Excellent performance of the first active house in Canada

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The number of realized Active Houses has already proofed that it is possible to make energy efficient buildings without compromising good indoor climate and building components lowering environmental impact. Projects as Home for Life, Lichtaktivhaus, Maison Air et Lumiere shown how to design and build with the focus on people's health and well-being, furthermore by inviting the families to test the buildings and sharing their positive experiences the success of these experiments was lastly confirmed. The thorough investigation has been made to determine standard building solutions in the region and show the alternative solutions that can bring the house to higher standard.

Keywords: nZEB, nealy zero energy building, low energy building, energy efficiency, active house, daylight.

Figure 1. Great Gulf Active House in Ontario, Canada, South façade. Interior is filled with natural light.

FACTS

Builder: Great Gulf

Design:
- Superkül Inc. Architect
- Enermodal Engineering, a member of MMM Group
- Quaile Engineering
- Building Science Corporation
- Building Knowledge Canada Inc
- Enerquality verified for "Energy Star" and "Green House" certification
- "Brockport Built" Fully panelized home Ensuring precision and quality
- Danish Technological Institute
- VELUX A/S, Building Industry

Area: Lot area: 600 m^2
Ground Floor: 153 m^2
Upper Floor: 154 m^2

Location: Thorold, Niagara Region, Ontario, Canada

Great Gulf Active House

The Great Gulf house was built in Thorold, Ontario, a community located in the Niagara Region and roughly 90 minutes west from Toronto, this demonstration building was achieved through a collaboration involving a team of Danish architects, the award-winning Toronto architecture firm superkül, and Great Gulf, the builder committed to bringing the Active House concept to Canada. Using the design guidelines of a traditional gabled roof design and adapting them for the Active House yielded a streamlined multi-functional roof design that provided a basis for double-height spaces and opportunity for excellent daylight conditions provided by multiply windows. The house is oriented with the long roof slope and major glazing facing south to maximize the efficiency of the solar hot-water system and passive solar gain.

Two intersecting axes guide the open plan of the interior to maximize cross breezes. By removing visual barriers between living spaces, the open plan also creates the impression of a larger home. To promote the comfort of the residents, superkül ensured that each room featured exterior views without compromising privacy. The patio that aligns with the width of the living room reinforces the visually seamless extension of the interior spaces.

The Great Gulf Active House scores excellently in all of Active House categories (**Figure 2**) which is an achievement taking into account that many already popular in Europe building techniques, components – as highly efficient windows are not yet common in production home building in Canada. In addition to it, the project refers directly to the standard house meeting requirements of Canadian building code (**Table 1**) and shows the comparison between enriched version realized according to Active House principles.

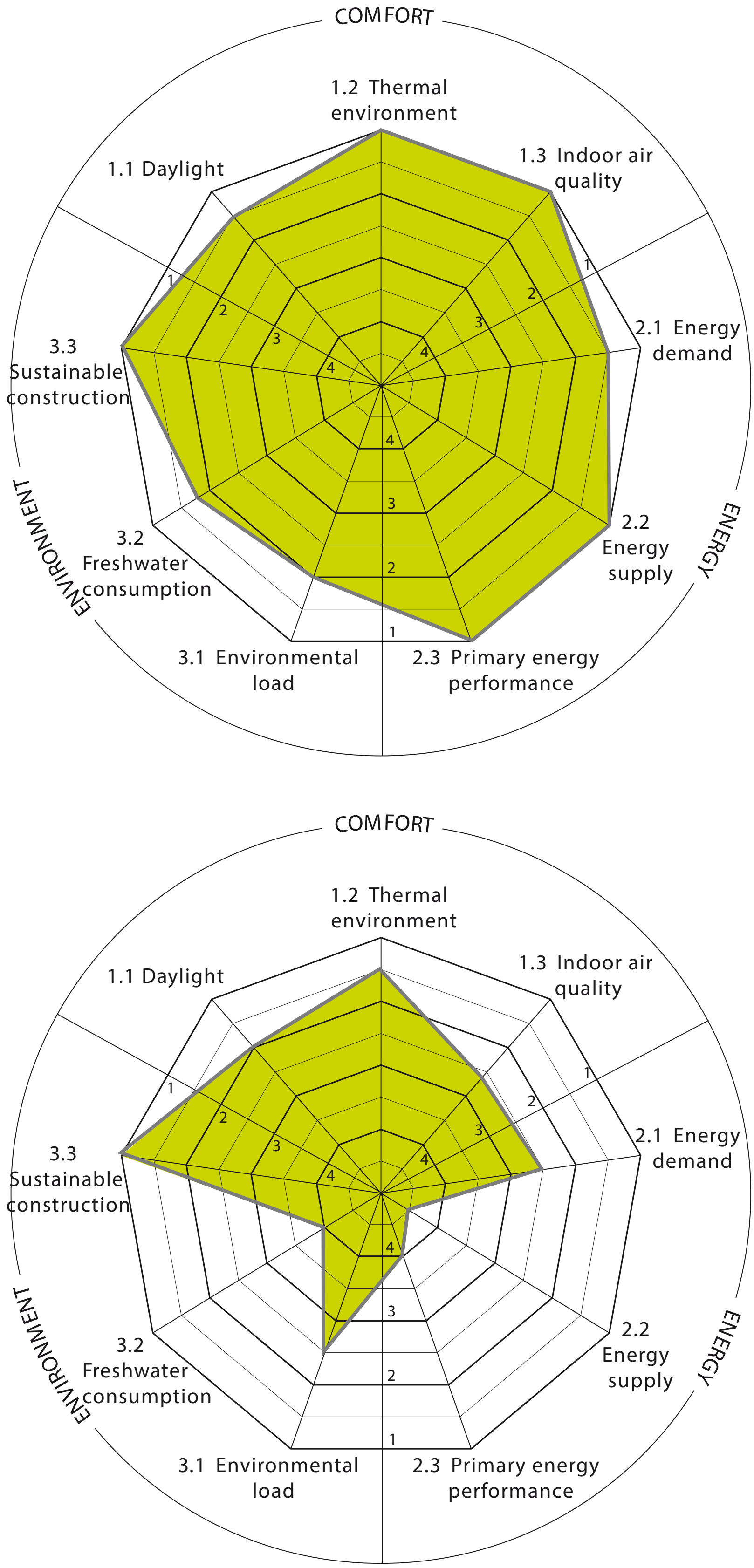

Figure 2. Active House evaluation for Great Gulf Active. House above and for standard house below (approximation), the results shown are based on calculations.

Daylight

The multitude of skylights and windows create naturally light-filled spaces and minimize the need for artificial light. This occurs even in the secondary living spaces where a skylight brings light to the shared washroom between the two adjoining bedrooms, or in the Master Bathroom where three skylights are complemented by a nearby horizontal window. The Danish design team modelled extensive computer visualizations to avoid insufficient levels of natural daylight in nearly every space of the home (**Figure 3**). Their work supported the

Table 1. Values show the differences in technical properties between Great Gulf Active House and standard house (the same project without 'Active' elements designed to meet the building code).

	Active house	Standard house
Windows & Energy		
Glazing (%)*	21.6%	16%
Facade windows	Triple glazed (0.97–1.19 W/(m²K))	Double glazed (< 1.6 W/(m²K))
Low/high heat gain by orientation	Yes	No
Skylights	Yes (2.29 W/(m²K))	No (< 2.8 W/(m²K))
Electric venting windows & skylights	Yes	No
Insulation		
Walls	0.17 W/(m²K)	0.26
Basement walls	0.47 (outside of wall)	0.47
Basement slab	0.75	–
Ceiling without attic	0.15	0.18
Mechanical		
Space heating AFUE *	97%	>94%
Zoned heating	Yes	No
HRV **	83%	>60%
Solar Water Heating	Yes	No
Grey Water Heat recovery	Yes	No
Cistern (toilets, irrigation)	Yes	No
Other		
Permeable driveway	Yes	No
Home Automation	Yes	No
Pre-fab panels	Yes	No
LED lighting	Yes	No
Durable, long lasting, low VOC finishes	Yes	No

*AFUE = annual fuel efficiency

** HRV =nominal efficiency of heat recovery in ventilation

architects' ability to select the most efficient sizes and the most effective locations for the skylights. The architects were able to maximize direct and indirect light, which can be reflected of walls, ceilings and the white hardwood strip flooring to help increase light reflectivity.

Thermal Comfort

The thermal environment of the Great Gulf Active House optimizes comfort and efficiency by using zoned heating, a modulating blower fan, and industry leading equipment which also ties into two HRVs (heat recovery ventilation). A modulating fan is used to deliver fresh conditioned air through the ducting system to each room, and since it can modulate down to a low speed, it can run continuously and more quietly to deliver fresh air to each room, even when heating and cooling are not being used. The house is divided in two zones by floor; in each there is centrally placed thermostat to control the desired daytime and evening temperatures, turning on the heating system or

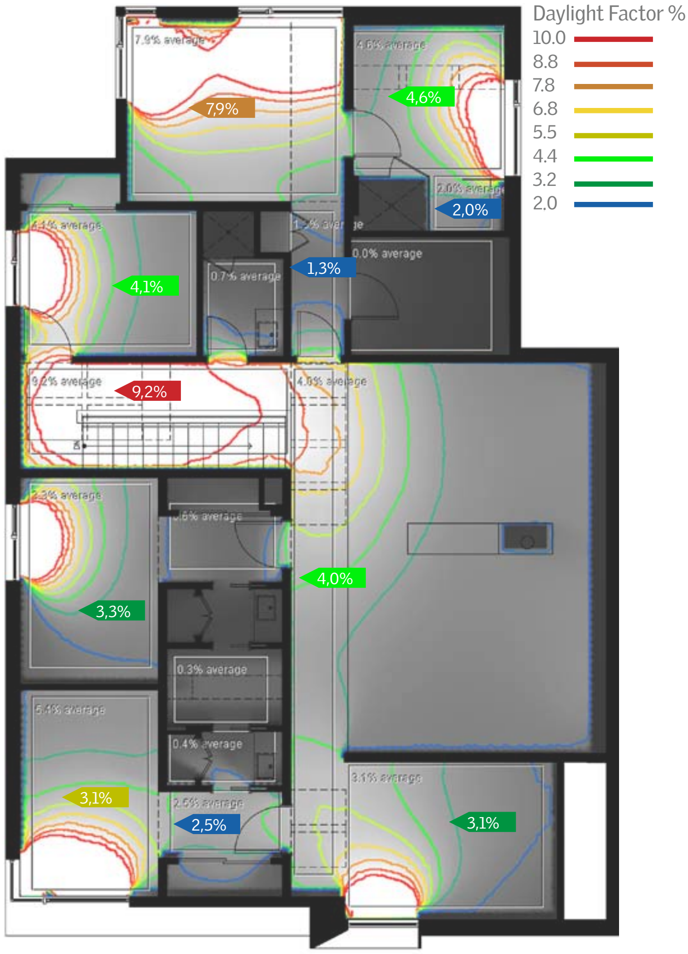

Figure 3. Daylight Analysis of the Upper floor.

Daylight factor

The daylighting performance of the Great Gulf Active House has been measured using the daylight factor (DF) as the performance indicator. The daylight factor is a common and easy to- use measure for the available amount of daylight in a room. It expresses the percentage of daylight available inside, on a work plane, compared to the amount of daylight available outside the building under known overcast sky conditions.

The higher the DF, the more daylight is available in the room. Rooms with an average DF of 2% or more are considered daylit. A room will appear strongly daylit when the average DF is above 5%. The daylight factor analysis has been performed using computer simulation software Daylight Visualizer.

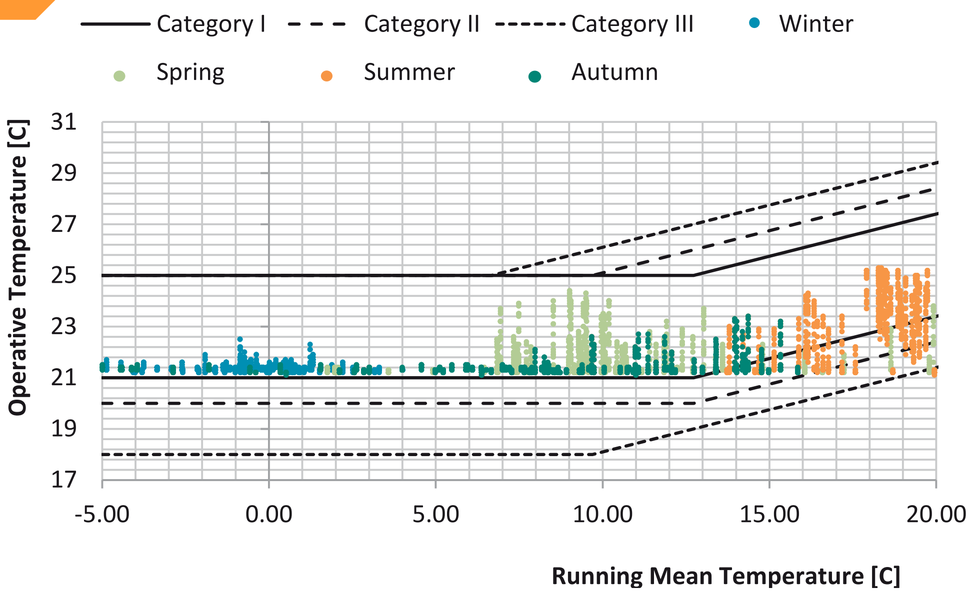

Figure 4. Indoor temperatures in the master bedroom plotted against running mean outdoor temperature for each hour of the year including Active House requirements. The dots are coloured to represent a season. The results shown are based on calculations.

air conditioner as needed on that floor. The duct work is insulated and sealed to ensure enough conditioned fresh air reaches each room. The benefits of a dual-zoned system allows occupants to heat their bedrooms at night while lowering the temperature of unused living spaces. The control-system that leads to the results is based on the assumption that the open motorized windows will provide adequate cooling until the indoor temperature reaches 24°C. If the temperature exceeds 25°C, the mechanical cooling will be activated and the windows closed.

The thermal environment in the building scores 1 (**Figure 4**). The score is a result of the combination of natural ventilation, the possibility of mechanical cooling on warm days and zoned heating during cold days.

Indoor air quality

The high indoor air quality and energy efficiency is assured by hybrid ventilation that contributes to providing an excellent indoor air quality with score 1 (500 ppm above the outdoor CO_2 concentration). Natural ventilation is encouraged by a dual-zone HVAC system connected to a Somfy Tahoma Smart House system that uses sensors to automate the windows, blinds and 14 skylights to open and close in response to the interior temperature and air quality. Openable, motorized windows provide cooling below 24°C, above the control system switches mechanical ventilation on (**Figure 5**).

The mechanical ventilation with two heat recovery ventilation, HRV units supply the house with fresh air through the furnace intake (**Figure 6**). Fresh air is pre-conditioned by one of two HRVs in the home. An HRV is a heat exchanger that uses the warm air being

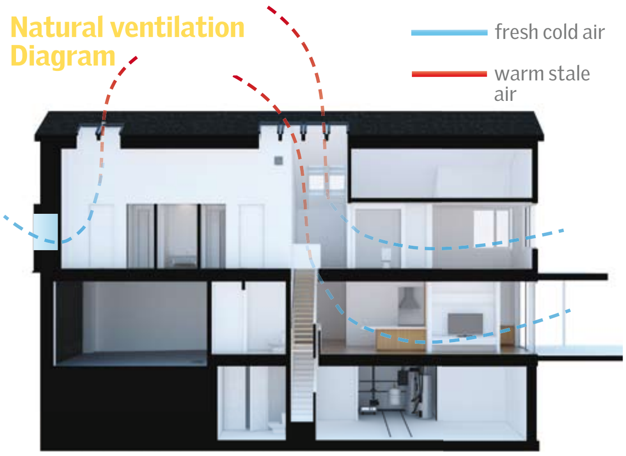

Figure 5. Openable motorized skylight windows can be used for ventilation and free cooling.

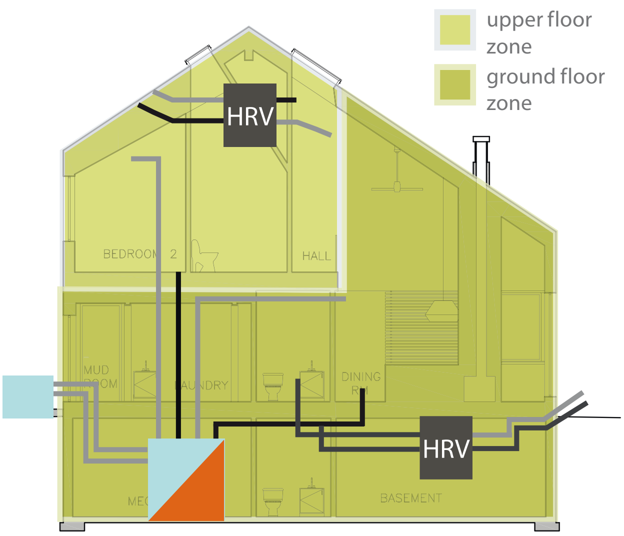

Figure 6. Two zones mechanical heating/ventilation system providing ventilation to each room separately.

exhausted from the home to pre-heat outside winter air coming in. Likewise, in the summer the HRV can pre-cool fresh air coming into the home which reduces the energy needed to heat and cool the home while providing ample amounts of fresh air to all rooms. A second HRV is located in the conditioned attic near the master bedroom and ensures each bedroom has ample amounts of fresh air, important for a good night's sleep. The air change rates and the volume of the house along with many other parameters have been accounted for.

Energy performance

Great Gulf Active House boasts fully integrated systems designed to optimize natural lighting and air quality while reducing its dependency on non-renewable energy sources. House annual energy demand is very low, **Figure** 7 (1,5 according to Active House specification what indicates ≤ of 50 kWh/m²) what is result of a design strategy utilizing natural energy resources like solar gain, natural ventilation, efficient technical equipment, heat recovery, a well-insulated and air tight building envelope and fenestration with a low U-values. The compactness achieved by building in two storeys with a finished basement also has a good effect on the energy performance. The grey water heat recovery unit captures heat from showers and baths and preheats incoming cold water which helps to reduce the energy demand for the domestic hot water. The energy supply is a combination of heat from the solar thermal panels and renewable gas from Bullfrog Power, the heat supply is considered as being 100% renewable. The electricity is also supplied by Bullfrog Power which comes in 100% from renewable sources. The score of the energy supply and primary energy performance is 1.

Environmental performance

Waste Water Heat Recovery

RenewABILITY Energy's Power-Pipe is a heat exchanger that is comprised of standard plumbing components: copper fresh water coils wrapped very tightly around an inner Type "DWV" copper drainpipe. As fresh water flows up the multiple fresh water coils, warm to hot drainwater flows down the inside wall of the drainpipe as a falling film. This counter-flow design maximizes the amount of energy that can be recovered from the drainwater while minimizing pressure loss. The Power-Pipe is a

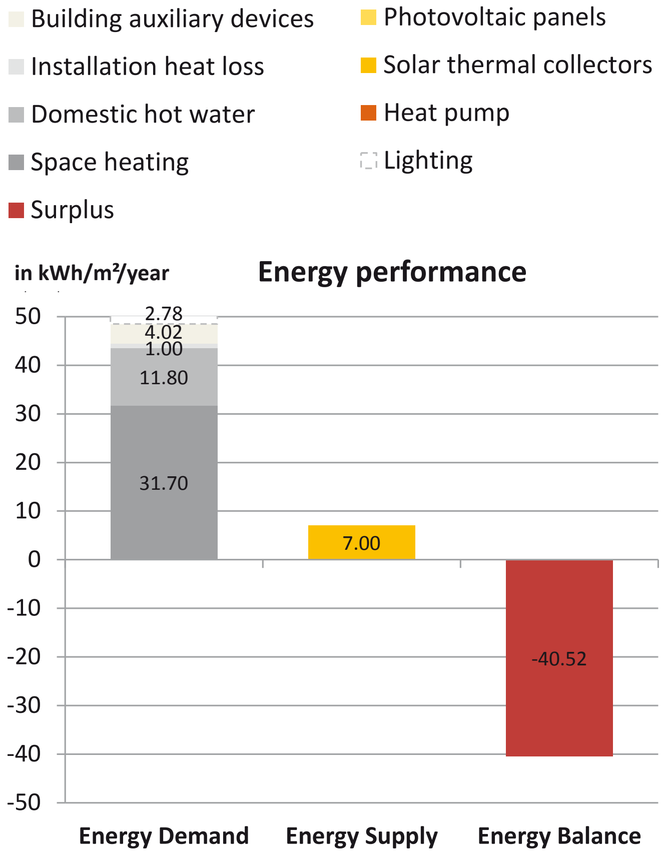

Figure 7. Annual energy balance of the Great Gulf Active House.

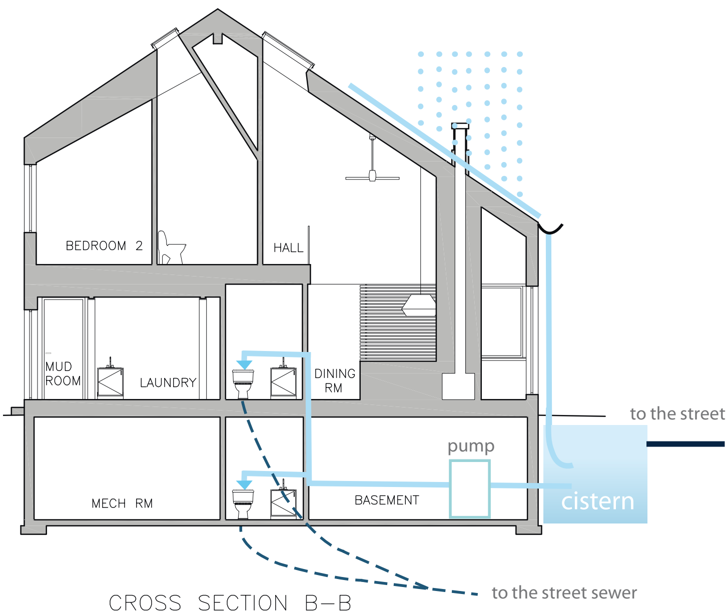

Figure 8. Water management system in the Great Gulf Active House.

Active House components: energy

- R-35 2LB closed cell spray foam insulation on all exterior 2 x 6 walls equipped with Icynene. Excel III R-1.5 exterior wall sheathing/ air barrier system
- Hybrid windows/ patio doors strategically orientated to provide high solar heat gain
- All supply and return ducts sealed and insulated to minimize heat loss
- 2 VanEE heat recovery ventilators to better provide conditioned air to all areas of house
- Somfy Tahoma Smart House Automation system to provide control of windows/skylights/ blinds
- LED light fixtures throughout to provide low electrical consumption as per Designer Specifications
- VELUX Operable solar powered ventilated Skylights strategically placed to provide an abundance of light
- Two south facing VELUX CLI U12 4000 collectors
- Water Heat Recovery

Active House components: comfort

- Dual zoned mechanical system with 97% efficient high efficiency variable speed furnace: Lennox and 19 SEER air conditioner providing a balanced distribution of air on all floors
- Somfy Tahoma Smart House Automation system to provide control of windows/skylights/ blinds
- Somfy system to provide automated control for operation of windows and skylights
- VELUX Operable solar powered ventilated Skylights strategically placed to provide an abundance of light
- Automated roller sun shades throughout to control sun and prevent from solar overheating
- Modulating fan to deliver fresh conditioned air to each room

Environment

- Upgraded low-flow plumbing fixtures
- Graff Rainwater Cistern utilizing rainwater collected from roof and ground to supplement municipal water in the operation of all toilets and the outside irrigation system
- Bullfrog Power supplying 100% renewable energy to both natural gas and hydro grids for total energy
- VELUX solar hot water collectors utilizing the sun to heat municipal water minimizing the natural gas usage
- "Brockport built" ensures that there is minimal waste during on-site assembly reducing the carbon footprint from removal of waste from site
- Eco Paver Permeable Driveway interlock system to better control surface rainwater runoff into local storm systems

passive energy saving device. It has no moving parts, it's self-cleaning and will require no maintenance.

Water management

A cistern and rain water collection system was installed to reduce the need for municipal water when watering the lawn or using the low-flush toilets. The system captures rain from the roof and lawn close to the house. The water is pumped from the weeping tile into the cistern. A saving potential of 35% has been calculated, based on the annual rainfall in Ontario combined with the area of the roof and the number of people in the house.

Construction

The climate and environmental in Great Gulf Active House features represent higher upfront costs for the consumer but are worthwhile investments, becoming increasingly commonplace as both energy and water costs rise. The use of innovative construction method/ prefabrication of building components as exterior walls, roof and floor systems contributed to low environmental impact of the house. The method reduces material waste and energy usage. Moreover it reduces risks of onsite accidents during the construction process, improves the accuracy and quality of construction and makes the building increasingly affordable to future homeowners. Automated premanufacturing allows the house to be erected in only one week. The wood frame panels are a more sustainable alternative to the typical steel structure.

Maintenance

The clean aesthetic of Great Gulf Active House's modernist architectural shape provides the foundation for maximum human comfort with the goal of reducing maintenance and operating costs. Even minor or imperceptible features such as interior and exterior LED lighting systems, permeable driveway surfaces, native plant species or cedar window frames help minimize maintenance costs.

Conclusion

The architectural intentions that define the Great Gulf Active prototype have enabled the architects, investor, and product manufacturers, opportunities to measure and study the Active House's performance, improve upon it, and then implement the necessary modifications before building next generation of homes. From Great Gulf's perspective, the value of offering various levels "comfort packages," or levels of energy efficiency, climate and environmental controls to the consumer will certainly shift the conversation from granite countertops to human comfort and wellbeing. ■