The NOW House Project

Kane, CD; van Wyk, JL; and Pollard, AR

Part 3: Monitoring the NOW House

A confidential report prepared for Beacon Pathway Ltd

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Beacon Workstream: NOW Home Knowledge and Future Monitoring Recommendations

Project: NOW 1

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EXECUTIVE SUMMARY

The NOW house is currently the most tangible evidence of Beacon Pathway's activities to date, and will continue to be so for some time. Accordingly, it will in some shape or form be a central part of Beacon's early change strategy, in the form of either a research or demonstration home.

The need to demonstrate the as-built and ongoing performance of the NOW house will be shaped by the role that it plays in Beacon's strategies, however it is important that consideration be given to this before the house is constructed, as advanced consideration of the need for cable runs, space for loggers, and any additional telecommunications infrastructure will make the final logging installation much simpler and less invasive for the occupants.

This report summarises the options available for monitoring of the NOW house, by considering the requirements in two distinct categories: construction monitoring, and operational monitoring. Originally, the aim of this report was to present a comprehensive and detailed stepwise set of instructions for monitoring the NOW house: however, during the compilation of this report additional information has surfaced from Beacon work streams CON 1 and NOW 7, the preliminary findings of which have overtaken this original intent.

In particular, the need for Beacon to employ significant flexibility in order to achieve its goals, as outlined in CON 1, means that the original expectations of the NOW project stakeholders (as uncovered in NOW 7) may actually delay or impede the attainment of those goals if strictly adhered to. Accordingly, the monitoring options are presented in the form of a list of items/variables which may be monitored to measure sustainability (as per the NOW design process), and supporting methodologies to enable this to happen. A reference list of the technologies available and their approximate costs has been provided to enable Beacon to derive rough numbers when considering its approach to monitoring the house.

Emphasis must be placed on the importance of the overall strategy that Beacon wishes to employ to derive maximum value from monitoring the NOW house – if it is to be a research house, then significant effort should be expended to ensure that as many as possible of the interdependent variables are monitored – for example when considering occupant comfort, it would be prudent to monitor indoor and outdoor temperatures and humidities, surface temperatures, energy use, ventilation, and lighting. If, on the other hand, the house is to be used for demonstration purposes only, then a simple measure of indoor air temperature and total energy consumption would probably suffice.

Once Beacon has decided on the type of information it will need from the NOW house, the design of a monitoring plan will proceed quickly by using this report as a resource to guide decisions, and will enable the construction of the house itself to proceed with adequate consideration given to the data collection activities.

INTRODUCTION

General

As the NOW house was originally a research project, there has been an explicit assumption since the project commenced that any physical structure (remembering that the original project related to wooden house *components*) would be performance tested to ensure it represented a step forward. This assumption has been carried through the NOW process; throughout the meeting minutes and design process reference is constantly made to the actual delivered performance of the building once constructed. Predominantly this has been in the context of ensuring that the design simulations and assumptions have been reality checked before being held up as an example of good practice.

However, it must be put to Beacon as new owners of the NOW project that the need to monitor performance should be assessed against the original goals of the project – as set out in key stakeholder's expectations. Useful information to make this decision is contained in Beacon Pathway Project Report NOW7, which assesses the potential uses of the built home against such expectations. Primarily, it must be considered that the NOW house process was driven more by researchers than marketers, and any assumptions that monitoring is necessary must be reviewed in light of this "bias", and the project expectations given in the NOW7 report.

This report considers the task of monitoring the performance of the NOW house, both during construction and also during use – the specific methodologies for which are given below under Construction Monitoring and Operational Monitoring respectively.

In order to ensure that the operation and construction targets of the NOW house are captured, they are included this report as Appendix B. This document, prepared at the conclusion of the NOW design process, captures the targets which the house should be expected to meet, and the justification for those targets. In addition, reference is given to "best practice" monitoring methodologies where they are available. In this document, six categories have been linked back to NOW values: Affordability, Desirability, Performance, Overall Eco-Performance, Personal and Community Health, and Resource Use. Implied in this is that it may not be possible to monitor some of the "sustainability" features of the house that we might wish to – and this is indeed the case. An obvious one is "neighbourhood", as a catch-all – monitoring the improvement in Neighbourhood spirit etc. as a result of one house (which isn't actually in any neighbourhood *per se*) is a difficult, possibly impossible exercise, and would return minimal value.

The final decision on what should be monitored must be taken by Beacon Pathway Ltd, and must be mindful of the recommendations of NOW7 and CON1 work streams – specifically regarding the place that the NOW house occupies in the behaviour change strategies that Beacon Pathway wishes to employ to reach its targets. For example, if the NOW house is to be a research tool, then heavy and detailed monitoring will be required to discern patterns of behaviour and their subsequent effect on resource usage, waste generation, and the like. However, if the house is to be used primarily for demonstration purposes, then basic energy and water consumption data may be all that's needed. Some of the thinking necessary is pre-empted below.

Motivation for Monitoring

Monitoring of the Now House may four fulfil one or more of four general objectives. Each of the objectives requires different levels of details and different monitoring technologies:
Marketing and promotion: Firstly the data can be used to understand the impact of the occupants and to demonstrate "hard numbers" to the public. This objective has a strong marketing aspect and the quality requirements on the collected information is not particularly stringent, i.e. if there is for example a week of data missing due to data logger failure, it is not critical for the objective.
Design target verification: The house was designed with a series of quantified resource usage and performance targets (refer to pg 8 of the design brief, and to Appendix B) based on international research studies. It is necessary to confirm in how far these targets have been achieved. As discussed in the next paragraph, it is however difficult to separate technology performance from occupant driven resource consumption.
Scientific performance evaluation: This objective will only be achievable if an occupancy rotation system, as described in the next section, can be set up for the Now House. This objective aims at conducting scientific research of the effects of occupant behaviour on resource consumption and of occupant satisfaction. Because the house and its technology are constant, any changes in resource consumption will be due to occupancy factors (after climate and weather has been corrected for). In addition to the measurable resource use the occupant satisfaction feedback can also be collected using survey techniques. Quantifying the occupant effects and feedback would be a significant and extremely valuable research output, which would be of great interest to policy makers.
Performance feedback to occupants: Studies have shown that occupants that have direct feedback of their resource consumption use resources more efficiently. The data logging allows direct real time feedback either through a dedicated LC Display or flat screen monitor, or via a connection to the home PC with data updated in regular intervals.

Occupancy rotation

International research shows that energy consumption in houses depends to about 50% on the physical environment and implemented technologies, and 50% on occupant behaviour. The Now House Concept offers the opportunity for a very well defined research study on occupant effects on energy consumption. In order to do this the following occupancy scheme is suggested:

- The occupancy is rotated on a fixed schedule at approximately 6-month intervals with changeovers at mid-winter and mid-summer. Occupants will occupy the house rent-free for this period. In return they commit themselves to assist in data collection as described below and to open the home once a month *(interval to be decided)* to the public. During these open days they function as visitor guides explaining the house technologies and sharing their experiences of living in the Now House.
- New occupants are selected every six months through a public application process. Selection criteria still have to be developed, but may usefully include suitability for PR and visitor guidance skills.

This concept would offer several important advantages:

- The house could be open to the public, while also being occupied.
- Visitors will get an opportunity to hear about "real life" living experiences with the house.
- The information provided by the occupants will be less biased than information from people who built a sustainable solar house themselves, because the Now House occupants have not made the investment decisions and do not have to post-rationalise them.
- Because a variety of different people will live in the house the success of technologies will be evaluated by a cross section of people, rather than only one "committed" occupant. The technology performance evaluation is therefore more representative.

- The monitored data (energy, water consumption…) can be compared between the different occupants. The situation would be ideal from an experimentation view, since the house and technologies are kept the same and any variations will be due to the occupants.
- The biannual search for new occupants would offer great marketing opportunities (newspaper ads, etc.)

There are of course also disadvantages of such a system. These would mainly be of a logistical nature, for the occupants of the house.

Recommendations

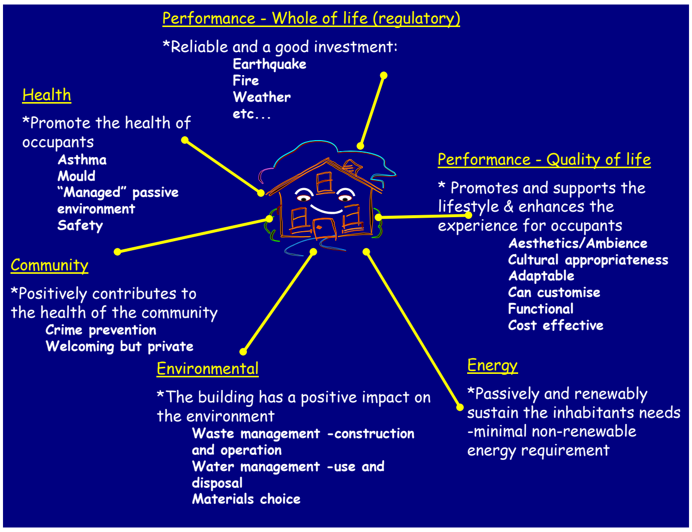
The monitoring recommendations given below consider the widest range of issues possible, in order to surface them for Beacon's consideration. Because of the dependence of the monitoring design upon the final change strategy developed by Beacon, no firm final recommendations can be given – however sufficient detail is included to make the development of the final monitoring brief a relatively simple exercise.

RECOMMENDED MONITORING FOR THE OLYMPIC PLACE NOW HOME

For various reasons, debated peremptorily above, Beacon Pathway may wish to monitor the NOW home to support its sustainability change initiatives. As a fundamental principle of Beacon Pathway is sustainability in the residential built environment, consideration of the performance of the home must include not just its function and consequent resource usage, but also the amount of time and material used in its construction.

Accordingly, there are two main monitoring activities for the NOW home – construction monitoring, which aims to determine what happens, and is used, on site as the house is being built; and operational monitoring, which measures the performance of the house in service. Obviously the construction monitoring should be undertaken during construction, however as it is also important that the operational monitoring equipment be fitted during construction, the responsibility for co-ordinating the monitoring set-up be undertaken as part of the building project and be overseen by the site project manager. Actual installation of the operational monitoring equipment should be undertaken by appropriately skilled technicians who will also be collecting the data as the house is used.

Monitoring for sustainability is a difficult exercise – the use of the hedgehog diagram (Fig 1) developed during the conception of the project allows some assessment of what should be monitored, if possible.



Performance – Whole of life (Regs)
Performance – Quality of life
Energy use
Environmental Impact
Community Wellbeing
Health

The design brief elaborated on this diagram, eventually leading to a 'sustainability filter' of 9 elements:
Personal Wellbeing; Community wellbeing; Environmental wellbeing; Performance; Desirability; Affordability; Energy resource management; Water resource management; Solid waste resource management

Figure 1:The NOW home 'hedgehog' diagram, and categories to be considered for monitoring

Because it has been recognised as difficult to monitor for sustainability, the monitoring benchmark document (Appendix B of this report) suggests that this be usefully reduced to six categories for which national or international benchmarks can be located; Affordability, Desirability, Performance, Overall Eco-Performance, Personal and Community Health, and Resource Use.

Construction Monitoring

It is recommended to station one person on site full-time with responsibilities for monitoring the construction process. This would most usefully, and economically, be the construction project manager. Measuring site waste, and analysis of the site construction sheets could be undertaken by an additional researcher.

The construction monitoring must include:

Materials usage

- transport (delivery distances from supply depot to building site),
- materials used – by meter, litre, kilogram, or coverage as appropriate
- waste generated.

Materials such as copper pipe, PVC, wire, etc. expected to be used may be available from the construction drawings as a first port of call, with actual usage recorded on site and checked against invoice data. Waste generated, ready for landfill or reuse disposal off-site, should be collected in bins, and tallied as absolute quantities wasted, and also waste as a percentage of the amount used. It is important that these bins have lids with locking devices, such that nothing is added to, or extracted from, these bins in the interim periods when construction is not occurring. A separate bin will be used to store 'offcuts' and 'reuseable' items, for on-site re use in the building project.

At the end of the construction process, a document should be produced detailing the weight, volume or linear dimensions of all materials used in the construction process and delivery distances as obtained from the delivery drivers.

Labour Monitoring

It is possible to measure labour productivity. It is recommended to use random activity sampling to determine what the site labour and contractors do during the day. This is a full time job with different trades coming and going all day – and may, in conjunction with the above, warrant the appointment of a full-time project manager.

The same classifications should be those as used in the report "Alternative Framing Materials in Residential Construction: Three Case Studies" by the U.S. Department of Housing and Urban Development[1]. The U.S. study did not include installation of services or finishing of the house.

Ecomatters Trust are happy to photographically log the construction daily, so that a "motion stop" compendium of progress can be produced at the end.

Cost

All of the cost in carrying out the construction monitoring is associated with time spent by either the project manager or dedicated students on site. An estimate will be required of the cost of the project manager before an approximate dollar value can be assigned to this.

[1] U.S. Department of Housing and Urban Development. 1994, Investigation into Alternative Framing Materials in Residential Construction: Three Case Studies, NAHB Research Centre, Upper Marlboro, MD, USA.

Operational Monitoring

In order to assess the operational performance of the Olympic Place NOW Home against the sustainability objectives of the project (as represented by the Hedgehog diagram) a number of measurements are required to be made. These measurements can be divided into those gathered by short-term inspection (normally upon conclusion of construction) and those gathered continuously from permanently installed equipment.

Appendix A provides detail on the techniques which are available, for further consideration once the final monitoring rationale is decided in support of Beacon's change strategies.

Measurements by Inspection

Blower Door Pressurization Test: The airtightness of the NOW home at a fixed pressurization (Ach/hr@50Pa), will be determined by the use of a blower door test once the house is outfitted. This information will be used in conjunction with other data to determine compliance of the complete house with NZBC E3.

Energy Audit Examine shadings, sun paths, window area etc for input into a chosen thermal/energy modelling programme such as ALF, WHEC, etc. Measure shower and tap flows, record power consumption levels of appliances.

Environmental Performance Assessment: A Green Home Scheme (or similar, as most appropriate) audit should be undertaken on house.

IAQ: Once the house is complete samples of air may be taken for tracer gas analysis of volatile organic compounds (formaldehyde, acetone, and other construction solvents)

Vertical Temperature Distribution (for Thermal Comfort): A vertical array of four temperature sensors should be installed for three weeks to assess the consistency of the temperatures within the living rooms of the NOW house. Discomfort is often associated with large vertical temperature variations, resulting from lack of air mixing.

Noise: On-site measurements to be taken once house is furnished and landscaping completed, but before occupancy. Measurements should be taken during morning or evening rush hour on a week day.

Water Quality: The tank water is to be sampled, and considered against Waitakere City guidelines for potability.

Occupants: By Post Occupancy survey. Questions could include attitudes, perceptions, background socio-demographics, consumption (of energy and water) behaviour. (A draft POE survey was created during the NOW house project, and is included in the 'Documents' section of this workstream in Itools.)

Measurements by On-Going Monitoring

Resource Use

Electricity: The total electricity use of the NOW house will be recorded every 10 minutes. The electricity can be recorded via a pulsed output electronic electricity meter (such as used for tariff collection by energy companies) installed on the meter board. Major electrical circuits (domestic hot water, solar water heater pump, lighting, cooking range, refrigerator (on a dedicated circuit)) within the house will be individually monitored again via additional electrical meters on the meter board. Due to the high levels of insulation used, it is not anticipated that electrical supplemental heating would be used however to ensure that occasional spot heating is recorded, one or two remote boxes (containing an electronic electricity meter and either a transmitter or datalogger) would be located within the NOW house.

Issues: cost: $100 per channel for electricity meter. Requires counter input card ($1000, provides 8 channels) on PC. Construction of remote boxes (with either data transmitter (preferred) or a logger $1000-$1500). This requires space on/near the meter board for addition meters as well as cabling back to PC. Electrician has to separately wire the outlet for the fridge/freezer.

Water Use: Total water use for the NOW house would be recorded (probably at a 10 minute resolution) by a number of standard pulsed output water meters (as used by Councils). These meters would also be cabled back the counter inputs on the computer. The individual sources of water would be separately recorded with meters on the water from the street, water from the rain tank, and water feeding into the hot water system. The level (capacity) of the water in the rain tank would be measured with a level sensor feeding into an analogue channel on the Agilent data recorder.

Issues: cost: $150 per meter (some meters (BRANZ) may be available), $500-$1000 (est.) for level sensor. Standard water meters require cold water, mains pressure.

Gas and Solid Fuel: No reticulated natural gas will be used in the NOW house, and neither would any portable LPG gas (either small 9.5 kg cylinders or larger 45 kg fixed cylinders) nor any solid fuel burners (wood burners).

Solar: Measure inlet and outlet temperatures of water into hot water cylinder feeding the solar water heater using thermocouples wired back to an Agilent data recorder connected to the PC. Measurement of the Global Horizontal solar radiation will be undertaken with an on-site pyranometer feed into the Agilent. Characteristics of the collector (panel size, orientation, etc.) would be noted.

Issues: having solar water heater as a pumped system allows the flow of water through the solar collector to be easily monitored.

Performance Monitoring

Moisture Content of Framing: The moisture content in the framing material can by determined by conductivity measurement. This would require an analogue input and the ability to switch power to the conductivity sensor. The 'Labjack' interface unit allows this switching to be undertaken and is inexpensive (~$300). The temperature of the internal and external linings of the cavity could also be easily recorded with the use of thermocouples.

Cavity Temperatures: In addition to the moisture content of the framing thermocouple measurement of the framing temperature as well as the internal and external linings could be recorded by the Agilent data recorder.

Envelope - Heat Flow Sensors: To determine that the insulation is working effectively, measurement of the heat flow through a well insulated wall section (clear wall) as well as the heat flow through a lower insulated section (thermal bridge) could be made.

CO_2 Measurement: With no combustion occurring within the house the measurement of CO2 in conjunction with measuring the occupancy would prove useful to estimate the passive ventilation of the NOW house.

External Conditions (Weather Station): In addition to the solar radiation, outside temperature and humidity could be recorded. Additionally rainfall and mean wind-speed and direction could be related to measured indoor conditions.

Issues: A meteorological station is reasonably close and hourly data would be available for this station. It is probably cost effective to limit the external measurements to the most critical variables (solar, temperature, humidity)

Zone Temperature/Humidity's: The temperature and humidity at a number of locations throughout the NOW house should be recorded to provide information on the comfort and consistency of the NOW house.

Issues: These sensors need to be located within the interior of the house making wiring the sensors back to a data collection impractical. Either radio transmitter remote sensors (preferable) or standalone loggers could be used.

Occupancy Sensors: There are a variety of occupancy sensors with most operating as switching sensors for lighting. A variety of technologies exist with all having a variety of benefits and limitations and it could be that a number of sensor types are used. It may also be possible to make use of the sensors used for the security system.

Occupant's Temperature Humidity Exposure: Measuring the ambient conditions within the NOW house does not fully provide information on what temperatures and humidity's people are exposed to as the occupants may only be in the house for a particular time and may move from room to room (which could be at different temperatures) when they are home. Circuit miniaturisation is such that wearable temperature-humidity sensors are possible. This exposure information, in conjunction with the occupancy sensors, would provide invaluable information on the range of conditions people within the NOW house encounter

Issues: Personal exposure monitoring of temperature and humidity is an emerging technology and a degree of development and trial work would be required. Logger technology is less battery intensive than remote so is better suited to miniaturisation. It would also be necessary to develop procedures for this data collection (are the sensors worn all the time (such as a wristband)? If it is a logger technology how do you retrieve the data and how do you know that the data is exposure in the NOW house?).

Data Management

Data processing (collecting, merging and cleaning) is considerably easier, and consequently less expensive, when centralised systems are used. Data could be collected by a computer on-site at the NOW house connected to various devices such as;

- Agilent Data Recorder (a precise DVM with multiple input cards) allowing the collection of thermocouple inputs as well as general analogue inputs.
- One or two pulse counter cards to provide inputs from electricity and water meters
- Labjack to provide switching of voltage to conductivity sensors and some general analogue inputs as well as a pulse counter input.
- Radio receiver from remote sensors (temperature/humidity sensors and portable electric heaters) – this may be undesirable due to alleged effects of RF on health but is presented as an option for completeness.

As the use of remote sensors would greatly aid with the collection of data from the NOW house it is recommended that trial equipment be purchased as soon as possible to allow for its evaluation. Should traditional data logging be used, it will be necessary to develop separate processing methods to merge and clean the data, regular monthly data collection visits to the NOW house as well as time to undertake the processing steps.

Regardless of whether or not remote sensors are used for the Olympic Place NOW house it would be recommended to have visits to the house every 2-3 months to note the meter readings of the electricity and water meters, the presence of any new appliances, the relocation of sensors (changing furniture positions, etc.) and any changes in households characteristics (new family members, away on holiday, etc.).

Performance Monitoring Equipment Costs

These costs are accurate to within about 10% (as at June 2004), and are compiled from a number of sources (listed in Appendix C). Note that should Beacon wish to proceed with a radically different monitoring regime than the one broadly proposed in this report, some of these costs will not be applicable. This will be most explicit if a much smaller programme is undertaken, as might be associated with a marketing rather than research strategy.

Core Monitoring

Item	Approx. Cost	Details
Computer Server	$3,000	On-site computer (server) for remote components, DAQ card – wired sensors. Programmed with a runtime LabView program. Computer to have cellular modem for uploading data. No data is to be broadcast.
Agilent data recorder	$4,000	High resolution DVM with 20 channel or 40 channel analogue input card. High resolution allows thermocouple input to be recorded. Also requires PC - GPIB interface
Labjack	$300	Switching of conductivity sensors, provides additional standard analogue inputs
Pulse counter card	$1000	Each card ~$1000 provides 8 pulse counter channels (A second card may be required if more electrical or water end-uses are measured)
Remote Receiver	$1000	Remote Data Receiver (for temperature sensors) (estimate)
Temperature / Humidity	$1500	Remote – 2 in living room, 1 in other rooms (otherwise use loggers) (estimate)
Moisture	$600	Two locations – Measure timber moisture content (conductivity) and temperature of the linings (thermocouples) (estimated)
Heat Flow Sensors	$1000	Two heat flow sensors (estimated)
CO_2	$1500	Measured in living room (estimated)
Occupancy Sensors	$300	Sensor in each room. Possibly in connection with an alarm system. (estimated)
Circuits (Electricity)	$600	Total, Lights, Range, Hot Water, frig/freezer (on dedicated circuit) feed through individual electricity meters wired to computer's pulsed counter inputs.
Portable Heaters (Electricity)	$1000	A portable outlet box with a electronic meter combined with either a pulsed transmitter (to be investigated) or a standard pulse logger. (estimated)
Solar Water Heating	$200	Measure temperatures (thermocouples), flow (item after next), irradiance (next item), flow meter, thermocouples
Solar	$1,000	Remote with pyranometer
Water Sources	$1500	Pulsed output water meters – total water, total hot water, total pumped rain water, level (storage volume) of rain water tank
External Conditions	$500	Temperature and Humidity (shielded) wired back to Agilent
TOTAL	$19,000	

Additional Monitoring

Item	Approx. Cost	Details
Temperature Humidity Exposure	$5000	Personal temperature and humidity sensors to be worn by the occupants when they are present within the house (estimated).
Water End-Uses	$2000	Sub metering of water end-uses. May require more specialised water meters if hot water end-uses are examined. (estimated)
Weather Station	$3000	Provide for more localised measurement of wind speed and direction and rain. (estimated)
Waste bin lids + locks	$400	Solid metal braced ply sheets, with bolt and padlocks
	$10,400	

Monitoring plan

BRANZ and FR have considerable experience in monitoring of buildings in service or during construction. The table below gives some hard-won advice, which should be considered when designing the final monitoring plan, and before beginning construction.

Specifications	**Reasoning behind specifications**
General	
Allow space for master units and PC close to meter board, but internally. Suggested position under the DHW cylinder with access through the garage. Raise the hot water cylinder approx 800mm above floor level. This will leave space for a floor level cupboard, that will house all the data logging equipment.	Burglar and weather proof.
Fit a Metering enclosure adjacent to the distribution board located at the end of the garage. This enclosure shall be large enough to accommodate all the Siemens meters required to monitor each logged circuit, including a total use meter. This enclosure may mount on the wall surface above the distribution board in such a way that its removal would need a minimum of remedial work.	Fit meters into enclosure.
Conduits to be run within the wall cavity to the data logger cupboard at the back of the hot water cylinder cupboard. One pair of data wires for each Siemens Meter to be run through these.	Send signals from the metering enclosure to the data loggers.
Distribution / circuit breaker board. This should be large enough to allow separate protection for individual monitored circuits if modified Siemens meters are used (Modified Siemens meters must be protected at 10Amps max). Allowance should be made to enable cable loops to be fed through to the metering enclosure to allow metering of each required circuit. This should be done in such a way that when metering is no longer required loops may be readily removed and circuits reinstated. This will allow the removal of the meters and metering enclosure.	Easy installation of Siemens meters for within each monitored circuit.
Telephone access for PC modem with separate telephone no.	Remote communication and data download. This option is cheaper than cell-phone.
Houses are easier to monitor if they have a ceiling with a roof space above i.e. NOT a skillion roof	Allows un-intrusive sensor cable runs
Fit disappearing attic stairs in the garage ceiling near the data logging cupboard.	Allows easy access to roof space.
Install 50mm diameter conduits into the roof space from ➢ Meter board ➢ Fuse board ➢ Water cylinder cupboard ➢ Solar water heater pipes or panel (depends on panel	Eases sensor cable connections and modifications after the house is complete

location and layout) ➢ PC/logger master unit location ➢ Wherever wiring is inaccessible after house completion (wall cavities, skillion roof, slab floor, etc.) Use smooth turn conduit sections at direction changes, so that cables can be pulled through after construction if need be	
Need power supply in garage for logging PC and data acquisition system.	Avoid extension leads to the logging equipment.
Conduit from the data acquisition PC to one of the living/play area walls for mounting a resource feedback monitor.	Feedback to occupants via wall mounted flat screen monitor
Electricity	
Dedicated wiring circuits for: ➢ One lighting circuit per room ➢ One power circuit per room ➢ Dedicated circuits for fridge/freezer ➢ Dedicated circuit for dryer (if installed) ➢ Dedicated circuit for water pump	Electricity monitoring systems are simpler if most info is collected at one point rather than individual power outlets.
Sufficiently large outside meter-board and inside fuse board to allow placement of loggers	Electricity monitoring systems are simpler if most info is collected at one point rather than individual power outlets.
Hot water power may be fed from distribution board with extra cable loop to external tariff meter and ripple control relay.	Removes need for signal cable runs from the meter board to the logging equipment.
Gas	
If reticulated gas is used one gas meter has to be installed in each end-use line (i.e. cooking, water heating if present, space heating if present) and wired back to meter board. Place gas meter (s) and electricity meter in close proximity. A metering enclosure should be provided external to the house large enough to accommodate tariff meter plus additional meters as required.	
Conduit to be run from gas meter to logger cupboard within wall cavity through ceiling cavity. One pair of data wires for each gas meter will be required through this.	
LPG cooking is the preferred cooking option, but may be difficult to monitor.	Low gas pressure will be even further reduced by flow-through gas meters – no solution currently exists to this.
Temperature	
no special requirements	Room temperature measurements through stand alone loggers
Installation of four thermocouples in wall cavities to measure internal wall surface temperatures and wired back to the master unit. Thermocouple wires to be run prior to wall lining from test site through ceiling cavity to data logging cupboard. Internal surface locations to be monitored: ➢ External bathroom wall	Measure condensation risks

➢ External kitchen wall ➢ External master bedroom wall ➢ External living room wall All walls as far as applicable should be facing South, alternatively West or East.	
Thermocouple wires should not be cut and joined	Risk of signal noise
Heat Flow	
Panels fitted to ceilings ➢ embedded in skillion roof ➢ on top of ceiling where ceiling is suspended	Use of thermopile heat flow meters, and external/internal temperature sensors (under temperature above)
Data cables and thermocouple wires run through ceiling to data logging cupboard.	
Solar Water Heater	
Solar water heater must be pumped (rather than thermosiphon)	In order to measure water flow from solar water heater.
Occupancy Sensors	
Possibly as part of the security system. Security system should be selected with this capability.	
Water	
Use mains pressure system	Low pressure systems might be influenced by in-line flow meters
Install water meters for all taps and toilet ➢ Shower ➢ Kitchen ➢ Laundry	Ensure that flow meters do not impede flow – carry out tests before installation
Water leaks	One off measurement during pre-occupancy
Water quality	Water samples to check the quality of the tank supply Sampling monthly from the outdoor tap and the hot water supply

Monitoring Logistics

Most of the data logging may be conducted automatically through a data acquisition system, which can be remotely downloaded. Data can possibly be displayed on the internet.

Radio frequency and similar technology options have yet to be evaluated – although as a general principle it may be difficult to justify installing additional sources of EMR in a house designed to be as "green" as possible. As a fall-back option the data could also be collected using stand-along data logging technology, for example as currently used in the BRANZ HEEP project. In this case no new technology has to be developed and implemented, however, data are not remotely available and data loggers might have to be distributed throughout the house. Metered data will be logged at half hourly or 10 min time resolution. Data will be off-loaded and processed at weekly intervals.

Only if unconventional non-electric technologies are used (LPG heaters, fire places) it will be necessary to have the occupants involved in the logging process. World-leading techniques to do this have been developed by BRANZ as part of HEEP, and can be applied if necessary. However, it is still expected that the occupants keep records of:

- Monthly energy bill
- House maintenance expenses
- Waste (no. of general waste bags/bins, recycled goods –paper, glass, plastic- and composting raw volume)

Occupant supplied data will be collected at monthly intervals.
Installation and set-up cost will be approximately $15-20,000.
(There is some flexibility in capital cost and installation cost, depending on used fuel types, logging technology choice and extent of data collection.)

Responsibility

It is suggested that BRANZ take overall responsibility of the monitoring for the Olympic Place NOW home. It will be an advantage to have local personnel trained and involved to deal with any day-to-day issues regarding the monitoring technologies – and this may mean the construction site project manager. From experience it will take about two months to get the technology installed and running to satisfaction. Waitakere City Council staff will contribute through specialised monitoring support for water quality measurements.

FR will support the monitoring through its expertise in construction process documentation and post-occupancy evaluations. The comfort of occupants is a very subjective measure, and FR has experience in monitoring this as a function of the Temperature Humidity Exposure of each occupant – the "wristwatch" type of wearable datalogger mentioned above may be useful in this exercise, although the usual caveat against new technology must apply.

Noise and indoor air quality measurements will be contracted to a specialist organisation such as Marshall Day Acoustics.

Occupants have to receive some basic training if logging is to proceed. A small manual will be prepared for them by BRANZ, which introduces them to the logging equipment and details any tasks expected from the as part of the monitoring. This may also include a simple logbook which has to be completed regularly by the occupants.

The ZALEH Survey

As part of BRANZ's Zero and Low Energy House project, Albrecht Stoecklein has developed a complex survey methodology to quantify the Non-Energy Benefits (NEBs) of low energy technologies. Although it is relatively simple to determine the dollar value of energy savings, ascribing such values to other benefits such as comfort and health require sophisticated techniques,-which are a very recent development as part of this FRST-funded project. These survey methodologies are available to the NOW house project, although they must be properly benchmarked against other local houses. Without knowing where the information required would fit within Beacon's change strategy, it is difficult to place a cost on the survey work – however each survey in the ZALEH project has cost approximately $4000 to carry out, record and analyse.

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Appendix A: Now House data collection schedule

Type of data collection	Variable type	Variable to monitor	Unit	Monitoring detail	Analysis	Equipment
One-off and infrequent monitoring						
	EMF	Indoor radiation	Gauss		Health (possibly)	?
	EMF	Outdoor radiation	Gauss		Building performance for EMF shielding and wiring layout and shielding	?
	Sound	Noise level (indoor)	average dB	measure sound level in living and bed room areas during average occupancy hours	Convenience/comfort	SPL meter
	Sound	Noise level (outdoor)	average dB	measure sound level at three locations round the house, before and after construction is completed	Reference for other sites, performance evaluation of building sound shelter	SPL Meter
	Air flow	Infiltration	ac/h	Measure, with blower door equipment, or using tracer gas.	Energy, Health	Blower door, GCMS, or CO_2 sensors.
	Air quality	Various pollutants and CO2	As appropriate	Measurements after building completion, and then at 6 monthly intervals during operational monitoring phase	Health	Sample taken to lab, or on-site GCMS
	Water quality	Various pollutants	As appropriate	monthly measurements from outdoor tap and hot water supply	Health	?
	Water flow	Water leaks	litres	one-off measurement	Water	?

					consumption	
Continuous data logging				all measurements half-hourly unless stated otherwise		
	Energy	Total electricity	kWh		Energy, CO_2	Siemens meter
	Energy	DHW	kWh		Energy, CO_2	Siemens meter probably electricity, maybe gas or solid fuel
	Energy	Lighting (living & family rooms)	kWh	(total lighting for living, dining, family, kitchen)	Energy, CO_2, natural lighting design	Siemens meter
	Energy	Lighting (bedrooms & bath)	kWh		Energy, CO_2	Siemens meter
	Energy	Fridge/freezer electricity	kWh		Energy, CO_2	Siemens meter
	Energy	Water pump	kWh		Energy, CO_2	Siemens meter
	Heat flow	Heat flow (living room)	W/m^2	embedded in insulation between rafters	Energy	Heat flux transducers
	Heat flow	Heat flow (play area)	W/m^2	underneath ceiling insulation	Energy	Heat flux transducers
	Heat flow	Heat flow (bedroom)	W/m^2	underneath ceiling insulation	Energy	Heat flux transducers
	Water flow	Total town water	litre		Town water consumption	KENT water meter
	Water flow	Total from rain water tank	litre		Total rain water usage	KENT water meter
	Water flow	Total hot water from cylinder	litre		Energy	KENT water meter
	Water flow	Shower hose (cold)	litre		Energy, water consumption	KENT water meter
	Water flow	Shower hose (hot)	litre		Water consumption	KENT water meter

	Water flow	Kitchen tap (cold)	litre		Water consumption	KENT water meter
	Water flow	Kitchen tap (hot)	litre		Energy, water consumption	KENT water meter
	Water flow	Toilet flush	litre		Water consumption	KENT water meter
	Water flow	Flow through solar water panel	litre		Solar collector performance	KENT water meter alternatively via pump power meter or pump on/off meter
	Water temperature	Cold inlet into cylinder	°C		Energy consumption	Thermocouple
	Water temperature	Hot out from cylinder (before mixing valve)	°C		Energy Consumption, Health (legionella)	Thermocouple possibly sufficient to conduct one-off measurements
	Water temperature	Hot out from cylinder (behind mixing valve)	°C		Energy Consumption, Health (scalding)	Thermocouple possibly sufficient to conduct one-off measurements
	Water temperature	Thermostat temperature	°C	feed thermocouple into thermostat tube	Energy Consumption	Thermocouple
	Water temperature	Out from cylinder in solar panel	°C	measure close to cylinder to capture actual solar contributions	Solar collector performance	Thermocouple
	Water temperature	In from solar panel into cylinder	°C	measure close to cylinder to capture actual solar contributions	Solar collector performance	Thermocouple
	Room temperature	Air temperature (living x 4)	°C	living and family room 2 heights each (about 2m and 0.4m near seating positions)	Comfort, Health, Energy	x 4 May not need all four positions, but desirable

	RH	Room RH (living)	%	living and family room 2 heights each (about 2m and 0.4m near seating positions)	Comfort, Health	(
	Radiant temperature	Radiant temperature (living x 4)	°C or W/m²	living and family room 2 heights each (about 2m and 0.4m near seating positions)	Comfort, Energy	x 4 (shielded with aluminium foil) Derived by measuring the air temperature only.
	Room temperature	Air temperature (master bed x 2)	°C	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health, Energy	
	RH	Room RH (master bed)	%	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health	x 2
	Room temperature	Air temperature (bed 2)	°C	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health, Energy	
	RH	Room RH (bed 2)	%	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health	x 2
	Room temperature	Air temperature (bed 3)	°C	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health, Energy	
	RH	Room RH (bed 3)	%	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health	x 2
	Room temperature	Air temperature (bath)	°C	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health, Energy	
	RH	Room RH (bath)	%	2 heights (about 2m and 0.4m near seating positions)	Comfort, Health	x 2
	Room temperature	Air temperature (garage)	°C	1 heights (about 1 m)	Energy	Thermocouple
	Room temperature	Air temperature (roof space)	°C	3 positions in roof space	Energy	Thermocouple x 3
	Surface temperature	Floor surface temperature (living x 4)	°C	embedded in concrete	Comfort	Thermocouple x 4
	Surface temperature	Wall surface temperature (living)	°C	internal wall surface, West wall	Comfort, Condensation	Thermocouple
	Surface RH	Surface RH (living)	%	internal wall surface, West	Condensation	BRANZ RH sensor

				wall		
	Surface temperature	Wall surface temperature (master bed)	°C	internal wall surface, East wall	Comfort, Condensation	Thermocouple
	Surface RH	Surface RH (master bed)	%	internal wall surface, East wall	Condensation	BRANZ RH sensor
	Surface temperature	Wall surface temperature (bed 2)	°C	internal wall surface, East wall	Comfort, Condensation	Thermocouple
	Surface RH	Surface RH (bed 2)	%	internal wall surface, East wall	Condensation	BRANZ RH sensor
	Surface temperature	Wall surface temperature (bed 3)	°C	internal wall surface, East wall	Comfort, Condensation	Thermocouple
	Surface RH	Surface RH (bed 3)	%	internal wall surface, East wall	Condensation	BRANZ RH sensor
	Surface temperature	Wall surface temperature (bath)	°C	internal wall surface, South wall	Comfort, Condensation	Thermocouple
	Surface RH	Surface RH (bath)	%	internal wall surface, South wall	Condensation	BRANZ RH sensor
	Room occupancy		on/off	number of movement detections per half hour monitored through security system IR sensors in each room	Occupant behaviour	IR occupancy sensors as part of security system
	Weather	External air temperature	°C		Building thermal performance	Thermocouple
	Weather	Total solar radiation on panel	W/m²	pyranometer placed next to solar collector horizontally	Solar collector performance, passive solar gains through windows	Pyranometer Direct normal and total horizontal can be derived from that (and used for thermal simulation window gains) alternatively retrieved from MetService database or as part of a

						complete weather station unit
Data retrieved from other sources	Weather	Wind speed	km/h		Building thermal performance, solar collector performance	alternatively from weather data
	Weather	Wind direction	deg		Building thermal performance, solar collector performance	NA alternatively from weather data
	Weather	Precipitation	litres		Building thermal performance (RH)	NA alternatively from weather data
	Weather	external RH	%		Building thermal performance (RH)	alternatively from weather data
Occupants' logbooks						
	Waste	Household waste (organic, glass, paper, rest)	kg/week		Occupant behaviour	NA
	Maintenance	Maintenance details and cost	$/month	record details of maintenance items and costs	Building durability and maintenance	NA
	Energy	Energy bills (all fuels)	$/month		Energy	NA
One off and regular expert evaluation						
	Occupant perception	Survey (Aesthetics)			Aesthetics	also ZALEH survey
	Occupant perception	Survey (Services provision)			Services provision	also ZALEH survey
	Occupant perception	Survey (Quality of light)			Quality of light	also ZALEH survey
	Occupant	Survey (Social aspects)			Social aspects	also ZALEH survey

	perception					
	Occupant perception	Survey (Comfort in general)			Comfort in general	also ZALEH survey
	Durability	Survey/Inspection (Mould growth)			Mould growth	NA
	Waste	Construction waste logbook			Construction waste	NA
	Building process	Construction process record		Video/photo record	Construction cost and speed	NA

Appendix B: NOW house monitoring benchmark match

Value	Component	Design targeting method	Measurement Method	Target	Justification for target (references)	Comment
Affordability	Capital cost	Total cost of construction.	Post construction budgeting	$150,000 (now $180,000)	Based on market demographics from census (Waitakere City Council, 2001a) and BRANZ building economist (Page, 2003).	Know from WCC 2001 census area units survey that for the NEW LYNN ward:
						o As a guide, can expect annual rent to be 6-9% of capital (house and section) value (Page, 2003). Assuming section to be about $70k, minimum rental is $253 per week. A rental of between $250 and $300 for a new house is seen to be reasonable (Lietz, 2003) Checking!
						o Average rent paid = $204 (in 2001).
						o Median household income = $34.6k (in 2001)
						o Median personal income = $16.0 k
	Operating energy.	**Operating**: sum monthly energy bills.	POE monthly energy bills	**Operating** bills:	**Operating**: Target estimated (Deacon, 2003), based on national figures.	o **Energy** STANDARD: National average figures are $1100 per year (Deacon, 2003).
				≤ $550/yr		o **Energy** TARGET: Combined savings from increased insulation levels, solar hot water, energy efficiency lighting, water efficient appliances, and accounting for 'take-back', likely energy savings to be approximately 50%
	Ongoing **maintenance** costs	**Maintenance**: sum maintenance log expenses.	House maintenance expenses		**Maintenance**: Target considered to be a 'reasonable' goal. (Page, 2003)	o **Maintenance** STANDARD figures, for the first 10 years, calculated from summing painting walls every 10 years ($3k), substantial decorate every 10 years ($3k) worth and hardware and miscellaneous ($1k) = $7k, or $700/yr.
				Maintenance:		o **Maintenance** TARGET estimated to be $6k, for the first 10 years, or $600/yr.
				≤ $600/yr for first 10 years.		STANDARD estimate is in-line with rule of thumb of 0.5% of capital value (i.e. $750 per year) for the first 15 years (Page, 2003).
						Need tenant to keep accurate estimates in log book, for accurate monitoring

Value	Component	Design targeting method	Measurement	Target	Justification for target	Comment
Desirability	Ergonomics	Adherence to Standards	PO check	Checklist of key features by independent designer.	Suggested by Moore (2003).	Developed own checklist, which uses various sources such as *Homes without barriers* (BRANZ, 2001) and NZS 4102: *Safer House Design* etc.
	Aesthetics	Post Occupancy review of occupier.	PO surveys of occupants	'Good' rating, POE review	Arbitrary	
	Saleability (Resale)	Professional evaluation (evaluators report).	PO professional evaluation (real estate or mortgage broker)	$150k building only.(now 180K)	Building only resale value, as land value is not applicable in this instance.	Hypothetical question is 'Was the capital spent on construction fully realised'? Use an independent evaluator.
Performance	Structural *Earthquake, wind, loads*	N/A	NA	N/A	NZBC compliance	
	Fire	N/A	NA	N/A	NZBC compliance	
	Thermal	Calculated performance using ALF to find building performance index (**BPI**)	Temperature monitoring in family and bed rooms	ALF **BPI** of 0.06 or less.	Halving NZBC requirements (Stoecklein, 2003).	o STANDARD **BPI**: The NZBC Clause H1.3.2 requires a BPI of equal to, or less than, 0.13 for warm (Auckland) locations.
						o TARGET **BPI**: 'Very Good' insulation level, estimated to be about double that of what is required by NZBC (Stoecklein, 2003).
						o STANDARD 16°C is a safe minimum internal dwelling temperature, particularly for the very old and the very young (Building Industry Commission, 1987).

Value	Component	Design targeting method	Measurement	Target	Justification for target	Comment
		Monitoring of thermocouples (with meter-board loggers).		Indoor temperature between 18°C and 25°C	ZALEH thermal runs, using similar house types $R_{av} = 3$	TARGET Comfortable (minimum) temperature - set at a more preferred temperature, for human health reasons, of 18oC, as suggested by Collins (1986). The temperature range to be met for all but 10 days/year (no space heating) for more than 5 hrs/day.
	Indoor Air Quality	None - pollutants levels cannot be compared to normal houses, as very dependant on the location and activities in the house so concentrations vary widely	NA	NZBC's E3VM1 or use BRANZVENT for good ventilation design (Bassett, 2003)	No sensible pollution level targets could be established (Bassett, 2003 and Gibson, 2003).	Existing workplace expose standards for NZ (Dept of Health, 1992) are not directly applicable to homes as they only apply to working populations and don't protect the very young, old and sensitive. Common practice is to refer to 1/10 TVL (Threshold Limit Value) or select exposure guidelines for other countries. Could use the exposure standards for contaminants in NZS4303:1990 (but they are at the 1984 level of knowledge and are applicable to outdoor air or medium to long term exposures in other countries). However, they can be used in absence of a Standard dedicated to IAQ (Bassett, 2003). They give the following levels of no concern: formaldehyde < 0.05 ppm; CO <2% COHb.
	Noise (Internal)	Sensor in lounge and bedroom		Quiet areas ≤ 27 dB(A) over 24 hours. No plumbing noise.	Public draft (AAAC, 2003), recommended by Emms, 2003.	No NZBC requirements for stand-alone residential housing. Based on Australian guidelines for apartments and townhouses.
	Noise (External)	Acoustic sound testing results		Living areas ≤ 30 dB(A) over 24 hours; bedrooms 27 dB(A) over 24 hours	Public draft (AAAC, 2003), recommended by Emms (2003).	No NZBC requirements for stand-alone residential housing. Based on Australian guidelines for apartments and townhouses.

Value	Component	Design targeting method	Measurement	Target	Justification for target	Comment
	Future proof - *Flexibility and services provision.*	(Needs to be assessed well after NOW House built)		Use checklist system but also invite occupant feedback.	Arbitrary	
	Light (Natural)	Post Occupancy review of occupier		POE 'good'.	Occupant-dependent. OR NZBC G7.3.1	NZBC G7 requires that natural light shall provide an illuminance of not less than 30 lux at floor level for 75% of the standard year. This is provided by having a window area of 10% of the floor area.
	Moisture	In-wall RH monitoring results. No targets for room ambient air RH, as too dependant on occupier.		Moisture content in wet-area framing to be similar to general framing mc.	Suggested by Bassett (2003).	
Overall Eco-Performance	Mainly environmental, but also health and safety issues examined.	BRANZ *Green Home Scheme* auditing procedure.		"Excellent" overall performance rating (BRANZ, 2003)	Shows high environmental competency for NZ house design (Jaques, 2000; BRANZ, 1997), considerably higher performance than NZBC requirements.	Newly (2003) revised BRANZ *Green Home Scheme* assessment worksheets to be used.
Personal and Community Health	Health & Safety	Reports in house log book.		No slips or falls which are 'building-induced'		Building induced – those incidences where the building, its finishes, layout or
	Security (with Privacy combined)	Waitakere City Council's in-house (qualitative) "Designing Out Crime" checklist. Has 6 generic criteria and 2 site-specific criteria.		At least 5/8 of the design principles met.	Public and private space must be clearly identified, so intrusion cannot occur accidentally (WCC, 2003)	STANDARD: About 25% o f existing suburban homes meet a significant number of the (6 general) criteria in the "Designing Out Crime" document (Mills, 2003). TARGET: Include at least 5 of these design principles (from

						WCC, 2003): 1. Side and rear boundary fences are visually permeable…2. Regardless of orientation, road frontage fencing is low, or visually permeable….3. There is a strong visual connection between the dwelling and the ECO Trust building…etc
Value	**Component**	**Design targeting method**	**Measurement**	**Target**	**Justification for target**	**Comment**
	Comfort	Post- occupancy review		'Good' rating at POE review	Arbitrary	
Resource use	Water consumption	Monitoring of public supplied (i.e. reticulated), toilet and garden tap.		140 l/person or less daily town supply water.	WCC rainwater collection program (Fan, 2003)	Estimated use calculated from improved appliance efficiencies (i.e. low flow) and supplemental (i.e. roof-sourced) water. Calculated from having a rain water tank of 3200 litres (fed from a 160 m2 roof) which supplements at least 80% of garden, toilet needs, OR 4600 litre tank for 80% of garden, toilet, and hot water needs.
	Energy consumption	Monitoring of meter box.		Less than 5100kWh/yr	BRANZ HEEP data (BRANZ, 2002), and moderated by Carpenter (1995).	Find the total energy delivered to the house HEEP houses found that average energy use was approx. 10,000 kWh/yr – but at lower comfort levels. The NOW house must meet higher comfort yet be lower in energy use as well.
	Embodied energy	Calculated/estimated from final design		Less than 1300 MJ/m^2 for sum of floor/walls/roof only (for super insulated construction)	N. Mithraratne (2001) for comparative houses and Andrew Alcorn (2003) for embodied energy values.	Embodied energy = accounting for life time operational energy plus materials. Only have considered top three building elements, as they account for the bulk (approximately 65%) of all embodied energy in a house (Mithraratne, 2001). NOTE: "TARGET" figures based on **super-insulated** construction, for fair comparison (Mithraratne, 2001). The super insulated house has a whole house R value of 4.4 $^oCm^2/W$ (c.f. NOW house R target of 3).
	Land use and Ecology (i.e. site impact)	Area disturbed by development, and resources used in construction and landscaping.		Where **landscaping** has been assisted by Park's Dept. and the change in **ecology** of site is 'MINOR'	Based on what can reasonably be performed for this site. Qualitative (descriptive) assessment adapted from Baldwin et al, 1998.	**Ecology** TARGET: Examines the pre-post constriction site changes, and categorises them as either:

						NEUTRAL: i.e. "where a building has previously occupied the site and has been demolished or extensively reused".
						MINOR but positive: "where a concerted plan mitigates the environmental impacts resulting from construction".
						SIGNIFICANT and positive: "where significant resources have addressed things such as landforms, habitat, restoration, visual impact etc".
Value	**Component**	**Design targeting method**	**Measurement**	**Target**	**Justification for target**	**Comment**
	Water production (*grey and storm)*	None – as too difficult to measure accurately.		No storm-water discharge at all.		
	CO_2 emissions	Derived (converted) from bought power, multiplied by coefficients from BRANZ (2002), and IPCC (1997).		≤ 2651 kg CO_2/yr gas/electric mix; or ≤ 3245 kg CO_2/yr all elect. system)	Based on predicted energy use (Mithraratne, 2001).	
						GHG emissions = 147 kg CO_2/m^2, accounting for life time operational energy plus materials (Mithraratne, 2001).
						NOTE: "TARGET" figures based on **super-insulated** construction (Mithraratne, 2001), for fair comparison. Assumed that the standard 100 m^2 BIAC house figures can be 'scaled up'.
	Materials *(sustainable, renewable, non-toxic, healthy*)	Use NZIA (1996) decision assistance charts where possible.		None – not applicable.	No tool available (Jaques, 2003).	No NZ specific tool operating today which is able to rate one material over another, which has current, comprehensive and scientifically valid information.
	Waste	**Construction:** visual volumetric assessment monitoring during entire phase, by students.		**Cstn:** ≤ 4 m^3 in total;	**Cstn:** www. rebri.org.nz and Mittermuller (2003)	**Cstn:** Through proper room sizing and careful use of materials, the amount disposed to landfill can be reduced to about 4 m^3 per average house build (Mittermuller, 2003).

		Occupation: Weight dumped (landfilled) during occupancy recorded (including that dumped in addition to weekly kerbside bags). NOT including that recycled.	**Occpn:** ≤ 4.3 kg/ household/week	**Occpn:** (Waitakere City Council, 2002a)	**Occpn:** These figures include the litter dumped as well as domestic waste. These figures DO NOT account for kerbside recycling. STANDARD is 450 kg/hh/yr, (or 150 kg/person/yr). This equates to 8.7 kg/hh/wk (OR 2.9 kg/person/wk). TARGET is half this at 225 kg/hh/yr, (or 4.3 kg/hh/week) to account for : a) the downward trend as a result of impact of user pays, b) the removal of organic waste (accounts for about 50% of waste – WCC, 2002a) as there will be provision for a compost bin, and c) a kerbside scheme operating in area, collecting usual metals, plastics and paper-based products.

Appendix C: Sources of monitoring information

Data Acquisition System
-Details of the RF system on http://www.rdsdistributing.com/cgi-bin/catalog.cgi?Wireless.
-Temperature and RH sensors are part of the RDS system and send data via RF link to the Point Server (http://www.rdsdistributing.com/cgi-bin/catalog.cgi?Wireless&Point_Server-M).
-The Point Server will receive pulsed input counts from Siemens meters (electricity), KENT meters (water flow), and security system (occupancy) via RF signalling or hard wired
-Thermocouples and RH sensors for surface measurements will be wired back to the Point Server providing voltage signals.

Room temperature and RH
Point Temperature/RH sensor from RDS Ltd.:
http://www.rdsdistributing.com/cgi-bin/catalog.cgi?Wireless&Point_Sensor_THL.

Room temperature
Point Temperature sensor from RDS Ltd.:
http://www.rdsdistributing.com/cgi-bin/catalog.cgi?Wireless&Point_Sensor_Temperature

Electricity
Electricity monitoring of end-uses via Siemens meters on the circuit board feeding into the data acquisition system. All metered end-uses are on separate circuits wired back to the distribution board. Therefore the Siemens meters will all be located at the distribution board.

Water usage
KENT PSM water meters (http://www.abb.com/global/seapr/seapr035.nsf/viewUNID/BAEFA2F983D09E0B412568480044EDC3) from Arthur Riley (Arthur D. Riley PO Box 37, Wellington, Phone 044727614, http://www.adriley.co.nz/) record water flow at 1 pulse per 0.5l.

Weather data
If weather data are not sufficient from the MetService station, then onsite weather measurements will be conducted. Logger possibly from http://www.davisnet.com/weather/index.asp.

EMF Monitoring

Attached letter from John Churchill (Armstrong Churchill & Associates Ltd), responding to request from Roman Jaques for input on RF/EMF monitoring (proximity of the overhead power lines may be regarded as a health problem).

> Dear Roman
>
> Our quotation is below, but I have a suggestion that could influence the overall cost and coverage of our proposed survey activities.
>
> As I indicated on the telephone, we like to help with worthwhile projects but as a very small organisation our options are usually limited to free or reduced price services.
>
> This project seems to be of wide benefit to the community and if the project is to have some publicity attached, appropriate recognition to Armstrong Churchill & Associates Ltd for EMF services would enable us to provide a comprehensive package, beyond that which would be economically possible within your budget. For example, we could carry out a preconstruction site survey, monitor the house

after completion but before occupation and again when occupied. Written reports and field level graphs etc would be provided to suit your requirements. We would also liaise with electrical contractors if required to ensure that low field options were chosen for wiring and/or provide them with simple written guidelines to follow.

Your budget of approximately $1000 plus GST would cover:

Two x site visits @ 2 hours each	$600
Simple report preparation @ 3 hours	$300
Travel time & km charges	$100
Total	$1000 (plus GST)

The work required to do this job properly with time-logged monitoring, field profiles for the HV distribution lines would be significantly greater with 5-6 trips to the site for instrument installation and retrieval, site measurements pre and post occupancy etc, plus preparation of logging results and an appropriate level of reporting (including reference to the NZ MoH guidelines for EMF exposure).

We can do all of that, either to your specification or as agreed on our recommendation within your budget which we would then see as little more than a direct cost-recovery situation.

If this proposal was acceptable, in return we would ask for mention of our company as a minor sponsor and specialist service provider in any publicity releases or documentation and if the project details are posted on the BRANZ website, a similar acknowledgement in that medium would also be appropriate. We are not looking for headlines, just an acknowledgement so that people who have interests in low electromagnetic field environments could see that we exist and that our services are available.

Please give it some thought as the extra time on site and extended monitoring would greatly enhance the value of the EMF measurement exercise.

Kind regards

John Churchill