procedure to test a Home*Smart* Home's performance against these requirements is discussed in the section below.

Temperature / Humidity

In order to assess whether the house meets the performance criteria for temperature and humidity, loggers would be placed within the living room and main bedroom (there are differing benchmarks for each area). Placement is key to avoid spurious heat sources and sunlight and be out of the reach of small children or pets. This project is only interested in temperatures at 'living height' within each room, therefore loggers will be placed within 0.6 to 1.5 metres above the floor. While both HEEP and the current NOW Home® monitoring measured temperatures at two heights in the living room, this will not be continued under this monitoring programme due to financial constraints.

As electricity consumption is being logged at half-hourly intervals it is proposed that the same time interval be used for temperature and humidity data. This would still allow an increase in observed temperature to be matched with a corresponding increase in electricity use for heating (should electricity be the heating energy source). The reduced amount of data (from current NOW Home® monitoring) also reduces time requirements for data download and analysis. Half-hourly temperature profiles would still allow an adequate understanding of how a house is being used – particularly when coupled with electricity data.

There are currently two options for the temperature and humidity logging equipment. Beacon currently uses HOBO measuring equipment in the current Papakowhai Renovation houses though an alternative is the 'iButton' from Maxim in the United States. A trial of each sensor will be carried out in one of Beacon's Papakowhai retrofit houses to determine which type of logger is most suitable for the larger projects.

The HOBO loggers have the advantage of familiarity and would appear to be easier to use. A basic HOBO temperature and humidity sensor costs around 75USD, though discounts are available for larger orders. A single iButton cost 95USD, plus shipping costs, though they are locally available through Powertech in Auckland who have quoted a price of 94NZD (plus GST and shipping) for orders of greater than 50. The iButtons are very small in size, possibly too small as they could be easily lost e.g. during vacuuming. It also appears that the interface is not particularly user friendly. An advantage they do have is that they would not require any replacement batteries over the course of the project, at a sample rate of 30 minutes the battery life is given as between six to seven years.

External temperature and humidity will also need to be collected. Depending on the Home*Smart* Home's location, the cliflo database could be used, though this would not provide half-hourly data. In order to get external data which matches the internal data another logger

would be used. This would need to be carefully placed, not only to ensure true readings, but also to protect the equipment from the environment. Reviewers note that external tiny tag loggers can be used or project could buy ventilated weather proof holders for loggers.

Ventilation

The actual amount of airflow through a space is very hard to measure. Typically CO_2 concentrations are used as a measure of fresh air supply to a space, and this is the method used in the Waitakere NOW Home® with some success (Pollard et al, 2008). Unfortunately CO_2 loggers cost around 440 USD apiece (from the same supplier as the HOBO temperature / humidity loggers), which is likely to be outside the budget allowance for both the NOW100 and Home*Smart* Renovation projects.

The Home*Smart* Home specification states that mechanical extracts be installed in both the kitchen and bathrooms / toilets to remove indoor moisture. The remaining living areas would have the ability to naturally ventilate according to the building code, which sets a simple requirement of five percent of the floor area as openable window (DBH, 2006). Most rooms with reasonably sized windows would meet this minimum requirement easily.

The ability to naturally ventilate is important to reduce overheating times and hopefully negate the need for air conditioning in summer (also a stated checklist item as shown in Table 5). It should be noted that there is a distinction between ventilation and infiltration, or the natural ingress of air through the building fabric. A high infiltration rate can make the house draughty and hard to heat, whereas a low infiltration rate can result in the air becoming stuffy and stale. The HSS® for ventilation is quantified in Air Changes per Hour (ac/h) and refers more to a desirable level of infiltration through the house. While CO_2 concentrations could be used to estimate the amount of infiltration the standard method is to use a blower door test.

A blower door test comprises fitting a large fan to an external door and pressurising the house with air. The pressure gain at the fan can be used to estimate the amount of air escaping the house through the fabric. Note that this would only have to be carried out once throughout the monitoring period, the airtightness of the house would not change appreciably over a year. The test would occur immediately after completion in the case of the new houses. BRANZ commented that only a sample of 100 houses will need to be tested unless homes are specifically being built to be very airtight (non-passive homes).

Other Parameters

There are other aspects of a Home*Smart* Home's environmental performance which do not have defined measurable HSS® targets, the most obvious being waste production (discussed below). It is important that the monitoring procedures are able to account for these additional criteria in some way, or at least flexible to account for others which may arise over time.

Waste

While there is no specific Beacon performance target for the production or reduction of solid waste (i.e. leaving the site to the landfill) the definition of a Home*Smart* Home includes waste reduction features such as areas for recycling and compostable waste (Karlik-Neale et al, 2008b). Guidelines and other information as to the usage of these features would therefore be included in the occupant's user guide for the house.

The easiest method of measuring the amount of waste produced would be to have the occupants self-report their waste production by recording the weight of their weekly kerbside rubbish (and also any recycling). A simpler method may be to record the number of council rubbish bags used every month, or possibly give each family an assigned number for the year when they take occupancy and then note how many extra / less were required by the end of the year.

Monitoring Procedure

Initial Survey

Shortly after the occupants move into the house (assuming a new-build Home*Smart* Home) a survey must be carried out to record the number and type of appliances in the household. Also the occupants should be interviewed to determine some aspects of the occupants' behaviours, expectations and occupant household characteristics. The occupants' previous energy and water (if available) bills would also be examined to gain an understanding of their resource usage in their previous premises. A telephone survey of all participants is proposed as the data collection method.

Some parameters intrinsic to the house would be known from the Home*Smart* Home building specifications such as size and number of fixed heaters (including non-electrical heating), flow rates of sanitary fittings and the insulation levels. A full set of drawings for the house would also be available if required.

Installation

Clearly for the monitoring to be successful there needs to be a process to ensure that all the monitoring equipment required in each house is installed and functioning correctly, and that download staff are able to identify monitoring equipment during their monthly visits. An example of an installation checklist is shown in the table below:

Table 4: Example checklist for monitoring installation

Parameter	Task	Location (description/mark plan)	OK?	Photo
Temperature / Humidity	Logger installed in Bedroom?	serial no: height:		
	Logger installed in Living Room?	serial no: height:		
	External logger (if present)	serial no: height:		
Water	Install main meter?			
Energy	Electricity meter installed?	initial read:		
	Channel A:			
	Channel B:			
	Channel C:			
	Fire diary supplied?			
	Install gas meter (if present)	initial read:		
Attendance	Attendance diary supplied?			
Appliances	Baseline appliances?			

Note that this is a summary of what would be required – each separate section of the table would be supplied to the relevant trade, along with any specifications and other installation instructions. The completed sections would then be consolidated once the installation was complete and signed off by a designated person on-site (e.g. site foreman / manager, download staff or Beacon team member).

The installation of monitoring equipment requiring specialist trades such as the electricity, gas and water meters will be covered by the inclusion of clauses within the house's specifications. In the case of the electricity meter these are supplied by Energy Intellect, while standard plumbing clauses will detail the gas and water meters (if this is not supplied by the council).

Data Collection

The current strategy is for download staff to visit each house monthly, though this may extend to two-monthly if costs become an issue. Monthly visits would be preferred to enable a greater understanding of any seasonality in environmental performance, water usage being the obvious example. The tasks / measurements the download staff would to perform at each visit are shown in the example checklist below (Table 5):

Table 5: Example checklist for download staff

Parameter	Task	Yes / No / Reading
Temperature / Humidity	download from Bedroom	
	download from Living Room	
	download external (if present)	
Water	read main meter	
	read tank meter *	
Energy	fire diary current?	
	read gas meter (if present)	
	read bottled gas invoices (if present)	
Attendance	attendance diary current?	
Appliances	any new appliances?	

Clearly the final checklist would be refined to reflect the finalised monitoring strategies and also allow for download staff to comment, record additional information and their own observations from each visit.

The most time consuming aspect of the visit is likely to be the downloading of the data from the temperature / humidity sensors. This data can be downloaded to a laptop via a USB or serial port and then emailed to the monitoring team for analysis. Although the iButton can store up to 84 days worth of half-hourly data it is desirable to download the data at shorter intervals to reduce the possibility of data losses and allow earlier detection of faulty equipment.

In order to benchmark the water usage per person there is clearly a need to have a measure of how many people are in the house for each period. This would also be monitored using self-reporting on the part of the occupants. They will have to record if visitors come to stay, or if the house's usual occupants are away for any time. Again, this would be recorded in some sort of 'attendance diary' which would then be read when the download staff visit.

The download staff would also be required to record any new appliances which the occupants had purchased during the monitoring period. There may also be other data which needs collection from an occupant survey or other type of interview.

Data Management

All data from the temperature /humidity loggers, and the meter readings and other information from the checklist would be emailed to the monitoring team for analysis. Raw data would be kept in text file format with the edited data being held in an excel spreadsheet.

The ten second electricity usage information from the Waitakere NOW Home® was found to require / cause very large file sizes, necessitating the need to summarise the data into ten-minute 'bins' (Pollard, 2007). With the half-hourly data being collected here this is not anticipated to be an issue. While each house being monitored will still have its own excel file all files will be linked to a summary document to allow easy comparison and analysis of the dataset as a whole. Reviewers noted that with large numbers of homes to be monitored excel is not optimal for data management and suggested other databasing options are explored, e.g. SPSS

Data security would be achieved through the use of standard office off-site backup procedures and the data being stored on two servers in two separate parts of the country.

Reporting

Throughout the monitoring programme, Home*Smart* Home occupants would be able to view their electricity consumption data and reports online through Energy Intellect's service. A final report detailing the house performance according to the HSS® benchmarks, accepted national averages, and their relative standing within the NOW100 dataset would be issued for each house at the conclusion of the year long monitoring programme.

In addition an overall summary report documenting the performance of all of the monitored houses would also be produced at the conclusion of the full monitoring.

Pilot Study

In order to assess the above monitoring protocol's suitability to purpose and likelihood of success a pilot study will be carried out using a Beacon staff member's home.

It is hoped that the pilot study could be started as soon as possible, with a month long monitoring period. This would depend on the availability of key participants, tradesmen in particular, and final agreement from BRANZ Limited on access to a home and the extraction of comparative data.

Costs

An estimate of the total costs for the project are shown in Table 6 below. The upfront capital costs and ongoing costs over the full years monitoring are shown and totalled separately.

Table 6: Schedule of costs per dwelling for NOW100 monitoring

Parameter		Initial Costs Per House	Ongoing Costs Per Month	Number required	Total Ongoing
Energy	Electricity	$750	$30	12	$360
	Solid Fuel	-	-	-	-
	Gas	-	-	-	-
Water	Mains Water	-	-	-	-
IEQ	Temperature / Humidity	$250	$20	1	$20
	Blower Door Test	nyc	-	-	-
Procedural	Download Staff	$120	$120	12	$1,440
	Data Analysis	$150	$150	12	$1,800
TOTAL		**$1,270**	-	-	**$3,820 + GST**

Reviewers noted that the costs estimated for data analysis / home are likely to be exceeded. The initial cost for a NOW100 house can be seen to be $1,270 + the cost of the blower door test. This costing is based on the assumption that the cost of the water meter can be included in the build cost of a new house (metering the main water supply is still good practice even if it not a mandatory requirement by the local council for the site) and the installed costs of the electricity meters are also reduced as the labour costs for the installation can be absorbed by the other related electrical works during construction. Despite this, the estimated cost here greatly exceeds Beacon's target of $500 per house for the monitoring set up.

The total ongoing cost is the same for each house. The three principal costs are: the download staff, the data analysis and the reporting. The extent of the data analysis and reporting does depend on the final scope of the monitoring programme. Note that the ongoing costs of recording the solid fuel, gas and water consumption are included in the costs for the download staff and data analysis.

3.3 Programme and Procedure Efficacy Data

There are a number of measures that can be used to assess the efficacy of the programme and its supporting processes and procedures, including:

- proportions of dwellings showing design fidelity
- user and stakeholder satisfaction with process and procedure manual, guidelines, plans and protocols
- usage levels of tools, plans, guidelines, plans and protocols, and
- compliance with inputs, processes and plans.

There are numerous opportunities for this data to be collected including:

- liaison meetings between Beacon and providers
- house audit, and
- workshops and meetings in which processes and procedures are disseminated and participants briefed.

The precise programme and instrumentation used must ensure that data collection does not impose unnecessary compliance and transaction costs on industry partners. For that reason, the instrumentation and collection methods will not be developed prior to agreements with particular providers. Nevertheless, it should be noted that the data collected from any participants involved in designing, building and approving NOW100 dwellings. It will not be restricted to the sub-set of monitored homes noted above.

3.4 Market Response Data

This data set is concerned with the actual and potential traction of NOW100 on the market. Take-up of Home*Smart* Homes is likely to be determined by shifts in the perception and practices of three groups:

- consumers
- the construction industry
- ancillary stakeholders
  - suppliers
  - real estate
  - regulatory agents.

Indicators of likely take-up among consumers are i.e. post-occupancy satisfaction, and perceptions of value-for-money, affordability and minimization of price barriers. Potential traction in the construction industry may be evidenced by: industry association and training awareness; satisfaction that skill and capability requirements can be met; satisfaction with margins and ability to charge a premium or increase market demand for product; and confidence in the acceptability of designs in the regulatory environment. Traction with ancillary

stakeholders is likely to be expressed in an awareness and positive perception of Home*Smart* Homes among suppliers, regulators and the real estate industry.

Due to the constraints in budget and scope of the NOW100 project, the data collection for this data set will be very limited and gathered as part of the data collection processes for the previously described data sets. The group that will, consequently, not be engaged in the research process is the real estate industry. Reviewers noted that not enough detail on methods is included here.

3.5 The Research and Evaluation Frame

The research and evaluation frame essentially focuses on where and what sort of industry partners be engaged in the programme and where should households be located to provide a robust set of data. In developing a process to recruit partners and monitor dwellings, both consideration of science issues and practical issues of project implementation must be taken into account. With regard to the latter, it must be recognised that the construction of 100 Home*Smart* Homes is a demanding target. This section presents an overview of the considerations that shaped the selection of areas for Home*Smart* Homes (Section 4.4.1) and concludes with an outline of the area frame (Section 4.4.2)

3.5.1 Considerations Shaping the Research Frame

It is important that the engagement of the construction industry ensures that those Home*Smart* Homes that are built allow for the promotion of the Home*Smart* Home in the market, testing designs for Home*Smart* Home performance, construction and market transformation under different conditions climatic, housing market, industry condition. The project needs to achieve the target of 100 homes while also:

- minimising the transaction costs of the research and monitoring
- ensuring optimising likelihood of provider involvement and dwelling completion
- ensuring that Home*Smart* Homes are tested in a range of industry, housing market, and climatic environments.

Minimising Transaction Costs

Reducing transaction costs for Beacon involves: (a) minimising the number of developers and builders, and (b) minimising travel time and travel expenses for monitoring and site visit purposes. It is important that critical Beacon personnel (the project leader, technical advisors and those involved with monitoring) can easily access building sites, builders, developers and relevant council offices. The methodology ensures that this will be facilitated by ensuring that areas and sites selected are easily accessible by air and car and the need for overnight accommodation is avoided. It is also recognises that it is desirable that synergies can be made with Beacon's Home*Smart* Renovations (Renovate1000) project.

Those considerations suggested that the areas in which dwellings are selected should be reduced to a minimum and the number of houses be maximised. This led to a recommendation that:

- the minimum number of dwellings in an area be no less than ten dwelling units
- no more than six areas are selected
- where a number of areas fulfil the necessary science criteria set out below, priority be given to areas that:
  - provide project management synergies with Home*Smart* Renovations (Renovate1000)
  - are best connected to Beacon team members.

Maximising NOW100 Pilot Success

In order to maximise the transformational effects of the project and meet its deadline it was recognised that the project must engage with developers and builders quite quickly. It was recognised that in order to ensure that a harvest of 100 homes is achieved, it is important that Beacon engages interest among builders/developers beyond the 100 home supply target – up to three times the final target.

In terms of area selection, an area was selected only if there are at least two potential providers of Home*Smart* Homes in the area, and that those providers should preferably focus on different market segments and/or house typologies. This was because, if we only initially engaged with a single builder/developer in an area, or selected only areas in which a preferred builder/developer with nationwide presence operate there were a number of risks of concern to the project. Specifically:

- It would expose Beacon to high risk if for any reason a selected and sole provider cannot deliver. Clearly, if Beacon has a variety of providers across its different areas of Home*Smart* Home development, the impact on Beacon's targets and outcomes of a single provider not delivering are reduced.
- Relying on a very limited number of providers, particularly if a provider has a virtual monopoly over the Home*Smart* Home product in an area, may restrict and limit take-up of the Home*Smart* Home product by other developers and builders.
- Using only a single provider in an area or selecting an area in which only a single provider is interested is interested in engaging with the Home*Smart* Home process may undermine the research robustness of NOW100. It is desirable that the Home*Smart* Home is tested in each area across a number of parameters including house typology and market segment. As, typically, builders and developers tend to be narrowly focussed both in relation to their building typology and their market segment, to select an area that has only one provider means that we will be unlikely to be able to test the Home*Smart* Home processes across different market segments and house typologies.

Targeting

The targeting of Home*Smart* Homes reflects two considerations: the technical performance of the homes; and, the likelihood of achieving market traction and a substantial improvement in the sustainability of new dwellings in New Zealand. There is some argument from a scientific point of view that testing the uptake of Home*Smart* Homes would be more robust if it was undertaken in areas that respectively represent low, medium, and high levels of activity in relation to new home building. However, given that our concern is to influence the new home market, and there are limited resources for and number of Home*Smart* Homes that are to be built, it was considered more desirable that we target a representation of higher building activity areas. Influencing builders and new home buyers in those areas to take-up Home*Smart* Homes will have a greater impact on the overall quality of the housing stock than achieving high levels of Home*Smart* Home take-up among builders in areas in which there is a low quantum of new stock.

Two indicators of residential building activity were examined to identify the local authorities with medium and high absolute and proportional levels of building activity. Those were the:

- proportional increase dwellings by local between the 2001 and 2006 census, and
- the absolute number of authorisations for new dwelling units.

Eighteen local authorities had increases in dwellings round 10 percent or more between 2001 and 2006. Those are:

- Waitakere City
- Manukau City
- Hamilton City
- Tauranga City
- Wellington City
- Rodney District
- Papakura District
- Franklin District
- Waikato District
- Waipa District
- Western Bay of Plenty
- Kapiti Coast
- Tasman District
- Marlborough District
- Waimakariri District
- Selwyn District
- Central Otago
- Queenstown Lakes District

In relation to absolute level of potential residential building activity, the year end 30 September 2007 shows that:

- Five local authorities authorized residential dwelling portraits in excess of 1,000 houses. They are:
  - Christchurch
  - Auckland
  - Manukau
  - Hamilton
  - North Shore
- Twelve local authorities authorized in excess of in excess of 500 dwelling but less than 1000. They are:

- Tauranga
- Selwyn
- Rodney
- Whangarei
- Franklin
- Wellington
- Waitakere
- Queenstown Lakes
- Waimakariri
- Waikato
- Marlborough
- New Plymouth

It was therefore decided that local authority areas eligible for inclusion in the sample of frame consisted in the, first instance, of all local authorities that have more than 500 new residential dwellings authorised in the September end 2007 year. Priority was then be given to selecting out of each medium activity and high activity category those districts that show medium or high proportional increases of dwellings in the intercensal period 2001 to 2006.

Range of Represented Characteristics

Four parameters have been taken into account in area selection to allow for robust scientific research. They are:

- bio-physical environment
- building typologies
- market segments
- council jurisdictions

i. Bio-physical Environment

There are a number of issues related to the biophysical environment which impact on sustainability. The Beacon Neighbourhood Sustainability Framework identifies poorly connected sites, green-field sites, and sites on fragile ecosystems as not sustainable and suggests that homes built in those settings do have compromised sustainability. At the district or area scale these have little selection impact. The critical issue is climate. Unfortunately, New Zealand's three climate zones, as set out, in the current Building Code, are relatively crude and provide little basis for robust comparative analysis.

To date we have one NOW Home® in Auckland and one in Rotorua on the Central Plateau. This means that two of the three climate/environmental zones used with the New Zealand Building Code are represented among the existing NOW Homes®. However, while we have a NOW Home® in Zone 1 and in Zone 2 respectively, there are no NOW Homes® in Zone 3 which consists of the South Island and the Central Plateau. The South Island is more likely to produce very high diurnal and seasonal variation with seasonally persistent cold or hot weather.

The most obvious example of a substantially populated area experiencing significant seasonal weather challenges is the burgeoning district of Queenstown Lakes. However, Canterbury, Marlborough and Nelson (to a lesser extent) also present more challenging climatic conditions than Rotorua or Auckland.

ii Building Typologies

While representing building typologies is primarily an issue for selection of projects once areas are established, it is clear that building typologies are influenced by position within the urban, provincial and rural setting. In some districts houses may be built in urban provincial or rural settings. In other districts, the settings are likely to be entirely urban, while in other districts again, the housing is either in a primarily provincial town or rural setting. Urban provincial focuses are more likely to have multi-unit typologies than rural areas. It has been decided, therefore, that there is, value to ensuring the areas selected provide either a potential to have mixed settings and housing typologies or will contribute to a sample of dwellings in which different typologies might be represented across the whole sample of 100 homes.

iii. Market Segments

There is a risk that the Home*Smart* Home will be seen as an upper end of the market product. There is a long standing perception that the industry and housing consumers must make a choice between affordable housing and green housing. The building of the NOW Homes® to date suggests that Home*Smart* Homes can be built within the affordable housing market. In this context we use the term affordable to mean the entry level housing market rather than social housing market. To test whether, in fact, Home*Smart* Homes can be built to meet the need of the affordable housing markets in various areas, it is important that some housing is built specifically to meet that market segment. This suggests that a mix of housing developers need to be engaged. Those housing developers can range over the private community of public sectors, but must also be selected to ensure that the affordable housing market segment is met. Like housing typology, ensuring a mix of Home*Smart* Homes across market segments is largely part of the selection process undertaken within in area. However, it is important that area choices ensure that a range of market segments can be targeted by the Home*Smart* Home product. Preference has been given to areas and sites in which builders or developers are serving a wide diversity of market segments already through their new home building.

iv. Council Jurisdiction

Two aspects of council jurisdiction are of interest here. Firstly, the operational effectiveness of councils is important. While from an analytic perspective having an opportunity to compare the processes needed to establish Home*Smart* Homes under differing regimes around policy and consenting, it is important that council processes do not inhibit the establishment of the 100 Home*Smart* Homes targeted by the project.

Some local authorities have significantly longer average times for consenting than others. Some local authorities are more sympathetic and committed to assisting developers attempting to improve the environmental performance of the built environment and its sustainability. The

preference in selecting areas will be given to those councils who fulfil the primary selection criteria for the area and can provide assurance that they can cooperate with the Home*Smart* Home process.

3.5.2 Area Frame for NOW100

In summary, a number of parameters and criteria were considered for selection of localities as a possible NOW100 area. Those are:

- climate zone
- council jurisdiction
- council consenting
- new house activity
- minimising transaction costs, and
- optimising the successful building of NOW Homes® for monitoring purposes.

Table 7 sets out potential areas for NOW100, using as the base criteria districts with residential building authorisations in the medium, or high category, and providing information regarding some characteristics of those districts in relation to climate zone and council jurisdiction.

The methodology provided that no more than six areas are selected, two areas in each climate zone. It also recommended that priority be given to areas that have high levels of activity and market segment opportunities, but that at least two councils are district and one council is a unitary authority. From the review of information summarised in Table 7 over the following districts were given priority focus as likely Home*Smart* Home districts:

- Zone 1: Manukau or Auckland, Waitakere
- Zone 2: Wellington, Hamilton or Tauranga
- Zone 3: Christchurch, Marlborough

Table 7 Housing Activity and Locality

Councils	Climate Zone	Housing Activity (Absolute)	Housing Activity (proportional)	Industry size	Connectivity	Market segment opportunities	HomeSmart Renovation synergy	Council
Franklin District	1	Medium	Medium	Low	Low	Low	Probable	Unknown
Selwyn District	2	Medium	High	Low	Low	Low	Less likely	Unknown
Rodney District	1	Medium	High	Medium	Low	Low	Less likely	Unknown
New Plymouth District	2	Medium	Low	Medium	Low	Low	Probable	Unknown
Queenstown Lakes District	3	Medium	High	Medium	Low	Medium	Less likely	Unknown
Waikato District	2	Medium	Medium	Medium	Medium	Low	Probable	Unknown
Waimakariri District	3	Medium	Medium	Medium	Medium	Low	Less likely	Unknown
Whangerei District	1	Medium	Medium	Medium	Low	Medium	Probable	Unknown
Auckland City	1	High	Medium	High	High	Medium	Probable	Unknown
Christchurch City	3	High	Low	High	High	High	Probable	Unknown
Hamilton City	2	High	Medium	Medium	Medium	High	Less likely?	Unknown
Manukau City	1	High	Medium	Medium	Medium	Medium	Less likely?	Unknown
North Shore City	1	High	Medium	High	Medium	Low	Less likely	Unknown
Tauranga City	2	Medium	High	Medium	Low	Medium	Less likely	Unknown
Waitakere City	1	Medium	Medium	Medium	High	Medium	Probable	Unknown
Wellington City	2	Medium	Medium	Medium	High	Medium	Probable	Unknown

Marlborough Unity Authority	3	Medium	Medium	Low	Medium	Medium	Probable	Unknown

4 Project Implementation: Making Partnerships

The Research Frame identified that project partners should be sought in four localities across New Zealand and the 3 Building Code Climate Zones.

Approaches were made to potential partners in Auckland (McConnell Property, G J Gardner Auckland, New Zealand Housing Foundation) and Christchurch (Stonewood Homes) based on past experience and contacts in these areas. It quickly became clear that these organisations were keen to work with Beacon, and willing to consider the undertaking of building Home*Smart* Homes in a mass market model.

Over time however, as the housing market has slumped, the enthusiasm from straight commercial project partners has reduced. In the case of McConnell Property, the development where Home*Smart* Homes were proposed to be built has been put on hold until at least 2009, and potentially later.

Getting partners from two other centres has proved more difficult, with sustainable building not being seen as a "competitive edge" in some other markets in New Zealand. A number of development companies in Wellington have been approached, however to date no development partner has agreed to participate in the project, with a number of factors having an effect, including:

- Housing slump, coinciding with the Project phase
- Small market in Wellington – very few developers/builders construct 100 homes or more per year
- Type of housing – majority of Wellington new housing is attached housing (eg terraces) or apartment units – the Home*Smart* Homes model is based on stand alone detached housing.

Tauranga-based Generation Developments have indicated a strong interest in the NOW100 project; however, they are focused on consolidating their move to Lifetime Design before undertaking a new initiative.

It is anticipated that franchise builders, GJ Gardner and Stonewood, will also provide additional scope for wider geographic coverage.

4.1 Partner Agreements and Intellectual Property

As part of the process of developing partnerships for the NOW100 Project, Partner Agreements and, in particular, agreements around how intellectual property is managed have been developed. As part of the process of developing partnerships for the NOW100 Project, attention is being directed to establishing clear agreements with our partners. These are being written as a “license to trial” and will cover key areas of intellectual property, communications, builder obligations and to minimise project risk and liability.

5 Results

5.1 Proposal for a Home*Smart* Homes development process

In order to fully understand the role that the Home*Smart* Home Procedures will play in development of the Home*Smart* Homes, it is necessary to envisage what process the NOW100 Project will follow and what could be the future of the Home*Smart* Homes beyond that. The process proposed below is in now way final, this is a suggestion to commence a discussion and start forming options. The future process for development of a Home*Smart* Home is envisaged to be following:

- **Engagement - Group builders**, **developers** or others wishing to build a Home*Smart* Homes (builders) approach Beacon (or in the future a support organisation established to manage the Home*Smart* Home process) and purchase the Procedures (includes the documents, training, self assessment checklists). Engagement and sales of Home*Smart* Homes are supported by promotion (advertising, public relations, sales material).
- **Design and Construction** - During the design and construction process the builders use the provided information and training materials to design and construct the home. They fill out self assessment checklists and submit that documentation and a copy of the house design to Beacon. The standard lay-outs and designs are developed by each partner individually and provided to Beacon. A random sample of these may be audited by Beacon against the Procedures.
- **Design and Construction Home*Smart* Home** - Once the design and construction self assessment checklists are reviewed by Beacon, they will issue a Home*Smart* Home Design and Construction Certificate (after code of compliance certificate is received).
- **Occupation** The occupier receives a *Homeowner Manual* (completed jointly by the builder and Beacon) with advice on how to get the best performance out of their home. They are also able to participate in an online community of homeowners with Home*Smart* Homes and Home*Smart* Renovations. Their home performance can be self-assessed at any time using the HomeSmarts tool.

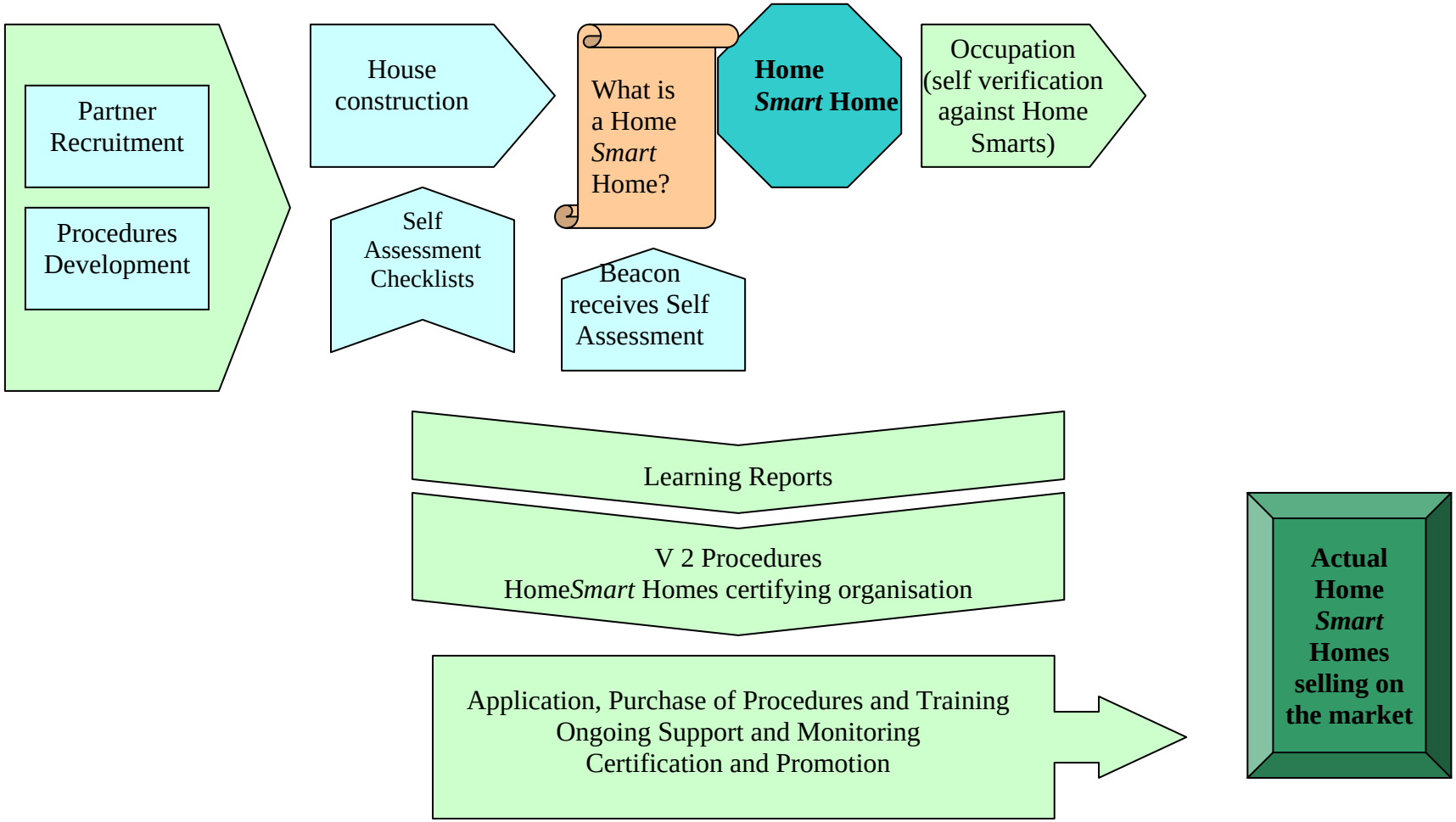
The pilot partners will be involved in development of the procedures and therefore there is no participation fee. It is envisaged that a licence fee will be required in the future to fund the support organisation. During the pilot stage the above process and the procedures will be tested with participants and other industry/council representatives, learning documented and reflected in a new Version 2 (it is envisaged that these procedures will need to be up-dated periodically. It is envisaged that new locations and house typologies will be added, for example medium density/attached housing).

The learning from the project will also be used to decide whether a separate support organisation is required. It is envisaged that the role of this organisation would be to:

- Manage applications, sell procedures and training. Award certification.
- Promotion and protection of the Home*Smart* Homes brand

Appropriate language requirements and branding will need to be developed.

A proposal for a Home*Smart *Home Development Process



6 Discussion

6.1 Research Evaluation and Performance Monitoring

While it was identified in the RIB that a $500 capital cost for the low cost monitoring equipment was required, it quickly became clear that if Beacon wanted to capture some key information about the homes, a higher capital cost would be required. Ultimately the proposed low cost monitoring has a capital cost of $1070 installed into the home, and this has meant that the full 100 pilot homes are not able to be monitored. This has had a significant impact on the overall approach to the case selection and research evaluation.

6.2 Next Steps

The next steps are for the piloting of the Version 1 Procedures through the NOW100 Project.

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