EQuilibrium™
HEALTHY HOUSING
FOR A HEALTHY ENVIRONMENT

Some Performance Results and Lessons Learned from EQuilibrium™ Housing Monitoring

2011 BCBEC AGM & Conference

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Canada

CMHC SCHL
HOME TO CANADIANS

Are we there yet?

- We have a full year of monitoring on three houses, and almost complete data on two more
- Have we reached the elusive net-zero goal?

Not quite but close

Avalon Discovery 3
Red Deer, AB

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Results From 3 Houses

Avalon Discovery 3 – Red Deer Alberta

Riverdale Net Zero – Edmonton Alberta

Eco-Terra – Eastman QC

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Partial Results from 2 projects

Chess – Laebon, Red Deer Alberta

Now House - Toronto

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What have we found?

- EQ houses are performing well, not perfectly, but well
- Householders use more electricity than predicted by developers and energy modellers
- PV output meets predictions in summer but is less than predicted in winter
- Snow exists in most of Canada
- Complicated systems can lead to oversights
- Simple monitoring does not allow for complex analysis

Riverdale NetZero Project
Edmonton, AB

A common criticism from builders and developers

Renewables output: predicted vs measured

- Predictions generally made using RETScreen
- Many assumptions in that process
- Measured PV output is generally close in summer but lower in the darker six months
- Shading, snow effects are contributing factors
- Modelling was also verified by SRC(Saskatchewan Research Council) often with different results

ÉcoTerra™
Eastman, QC

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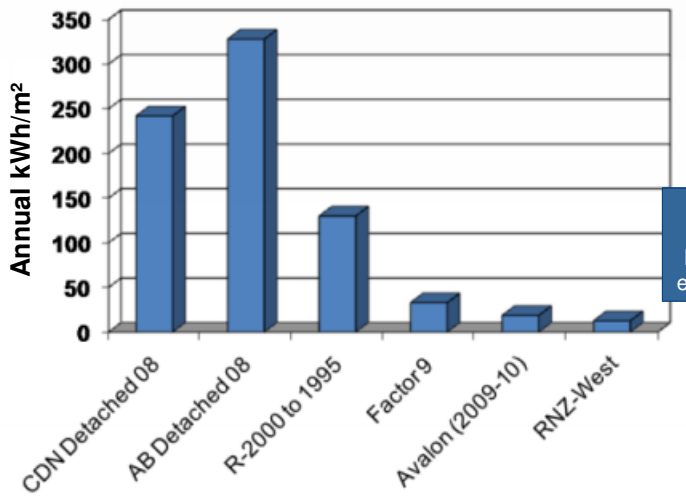
Energy use by different Canadian houses



Factor 9 and Avalon and RNZ are "net energy usage"

- Riverdale NetZero West net- Energy Consumption: 2978 kWh

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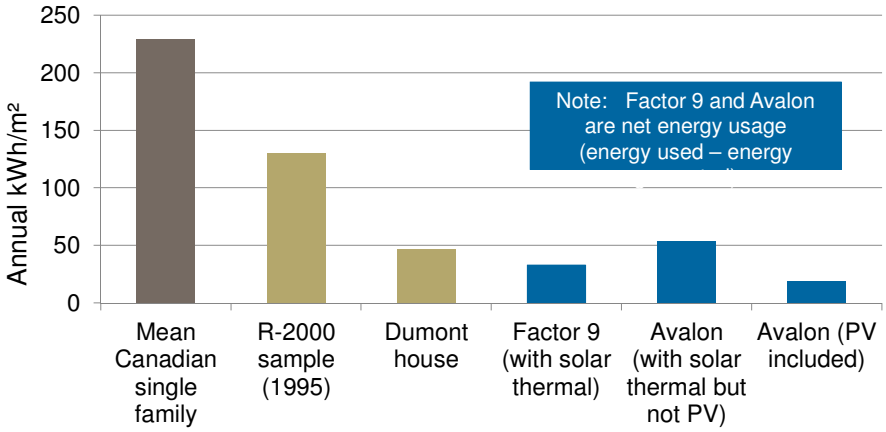
Energy usage by different Canadian houses



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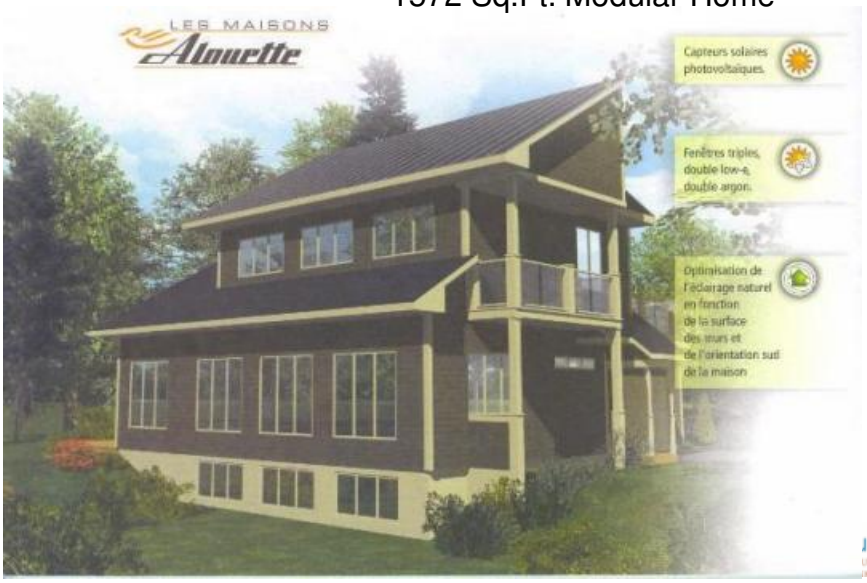
EcoTerra: Eastman, Quebec

1572 Sq.Ft. Modular Home



From foundation to 90% complete in one day

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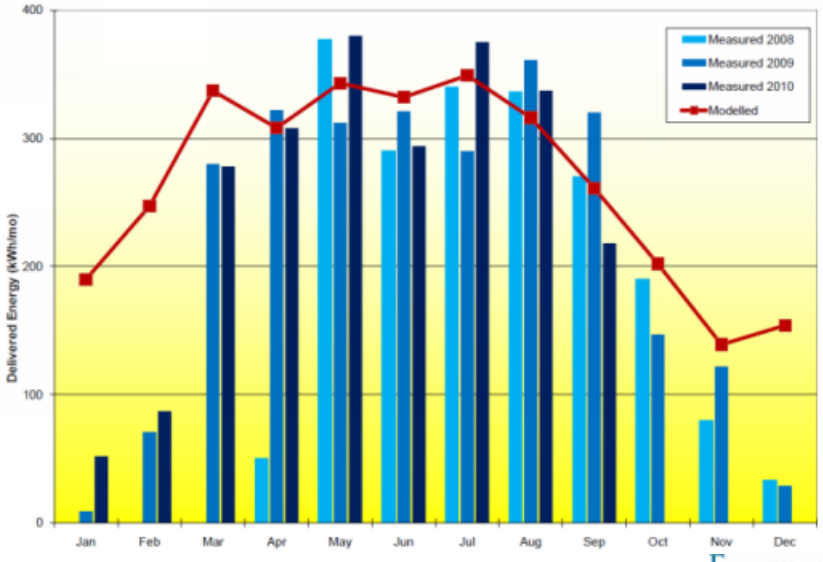
ÉcoTerra™ Delivered Energy



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Avalon Discovery 3 – Red Deer Alberta

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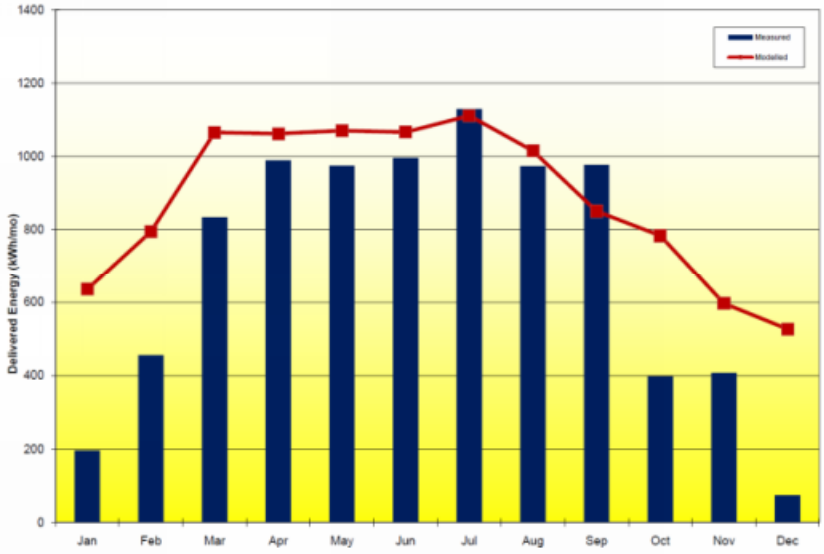
Avalon Discovery 3 (July 2009 – June 2010)



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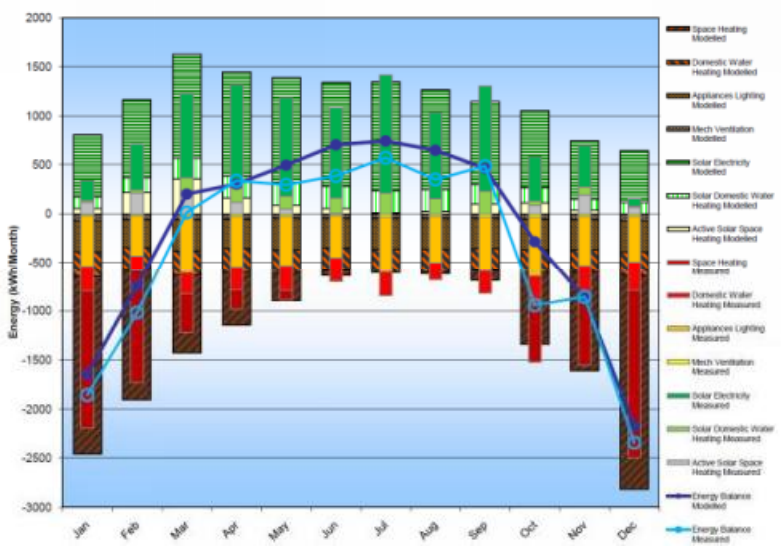
Avalon Discovery 3



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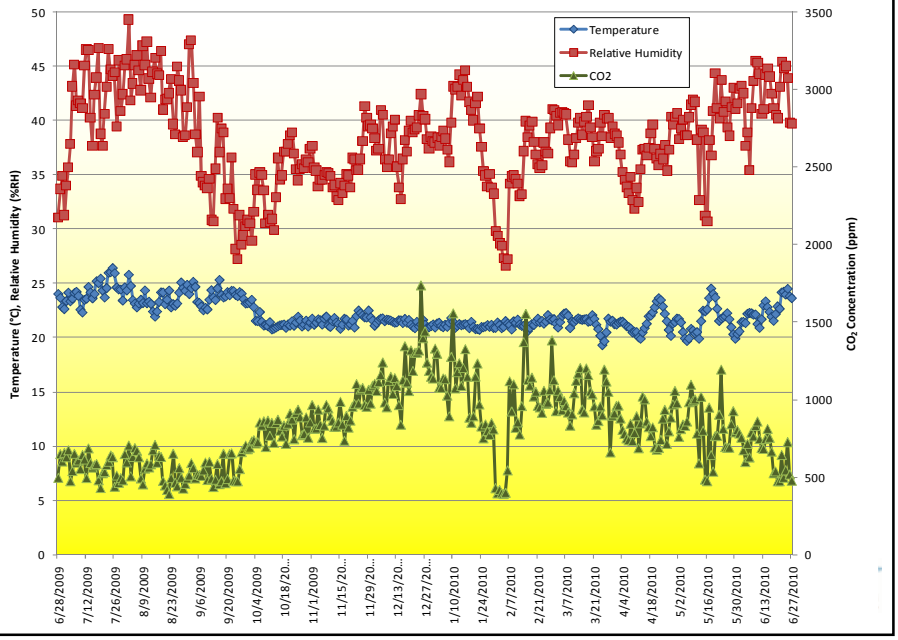
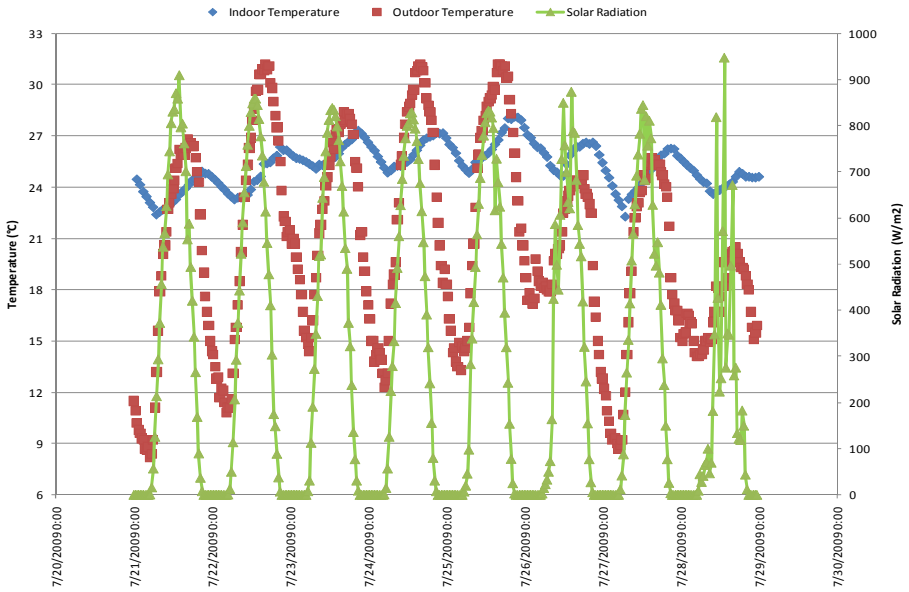
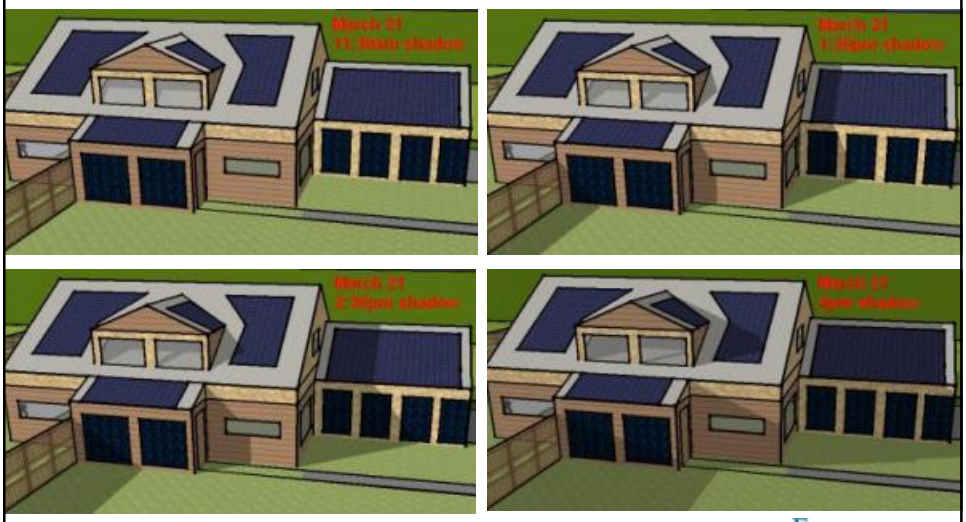
Measured Daily Average Temperature, Relative Humidity and CO_2 Concentrations



Hourly Fluctuations of Temperature



Avalon Discovery 3 — March 21st shadow patterns



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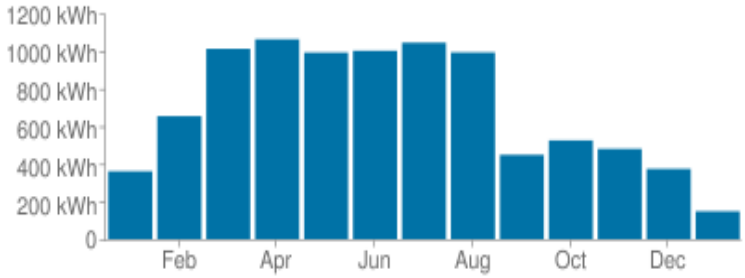
Shading study seems accurate for Avalon

CHESS-Laebon system has no shading

Chess Laebon PV output



PV output: Predicted vs measured

- From January 2010 through mid-July:
  - Avalon with an 8.2 kW system produced about 5600 kWh
  - CHESS with a 6.7 kW system produced about 6000 kWh
- Predictive programs could not deal with the subtleties of shading

Compare PV output of Avalon and CHESS

- Predicted outputs correlated with their installed capacity:
  - Avalon annual PV energy predicted to be 9720 –10,563 kWh vs 5600 KWh Measured (calculations by different contractors) from an 8.2 kW system or 683 kWh/kW
  - CHESS annual PV production predicted to be 8300 kWh vs 6000 KWhr measured for a 6.7 kW system or 895 kWh/kW.
  - NRCan predicts 1265 kWh/kW for a Red Deer location and ideal slope

Actual electrical consumption larger than predicted

- Consumption predictions were biased low by proponents to meet net zero targets and to avoid more expensive PV capacity
- Homeowners are not necessarily being as energy efficient as predicted
  - Monitoring equipment loads will also be a factor in some cases

Riverdale Net Zero

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Riverdale NetZero Heating System

- Solar combi-system, fan-coil unit with hot water coil:
  - Solar thermal system as primary energy source
  - Electric element in hot water tank as back-up
- Heating system for upstairs pre-wired, not installed

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Active Solar Heating Main Components

- Seven flat-plate solar collectors per unit totalling 21 m^2 (226 sq. ft.)
  - Mounted vertically on the southern elevation walls of the home
- One 17,000 L (4,490 US Gal) seasonal heat storage water tank built on site in basement;
- One 300 L (79 US Gal) electric domestic hot water (DHW) storage tank;

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EQuilibrium™ Demonstration: Riverdale NetZero

Active Solar Water & Space Heating System

- very efficient flat-plate solar thermal collectors
- 7 collectors per unit; 19 m2 of area
- Vertical tilt
  - eliminate winter snow cover
  - maximize winter gain and reflected snow
- 17,000 litres of rainwater storage in basement
- 14 kW electric resistance heater backup

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Riverdale NetZero – Mechanical room

EQuilibrium™ Demonstration: Riverdale NetZero

Solar Photovoltaic (PV) system

- Grid-interconnected; no battery bank
- 33 m2; 5600 W in bright sunshine
- 28 Sanyo HIP 200 W modules
- 17% efficient modules
- Solar array is a 53°tilt to minimize snow cover and maximize annual energy collecti

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EQuilibrium™ Demonstration: Riverdale NetZero

High Performance Building Envelope

- Air tight building envelope (0.5 AC/H at 50 Pa.)
- R-24 under slab insulation
- R-100 ceiling ins
- R-56 double wal

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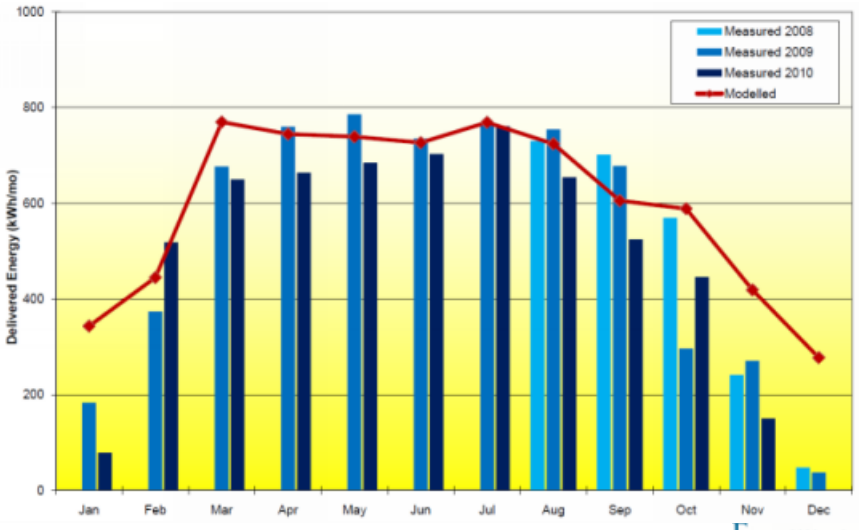
Riverdale NetZero West



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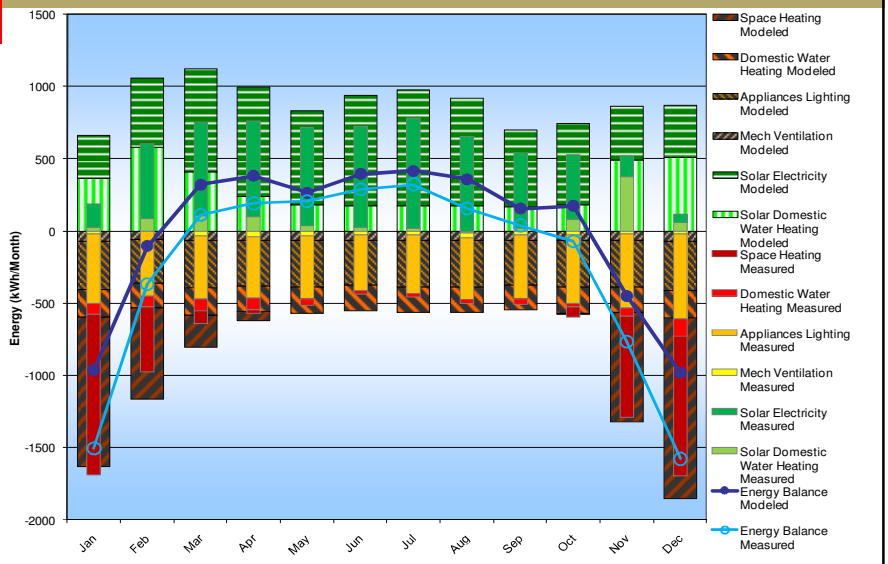
Riverdale NetZero West Unit



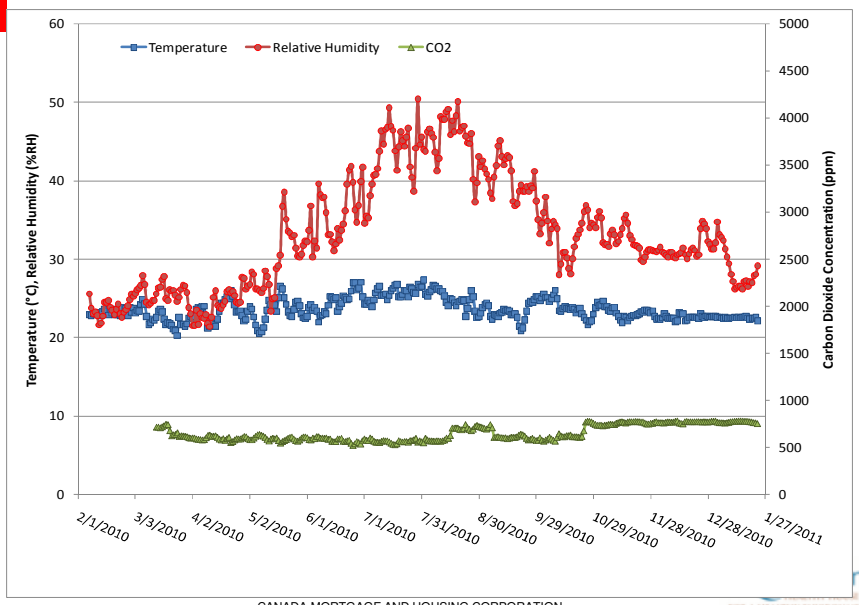
RNZ – West Overall Net-Energy Consumption

Predicted Annual Energy Consumption	Profile	SRC	Actual	
Space heating	14.97	16.93	14.58	kWh/m²
Domestic water heating	9.44	9.16	2.85	kWh/m²
Appliances/lighting	16.39	16.60	23.32	kWh/m²
Mechanical ventilation	2.02	3.24	1.37	kWh/m²
Total energy consumption	**42.82**	**45.93**	**42.12**	**kWh/m²**
Predicted Renewable Energy Production				
Solar (photovoltaic) electricity	26.60	38.51	25.54	kWh/m²
Active solar system	17.72	14.70	3.85	kWh/m²
Total energy generation	**44.32**	**53.21**	**29.39**	**kWh/m²**
Predicted & Actual Annual net-Energy Consumption	**-1.50**	**0.18**	**12.73**	**kWh/m²**

Space and DHW Heating Results

	Modelled Consumption (kWh/yr)	Measured Consumption (kWh/yr)	Modelled Generation (kWh/yr)	Measured Generation (kWh/yr)
DHW	Profile: 2210 SRC: 2143	667	Profile: 4150 SRC: 3667	902
Space Heating	Profile: 3500 SRC: 3963	3413		

Measured Daily Average Temperature, Relative Humidity and CO_2 Concentrations



Riverdale NetZero

"Next generation" – simpler and less expensive

Mill Creek Net Zero Home
Edmonton, AB

- team developed four net zero energy projects since Riverdale
- similar performance but simpler and less expensive
- much lower costs ($50K - $60K more than conventional home)

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Now House – The only retrofit project

The Now House™:

Retrofit of a 60 year old wartime house

Toronto, ON

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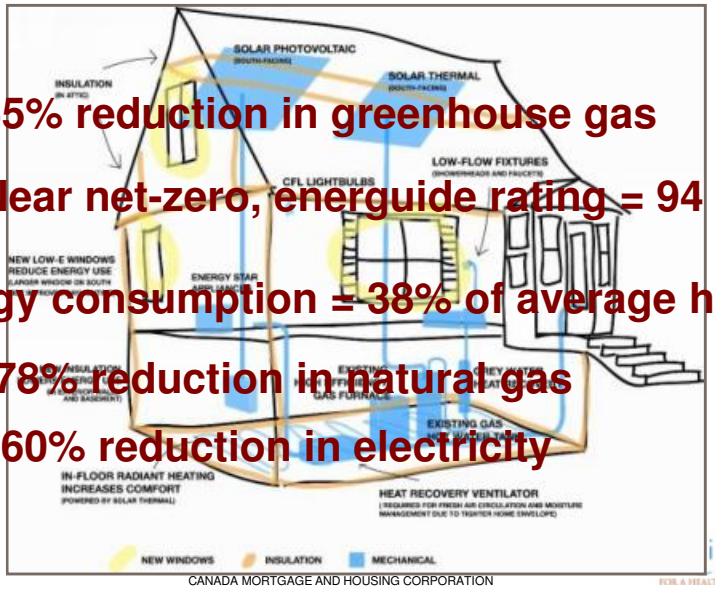
The Now House



55% reduction in greenhouse gas

Near net-zero, energuide rating = 94

Energy consumption = 38% of average home

78% reduction in natural gas

60% reduction in electricity

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Thermal characteristics

- Roof flat: R50
- Roof sloped: R32
- Walls above grade: R33
- Walls below grade: R25
- Floor below grade: R25
- Windows: Triple glazed : R5.7
- Air-tightness: 1.5 ACH @ 50 Pa

Renewables

- Photovoltaic
  - 2.0 kW grid connected to generate 2,410 kWh/year
- Solar space and water heating
  - 13.12 kWh/m²
- Shower drain water heat recovery
  - 8.9 kWh/m²

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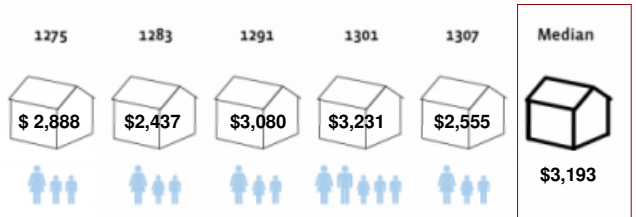
2007 Occupant and Resources Statistics for Rankin Street Houses



Energy Costs Before Retrofit

Electricity use-kwh Cost	11,688 $1,357	5,447 $679	11,969 $1,395	8,142 $968	3,269 $968	8,103 $1,368
Gas use-CM Cost	2,950 $1,531	3,454 $1,758	3,293 $1,685	4,577 $2,263	3,176 $1,587	3,490 $1,825
EGH	55	55	28	35	18	35

Now House™ Technical Models

Models based on Now House Windsor 5 Median EGH 35

Base Model
$25,000

What is included?
- Comprehensive Air Seal
- Insulation
- Water Reduction Package
- CFL Bulbs

Base Model
Plus: **2 ENERGY STAR appliances**
$33,000

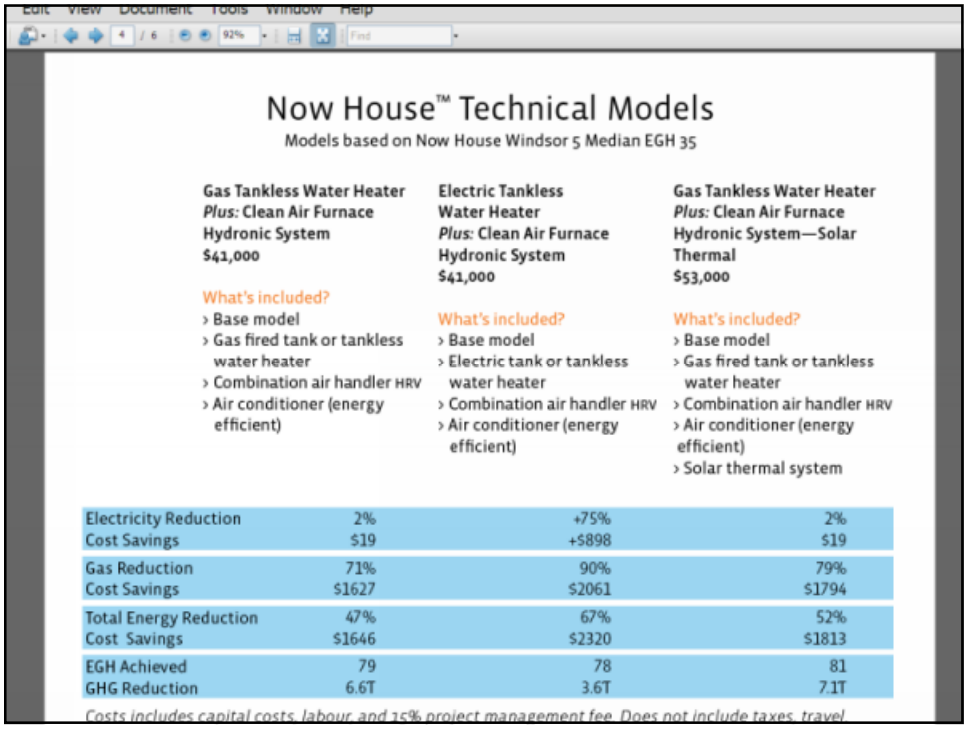
What is included?
- Comprehensive Air Seal
- Insulation
- Water Reduction Package
- CFL Bulbs
- ENERGY STAR Refrigerator and Front Load Washer

Forced Air
$40,000

What is included?
- Base model
- High efficiency furnace
- High efficiency water tank
- High efficiency air conditioner
- HRV

Electricity Reduction Cost Savings	+2% +$27	20% $246	3% $32
Gas Reduction Cost Savings	65% $1487	61% $1398	72% $1634
Total Energy Reduction Cost Savings	42% $1460	47% $1644	48% $1655
EGH Achieved GHG Reduction	76 5.5T	77 6.8T	79 6.6T

Costs includes capital costs, labour, and 15% project management fee. Does not include taxes, travel

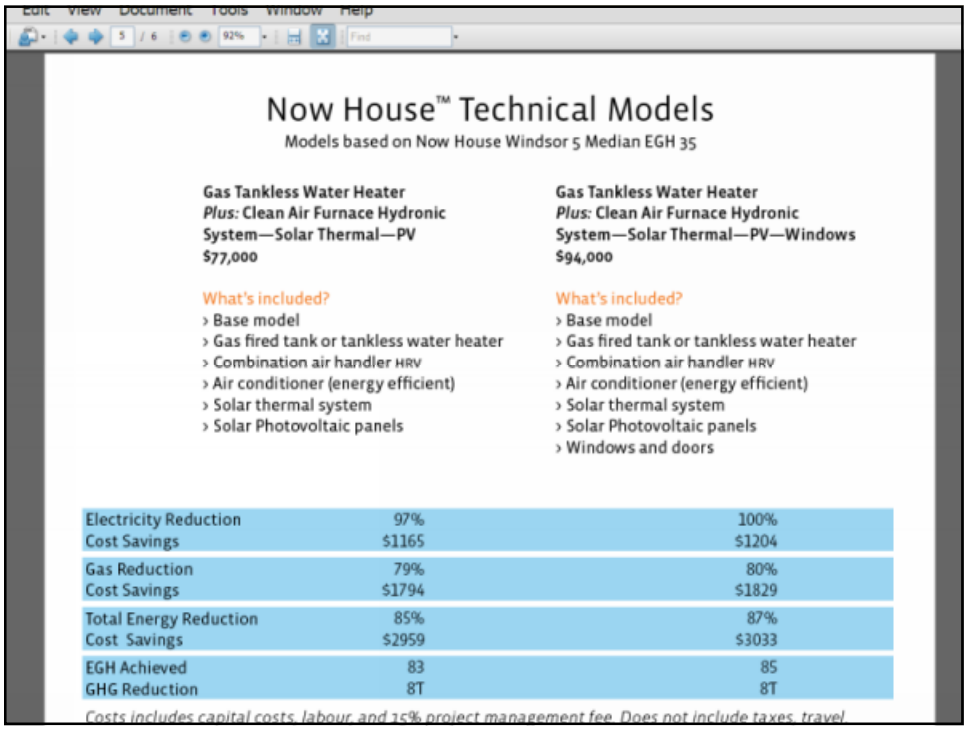


Now House™ Technical Models

Models based on Now House Windsor 5 Median EGH 35

	Gas Tankless Water Heater *Plus:* Clean Air Furnace Hydronic System $41,000	**Electric Tankless Water Heater *Plus:* Clean Air Furnace Hydronic System $41,000**	**Gas Tankless Water Heater *Plus:* Clean Air Furnace Hydronic System—Solar Thermal $53,000**
What's included?	› Base model › Gas fired tank or tankless water heater › Combination air handler HRV › Air conditioner (energy efficient)	› Base model › Electric tank or tankless water heater › Combination air handler HRV › Air conditioner (energy efficient)	› Base model › Gas fired tank or tankless water heater › Combination air handler HRV › Air conditioner (energy efficient) › Solar thermal system
Electricity Reduction	2%	+75%	2%
Cost Savings	$19	+$898	$19
Gas Reduction	71%	90%	79%
Cost Savings	$1627	$2061	$1794
Total Energy Reduction	47%	67%	52%
Cost Savings	$1646	$2320	$1813
EGH Achieved	79	78	81
GHG Reduction	6.6T	3.6T	7.1T

Costs includes capital costs, labour, and 15% project management fee. Does not include taxes, travel



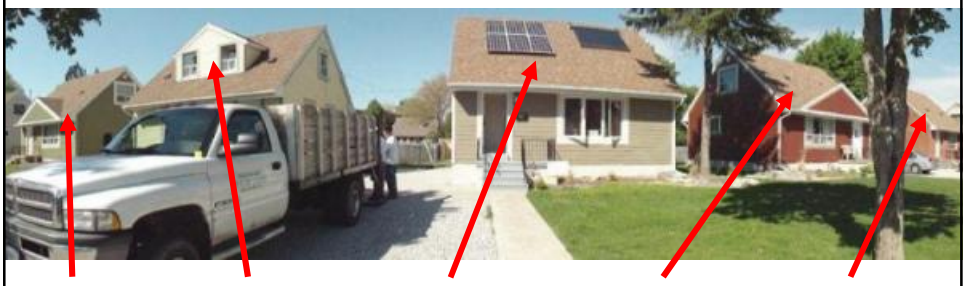
Now House™ Technical Models

Models based on Now House Windsor 5 Median EGH 35

	Gas Tankless Water Heater *Plus:* Clean Air Furnace Hydronic System—Solar Thermal—PV $77,000	**Gas Tankless Water Heater *Plus:* Clean Air Furnace Hydronic System—Solar Thermal—PV—Windows $94,000**
What's included?	› Base model › Gas fired tank or tankless water heater › Combination air handler HRV › Air conditioner (energy efficient) › Solar thermal system › Solar Photovoltaic panels	› Base model › Gas fired tank or tankless water heater › Combination air handler HRV › Air conditioner (energy efficient) › Solar thermal system › Solar Photovoltaic panels › Windows and doors
Electricity Reduction	97%	100%
Cost Savings	$1165	$1204
Gas Reduction	79%	80%
Cost Savings	$1794	$1829
Total Energy Reduction	85%	87%
Cost Savings	$2959	$3033
EGH Achieved	83	85
GHG Reduction	8T	8T

Costs includes capital costs, labour, and 15% project management fee. Does not include taxes, travel

Reno Results: EnerGuide Rating



$42K Reno		$65K Reno		$81K Reno		$41K Reno		$31K Reno	
EnerGuide Rating		*EnerGuide Rating*		*EnerGuide Rating*		*EnerGuide Rating*		*EnerGuide Rating*	
Pre-	55	Pre-	55	Pre-	28	Pre-	35	Pre-	18
Post-	74	Post-	81	Post-	79	Post-	79	Post-	77

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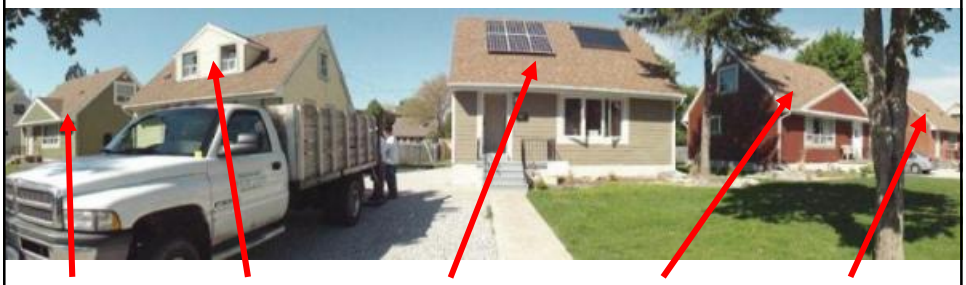
Reno Results: Air Tightness



$42K Reno		$65K Reno		$81K Reno		$41K Reno		$31K Reno	
Air Changes / Hr		*Air Changes / Hr*		*Air Changes / Hr*		*Air Changes / Hr*		*Air Changes / Hr*	
Pre-	10.6	Pre-	8.7	Pre-	28.6	Pre-	25.8	Pre-	43.8
Post-	4.1	Post-	4.2	Post-	4.4	Post-	3.5	Post-	7.8

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Complex systems can lead to errors or oversights

If it isn't easy, errors are more common

- Electrician shut down PV output in Now House® while installing sensors and forgot to turn it back on. Several weeks of production were lost.
- Solar thermal systems do not appear to be providing as much energy as predicted
- Even solar DHW is often far below predicted production especially in winter.
- Storage tank mix-ups have affected energy usage in at least two houses.

Simple monitoring

CMHC chose to do simple, monthly monitoring in the EQ houses

- Lower cost to install and analyze
- Lower burden on homeowner (less equipment in view)
- Low to no energy usage by monitoring system to affect the energy balance
- Fewer electronic glitches

Inspiration – the Minto ecohome
Ottawa, ON

Simple monitoring (cont.)

This simplicity has its drawbacks

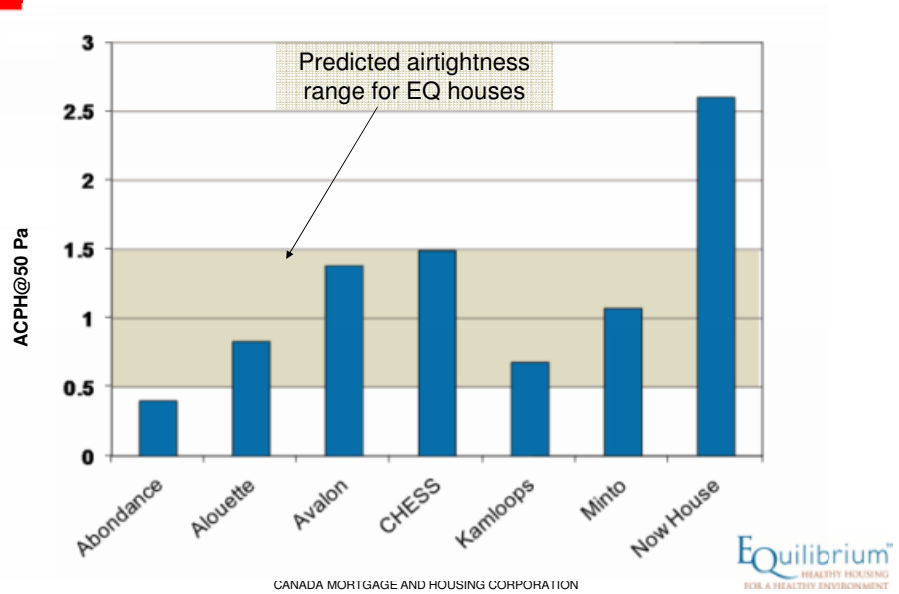
- Consultant visiting the site may miss
  a month here or there
- Harder to account for performance deviations in complicated equipment
- Lacks instantaneity of electronically-dispatched data

Now House®
Toronto, ON

Airtightness targets

- All EQ houses were predicted to be very airtight
  - E.g. in a range that runs from Passivhaus (0.6 ACPH @50 Pa) to R-2000 (1.5 ACPH @50 Pa)
- Actual tests show that some have met targets and some houses have more air leakage than anticipated
- All those tested so far are quite airtight

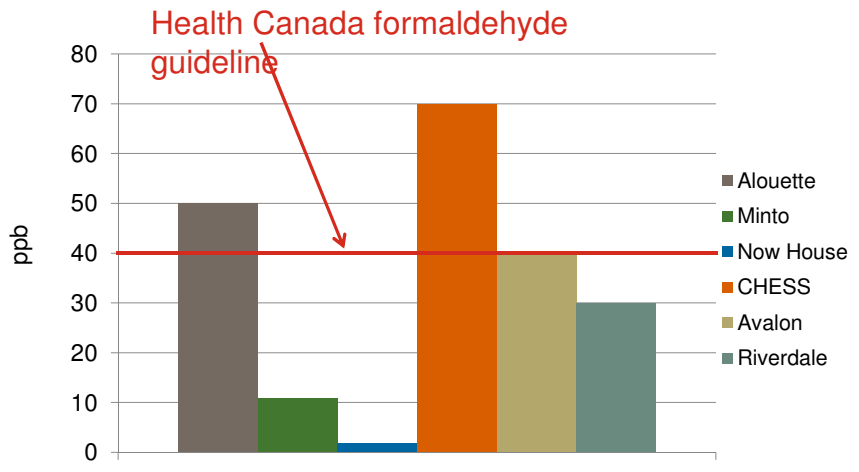
Airtightness test data



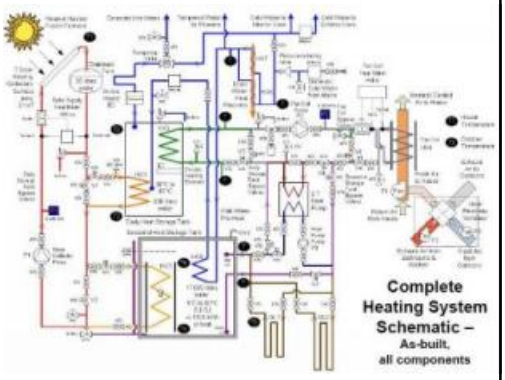
Air quality testing

- There is limited air quality testing to ensure that the houses meet guideline concentrations
- CMHC will have CO_2 readings, humidity records, and formaldehyde tests
- Ventilation rate testing (when occupied) will show whether the mechanical systems in place are providing code required amounts of fresh air
- Little data available so far with more testing this fall

Formaldehyde measurements



System Complexity – Design, Installation, Commissioning, Maintenance



Its No Secret Its a System

- Conservation First
  - Reduce demand loads
    1. Reduce heating loads with a well insulated air tight building envelope and good windows.
       - Don't forget the HRV system.
    2. Use efficient lighting and appliances.
    3. Use water efficient fixtures and domestic sized solar water heating.
- Then consider renewable energy systems

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Harmony House Update

- Completion scheduled for late November
- Industry tours and public open houses Jan 2012
  - On site displays and information from suppliers
  - Mechanical installations
  - Insulation systems
  - Windows
  - Roofing
  - Finishes
  - Blower door test results
  - Real time monitoring

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Thank you!
There will be much more information to come as the projects complete the monitoring period. Follow them on our website WWW.CMHC.ca

Allan Dobie
Sept. 2011

Canada

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HOME TO CANADIANS