

# The Challenges of Designing and Building a Net Zero Energy Home in a Cold High-Latitude Climate

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# What is this paper all about?

- describes the challenges of  
designing and building  
the Riverdale NetZero energy home  
in the extreme climate, energy pricing and policy conditions  
in the city of Edmonton  
in the Canadian province of Alberta.
- makes recommendations to overcome the challenges.

# Edmonton, Alberta

Latitude:

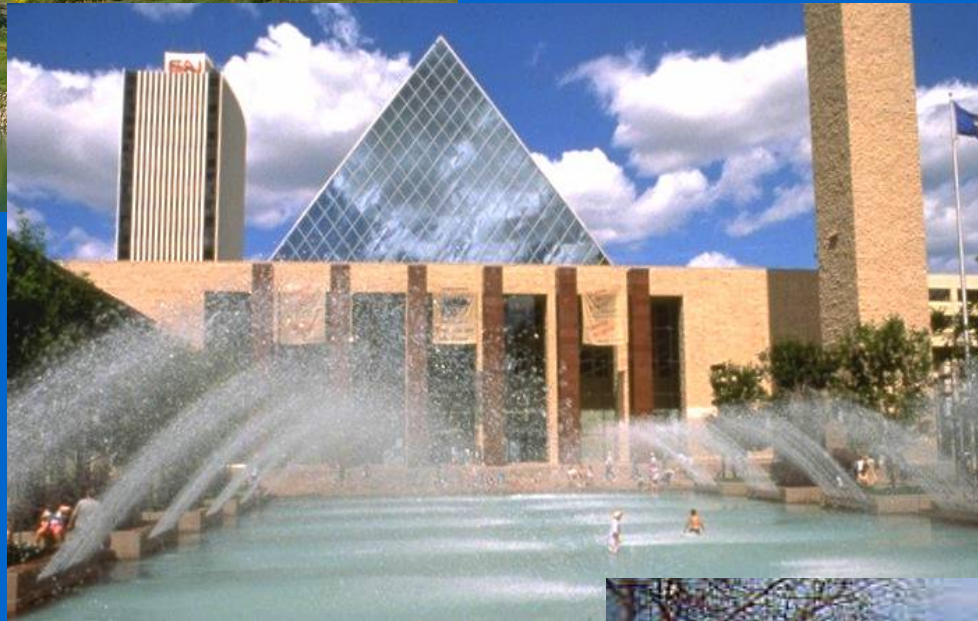
- Edmonton
  - 53 degrees North
- Adelaide
  - 35 degrees South

(Los Angeles  
– 34 degrees North)





# Edmonton's Environmental Policy



“The City of Edmonton,

- through its planning, decision-making processes and leadership,
- will promote the development of an environmentally sustainable community
- that functions in harmony with the natural environment.”

# Edmonton's Environmental Strategic Plan

- Clean Air
- Climate Protection
- Environmental Emergency Response
- Natural Areas Systems
- Resource Conservation
- Solid Waste Management
- Sustainable Business Development
- Sustainable Urban Planning & Development
- Toxics Reduction
- Water

# What is a Net Zero Energy House?

- A house that generates all its own heat and electricity on an annual basis...
- Net zero energy is just the dividing line between
  - net deficit energy (which is where all our houses are), and
  - net surplus energy (which is a net benefit to the environment)
- It has never been done before in Canada.





# What is the Riverdale NetZero House?

- A net zero energy house being built in Edmonton
- One of 12 winners of Canada Mortgage and Housing Corporation's national net zero energy healthy home design/build competition, which focussed on Health, Energy, Resources, Environment and Affordability.
- Now branded as "EQuilibrium" Sustainable Housing Initiative  
See [www.cmhc.ca](http://www.cmhc.ca), search for EQuilibrium.

# How does it Achieve the NZE Goal?

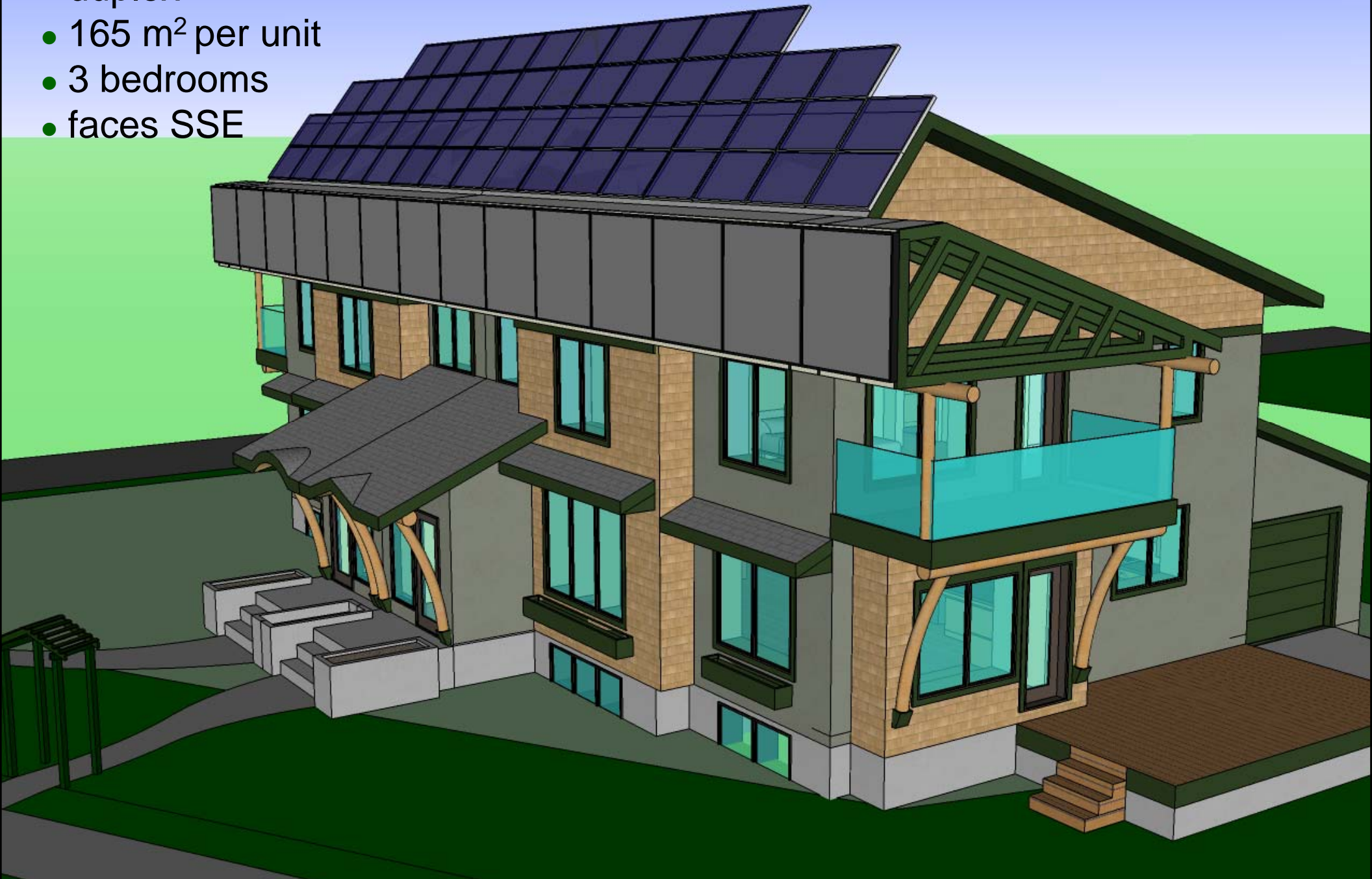
- First and most important:  
**Reduced** energy consumption by 65% through energy and water efficiency.
- Second:  
**Supplied** 35% of thermal and electrical energy through on-site renewable energy resources (e.g., solar, wood, wind, hydro).

In urban centres, the sources would likely be limited only to solar for heating and electricity.



# Riverdale NetZero Energy Home

- duplex
- 165 m<sup>2</sup> per unit
- 3 bedrooms
- faces SSE



# Why is it a Challenge to Design and Build?

Challenges arise in the following areas:

- Environmental
  - Equipment Performance
- 
- Training
  - Financial
  - Policy

With solutions that are:

- Technical
  - Technical
- 
- Organisational
  - Organisational
  - Organisational

# Environmental Challenges in Edmonton

- **Long cold winters**

- 5589 Kelvin-days of heating ( 919 Kd for Adelaide) (600%)
- Negligible cooling (476 Kd) (2392 Kd for Adelaide) ( 20%)

- **Solar energy resource**

- 1.3 sun-hour per day on horizontal surface in winter  
(2.6 s-h/d for Adelaide)

- **Wind energy resource**

- Usually would not be permitted in a city

- **Hydro energy resource**

- Usually not available in a city

- Typically Alberta's houses use 6 times more energy for heating than for domestic electricity (and basically none for cooling), so the challenge is home heating, not electricity.

# Technical Options – Energy Reduction

## Heat Options

- Wall, ceiling construction
  - Stud walls with insulation
    - fiberglass, polystyrene, rock wool, cellulose fibre
  - Insulated concrete forms (ICF)
  - Structural Insulated Panel Systems (SIPS)
- High performance windows
  - 3-glazed, 4-glazed
  - Argon gas, low emissivity coatings
- High performance doors

## Electricity Options

- Highly efficient appliances
- Highly efficient equipment
- Highly efficient lighting
  - Compact fluorescent
  - LED
  - Task
  - Solar illumination

## Water Options

- Ultra low volume appliances and water fixtures

# Technical Options – Energy Supply

## Heat Options

- Passive solar space heating
- Active solar space heating
- Active solar water heating
- Active solar air heating
  - Stand-alone collectors
  - Integrated with solar PV
- Heat pumps
  - Ground-source (geothermal)
  - Air-source
- Wood

## Electricity Options

- Solar photovoltaics (PV)
- Microwind
- Microhydro

## Heat Recovery Options

- Ventilation air heat recovery
- Drain water heat recovery



# Order of Priorities for Achieving a Net Zero Energy Home

## - cheapest to most expensive

- Electrical fixtures and appliances – electrical
  - Water fixtures and appliances – water
  - Building envelope – heating
- } Ultra-high efficiency technologies
- 
- Passive solar home heating...???
  - Active solar heating...???
  - Geothermal heat pump...???
- } Heating technologies
- 
- Solar photovoltaics...???
  - Microwind...???
  - Microhydro...???
- } Electricity technologies

# #1. Electrical Efficiency



- **Energy Efficient Appliances**

- Stove/oven, refrigerator, clothes dryer, clothes washer
- Using the most efficient EnerGuide rated appliances

- **Energy Efficient Lighting**

- compact fluorescents, LEDs
- task lighting
- day lighting through windows

- **Energy Efficient Motors**

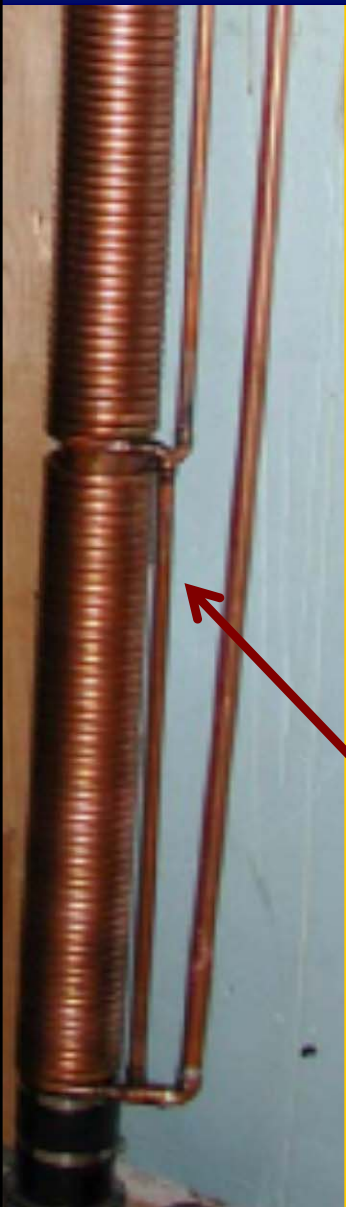
- ventilation, heating

- Control of **Phantom Electrical Loads**



## #2. Water Efficiency + Heat Recovery

- To reduce consumption of water and the energy used to heat it
- Household hot water consumption:
  - average: **225** L per day
  - Riverdale: **100** L per day
- Low flow shower heads
- Water conserving dishwasher
- Water conserving clothes washer
- Drain water heat recovery
  - reduces water heating to equivalent of 90 L/d (??)



# #3. Energy Efficiency

– most important

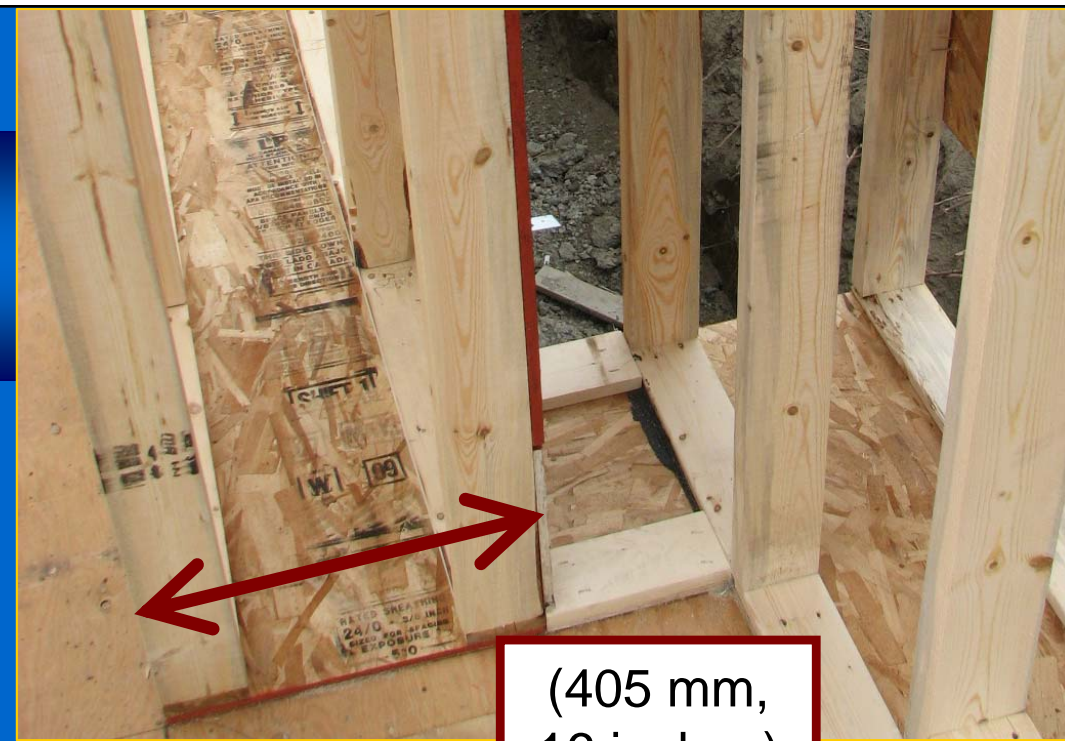
	<u>Riverdale NZE</u>	<u>90s house</u>	<u>70s house</u>
Wall construction:	double 2x4	single 2x6	single 2x4
<u>Insulation:</u>			
– ceiling:	RSI-17.6 (R100)	RSI-4.9 to 6	RSI-2.1
– walls:	RSI-9.9 (R56)	RSI-3.5	RSI-1.4
– basement walls:	RSI-9.5 (R54)	R-1.4 (upper)	nothing
– basement floor:	RSI-4.2 (R24)	nothing	nothing
Windows:	3-glazed (S, E, W) 4-glazed (N) low-e, argon gas	2-glazed	2-glazed
Rated air leakage:	0.5 AC/hour	4 to 6 AC/hour	5 to 7 AC/hour
Ventilation system:	with heat recovery 80% efficient	none	none



# Wall Construction and Insulation

- **Double-stud 2x4**

- Easily able to be reproduced by home builders



(405 mm,  
16 inches)

- **Cellufibre insulation**

- Recycled newspapers
- Low embodied energy
- Locally produced
- Sequestered carbon
- Not a hydrocarbon product
- Walls: 400 mm (RSI-9.9)
- Ceiling: 690 mm (RSI-17.6)





# High Performance Windows



South windows  
3-glazings  
RSI-1.3 (R7.3)



East/west  
windows  
3-glazings  
RSI-1.5 (R8.3)

- Soft low emissivity coatings
- Argon gas between the glazings
- “Warm edge” spacer
- Insulated fibreglass frames
- Manufactured by Duxton, Winnipeg

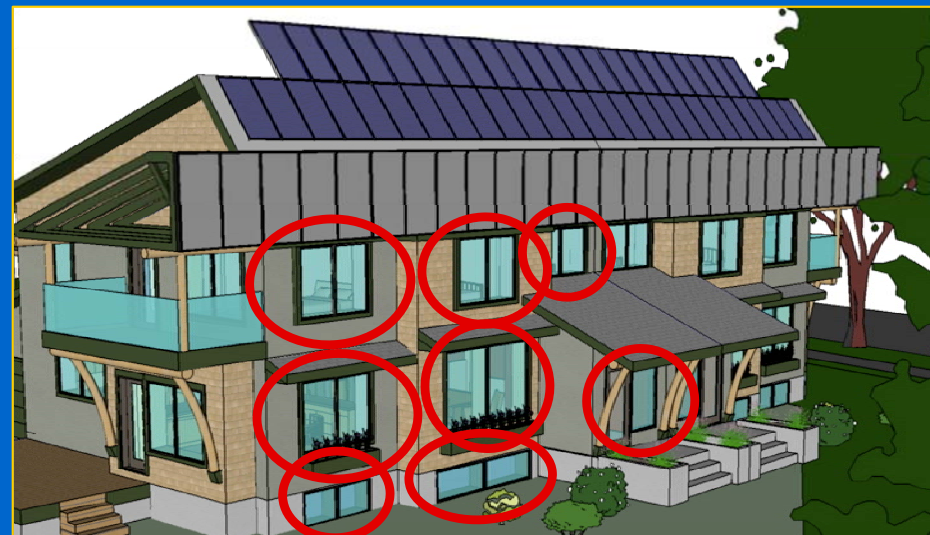
North windows  
4-glazings  
RSI-1.8 (R10)





## #4. Passive Solar Home Heating

- 16.9 m<sup>2</sup> of south glazing  
= 10% of floor area
- Provides daylight to further reduce electricity consumption
- 20,000 kg thermal mass
  - Feature wall
  - Concrete counter tops
  - Extra drywall

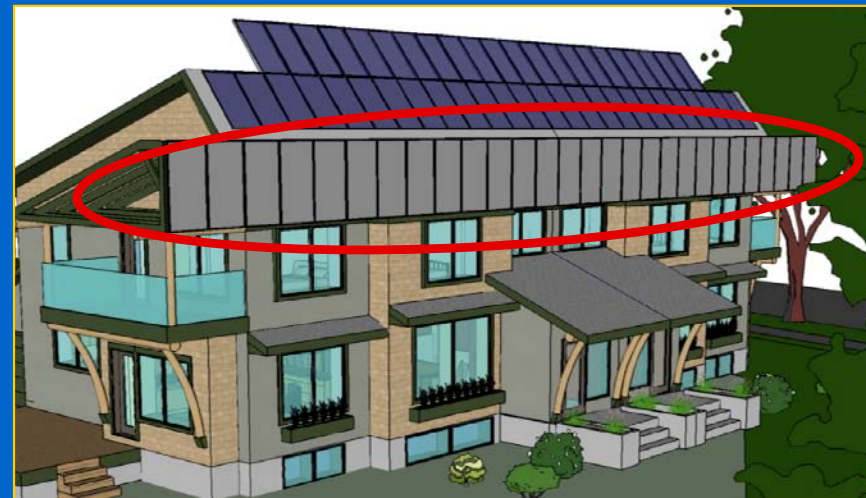


# #5. Active Solar Water Heating

combined system

# #6. Active Solar Home Heating

- 7 Zen collectors  
21 m<sup>2</sup>
  - high-efficiency flat-plate collectors
  - mounted on a vertical tilt
  - to maximise winter solar gain
  - to eliminate snow cover
  - to maximise reflected solar energy
- 17 000 litres – warm water storage in basement – home heating  
+ 300 litres – hot water storage – water heating
- Drainback system – water-based
  - does not use glycol
- May include a very small solar-assist heat pump (3/4 T)



## #7. Geothermal Heat Pump...?

- We did consider a geothermal heat pump (GTHP).
- We needed 1220 kWh of remaining heat. That would cost \$20,000 for the GTHP plus the PV equipment to operate it.
- Instead we eliminated the GTHP and installed a larger PV system to provide 1220 kWh of deficit heat.
- This extra PV cost ~\$12,000 instead.
  - We saved ~\$8,000 by not having a GTHP.

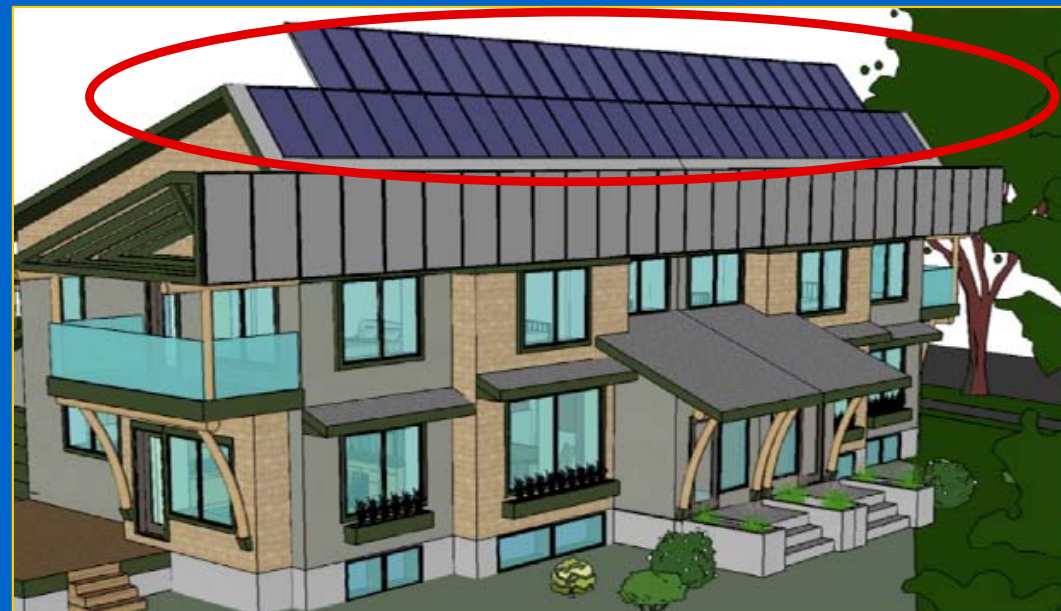


# #8. Solar Electric Power System

called “photovoltaics” or PV

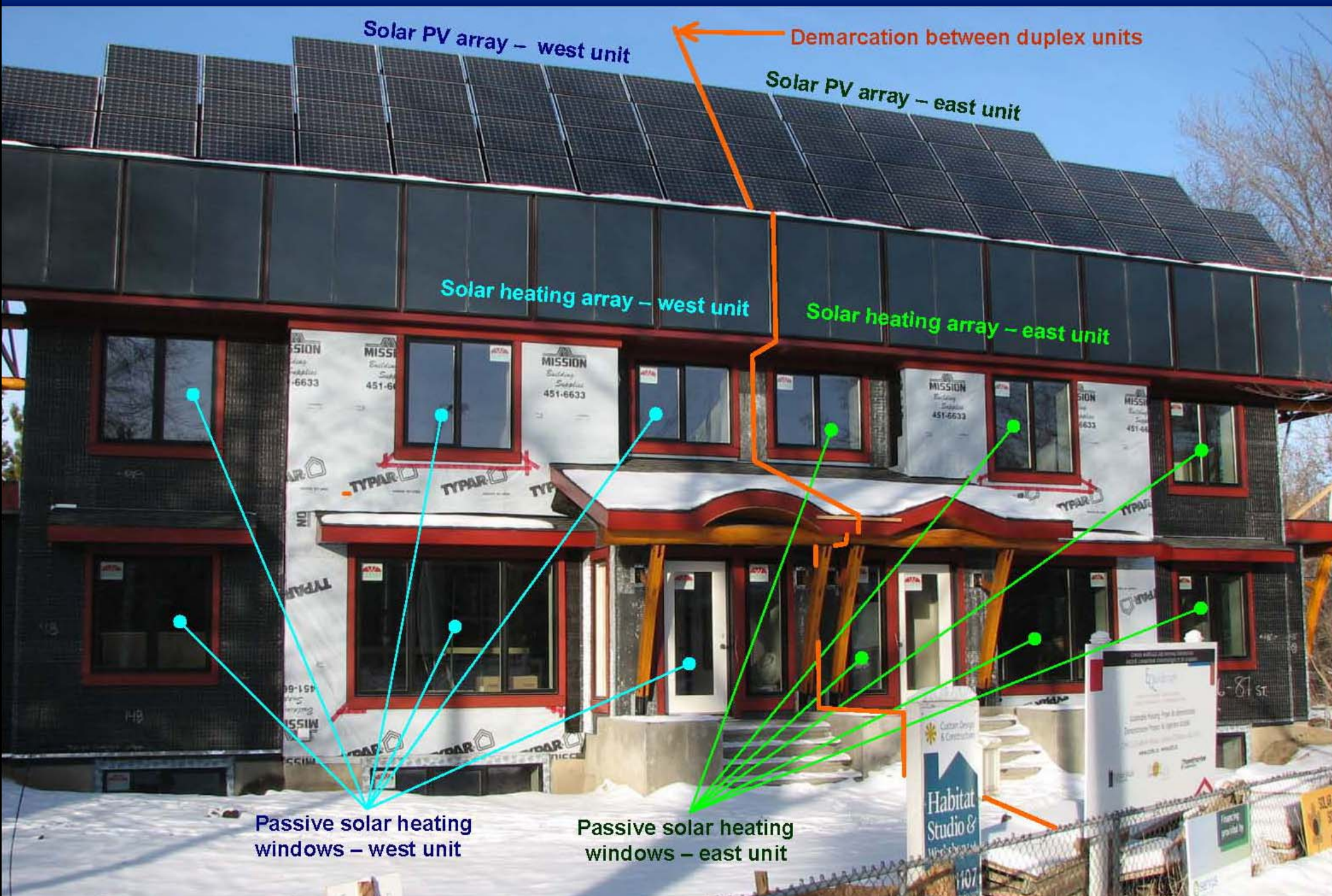


- 28 Sanyo high efficiency (17%) 200 W PV modules (Japan)
  - 33 m<sup>2</sup>, 5600 W in bright sunshine
  - Solar array is mounted at 53° tilt to:
    - reduce snow cover, and
    - maximise annual electricity production
- SMA Sunny Boy 6000W grid-dependent inverter (Germany)
- No battery bank
- Exports to grid every day of the year (even cloudy days)





# 2008 January 03

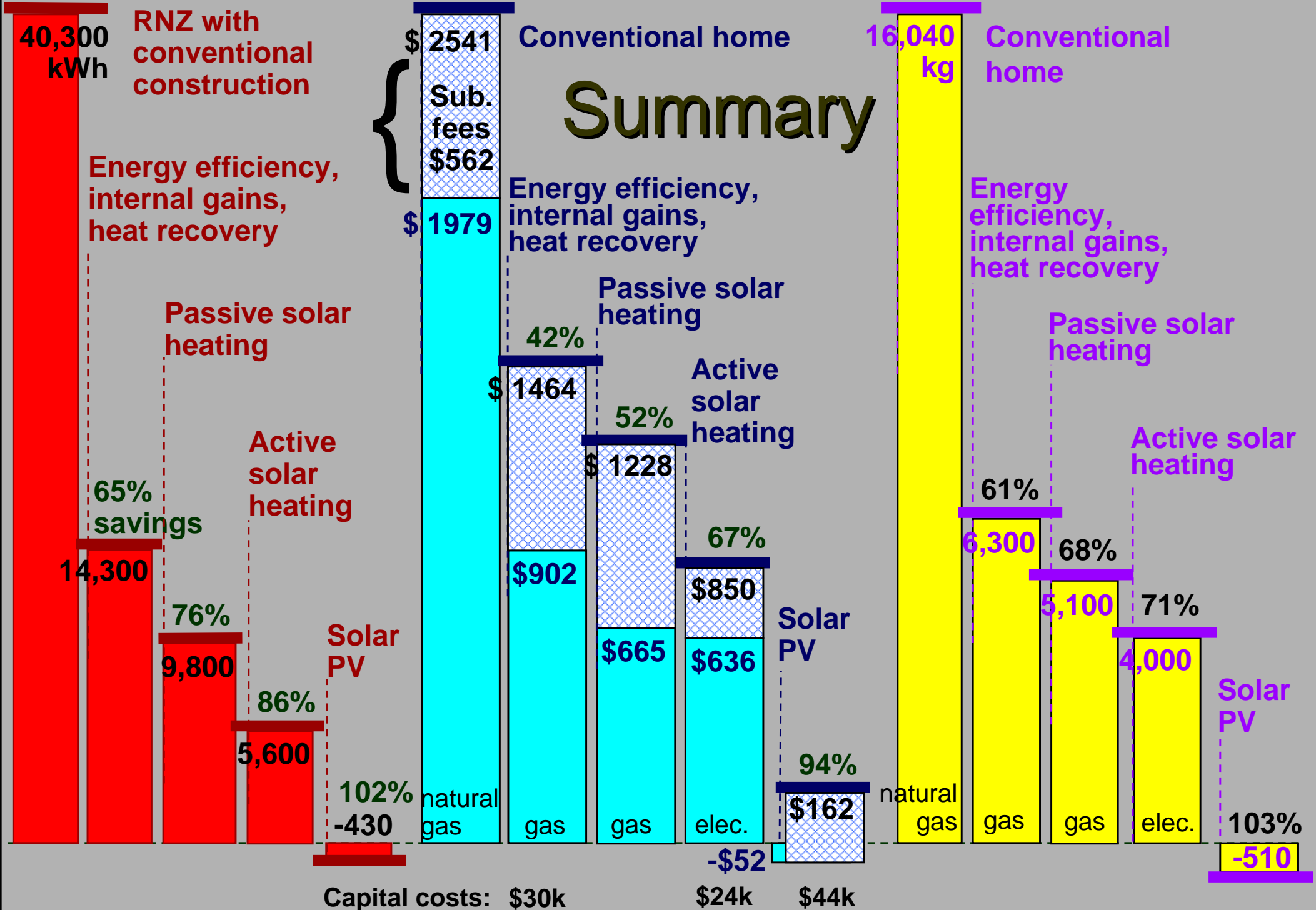


## Total fossil energy use

## Total energy bill

## Total emissions

# Summary





# Technology Challenges

## Challenges

- Energy reduction:
  - Appliances and equipment
  - Insulation, windows, doors, shutters
  - Window shutters
  - Heat recovery
- Heat supply:
  - Passive solar heating
  - Active solar domestic water heating
  - Active solar space heating
  - Geothermal heat pumps
- Electricity supply:
  - Solar PV

# Organisational Challenges

## ● Training and Awareness

- integrated design
- performance modelling
- building trades
- plumbing codes
- performance standards
- design professionals
- need better software
- energy efficient construction, solar installation
- grey water recycling, solar water heating
- needed for drain water heat recovery, solar space heating, insulation systems
- grid-connection
- utility companies and regulators
- marketing
- real estate agents

## ● Lack of community design standards

- land-use bylaws
- solar access
- subdivision design
- for selling PV electricity, installing microwind
- how to maximise solar gains

# Economic Climate

- **Alberta's economy**
  - based on coal, oil, natural gas, tar sands
- **Government policies** (energy regulatory, fiscal, economic development and environmental)
  - Strongly value economic growth
  - Do not value the environment
  - See that reducing energy consumption is a threat to the economy
  - Have the effect of increasing the production and consumption of fossil fuels
  - Have the effect of subsidising fossil fuel prices
- These challenges are relational, and thus have solutions that are organisational in their nature, not technical.



# Economic Challenges

- **House cost**
  - some \$85 to \$100k extra to build because of net zero energy features
- **Energy bill savings**
  - around \$2400 per year.
- **Simple return on investment**
  - Perceived to be 2.4% (42 years payback)
- **Government regulatory policies** regarding
  - Generating electricity into the grid
  - Value of the environment
  - Subsidies of fossil fuels (implicit and explicit)
  - Loan financing
  - Increase the operating costs for the house
  - Reduce the savings and benefits of energy efficiency and solar energy
  - Result in a **minus 4%** per year ROI (payback is never).

# Policy Solutions

- If government regulatory polices
  - **Valued** the environment
  - **Allowed** full cost recovery of all electricity fed into the grid
  - **Valued** increasing Canada's solar industrial capacity
  - **Harmonised** grid-connection and metering regulations
  - **Removed** fossil fuel subsidies
  - **Required** fossil fuels to pay for their environmental damage
  - **Provided** ultra-low interest green loans
  - The energy operating cost of the house would be zero
  - The benefits of energy efficiency and solar energy would be fully valued
  - Would result in a **+5.2%** per year ROI (18 year payback).

The changes to achieve this relate to how we want to organise ourselves, they are not technical.

# Policy Recommendations

...organising government policies to facilitate net zero energy housing.

- Governments
  - **Eliminate** barriers to net zero energy housing and to micropower grid access
  - **Develop** ultra low-interest “green” loans
  - **Develop** and **demonstrate** net zero energy housing
  - Have a common micropower grid-connection **approvals process**
  - Use **utility energy prices** to provide realistic economic returns for the reduction in emissions, use of energy efficiency and renewable energy
  - Provide ways for **utility companies to profit** from energy efficiency and renewable energy
  - **Revise** land-use bylaws, solar access laws, building codes, energy codes and product standards to reflect the full costs of all energy use

# The Challenges of Designing and Building a Net Zero Energy Home in a Cold High-Latitude Climate

Download a  
copy of the full paper and detailed presentation from:  
[www.edmonton.ca/ecovision](http://www.edmonton.ca/ecovision) and  
[www.riverdalenetzero.ca/PRESENTATIONS/SolarCities](http://www.riverdalenetzero.ca/PRESENTATIONS/SolarCities)

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