Single Family House in Kingston House, Ontario, Canada

PROJECT SUMMARY
Retrofit to house: multiple contracts
Private residence
Funded by various sources
81% reduction of primary energy

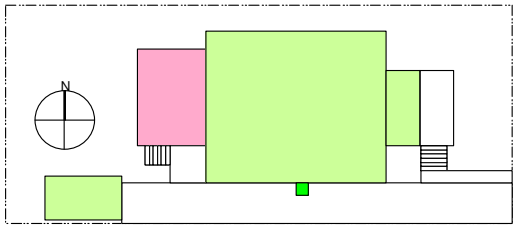
SPECIAL FEATURES
High insulation
Insulated concrete form (ICS)
House addition
Solar thermal and solar PV

PROJECT TEAM
Owner contract

OWNER
Private
Kingston, Ontario

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

IEA – SHC Task 37
Advanced Housing Renovation with Solar & Conservation



Site Plan

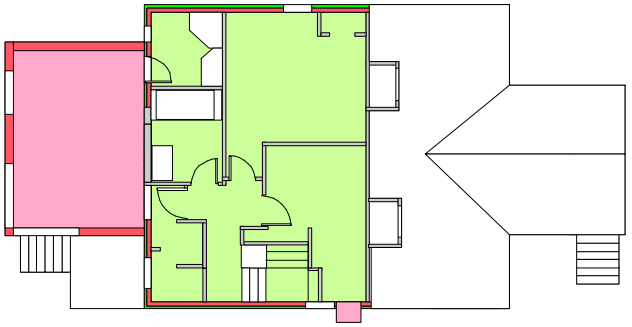
Renovation Existing structure

BACKGROUND

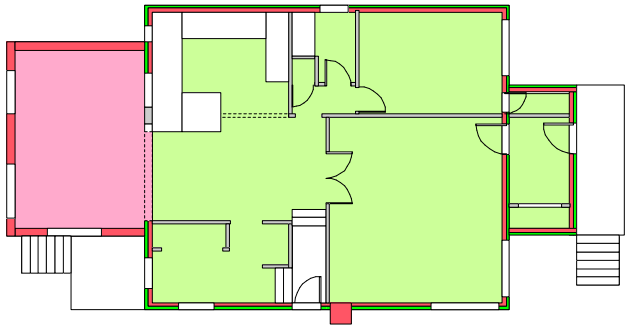
The Kingston House is a typical 1½ storey 134 m² house which was expanded by adding a 1½ storey 58 m² extention at the rear of the house. The strategies to save energy were: to upgrade insulation in the existing house with polyurethane spray foam, construct the addition at the rear with an insulated concrete form (ICF) system, and to accommodate solar installations by altering the front porch (to take solar collectors) and orient the new extension roof for solar PV panels. Work was completed in 2007.

Additional upgrades included a high efficiency furnace (92%), an instantaneous hot water heater (81% effic.) and a high efficiency wood burning stove. A grey water collection system and wastewater heat exchanger address both recycling of water and energy. An upstairs bathroom had a 'suntube' installed rather than north facing skylights.

The photographs on the left illustrate how the renovations minimally alter the street character of the house.



Second Floor



Ground floor

Renovations to Kingston house

Renovation

Existing structure

Photographs demonstrate the ICF wall system used for the rear addition. The roof is shaped to seasonally shade the south facing windows (see shadow), an additional shade faces west (see photo of rear elevation). The ICF system is brought up to the base of the roof deck. The bottom photograph shows the pumping of concrete into the ICF forms- in two separate pours. Reinforcement around the window openings stops deformation of the formwork.

SUMMARY OF THE RENOVATIONS

Existing house

Attic roof insulated : with polyurethane foam
U-value: 0.16 *W/(m²·K);* RSI: 6.5 m^2K/W; R: 36
External walls insulated : with polyurethane foam
U-value: 0.19 W/(m²·K); RSI-5.22 m^2K/W; R= 30
Basement foundation walls : with polyurethane foam
U-value: 0.17 *W/(m²·K);* RSI: 5.6 m^2K/W; R: 32

New Addition

Attic roof insulated : 25mm spray foam and cellulose
U-value: 0.11 *W/(m²·K);* RSI: 8.748 m^2K/W; R: 50
External walls insulated : Insulated Concrete Form
U-value: 0.25 W/(m²·K); RSI-3.89 m^2K/W; R= 22
Basement foundation walls : Insulated Concrete Form
U-value: 0.25 W/(m²·K); RSI-3.89 m^2K/W; R= 22
Basement floor insulated: with rigid polystyrene
U-value: 0.71 W/(m²·K); RSI: 1.4 W/m^2K; R: 8
Windows: double glazed, low-e, argon, vinyl frames
Doors: all replaced with insulated units
Ventilation: HRV with HE furnace
Upgrade Natural Gas furnace : HE furnace 92% effic.
Upgrade Domestic Hot Water: Instantaneous hot water heater, 81% effic.
Wastewater heat exchanger: Power-Pipe by Renewability
Greywater collection: BRAC collection system and tank
Renewable energy:
Solar PV: 1.36 kWp fixed panels on rear roof, 8 x 170Wp panels (Sharp NE-170OUI), Xantrex GT 2.8 inverter
EnerWorks 2-panel solar thermal hot water system

Rear elevation

View of rear elevation finished with vinyl siding. The base of the ICF system is covered with protective mortar. The solar PV 1.36 kWp system can be seen to the right of the gable. It is expected that 1,600 - 1,700 kWh/a will be produced, with an 18 year payback period through the Ontario Standard Offer Contract ($0.42/kWh). This represents approximately 17% of the annual electrical consumption for a family of four. The eight panels create an array that is 3 x 3 m. There is room for an additional four panels. The remaining electricity is purchased from a green electricity retailer.

These photographs show preparation work for spray foaming to the existing sloped roofs which attain a U-value of 0.16 *W/(m²·K)*. Air barriers are required before drywall is fixed. Black lines show sealants between these membranes to ensure air tightness. Flat ceilings are sprayed with 25 mm of foam and then received approx. 350mm blown cellulose, U= 0.11 *W/(m²·K)*.

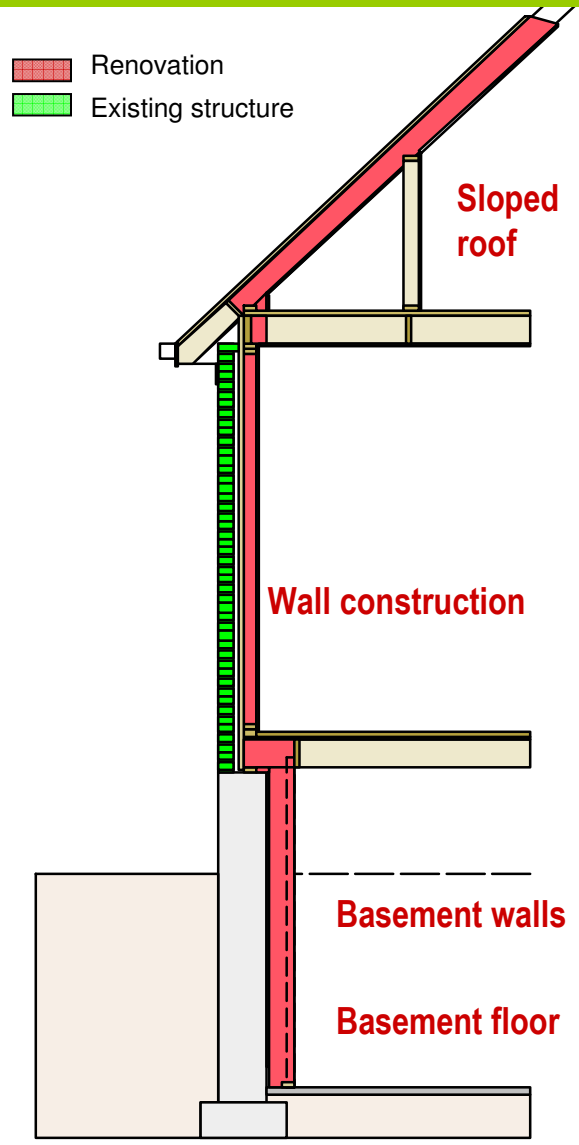
CONSTRUCTION

New roof (sloped & flat)	*U-value:* 0.11 *W/(m²·K)*	
Renovated sloped roof	*U-value:* 0.14 *W/(m²·K)*	
Shingles on plywood deck		20 mm
150mm HD Polyurethane spray foam c/w wood exist.rafters @ 400 mm o.c.		150 mm
Air barrier membrane		1 mm
Gypsum board		13 mm
Total		184 mm

New ICF walls (300 mm)	*U-value:* 0.25 *W/(m²·K)*	
Renovated walls	*U-value: 0.19 W/(m²·K)*	
Gypsum board		13mm
HD Polyurethane spray foam c/w 100mm existing wood stud		100mm
Pine Sheathing T&G planks		25 mm
Single brick exterior wall		110 mm
Total		248 mm

Renovated basement walls	*U-value: 0.18W/(m²·K)*	
Plastered drywall		13 mm
HD Polyurethane spray foam c/w 50x57 wood studs set off wall		175 mm
Dimpled drainage layer		10 mm
Exisitng concrete wall		300mm
Total		498 mm

Basement floor	*U-value: 0.71 W/(m²·K)*	
Finish flooring		13 mm
New conc. slab w/ heating tubes		100 mm
Polystyrene- taped joints & DPM		25 mm
Total		138 mm



View of scissor trusses used in rear addition

View of foundation wall stage for the ICF system

This view of the new basement at the rear of the house demonstrates the complexities of tying into existing foundation walls and the need to ensure that there is adequate underground drainage. The ICF system is protected with a bitumous water membrane and mortar layer for when the ground is brought to the external foundation walls.

CONSTRUCTION CHOICES FOR THE ADDITION

The rear addition is constructed with a 150 mm cavity insulated concrete form (ICF). It achieves a U-value of 0.25 W/(m²·K) (R-22; RSI 3.89) for the complete wall envelope (including the new basement). Expanded polystyrene (EPS) is the the insulating foam component of the Arxx wallsystem form.

The photograph (top left) shows black plastic strips for fastening webs for internal finishes. Reinforcement bars are installed within the concrete. The wooden scissor trusses (@ 400 mm o.c.) were designed to form a cathedral ceiling. The roof is insulated with 25 mm spray foam against the roof deck and 300 mm of fiberglass batt insulation.

Street facade

This view shows the street character. The extended porch was designed to visually respect adjacent houses.

Solar storage and heat exchanger

The existing 185L natural gas hot water tank was retained and converted as the storage tank for the solar thermal system. It had to be insulated (silver backed insulation) and is assisted with a remote heat exchanger to accurately sense differential temperature changes from the solar panels and controlling pump operation to ensure maximum capture of solar-generated energy. A food grade glycol is the working fluid (locally sourced).

The waste water copper heat exchanger (shown left of ductwork) is contained in a closet on the main floor. The bathrooms are upstairs and connected to the grey water system in the basement.

Layout of electrical equipment, showing the grid tied inverter which supplies electricity to the meter located just outside the window.

BUILDING SERVICES

Baseline heating before renovations was 90,500 kWh/a. After improvements, space heating is estimated to be 22,000 kWh/a (a drop of 75%) while internal space increased from 134 m² to 192 m². Current electrical base demand for a family of 4 is 9,000 kWh/a and can be reduced to 6,000 kWh/a through the installation of Energy Star rated equipment.

Domestic Hot Water (DHW) originally required 8,000 kWh/a. By installing a tankless hot water heater this is reduced to 5,000 kWh/a; the solar thermal panels are estimated to produce 3,000 kWh/a, currently stored in a 185L adapted natural gas hot water tank (this will be increased to a 300L tank). A further 25% savings is estimated to be gained from the installation of the Wastewater heat exchanger. Placement of the heat exchanger on the main floor allows pre-heating of cold mains water before it enters the water heater from waste water entering the grey water system.

About 1/3 of water is used to flush toilets, the purchase cost of water is doubled because it has to be discharged into the sewers. To reduce water wastage and costs a grey water system has been installed in the basement . This captures only grey water from showers and sinks (not toilets or kitchen) to provide flushing water.

Summary of U-values W/(m²·K)

	Before	After
Attic	0.63	.13
Walls	1.1	.21
Basement	3.44	.20
Windows	4.8	1.3

ENERGY PERFORMANCE

Space + water heating+ ventilation (primary energy)

Before: 735 kWh/ (m². a)
After: 142 kWh/ (m².a)
Reduction: 81%
Standard ecoENERGY for Houses rating (Cnd): 75
(before adjustment for renewable energy)

INFORMATION SOURCES

ARXX Corporation, Cobourg, Ontario:
http://www.arxxbuild.com/technical/specifications/
Power Pipe drain water heat exchanger:
http://www.renewability.com/general/index.html
Sun tube
http://www.sun-dome.com/
Green electricity retailer
www.bullfrogpower.com

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