# SmartHome Smart Communities

*- A Solution for Tomorrows Housing, Today -*

December, 2012

BC Spaces for Nature

with support from
The Real Estate Foundation of BC

*BC Spaces for Nature wishes to thank*
*The Real Estate Foundation of British Columbia*
*for their financial support to undertake and document the*
*SmartHome, Smart Communities Project.*

## Table of Contents

## 1.0 The SmartHome Concept

A SmartHome is designed to achieve: compactness, expandability, energy efficiency, quality *and* affordability. It will especially appeal to the cost conscious and environmentally concerned buyers. It features:

1. **Compact Effective Design**: A SmartHome's clever, effective design makes for a small house (1,100 square feet) whose open plan creates a pleasing sense of spaciousness. Halls are eliminated and floor space usability is maximized.

2. **Energy Efficient:** A SmartHome incorporates:
    a. high levels of insulation
    b. air-tight construction
    c. heat recovery ventilation, and
    d. passive solar building design to achieve a very high level of operating efficiency, comfort and a healthy indoor environment.

3. **Affordable:** A SmartHome's compactness and energy efficiency lead to savings that make single home ownership attainable for those on more modest budgets. In a time of high real estate prices, a SmartHome will appeal to cost-conscious younger buyers wanting to raise a family and also to older homeowners seeking to downsize. As well, a SmartHome's efficiency insulates its owners from future rising energy and operating costs.

4. **Expandable**: The SmartHome design allows for rooms to be easily added on as a family - and its income - grows. This makes it especially appealing to younger owners. Doorways to future rooms are already framed into the house's structure. As well, wiring is in place to allow for easy additions. This expandability is versatile: multiple options exist to add on rooms in various locations to the home's core. (The core incorporates the kitchen, dining room, living room and bathroom). In this way a SmartHome can grow from two bedrooms to five, with a range of layouts.

5. **Simplicity and Style:** With dimensions based on two-foot increments and with simple rooflines, materials wastage - and hence building cost - is greatly reduced. Quality finish details (e.g. staggered gable shingles) make for a distinctive, attractive home. Since rooms can be added in a number of locations, the look of a SmartHome will vary.

6. **Environmentally Responsible**: Due to its compactness, a SmartHome has a much smaller ecological footprint. It requires far less energy to heat and therefore generates significantly less greenhouse gases. It is built to strict criteria to meet the highest LEED Certification standards, stressing water conservation, incorporating locally produced building materials, and using less-toxic, environmentally-friendly materials.

7. **Can Help Revitalize Smaller Communities:** Since SmartHomes are more affordable, they offer the potential for smaller communities near to major cities to attract and retain younger residents - especially knowledge workers - to raise their families. Given their compactness and expandability, SmartHomes are ideal for small 'cottage lots' and therefore amenable to higher density *Smart Growth* town planning principles.

smart

## 2.0 Background

The SmartHome Concept is the result of synergy and serendipity. The designer, Ric Careless' past experience with innovative energy conservation building techniques and the wish to help his daughter and son-in -law be able to afford a home in the high cost, west coast BC real estate market resulted in a new effective housing solution. Knowing the story behind each of these two threads is fundamental, since the SmartHome derives from the convergence of these two experiences.

### 2.1 Story of the Cranbrook Energy Centre: Achieving Housing Efficiencies

In the early 1980s, the economy of the western world was crippled by rapidly soaring oil costs due to price hikes orchestrated by the Organization of Petroleum Exporting Countries (OPEC) as a response to military disturbances in the Middle East. This situation resulted in a sudden, first-time interest in Canada to try to find a means to reduce dependency on high-priced oil. One of the outcomes that emerged was a focus on the development of much more energy efficient home building techniques. Fortunately, in the prior few years, scientists working with the National Research Council (NRC), at the University of Saskatoon, had been exploring a system of energy conserving construction techniques that utilized conventional building materials. The approach taken by these scientists was to integrate three different building strategies, which would result in houses that operated with much lower energy needs, and therefore more cost efficiency.

The first element was to significantly increase the level of insulation being installed in homes. Previously, Canadians had considered a well-insulated house to be a 2 x 4 frame construction with R12 fiberglass bats. In the roof, perhaps the insulation level would have been about 6 inches or R20 of insulation. The NRC scientists suggested this needed to be significantly increased, proposing from R20-40 inches of fiberglass insulation in the walls and from R40-60 in the ceilings, depending upon the climate zone where the house is located. Since they utilized conventional insulating materials, common building techniques could be used.

The second key element was to achieve greatly increased air-tightness in the homes. Typically, Canadian homes (and elsewhere) had been built with very little attention to controlling air leakage. Houses tended to be very drafty, with the cracks around windows, doors, pipes and vents adding up to a hole in the wall of the structure equivalent to a couple of exterior doors left wide open. As a result, at the time it wasn't uncommon for Canadian homes to exchange their entire volume of air up to twice an hour. The need to heat such an extensive volume of air resulted in great energy inefficiency. The NRC scientists devised an approach whereby the plastic barrier typically placed in walls to control water condensation could be more rigorously installed and sealed to also dramatically reduce air leakage. What had been called vapour barriers previously, now came to be known as air-vapour barriers. The result of this strategy led to homes being built which were far more efficient in terms of controlling air leakage and infiltration. A well-constructed air barrier in a home could result in an equivalent cumulative hole in the wall of a few square inches, with air change also reduced radically. It became quite reasonable to see an air change once every couple of hours being achievable. In effect, the scientists had come up with a design that 'bagged' the house and allowed a continuous barrier built around all components of the house.

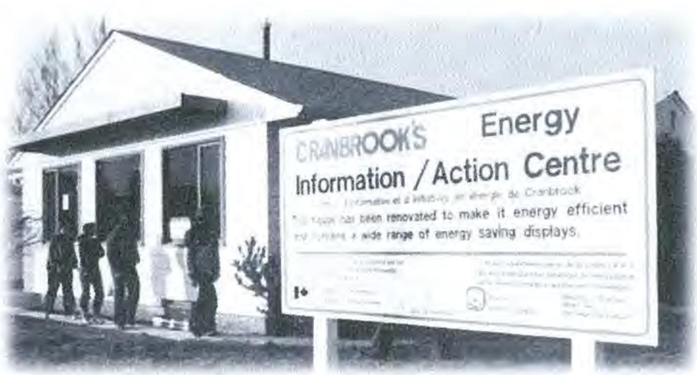
Naturally, with such dramatic reduction in accidental air filtration, the risk was that air quality would suffer. Hence, the third element of the approach: the use of heat recovery ventilation. The NRC scientists' designs incorporated the use of air-to-air heat exchangers. These were basically boxes with a series of baffles in them – cold air was drawn in on one side of the baffles and exhausting warm house air was run out the other side. The heat from the outgoing air transferred across the baffles (typically made of plastic) and pre-warmed the incoming air. The result of using heat exchangers now made it possible to retain up to 70% of the heat energy in the air that was being exhausted from of the house. This also had very significant energy conservation implications. Whereas traditionally, Canadian homes had ventilated *accidentally* with all the leakage in the walls, now with the walls and ceiling so well sealed in this new approach, ventilation occurred *purposefully*. No more air was brought in than was needed for air quality, and of that, the level of heat recovery through the heat exchanger meant in fact, there was much increased efficiency.

This combination of high levels of insulation, airtight construction, and heat exchange ventilation is what made for this revolution in the National Research Council's housing technology. By the early 1980s however, although the technology had been tested within the NRC and a few prototype houses, there was very little awareness of this approach by the Canadian public, and especially amongst the building trades. To begin to address this, in British Columbia, the federal, provincial and four municipal governments got together to create Energy Conservation

Demonstration Centres in four locations: Cranbrook, Port Coquitlam, Victoria, and Dawson Creek. Ric Careless - who today serves as BC Spaces for Nature Executive Director - was then, the Director of the Cranbrook Energy Centre. Arguably the most ambitious of the four BC Energy Centres, in Cranbrook the municipality purchased a 1950s house, which typical of its age was very inefficient in its energy use. With funding from the provincial and federal government, this house was retrofitted to state of the art standards using the NRC's combination of super-insulation, air tightness, and heat exchange ventilation. As well, simple passive solar was incorporated into the house. After the house had been completely retrofitted, its energy bills and air tightness were analyzed. The results showed the retrofitted house operating at 90% more energy efficiency than prior to the upgrade.

With the home retro-fitted, the Cranbrook Energy Centre was equipped with a complete set of displays, such as cut-away walls, which could be used to train builders and inform home-owners as to how to achieve much greater efficiency in the construction and upgrading of their homes. A community-wide low-cost, no-cost draft ceiling program focused on lower income homes, and a variety of training seminars were run out of the Centres.

Over the two years that the Cranbrook Centre functioned as a training facility, one of the key results was the building of 25-30 new super-energy-efficient homes in the town. These homes used the double wall framing technique that allowed a very cost efficient means of achieving air-tightness, and super-insulation. Of course the houses were also built with air exchange ventilation. One of the exceptional aspects of Canada's energy efficient home technology was that it utilized conventional materials, and for the most part, conventional building techniques. As a result it was very easy to train builders as to how to construct homes in a much more efficient manner. Indeed, by the end of the two-year demonstration period, these houses were being constructed for the same cost as conventional housing and yet they could operate in Cranbrook's winters (temperatures going down to -40°C) on the equivalent energy of two pop-up toasters.




Clearly the efficiency of this Canadian technology was being demonstrated. Unfortunately, shortly after the two-year demonstration period ended at all four Energy Centres in BC, the price of oil had so diminished that governments lost interest in promoting this approach to building. And while these Centres and the

NRC technology was fundamental to the creation of the R2000 construction technique, the R2000 homes did not reach the level of efficiency and effectiveness achieved by the homes built in Cranbrook and the other three communities where the Centres operated. As a result, Canada's fast emerging leadership in energy efficient home building technology was soon forgotten. Soon after, the Centres closed and people got back to 'life as usual' including being unconcerned about the price of oil.

In 2005 the cost of oil again began to surge dramatically, even beyond the prices seen in the early 1980s. As well, the fast emerging awareness of the contribution of the burning of fossil fuels to climate change has led to the acknowledgement of the importance of dramatically reducing carbon production, including that associated with our building structures. Fortunately, the NRC's technological approach in the early 1980s to build energy efficient homes also resulted in homes that have greatly reduced carbon impacts. These homes are clearly advantageous from both energy and climate change perspectives.

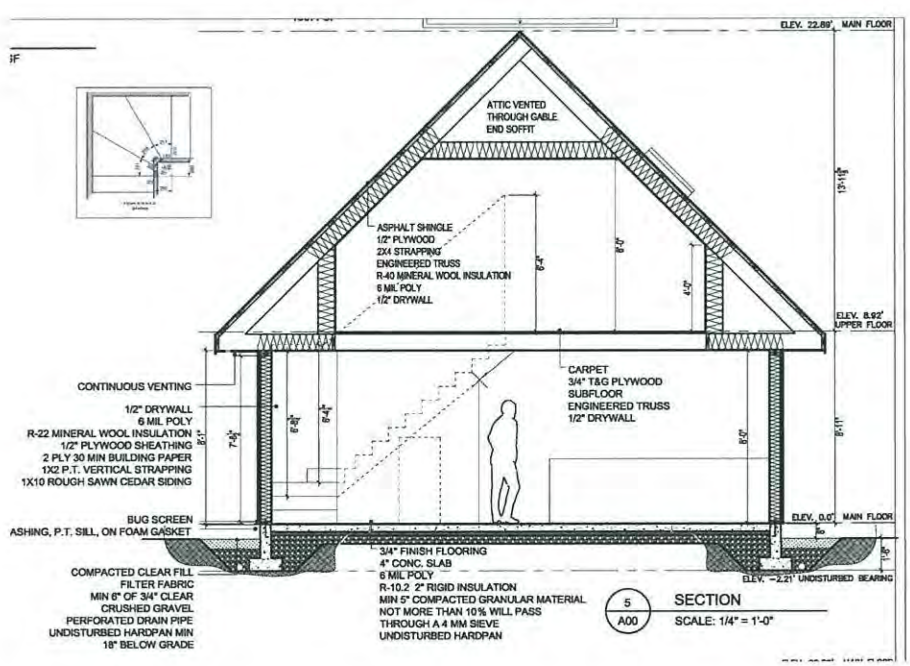
Given this background, it is not surprising that the energy conservation technology, which Ric Careless became familiar with while training builders at the Cranbrook Energy Conservation Centre should 30 years later become a fundamental element to the development of the SmartHome. The designer certainly recognized that by utilizing the techniques associated with the super-efficient homes built in Cranbrook in the early 1980s, a house could be constructed that would not only be cost efficient to build but also inexpensive to operate. As well, it would insulate homeowners not only from cold temperatures, but also from future increases in energy prices. As such, it just made sense to design the elements of the system that NRC had identified so many years ago into what has become SmartHome.

To further that concept, a fundamental element built into SmartHome was that of compactness. The idea is very simple: the less volume means less area needs heating, and thus the costs of heating are reduced. As a result, a key focus was on designing a house that could be as compact as possible. This served multiple purposes as it achieved much increased energy efficiency, and greatly enhanced affordability.

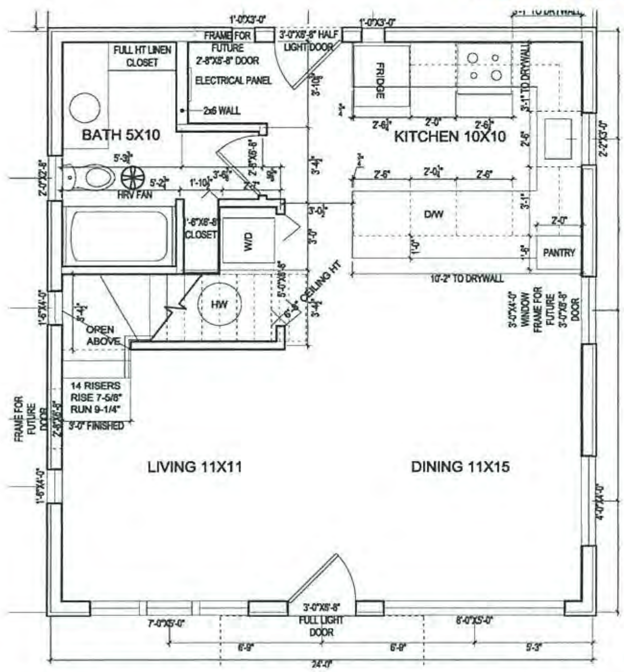
## 2.2 Story of a Young West Coast Couple: Achieving Housing Affordability

The realization of the SmartHome Concept was also a personal one. Ric Careless, who designed the house, was trying to solve a common problem for parents wishing to assist their children become homeowners in the very expensive Vancouver regional housing market. From 2000-10, the price of real estate in the Vancouver area, including the Sunshine Coast, had essentially doubled. This meant that young people trying to enter the housing market in 2010 found they would have to pay twice the price for a home than they would have if they had bought a decade earlier. Unfortunately wages had not increased anywhere near this; rather, they had basically straight-lined. The result was that houses in the Vancouver region had moved dramatically out of reach for many would-be first time buyers. Whereas the Canadian Mortgage and Housing Corporation (CMHC) suggests that no more than 32% of pre-tax income should go to housing purposes (which includes mortgage, utilities and property taxes), in the Vancouver region the level of pre-tax income required for housing had gone as high as 80%. For so many younger people, being able to own their own home now was increasingly seemingly like an impossibility.

Indeed by 2010, the Vancouver region was recognized as being one of the most expensive locations to buy a home in the world. And even though Gibsons' had somewhat lower housing prices compared to Vancouver, it was still very expensive relative to the rest of Canada. The ability of Ric's daughter and her husband to get into the real estate market appeared unlikely. This was when the suggestion of designing a house that would be small enough so as to be affordable was first considered. The design challenge to achieving this was considerable. However after analysis it resulted in the development of an extensive set of design criteria that would integrate compactness, efficient construction, energy conservation, and expandability thereby creating a home that was affordably priced.



# 3.0 SmartHome Design Criteria and Linkage with LEED Certification




The SmartHome's unique formula for successful design is built upon well-defined and thoughtful criteria that focus on four key components that drive the overall process and guide decision-making from site selection to completion: *design process, energy conservation and carbon footprint, affordability and environmental sustainability*. Section 3 of this report details all four components of the design criteria concept, including its application and scoring within the LEED certification process.

While the SmartHome concept was originally focused on solving affordability and energy efficiency issues, the course of the construction it became apparent that it could link well with the LEED sustainable building certification process. Hence the criteria upon which the SmartHome was designed have been developed so as to link with LEED Certification standards to the maximum extent possible (Platinum Level LEED Certification).

## 3. 1 Design Process

The SmartHome design process focused on five key priorities: team collaboration, space efficiency, expandability, quality construction, and materials efficiency/minimized wastage.

### 3.1.1 Team Collaboration

The SmartHome team was involved throughout the design/construction process at least monthly and (several members were involved multiple times per month); the exception was Kevin Ryan who was consulted only occasionally (due to the fact that he lives in interior BC).

**LEED Link:**

**Innovation and Design Process (ID)**

**ID 1.2 Integrated Project Team *(1 Pt)***

- **Ric Careless** (Ethos Environmental), Land Use Planning; Energy Efficient/Green Home Design: Ric developed the SmartHome design criteria and designed the house. As well, he was on-site regularly during construction so as to improve the final building and also to train staff.

- **Howard Leung** (Sandrin-Leung Design Group), Architect, LEED AP, Green/Sustainable Building Design: Howard advised and tuned the design and prepared the final building plans.

- **Leighton Bell** (Wakefield Construction), Project Construction Manager: Leighton oversaw the actual construction and project management of the house.

- **Ray Dierolf** (Wakefield Construction), Business Development Officer: Ray played a key role in bringing Wakefield in to build this home to LEED standards. Wakefield Construction is a Deep Green company that specializes in energy/environmental efficient construction on the Sunshine Coast.

- **Jeff Paleczny** (Town of Gibsons), Planner and Development Officer: Jeff is a strong proponent for environmentally and energy responsible housing.

- **Kevin Ryan** (Blue Green Architects Group), Architect: Kevin is a leading BC architect specializing in Sustainable Environmental Home design including Future Framing systems.

### 3.1.2 Space Efficiency

A SmartHome's clever, effective design makes for a small house with an open plan that creates a pleasing sense of spaciousness. The size of the two bedroom SmartHome was calculated from the building plans by Troy Glasner (E3 Consultants) to be 1010 sq. ft. Because of the compactness of the house, the point threshold that is needed to attain LEED Platinum Certification is lowered from the standard 90 points required to just 80 points.

**LEED Link:**

**Home Size Adjustment *(-10 Pt)***

**Adjustment to Award Threshold (Exhibit 4, p. 21**

Space efficiency is best achieved by the following:

*a) Compact floor plan*

- total square footage is 1010 ft$^2$
- alternate floor plans provide for either a one storey and a half design or two bedrooms upstairs with a 12:12 roof (the layout of the Gibsons house), or a one floor rancher

*b) Simple lines and shape*

- built out from an essentially square (24x26 ft$^2$) core centre area, with simple roof lines maximizes interior usable space

*c) Open plan*

- an open floor plan allows for a spacious feel
- no halls, with good traffic corridors through open plan rooms

- efficient kitchen, bathroom, laundry and entrance area layout

### 3.1.3 Expandability

The SmartHome design allows for rooms to be easily added on as a family and its income grows. A 24 x 26 $ft^2$ core includes the kitchen, dining room, living room, and bathroom, and is a central feature of SmartHome. This core is integral to its design as well as energy efficiency performance. The core is constructed with built-in expandability features that facilitate pre-planned and designed expandability for future additions of three to four additional rooms. Future door portals are already framed, pre-wiring is installed to access future rooms, and roughed-in plumbing allows for the addition of a second bathroom in the future. The house is sited on the lot to allow for these room expansions within setback building requirements.

### 3.1.4 Quality Construction

A SmartHome is durably built with quality design, workmanship and materials so the house enjoys an extended lifetime. Ensuring quality construction reduces materials, energy usage, and also mitigates carbon lifecycle impacts by lengthening the sequestration period.

Wakefield Home Builders was the builder selected for the construction of the Gibsons' SmartHome. Quality control and durability is core to Wakefield's brand. Wakefield is also a certified *Built-Green* Builder. Selecting a builder who emphasizes quality workmanship and will provide ongoing construction management/ supervision to ensure the design criteria are followed and quality practices employed is essential.

Notable examples of quality construction, as it relates to SmartHome, include the following:

- All sheathing is plywood rather than oriented strand board
- Design embellishments are incorporated to enhance house attractiveness: such as random-pattern shingled gable ends; wide fascia boards and window trims; covered porch; wooden decks
- Natural wood products are used inside and outside to render a fine quality look: cedar siding; exterior trim and soffits; cabinets, interior doors and trims

**LEED Link:**

**Innovation and Design Process (ID)**

**ID 2.1 Durability Planning (Pre-Req)**

**ID 2.2 Durability Management Processes (Pre-Req)**

**ID 2.3 Third Party Durability Management Verification (3 Pts)**

- Stained siding (i.e. not painted) means lower ongoing maintenance and an especially attractive appearance
- High-efficiency vinyl double-glazed windows as required by the building code
- Given its compact size, a SmartHome can afford to incorporate higher quality materials and workmanship and still be affordable. For example, as a result of this smaller size, it only cost $300 extra to install lifetime asphalt shingles, as apposed to 15 year shingles

### 3.1.5 Materials Efficiency/Minimized Wastage

With the SmartHome, the intent was to minimize construction waste and ensure efficient use of materials right from the outset, as per the design criteria. To achieve this, the following techniques and design choices were utilized:

**LEED Link:**

**Materials and Resources (MR)**

**MR 1.1 Framing Waste (Pre-Req)**

**MR 1.4 Framing Efficiencies (2 Pts)**

**MR 3.1 Construction Waste Management Planning (Pre-Req)**

**MR 3.2 Construction Waste Reduction (2.5 Pts)**

- Use of *Future Framing* techniques (e.g. 2x6 framing on 24" centres) to reduce the framing materials required
    - Attic trusses used for second storey/roof minimized framing wastage while maximizing useable floor space
    - The number of exterior corners were minimized, using a simple exterior wall perimeter: a 26' x 24' rectangle with no wall jogs, bay windows, etc.
    - Simple rooflines (no dormers, valleys etc.) and wall/roof lines so as to minimize wood waste
    - House dimensions were in four or two foot multiples to reduce framing/ sheathing/ boarding waste
    - Finger-jointed lumber was used where possible
    - Building waste was recycled to the maximum extent possible
    - Unused wood was salvaged for use in other projects to the greatest extent possible
    - Framing waste was used for blocking and drywall backing

Any unused house construction waste was directed to the local Gibsons Recycling Centre to maximize recycling. Metal, plastic wrap, polyethylene barrier material, Styrofoam, drywall, cardboard, and metal were all recycled by the Gibsons Recycling Centre and as such have been diverted from either the landfill or incineration. (NB This was confirmed through a discussion with the Gibsons Recycling Centre owner/manager.)

Wood waste that could not be reclaimed for lumber went for use as hog fuel energy generation at the local pulp mill in Port Mellon. (Although this avoids landfill burial and displaces other energy sources, under LEED it is still being incinerated and as such is not considered to be a diverted waste). Wood waste was reduced to the fullest extent possible, by using framing shorts for blocking and backing, with any usable wood framing and sheathing material salvaged for future building projects by the owner.

**House Construction Waste Formula:**

(# of $yd^3$ per trailer load) x # of trailer loads taken to Recycling Centre) x (% of waste not recycled i.e. the wood waste)

**Therefore, the waste calculation is as follows:**

1 large trailer-load@ 3.5 $yd^3$ x 80% wood = 2.8 $yd^3$
4 small trailer-loads@ (2.25$yd^3$ x 4) x 33% wood = 2.8 $yd^3$
Total non-recycled wood waste = 5.6 $yd^3$

As per LEED Table 27B: a 1000 sq ft of house with 0% waste reduction would generate 25.5 $yd^3$ of waste.

Size of Gibsons SmartHome = 1010 ft, therefore, with 0% waste reduction would generate 25.8$yd^3$ of waste.

Accordingly, **Percentage of Waste Reduction of the Gibsons SmartHome** = [(25.8 - 5.6) / 25.6] x 100 = **78.9%**

Thus, **Percentage of Waste of the Gibsons SmartHome** = 100 - 78.9 = **21.1%**

## 3.2 Energy Conservation and Carbon Footprint

SmartHome maximizes energy conservation, while reducing its carbon footprint. Its design incorporates high levels of insulation, airtight construction, heat recovery ventilation and passive solar elements giving it a high level of operating energy efficiency and a healthy indoor environment. Its compact design and use of local materials help to further reduce SmartHome's carbon footprint.

### 3.2.1 Overall Energy Performance

The SmartHome achieves an *Energuide* 82+ rating. This rating was calculated using HOT2000 software. HOT2000 is Canada's leading residential energy analysis and rating software, as per Natural Resources Canada. First introduced in Canada 1987, it has evolved over the years to become the national standard for evaluating the energy performance of houses and multi-unit residential buildings. HOT2000 is the most widely used energy analysis tool worldwide, being used by over 25,000 people in 150 countries.

**LEED Link:**

**Energy and Atmosphere (EA)**

**EA 1.2 Exceptional Energy Performance (12 Pts - 14 Pts potential)**

### 3.2.2 Space Heating

A SmartHome is built for air tightness, and utilizes a heat recovery ventilation system (HRV or ERV depending on local climate). It also minimizes volume and surface areas and incorporates passive solar elements into its design.

The compact house volume of SmartHome greatly reduces heating costs. The fact that it was designed as a 1½ storey essentially square house helps to reduce the home's exterior surface area and hence its heating costs. The use of an insulated slab, rather than a basement or crawl space, also makes a difference in terms of reducing the home volume to be heated.

*SmartHome's design also includes key passive solar elements, specifically:*

**LEED Link:**

**Innovation and Design Process (ID)**

**ID 1.5 Solar Orientation (1 Pt)**

- The house and its windows are oriented for south-facing solar gain and to minimize heat losses on the north.
- The south windows on the main floor are shaded by a louvered sunshade to block out the high summer sun so as to prevent overheating yet allow the low-angled winter sun in to help heat the house.
- The upper story south windows are 50% shaded by the roof overhang.
- An insulated concrete floor serves as a solar battery and reduces temperature swings within the home.
- SmartHome is ready for a future connection to a solar hot water panel. While the roof is not oriented to allow easy solar panel mounting, the plan is to mount future panels on a rack on the south-facing slope below the house deck, on the edge of the garden. This may enable thermo-siphoning thereby minimizing/ eliminating need for a circulatory pump. The feed lines are already installed for this purpose, and link into piping already built into the insulated concrete floor.

### 3.2.3 Reduce Carbon Impact

SmartHome reduces its carbon impact through four important principles built into the design criteria:

**LEED Link:**

**Materials and Resources (MR)**

**MR 2.2 Environmentally Preferable Products (c) Local Production (5.5 Pts)**

**Innovation and Design Process**

**ID 3.2 Innovation 2 (1 Pt potential)**

- First, SmartHome utilizes local building materials to the maximum extent possible;
- Second, the house itself is built to maximize energy efficiency through increased insulation, air tightness and heat recovery;
- Third, SmartHome's increased lifetime achieved through the use of quality materials increases carbon

sequestration, thereby reducing its carbon and climate impacts, and;
- Fourth, due to its compactness, SmartHome has a much smaller ecological footprint – it requires far less energy to heat and therefore generates significantly less greenhouse gases.

As well, the design of the front porch, to specifically to serve as an under-cover bicycle parking location, may receive a LEED Innovation point since the use of bikes by the owners of this home (who choose not to own a car) is intended to reduce carbon and energy impacts. The chosen location of the home close to shopping, services and schools is within easy walking and biking distance.

### 3.2.4 Hot Water Efficiency and Appliance & Lighting Efficiency

All hot water heater and pipes are insulated within the SmartHome. Additionally, the SmartHome is outfitted with *Energy Star* appliances, installed with airtight vent fans. The installation of an outdoor clothesline will reduce dryer use to the maximum extent possible. 85% of the light fixtures have energy efficient CFL/LED lamps, and there are three dimmable track fixtures .

**LEED Link:**

**Energy and Atmosphere (EA)**

**EA 8.3 Advanced Lighting Package (3 Pts)**

**EA 9.1 High Efficiency Appliances (2 Pts)**

**EA 11.2 Appropriate HVAC Refrigerant (1 Pt)**

**EA 7.1 (c) Compact Rating System (2 Pts)**

**EA 7.2 Pipe Insulation (1Pt)**

**EA 9.2 Water Efficient Clothes Washer (1 Pt)**

## 3.3 Affordability

The SmartHome's compactness and energy efficiency lead to savings that make single home ownership attainable for those on more modest budgets. Hence a SmartHome will appeal to cost-conscious younger buyers wanting to raise a family and also to older homeowners seeking to downsize. As well, a SmartHome's efficiency ensures its owners are protected from future rising energy and operating costs. Sections 6.2 and 6.3 of this report provide detailed accounts of the SmartHome Prototype cost as it relates to both the actual house construction ($163/sq ft construction cost), as well as an ongoing housing cost formula demonstrating its affordability to family incomes in the range of $57,000 to $65,000 per year (based on 30 – 35% of cost to pre-tax income).

**LEED Link:**

**Materials and Resources (MR)**

**MR 2.2 Environmentally Preferable Products (6 Pts)**

**(a) Environmentally Preferred Products (.5 Pts)**
**(b) Low Emissions (.5 Pts)**

## 3.4 Environmental Sustainability

The SmartHome is built to according to strict design criteria for environmental sustainability. Some of the key elements include: ensuring a healthy indoor living environment by using a ventilation system as well as less-toxic, environmentally-friendly materials; careful lot development to minimize the house's disturbance to the land, and maximize water conservation; and ensuring the use of ecologically responsible building materials in its construction.

### 3.4.1 Indoor Environmental Quality

The issue of interior air quality was a high priority and an ongoing concern throughout the house design and construction process. This resulted in the choice of lower contaminant products, where possible. During the construction period, venting of the house occurred recurrently for extended periods (well in excess of 48 hours cumulatively) to remove off gassing contaminants associated with glues and paints. Typically this would involve overnight, and sometimes multiday, venting with doors and windows wide open. Additional fans were also used after sealing the concrete. Since the house was built in spring and summer, when temperatures were mild, such extended periods of venting were easy to accomplish.

Once the house was ready for occupancy and the Energy Recovery Ventilation Unit (ERV) and vent fans were installed, the house was flushed for an additional two days with fans running and windows open. The ERV filter was cleaned upon moving in. Once the house was occupied, the owners kept the ventilation rate up (the ERV running continuously) with windows and second floor skylight open for the first couple of months (it was summer) to continue to assist the flushing of any off-gassing chemicals.

Some of the other key SmartHome design elements that ensure healthy indoor air quality include the following:

- Exposure to volatile organic compounds (VOCs) is limited through the use of low toxicity materials; especially low VOC paints, sealants, and adhesives.
- Ensuring adequate ventilation means that heating, ventilating, and cooling systems effectively distribute and exchange air within the house.
- Over 45% of the flooring in the house is sealed concrete. Concrete flooring contributes to better indoor air quality as well as energy efficiency, and cost effectiveness as compared to conventional carpets.
- The high efficiency fiberglass insulation used in the SmartHome is formaldehyde free.
- There are no unvented combustion appliances since natural gas or wood is not used in the SmartHome. Heating is supplied by electric baseboard, electric hydronic (hot water), or passive solar.

- o An Energy Recovery Ventilation Unit (ERV) with a humidistat is installed to control moisture loading and to provide continuous ventilation allowing fresh air into the home.
- o Electric baseboard units have thermostat controls on individual units in each room. As well, the in-floor hydronic system installed in the fully insulated concrete slab on the ground floor has two independently controlled zones.
- o Mats are installed at each door and a shoe removal area is located at the front door helps with indoor contaminant control.
- o The SmartHome has no garage, thereby eliminating garage pollutant protection concerns. Parking for cars is on the gravel parking area and driveway (although the owners actually choose not to own a car and instead use bicycles due to their environmental concerns).

### 3.4.2 Optimal Lot Development

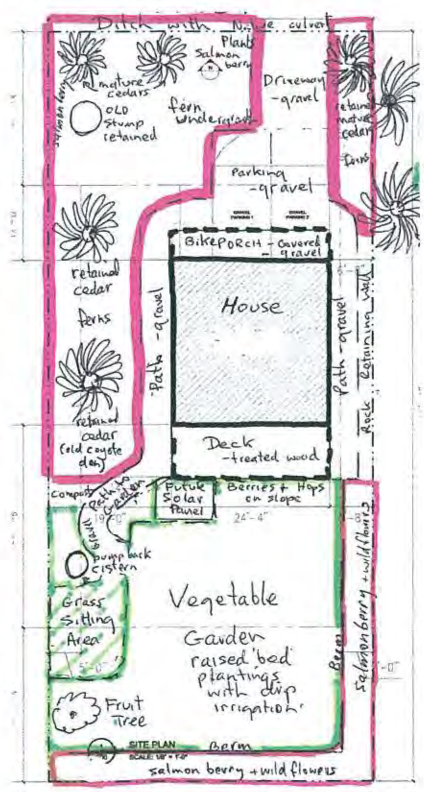
The SmartHome carefully considers lot development and landscape design with the goals of controlling/minimizing erosion, minimizing the house's disturbance to the land, and maximizing water conservation. As well, the house is sited on the lot to allow the addition of future rooms within the setback allowances. Its orientation emphasizes a southerly exposure to maximize solar gain, and its prime view focuses on the south-facing view to the garden in the backyard, which also maintains a sense of privacy. Landscaping was also a key concern: food growing and the retention of native plants were very high priorities for the homeowners.

**LEED Link:**

**Sustainable Sites (SS)**

**SS 1.1 Erosion Controls During Construction (Pre-Req)**

**SS 4.2 Permanent Erosion Control (1 Pt)**




### Erosion and Run-off Control

Erosion and run-off control was emphasized throughout the construction period, especially since the house was built during a very wet spring. A hydrologist was retained to advise on run-off management and erosion control. Several key actions resulted:

- All disturbed topsoil from the house site was relocated onto the garden area. The owners immediately seeded this with a rye grass/legume seed mix as a green mulch to control erosion and also weed growth. This made this portion of the lot ready for gardening as soon as house construction was complete.
  - o Mature trees were retained on the lot, especially on the north property line.

- The native vegetation adjacent to the street-side ditch was not disturbed. Care was taken to keep materials out of the ditch and a culvert was installed early, when the underground services and drains were laid.
- In the garden area care was taken not to disturb tree roots, and a berm was built around the perimeter to control any run-off. The berm side slopes were immediately seeded with a native wildflower mix. Native plants such as salmonberry, thimbleberry and trailing blackberry were also retained on the berm slopes.
- A curtain drain was installed early on to intercept driveway rainwater run-off. It and the perimeter drains were directed to a cistern in the garden. A sump pump was installed in the cistern to pump these waters up to the existing roadway ditch (north side of property). The cistern water can also be used to irrigate the garden.
- The east lot margin adjacent to the house, where there is a three-foot grade difference, was stabilized with a rock retaining wall. This was the only place on the lot where such stabilization control was required.
- The south of the house was gradually sloped to reduce the gradient to the garden area.

**Minimizing Disturbance to the Land**

With regard to minimizing the house's disturbance to the land, major effort was taken to retain several large mature cedar trees on the east, north and west of lot (including one with a former coyote den!) as well as the native fern understory. One very large cedar tree was topped in order to retain it in a safely. (Gibsons can be very windy in the winter.) A massive old cedar stump and native salmon berries were retained on the north (street] of the lot. The berm edges of the garden were retained in salmon berry. All natural vegetation areas were kept off-limits to equipment during construction to avoid soil compaction of the future garden.

The total area of the lot is 6,000 sq ft. (120' x 50'). Of this, the house footprint is only 1,040 sq ft, or 17% of the entire lot. The SmartHome's compact story and a half house plan not only minimizes the house footprint but also maximizes space available for native plants and garden. Approximately 40% of the lot remains in its pre-existing native vegetation, and about 45% will be cultivated into a food garden. The only ongoing disturbed portion of the lot is the driveway and parking area (about 720 sq ft.), which has been graveled rather than paved to minimize run-off impacts. Given the care taken in site preparation for the SmartHome, from the street the house now looks like it sits within a woodland and that it has been established for many years.

**LEED Link:**

**Sustainable Sites (SS)**

**SS 1.2 Minimize Disturbed Area (1 pt)**

**SS 2.2 Basic Landscape Design (2 pt)**

**SS 2.3 Limit Conventional Turf (3 Pts)**

**SS 2.4 Drought Tolerant Plants (1 or 2 Pts)**

**SS 4.1 Permeable Lot (4 Pts)**

**SS 4.3 Management of Run-off (2 Pts)**

**SS 6.1 Compact Development - Moderate (2 pts)**

The SmartHome's landscape design is well planned with only very limited grass being planted. In the garden a 15' x 15' lawn for use as a sitting area has been established using drought tolerant grass seed. This grassy area will be left un-watered and allowed to turn yellow during the summer as recommended by the Sunshine Coast Regional District Water Conservation program. All areas under trees are being retained in native vegetation (ferns, tall mahonia and salmon berry, thimbleberry and trailing blackberry). The south-facing slope in front of the house will be planted in hops (one of the owners brews his own beer!) and berries. As previously mentioned, the slopes on the garden edge berms have been planted in salmon berries and wildflower seeds. Other than garden vegetable plants (which will be drip irrigated), all installed plants will be drought tolerant and appropriate to the Coastal Douglas Fir Biogeoclimatic Zone in which Gibsons is situated.

Also of note is that all of the lot (other than the actual house site) is in permeable landscaping. This includes: the gravel driveway and parking areas; gravel paths; gravel north porch; wooden south deck (with gaps to allow water to drain to gravel underneath; the retained native vegetation areas; the vegetable garden; and the grass sitting area.

**Water Conservation and Management**

SmartHome's design criteria places high priority on water conservation and management. Key features include:

- Drip irrigation used for the garden
- Rainwater harvest using storage barrels that provide gravity fed water supply to the drip irrigation system
- No watering of grass or native plants
- Minimized use of grass to a small sitting area, the grass used is drought tolerant
- Lot permeability maximized: gravel driveway/parking area, paths, and drip-through wooden decks
- Use of cistern and sump pump to return run-off water to street storm drain (and/or delivered to drip irrigation system)
- Low flow toilets and plumbing fixtures

**LEED Link:**

**Water Efficiency (WE)**

**WE 1.1 Rainwater Harvesting System (currently 0 but 3 Pts potential)**

**WE 2.2 High Efficiency Irrigation System (3 Pts)**

**WE 2.3 Third Party Inspection (1 Pt)**

**WE 2.4 Non-Potable Water Irrigation System (currently 0 but 4 Pts potential)**

**WE 3.2 High Efficiency Fixtures (3 Pts)**

Because the owners of the Gibsons SmartHome place such high priority on growing a food garden, but are also sensitive to water conservation issues, a drip irrigation system will be installed in the garden. This will include:

- an irrigation timer
- a central shut-off valve
- drip irrigation to more than 50% of planting beds and

- separate zones for bedding areas based on irrigation needs

A roof rainwater harvesting system is installed using rain barrels (fed by gutter downpipes), which supplies water by gravity flow to the garden irrigation system.

### 3.4.3 Ecologically responsible materials

Another key environmental sustainability issue involved the use of ecologically responsible building materials in the construction of the SmartHome. This includes the use of Forest Stewardship Council (FSC) certified lumber where possible as well as the avoidance of tropical hardwoods. In fact, no tropical woods were used in the house. All wood used - structural, sheathing, siding, and decking - was from BC forests. The only possible exception may have been the maple veneer interior doors and trim, which might be from trees grown in eastern Canada.

**LEED Link:**

**Materials and Resources (MR)**

**MR 2.1 FSC (Pre-Req)**

### 3.4.4 Miscellaneous Exterior Considerations

**Heat Island Effect**

While more relevant for urban and warm climate locations, than the Gibsons area, nevertheless the SmartHome is designed to reduce the 'heat island effect'. The driveway, parking areas, north porch and side paths on the east and west are all shaded in summer by the existing large cedar trees that were intentionally retained during lot development and house construction. To further that, the driveway, parking areas and paths and are surfaced in light coloured gravel. The south side deck is built of unpainted treated wood that will weather to silver-grey.

**Non-Toxic Pest Control**

SmartHome was designed to provide pest control protection. Specifically:

- all external cracks, joints etc. were sealed
- there is no exposed foundation insulation
- all wood to concrete contacts were avoided through the use of plastic gaskets under exterior wall plates and post bases
- all mature plants are at least 24" distant from the home (including tree branches).

**LEED Link:**

**Sustainable Sites (SS)**

**SS 3.1 Reduce Heat Island (1 Pt)**

**SS 5.1 Non-Toxic Pest Control (1.5 pt)**

# 4.0 Building Specifications

The building specifications for SmartHome are rigorous, and therefore effective at achieving energy, cost and environmental efficiency. SmartHome construction is intended to meet and where possible, exceed the Building Code standards. The following section details specifications for:

1. SmartHome building **components**
2. the **operating systems** that enable the house to function in an energy and cost effective manner, as well as,
3. **room-by-room design criteria**.

## 4.1 Components

**Foundation and Slab Floor**

- 6" thick reinforced concrete perimeter foundation on footings
- 4" mesh reinforced concrete slab-on-grade; stamped and dyed darker (to increase solar heat absorption)
- slab is fully insulated with 2.5" extruded SM Styrofoam (R12) poured atop 6 mil vapour barrier on compacted sand pad
- all pipe penetrations through the slab are urethane foamed
- 1/2" PEX tubing in floor (mounted on 1" saddles) for hot water heating system with future solar panel connection lines

**Exterior Walls**

- 2" x 6" studs on 2 ft centres
- stack studs, trusses and ceiling joists for efficient framing and load bearing
- align windows with 24" on centre stud spacing, as long as other design items are not compromised
- use 2 stud corners
- eliminate use of headers when trusses carry roof loading
- frame in doorways for potential future add-on rooms

- align windows with 24" on centre stud spacing, as long as other design items are not compromised
- use 2 stud corners
- eliminate use of headers when trusses carry roof loading
- frame in doorways for potential future add-on rooms
- 1/2" plywood sheathing
- exterior wind (air) barrier: taped *Tyvek* house-wrap; or double building paper
- rain-guard barrier installed under siding
- 8" beveled clear stained cedar siding

**Interior Walls**
- 2" x 4" construction
- non-load bearing; trusses carry load of second storey/roof. This enables maximum floor plan flexibility
- 1/2" dry wall finish; use of drywall corner clips
- vapour barrier primer paint with low emission latex based paint on interior walls/ceilings
- clear stained wood doors and trims

**Roof**
- attic trusses are on 2 foot centres
- 1/2" plywood sheathing
- vented eave and peak
- asphalt 'life-time' shingle roofing (i.e. 30 years). (Metal roofing optional.)
- 1" x 12" wood fascia boards colour stained for design accent
- T&G clear stained wood soffits

**Ceilings**
- non-textured dry wall, vapour barrier primer; low VOC latex paint

**Floors**
- ground floor: stamped, dyed, sealed concrete
- cork in kitchen
- 2nd floor: 3/4 T&G plywood glued/screwed; carpet & underlay

**Windows**
- total window area: 205 ft$^2$ (NB: all window numbers cited are nominal size)
- windows focused on south side: 117 ft$^2$; or 57% of total glass
- north windows reduced: 36 ft$^2$ or 18%

- east windows (incl. skylight): 35 $ft^2$ or 17%
- west windows: 17 $ft^2$ or 8%
- no south or west skylights are used to prevent overheating; no north skylights are used so as to reduce excessive heat loss
- low E, double pane windows with vinyl frame; rated *Energy Star* Zone B, which is one zone more rigorous than required by Building Code for BC south coast
- opening windows are casement style for air tightness
- urethane foam filling with backer rod between rough opening & window
- air/vapour barrier sealed to window frame
- windows located for: light, solar gain, view, privacy and ventilation (both cross and stack venting)
- drywall return on windows with varathaned wood sills

**Doors**

- exterior doors:
    - 3' wide metal foam-filled with double pane windows
    - weather-stripped with sweeps for air tightness
    - foam filled around rough opening
- interior doors:
    - stain grade wood veneer; 2' 6" wide (may vary)
    - folding or sliding wood veneer closet doors

**Attic Hatches**

Since the attic area is very small and subdivided by trusses, it is of minimal utility. Hence it is not considered part of interior space and attic hatches are not required for regular homeowner access purposes. However, attic hatches are framed for emergency fire access (consistent with Building Code) with drywall cut and trim frame installed atop, to identify hatch locations. It should be noted that the air vapour barrier is **continuous and not cut** over the attic hatch portal. The hatch access portal is fully insulated.

## 4.2 Operating Systems

**Insulation**

- plastic foam gasket (two layers) is glued to exterior wall bottom plates (to isolate and air seal them from the concrete foundation)
- walls and ceiling insulated with high efficiency non-formaldehyde fiberglass:
    - R22 exterior walls
    - R40 horizontal 'exterior' ceiling
    - R28 sloped 'exterior' ceiling
- header spaces insulated with R12 *SM Styrofoam*

**Air Tightness**

**Air Tightness**

- 6 mil poly air/vapour barrier installed in 20 foot wide sections (for minimal seams) and caulked (using acoustical sealant for ongoing flexible seal) to exterior walls and ceiling framing members
- all locations where barrier seams occur have wood backing and are taped
- air/vapour barrier continuity ensured from first to second floor by use of caulked plywood panels between the trusses.
- the vapour barrier placed under the concrete slap extends upwards around its perimeter to enable it to be caulked to the exterior wall bottom plates and wall air/vapour barrier thereby ensuring air/vapour barrier continuity
- all penetrations of the air/vapour barrier by pipes and ducts are caulked and backed by plywood
- rubber gasket sleeves installed over plumbing drain pipes penetrating the air/vapour barrier to allow them to expand/contract without breaking the caulk seal. These gaskets in turn are caulked to the a/v barrier atop plywood backing plates.
- the air/vapour barrier is caulked to outlet box flanges on exterior walls/ceilings
- no pot lights are installed on exterior ceilings
- exterior ceiling junction boxes are placed in poly-pans to which the air/vapour barrier is sealed
- all wire penetrations (i.e. where they enter outlet boxes) are caulked
- the electrical panel is located on an interior wall to increase house air tightness
- the underground electrical conduit (that carries the main electrical cable from the meter to the panel) is sealed at one end with urethane foam to prevent air leakage
- the dryer air vent is fitted with an air tight spring-loaded cover

It should be noted that great care was taken when installing the drywall not to cut or puncture the air vapour barrier. This was done by measuring all drywall before it was cut and drawing on the stud and outlet box locations prior to screwing it in place. The house was blower door tested and exceeded 2 ACH @ 50 Pascal.

*Note: An alternative to using a caulked interior air vapour barrier is to use a taped exterior Tyvek barrier (on outside of wall sheathing) with an interior paint vapour barrier applied to the drywall. There is concern however that this approach could trap moisture in the wall in the moist, cool Vancouver area climate, which could lead to rot problems. To avoid this risk the choice was made for the Gibsons prototype to use an interior air/vapour barrier.*

**Ventilation**

- an energy recovery ventilator (ERV) is used to a pre-heat incoming fresh air with heat associated with air being exhausted from the house. Given the SmartHome's open installed in the dining area ceiling allows for whole house ventilation. This approach avoids the need for room-by-room ducting.

- bathroom fans with low energy DC motors are used (*Panasonic Whisper Green*) with a timer and humidistat.
- an air tight, spring-loaded dryer vent cap is installed to prevent leakage of warmed house air to the outside when the dryer is not in use.
- passive venting is ensured: opening windows are located to enable good cross venting and stack effect venting
- a through-exterior wall gate-vent is installed near floor level behind the fridge to enable fine-tuning of the house air change rate. This location allows pre-warming of any in-coming air by heat given off by the fridge coils.
- ventilation ducts are:
  - short in length
  - smooth metal
  - vented directly to outside
  - taped
  - insulated when exterior of the air/vapour barrier

**Heating**

- baseboards with thermostat room controls. These allow for room-by-room zone control and also use minimal floor area.
- hot water heating in main floor concrete slab using 20 gal electric HW tank (insulated). Plumbed for two zones and also for future possible solar panel tie-in
- passive solar contributes to house heating using larger south-facing windows
- the exposed insulated concrete floor slab serves as a 'solar battery' and moderates house temperature swings. The slab is dyed darker to enhance heat absorption and stamped and sealed for use as an attractive finished floor

- the south-facing sunshade helps stop summer overheating while allowing full solar exposure in winter
- there are no natural gas or wood appliances in the house so as to enhance air tightness. This also avoids need for combustion make-up air.

**Plumbing**

- plumbing is proximate and compact with runs from HW tank to fixtures less than 20ft
- the future second bathroom is rough-in plumbed only
- hot water pipes are insulated, including under the slab
- plastic PEX feed-water plumbing
- the 40 gal HW tank is located in house interior to aid space heating. *Note: Use of a tankless electric demand hot water heater would be preferable. This could reduce hot water heating costs by 15% or more and would save 4 sq ft. of floor area (that*

*could be used instead for storage). However, at the time of building the Gibsons home BC Hydro did not yet allow the use of electric tankless heaters.*

- the hot water tank is insulated
- low flow faucet and shower fixtures are used.
- low flow, two-phase toilets are used
- bathroom grey water can be linked to garden irrigation system (if permitted)
- municipal water/sewer hookup
- frost-proof outside faucets

**Electrical**

- underground service wire enables future expansion of house with no need to relocate service; conduit is sealed with urethane foam to stop air leakage
- 200 amp service
- panel located on interior wall to eliminate air leakage
- dimmers used on lights wherever appropriate
- LED (or CFL) lights used throughout house other than for halogen track lights. These halogen bulbs will be replaced once dimmable LED bulbs become available
- no pot lights are used where they would penetrate air/vapour barrier
- outlet boxes with flanges and seals are used on outside walls/ceilings to permit sealing to air/vapour barrier
- all wires caulked that penetrate the air/vapour barrier. Wood backing is provided where required
- heating and lighting wires are pre-installed to edge of framed-in door portals with accessible junction boxes to allow easy wiring of additional rooms if the house is expanded in future

**Communications**

- telephone hook up in: kitchen/dining room; upstairs office/bedroom
- cable hook-up in living room
- data centre/router beside electrical panel in entrance area
- all wires have wood backing and are caulked where they penetrate the air/vapour barrier

## 4.3 Room by Room Design Criteria

**Living/Dining Area**

- 292 $ft^2$ combined open plan provides spacious feeling
- dining area adjacent and open to kitchen;
- large south windows with view into garden
- exposed stamped and dyed concrete floor absorbs solar heat from south windows
- partially open staircase to upstairs enhances open feeling and interior ventilation

- passage ways through rooms informally define different use areas
- lights are on dimmers
- the TV area is wired for cable/internet

**Kitchen**

- Efficient U-shape kitchen: 100 $ft^2$; 10' x 10' counter; 4' well
- open plan and adjacent to the dining area with 3' wide peninsula, overhanging counter with stools tucked under
- appliances: white *EnergyStar* Kenmore or Frigidaire (energy and cost efficient)
- double stainless steel sink
- higher quality wood Ikea cabinets (attractive yet cost effective)
- lazy susan corner cabinets
- drawers for lower cabinets
- arborite counters; 25" deep; 36' deep' for peninsula counter
- good view to outside over peninsula counter to dining room and living room windows
- window over sink
- vent fan over stove; air-tight flapper valve on vent opening
- space for microwave
- track lighting on dimmer
- under-cupboard lighting on dimmer
- cork floor: comfortable to stand on
- main entrance door nearby

**Bedrooms**

- two with ability to increase to five (six)
- master bedroom: 140 $ft^2$; (10' x 14') (closet adds 20 $ft^2$)
- office/bedroom: 136 $ft^2$ (11' x 11' + 2.5' x 6') (+15 $ft^2$ closet); 1/2 wall and no door to enhance openness of stairwell and second floor ventilation
- future add-on bedrooms: 115 $ft^2$ (11.3' x 11.5') (+15 $ft^2$ closet)
- master bedroom closet: 8' x 2.5'
- smaller bedroom closets: 6' x 2.5'

**Bathroom**

- compact & efficient: 56 $ft^2$: 7' x 8'
- combined bath & shower: wall insulation and air/vapour barrier put in place behind unit prior to its installation to ensure integrity if barrier
- sink & vanity cabinet (4' x 2') with arborite counter
- medicine cabinet/mirror
- linen storage shelves: 3' x 1.'
- broom closet: 1.3' x 3'
- low flow fixtures
- low flow, two-phase toilet
- low energy DC vent fan with timer switch and humidistat

- bathroom with wheelchair accessible

**Second (Upper) Bathroom**
- rough-in plumbing only initially
- space for future sink and vanity, toilet, bath
- 2' x2' opening skylight
- low energy DC vent fan with timer/humidistat switch
- use for storage or computer nook on short term

**Laundry Area**
- include in or adjacent to lower bathroom under stairs with closet doors
- stacking *Energy Star* front-loading washer/dryer: 2.5' x 2'
- 40 gal insulated HW tank under stairs (or tank-less electric demand heater if permitted)
- 20 gal HW tank (insulated) for infloor heating
- floor drain

**Storage**

- total inside storage > 20' by 2.5'
- entrance area: coat hanging and shoes (3' along wall with shelf)
- coat closet near entrance (in HW/ laundry space under stairs) (3' x 2.5')
- linen closet in bathroom (3' x 1')
- broom/cleaning materials closet (1.3' x 3')
- bedroom closets: 'master: (8' x 2.5'); standard (6' x 2.5' )
- possible north side porch outside storage area ( 4'x 8')
- outside garden storage shed (10' x 8'); insulated, vented, with lighting and heat if required. Also with 2' outside covered alcove extension for garden tools

**Stairs:**
- 3 feet wide
- 3' x3' landing at bottom and top
- minimize stairs incursion on living room
- total run of 13' with 14 risers @ rise = 7 5/8"; run = 9 1/4"
- use of winder
- partial open railing
- HW tanks and coat closet under stairs

**Access Passages**
- halls eliminated
- access passageways through open plan rooms are 3' wide
- for single floor house wheelchair accessible
- on-grade entrances (no stairs)

# 5.0 Building Sequence

The key reason the SmartHome can achieve the cost, energy and space efficiency it does is related to the planning that goes into it. Building the Gibsons prototype took just 3 months from breaking of ground to occupancy. This short construction period resulted in benefits including reduced homeowner stress and much reduced construction finance interest charges. When the house was completed it came in exactly on budget. The fact that this was achieved is due to the attention afforded to the SmartHome's design (as discussed above) and also the decision, project management and construction sequence that was followed. To assist others who might like to build a SmartHome, the sequence that the Gibsons prototype went through is detailed below.

## 5.1 Initial Financial and Real Estate Analysis *(prototype timing: December 2010)*

- decide whether to **rent or own?**
- decided whether to **buy an existing house or build a new one?**
- *After having viewed numerous homes in the Gibsons area, the prospective owners had a good sense of the real estate prices and the quality of the available housing stock on the market. Quite high prices of existing houses of lesser quality houses led to a decision to explore the possibility of building a new home*
- determine: **is building a new home is feasible**? Determine the budget available to the prospective owners to build new house. *Affordability was the primary concern. The prospective owners had to identify the maximum price they could to pay for a home. The intention was to keep the home mortgage within CMHC maximum affordability measure of 32% of pre-tax on a 25-year mortgage and to also be able to absorb a 2-3% increase in mortgage rate. Size of possible down payment factored strongly into this calculation.*
- Develop **preliminary construction budget:** determine whether the SmartHome can be built at a price that is affordable.
    - get **bank pre-approval on the mortgage** to required borrowing level for new home based on preliminary budget

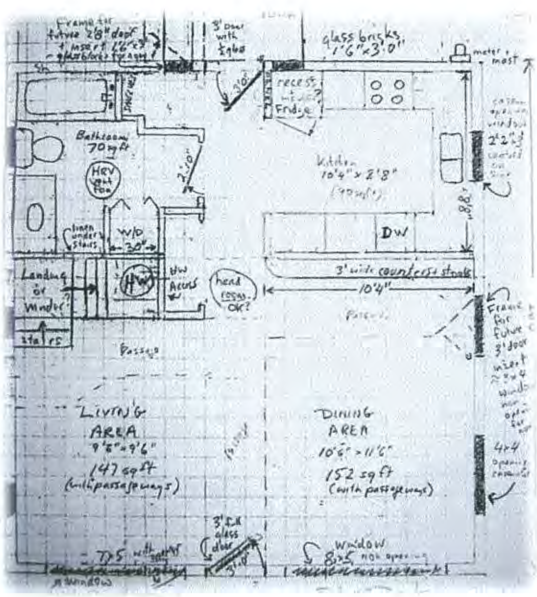
## 5.2 Lot Selection & Purchase *(January 2011)*

- identify **neighbourhood location criteria**
- research municipal **zoning**
- **research/view lots for sale** and determine pricing
- **select realtor**
- commence purchase by negotiating with seller and reach **Agreement for Sale** including deposit & subject to clauses

- due diligence research re: **subject to clauses; permit/hook-up etc. costs**
- arrange **land financing; construction loan, down payment & mortgage**
  - **remove subject to clauses**
- **lawyer and conveyancing**
  - **closing of sale and possession of land**

## 5.3 House Design (January - February 2011)

- **formulate house design criteria**
- **research building methods and products**
- **formulate house specifications**




- get builder, friends, inspector **feedback and refine design criteria & specs**
- identify whether: **one or two story design; east/west or north/south house orientation**
- design **floor plan(s)** incorporating the following elements:
  - o room orientation and size
  - o traffic pattern and doors/access
  - o stairs and landings
  - o kitchen layout
  - o bathroom layout
  - o laundry area layout
  - o utility spaces (including panel and hydro link)
  - o heating & plumbing layout
  - o storage spaces
- determine **foundation type**
- design **house elevations**, including windows to get architectural balance
- get **feedback and refine floor plan** and design
- **check zoning re: setbacks**; plan house site for
  - map **lot layout** including:
    - o future expansion possibilities
    - o driveway
    - o garden area
    - o side access routes
    - o utilities corridor routing (hydro, water, sewer, gas)
- develop detailed **house construction cost spreadsheet;**
- ensure house **design can be built within budget**

## 5.4 Pre-Construction (February - March 2011)

- **shop for builder and get house construction estimates** from at least three (unless owner will be the general contractor or the builder)
- **select builder**

- have **plans drafted professionally**
- get **builder to cost out drafted up plans**
- **revise/refine plans** if required
- **negotiate fixed contract price** and specifications with builder
- sign building contract with builder
- **revise home budget spreadsheet** based on builder contract agreement
- **track contract cost** throughout project to ensure stay on budget
- get **structural engineering** and approval
- get **geotechnical survey** and approval
- **submit plans to building inspector and get permit**
- get **bank appraisal** based on plans
- **finalize construction loan** so can start draws when building starts

## 5.5 Lot Preparation *(March 2011)*

- **talk to neighbours** about intentions
- **log &/or top trees**; dispose of wood
- **level lot**
- **finalize house site** location
- **get survey** to ensure within setbacks
- get portable **toilet; waste bin**
- **excavate house site,** fill & compact
- lay in **drains:** perimeter/curtain drains and storm sewer
- lay in **sewer, water, gas lines and power cable** (if underground)
- arrange for **construction power:** generator or temporary service
- put in **driveway** and culvert

## 5.6 Construction (April 1 - July 31)

### *5.6.1. Foundation and Yard*

- **form up foundation**
- **perimeter insulation** of foundation
- **pour foundation** concrete
- **strip forms**
- **foundation inspection**
- **back fill** foundation
- **spread top soil** and contour lot
- **seed top soil**

### *5.6.2 Framing*

- **frame and sheath exterior walls**
- **install attic trusses** with crane
- **sheath roof**
- install **roof shingles**
- install **upstairs floor**

- install **windows; exterior doors**
- install **building paper/house-wrap** & window peel & stick
- install pre-stained **siding**
- install pre-stained **exterior trim**
- install **gutters**
- install **decks & porches**

### 5.6.3 Interior Floor

- **sub-slab fill** and compact
- **sub-slab plumbing and electrical conduits**
- **under-slab vapour barrier and insulation** (Styrofoam)
- install **reinforcing mesh**
- install **slab water heating tubing** (PEX)
- **pour slab using dyed concrete**
- **stamp pattern in slab**
- **highlight dye pad**
- **seal pad**

### 5.6.4 Utility Systems

- **rough-in plumbing**
- **plumbing inspection**
- **rough in wiring** including panel
- **hydro** hook-up
- **ventilation system**: ERV, duct work
- **electrical inspection** (if owner build)

### 5.6.5 Insulation and Air/Vapour Barrier

- **insulate** walls and ceiling
- **widow/door cavity insulation**
- **air/vapour barrier installed**
- **ductwork insulated**

### 5.6.6 Interior Finish

- **drywall walls and ceilings**: board and mud
- **paint interior**: prime and 2 coats
- **kitchen/bathroom cabinets**
- **kitchen/bathroom counters**
- **plumbing fixtures**
- **electrical fixtures,** including baseboard heaters and ERV
- **flooring:** carpet on stairs and second floor; cork in kitchen
- **interior doors**
- **interior trim**
- **shelving,** towel racks etc
- **hot water tank**
- **appliances: stove, fridge, dishwasher, washer dryer**

## 5.7 Final Items *(July 2011)*

- **gravel driveway** and paths
- **clean up lot**
- **start garden, lawn and landscaping**
- **occupancy permit**
- **move in**

## 6.0 Performance

Once the Gibsons' prototype SmartHome was built and its owners had moved in, the next key step was to analyze what it had in fact cost to build and also to begin to monitor the house's performance to see if it would operate as expected in terms of its energy and cost efficiency. Section 6 provides a breakdown of the SmartHome's:

- Actual Construction Costs
- Affordability Calculations
- Energy Efficiency Performance

### 6.1 The SmartHome Prototype Costs

***A) Land***

| | | |
|---|---|---|
| Land Cost | $165,000 | |
| Lawyers Fees | $985 | |
| Loan Interest | $1,960 | |
| Tree Felling | $1,700 | |

**Land Total** [a]
**$169,645**

| | | | |
|---|---|---|---|
| ***B)*** | ***House*** | | |
| | House Plans [b] | | $1,830 |
| **C)** | **Building Company House Construction Cost** [c] | | $146,804 |
| **D)** | **Materials Costs Paid by Owners** | | |
| | Plumbing materials | $3,100 | |
| | Painting materials | $1,237 | |
| | **Subtotal** [d] | | $4,337 |
| **E)** | **Labour Donated by Owners** | | |
| | Plumbing | | |
| | Materials | $620 | |
| | Labour | $5,580 | |
| | Trim paint labour | $300 | |
| | Interior paint labour | $1,762 | |
| | Clean-up | $2,000 | |
| | **Subtotal** [e] | | $11,262 |

**F) Building Company Management Fee**
**@ 10% if donated labour was billed** [f] $1,126

**G) Total House Cost Pre-HST** [b+c+d+e+f] $165,359

**Tax on house @ 6% (with rebate)** $9,922

**House Cost with tax** [g]
**$175,281**

**Total Land and House Cost incl. tax** [a + g]
**$344,926**

**Bank Appraised Value** (determined from plans)
$355,000

**Pre-Tax Sq Ft Cost to build** ($165,359/1091 sq ft)
**$152/sq ft**

## 6.2 Affordability

The Canadian Mortgage and Housing Corporation (CMHC) considers that for a home to be affordable monthly housing costs shouldn't exceed 32% of homeowners' gross (i.e. pre-tax) monthly income. According to CMHC, such housing costs include: mortgage payments, taxes and heating expenses. To enable the housing costs of the Gibsons' prototype to be determined, the owners have tracked these items for a year.

**Scenario 1: Annual Housing Costs with 20% Down-payment:**

| | |
|---|---|
| SmartHome total cost: | $345,000 |
| Down payment @ 20% of total cost: | 69,000 |
| Amount to Mortgage: | 276,000 |
| | |
| Mortgage Payment (@3.5%; 25 yr): $1378/month x 12 = | 16,536 |
| Property Tax: | 1,295 |
| Municipal Tax: | 382 |
| Heating & electricity: | 931 |
| | |
| Total Annual Housing Cost: | $19,144 |

**Household Income required if housing costs @ 32% pre-tax income:**
**$59,825**

**Scenario 2: Annual Housing Costs with 5% Minimum Down payment:**

| | |
|---|---|
| SmartHome total cost: | $345,000 |
| Down payment @ 5% of total cost: | 17,250 |
| Amount to Mortgage: | 327,750 |
| Mortgage Payment (@3.5%; 25 yr): $1636/month x 12 = | 19,632 |
| Property Tax (annual): | 1,295 |
| Municipal Tax (annual): | 382 |
| Heating & electricity (annual from SmartHome Hydro bills): | 931 |
| Total Annual Housing Cost: | $22,240 |

**Household income if housing costs @ 32% pre-tax income: $69,500**

## 6.3 Energy Efficiency

**SmartHome Energy Performance Data:**
**Year One (4/8/2011 - 31/7/2012)**
**BC Hydro Homeowner Billing Data**

**Electricity Usage**

| | |
|---|---|
| • One year electricity usage: | 11,030 kwh |
| • Monthly average electricity usage: | 919 kwh |
| • Monthly maximum usage (January 2012): | 1,321 kwh |
| • Monthly minimum usage (July 2011): | 429 kwh |

**One-Year Electricity Cost**

| | |
|---|---|
| • One year electricity cost (pre tax): | **$931.27** |
| • One year energy credit discount: | **$65.19** |
| • One year net electricity cost (pre tax): | **$866.08** |
| • HST Tax: | **$111.66** |
| • Total One year electricity cost: | **$977.74** |
| **Monthly Average Electricity Cost:** | **$81.48** |

**Apportioned Annual Electricity Usage**

- **Appliances** annual usage based on Energuide ratings): **2355 kwh or 21%**
- **Hot Water** annual usage: Energuide rating $507/yr
  - which is 52% of total cost;
  - hence hot water electricity usage = 11,030 x.52 = **5736 kwh or 52%**
- **Space Heating** annual usage = 11,030 - (2355 + 5736) = **2939 kwh or 27%**

**Apportioned Average SmartHome Monthly Electricity Cost**

| | | | |
|---|---|---|---|
| • **Appliances** | @ 21% x 81.48 | = | **$17.11** |
| • **Hot water** | @ 52% x 81.48 | = | **$42.37** |
| • **Space Heating** | @ 27% x 81.48 | = | **$22.00** |
| **TOTAL** | @100% | | **$81.48** |

# 7.0 Education and Awareness for Community Smart Growth

Since SmartHomes are more affordable, they offer the potential to revitalize smaller communities near to major high-price cities (especially Vancouver) by attracting younger residents - especially knowledge workers - to raise their families. As well, they can be attractive to seniors looking to downsize their housing. Therefore SmartHomes can promote diversification of homeowner demographics by broadening the range of affordability for lower-middle income earners.

**LEED Link:**

**Location Linkages (LL)**

**LL 2 Site Selection (2 Pts)**

**LL 3.2 Infill Lot (2 Pts)**

**LL 4.1 Existing Infrastructure (1 Pts)**

**LL 5.3 Outstanding Community Resources/ Transit (3Pts)**

**LL 6.1 Access to Open Space (1 Pt)**

## 7.1 SmartHome Encourages Smart Growth Community Development

### Location is Key

SmartHomes are ideally built on lots within walking and biking distance to stores, services, schools, parks etc. This minimizes car usage thereby saving energy, and money. Ensuring outstanding community resources and nearby transit access is key to its location. Accordingly, the Gibsons SmartHome is located within easy access of 40 shops and restaurants, a high school, elementary school, dental office, ambulance station, fire station, arts theatre, church, veterinarian, and the Royal Canadian Legion.

Having nearby access to open space is also a highly desirable quality when choosing a house location. A ravine and creek natural area, which is legally designated as Green Space under the Gibsons Official Community Plan is and also under the Town' s Zoning Bylaw, is located directly across the street from the Gibsons SmartHome. As well, a children's neighbourhood park with playground is located only one block away.

### Site Selection

The Town of Gibsons encourages and has a priority for in-fill lot development within its boundaries. SmartHome is built on an in-fill lot with utilities and road already available to the property line. The home is also well suited to being built on a smaller 'cottage lot'. These 3000 sq ft lots are becoming a key component of new subdivisions in Gibsons as the Town pursues higher densification, Smart Growth principles and tries to provide cheaper building lots. As such the SmartHome concept is clearly consistent with Town zoning, and the Official Community Plan and the building permit process.

**LEED Link:**

**Awareness and Education (AE)**

**AE 1. Operations Training (Pre-Req)**

**AE1.2 Enhanced Training (1 Pt)**

**AE 1.3 Public Awareness (1 Pt)**

## 7.2 SmartHome Offers Education and Awareness Opportunities

### Enhanced Training

SmartHome offers training and skills development opportunities for the construction and building trades. In the case of the Gibsons prototype, on-site training sessions included:

- Understanding the energy efficiency/sustainability intent of the house - including LEED certification;
- Training for specific key energy efficient construction details and techniques (e.g. air/vapour barrier installation etc.).

Both Wakefield staff, and all sub-trades had the benefit of this training as it was necessary to ensure the best quality of work for the maximum performance of the house. Training was ongoing throughout the project. It was delivered by the designer, Ric Careless, who drew upon his Cranbrook Energy Centre experience in training builders/trade in energy-efficient construction techniques. Typically, the designer was on-site several times each day, and was readily available whenever an issue arose.

### Public Awareness

The Gibsons SmartHome offers a showcase example for the community as a whole. In addition to educating the SmartHome owners, it also provides an opportunity to build general public awareness of key principles for choosing to live sustainably.

Multiple tours were given through the house during its construction, this included: the Town of Gibsons Mayor and councilors; Town of Gibsons planners; the Sunshine Coast Regional District Energy Coordinator, members of the BC Spaces for Nature Board of directors; and several interested members of the public, including some who are currently considering building a SmartHome. This awareness can help inspire people to think more about making choices to live more sustainably.

## 7.3 Proposal for a SmartVillage Development in the Town of Gibsons

Once the SmartHome construction was complete, and the house performance verified, the work with Wakefield Homes moved into a second phase to examine the feasibility of developing a SmartHome subdivision within the Town of Gibsons.

Work was carried out by BC Spaces and Wakefield staff (including Wakefield's owner and CEO). Eventually, a 'SmartVillage' subdivision comprised of 14 SmartHomes was proposed for development.

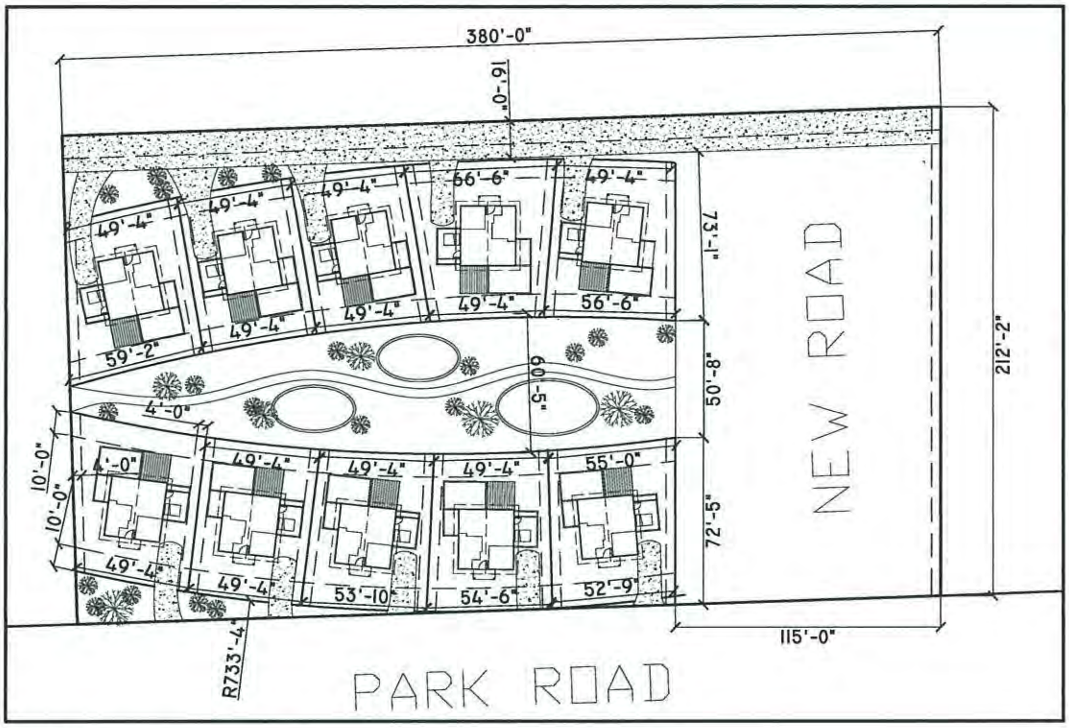
This SmartVillage subdivision development offered an opportunity for Wakefield to broaden their "Deep Green" business philosophy, to include cutting edge, affordable housing that would appeal to a wide range of young families, first-time home buyers, and down-sizing seniors - not their typical client, however, a recognized emerging market that they had yet to capture.

For BC Spaces, developing such a subdivision offered an opportunity to further refine the SmartHome concept and design criteria within a fully commercial context. As well, BC Spaces' goal of achieving a new vision for housing in Smart Communities would be fully realized and demonstrated though the construction of the SmartVillage.

With both partners fully engaged, the team prepared a *Pro Forma* financial analysis, which demonstrated that the subdivision would indeed be financially viable. Concurrently, a search was undertaken for appropriate properties on which to build the SmartHome subdivision. A key objective of the SmartVillage project would be to get the 14 homes LEED certified, ideally to the highest level: Platinum. This would both demonstrate the sustainable design associated with SmartHome and enhance the marketing of the SmartVillage. As previously indicated in this report, the requirements for LEED certification are such that location and lot selection are of critical importance in order to satisfy a number of scoring criteria. Specifically this meant finding a parcel of land for the subdivision that was near community amenities – within walking and biking distance – as well as accessible by public transit services.

Several possible locations were considered. Initially, the cottage lots in the Upper Gibsons Parkland development were assessed. While these lots held promise in terms of their pricing and location, the Parkland Land Development Design Requirements were not at all suited to SmartHome. The requirement to construct a car garage - *not* a desired SmartHome item - as well as a back laneway, dramatically reduced the lot size for SmartHome. Once the required lot setbacks were considered, this actually rendered the lot too small to allow for the expandability of SmartHome, and also did not allow adequate yard space for a food garden. These limitations would seriously impact on the SmartHome design concept. Therefore the decision was make to look elsewhere.

Next investigated, was the possibility of developing SmartVillage on a lot in Upper Gibsons (see Park Road subdivision plan). This location and lot appeared to be very promising, and hopes were high. Unfortunately, upon meeting with the Town of Gibsons, it was discovered that a large section of the lot had already been assigned for road right of way. As well, additional development charges would need to be incurred to bring utility services to the lot line. The road allowance requirements meant reducing the SmartVillage from the initial 14 SmartHomes down to 10. Based on the *Pro Forma* analysis, this reduction in the number of houses coupled with the




PROJECT:
PARK ROAD DEVELOPMENT
NOT TO SCALE - 10TH OCTOBER, 2011

increase in lot development costs, meant that this property also became unfeasible. A third location in upper Gibsons was considered . Again it was discovered that this property also needed a large road designation as well as a bridge to allow access. Once again, these extra site expenses deemed this location unsuitable for the proposed SmartVillage development. Further land searches were attempted, but turned up empty.

Consequently, the challenges around land availability, land costs, and town development requirements, required t the SmartVillage development be temporarily put on hold. However, the idea and concept is still very much alive, and SmartVillage development idea will be revisited with Wakefield again in the coming year.

# 8.0 Next Steps

Now that construction of the SmartHome is complete and the house performance has been tracked for a year, the potential of SmartHome is becoming clearer. Several opportunities now present themselves going forward:

- exploring a collaboration with the Town of Gibsons to develop affordable SmartHome housing on available cottage lots
- the production of online resources to educate and showcase and the potential for SmartHomes and Smart Communities regionally and beyond
- a publicity/outreach campaign to increase SmartHome's profile as a precedent-setting model for home design

## 8.1 Partnership with Local Government

The ability of SmartHomes to capitalize on energy efficiency as well as offer affordability benefits to the community as a whole, has piqued the interest of Town planners in Gibsons. Meetings with planning staff at the Town have resulted in the identification of several ongoing opportunities whereby SmartHome not only compliments, but also furthers Town goals as they relate to:

- Supporting the Town's mandatory reduction of GHG emissions to meet the required provincially established goals – specifically, the creation of a Town of Gibsons SmartHome program was discussed as a means to compliment and further the goals of the Upper Gibsons Geo-Exchange District Utility project
- Development that fits two new zoning designations, for cottage lots and cluster housing, that form the majority of new housing to be developed in the Town of Gibsons under three of its most recent neighbourhood development plans
- Meeting the goals and aims of the Town's housing mandate to increase the supply of affordable/attainable housing in the community
- Encouraging housing that supports the Town's Affordability and Community Amenities Policy
- Promoting local sustainable economic development through a housing development model that emphasizes training for local trades by a local organization, the employment of local services of builders, and the purchase of materials from local suppliers, thereby creating growth that re-invests back into the local community

## 9.0 Conclusion

Given that SmartHome has the capability to achieve LEED Platinum Rating for its energy efficiency/environmental sustainability, and is also compact, affordable and expandable, this prototype house design can serve as a precedent-setting style of housing. Quite simply, SmartHome has the potential to be tomorrow's house today.