RiverdaleNetZeroProject

– What does
conduction, convection and radiation
have to do with reality? –

American Association of Physics Teachers
conference
2008 July 21

Gordon Howell, P.Eng.

Edmonton
Phone: +1 780 484 0476 E-mail: ghowell@hme.ca

Riverdale NetZero Team
– Proponents

- Peter Amerongen — Habitat Studio and Workshop
  - designer, builder, developer
- Andy Smith, P.Eng. — Solnorth Engineering
  - consultant, structural engineer, passive solar heating
- Gordon Howell, P.Eng. — Howell-Mayhew Engineering
  - consultant, electrical engineer, solar PV, performance monitoring
- Plus 45 additional team members…

Habitat Studio & Workshop Ltd

Solnorth Engineering Ltd

howell-mayhew engineering,inc.

Net Zero Energy Healthy Housing Competition

- 72 teams across Canada indicated their interest to CMHC in 2006 July.
- 20 were selected to design the project in 2006 August.
- 12 were selected to build their proposed project in 2006 October:
  - Quebec – 3 projects (Verdun, Eastman, Hudson)
  - Ontario – 3 projects (2 in Toronto, 1 in Ottawa)
  - Manitoba – 1 project (Winnipeg)
  - Saskatchewan – 1 project (Prince Albert)
  - Alberta – 4 projects (Edmonton, 2 in Red Deer, 1 in Calgary)
- CMHC brand: "EQuilibrium Housing"

Elements of EQuilibrium Housing

- Health
  - Indoor air quality
    - Emissions
    - Thermal comfort
    - Moisture
    - Particle control
    - Ventilation
  - Daylighting
  - Noise control
  - Water quality
- Energy
  - Annual energy consumption
  - Renewable energy strategy
  - Peak electricity demand
  - Embodied energy strategy
- Resources
  - Sustainable materials
  - Durability
  - Material efficiency
  - Water conservation
  - Adaptability / flexibility
- Environment
  - Land use planning
  - Sediment and erosion control
  - Storm water management
  - Waste water management
  - Solid waste management
  - Air pollution emissions
- Affordability
  - Financing
  - Marketability

Canada

EQuilibrium HEALTHY HOUSING FOR A HEALTHY ENVIRONMENT

CMHC SCHL

Discussions of EQuilibrium Housing

- Technology
  - Products
  - Performance simulation
  - Design
  - Installation
  - Operation
  - Monitoring
- Attributes of House
  - Energy
  - Indoor environment (air, water)
  - Outdoor environment (water, landscaping)
  - Sustainability, materials
  - Emissions (air, water, land, waste)
  - Costs, economics
- Technology Transfer
  - Communication
  - Awareness
  - Education
  - Training
  - Demonstration
  - Marketing
- Organisation of Society
  - Policy
  - Infrastructure
  - Industrial capacity
  - Incentives
  - Subsidies
  - Remove competing subsidies

Service to others…
is the rent you pay for your room here on earth. Muhammad Ali

Why is it called a Net Zero Energy Home?

- A home that generates all its heat and electricity on an annual basis.

- It still uses energy…
- but it gets all its energy from renewable sources (usually solar)

Net zero is just the dividing line between

– net deficit (when your house needs energy from the grid because it doesn't generate enough), and

– net surplus (when the environment is better off because your house exists).

How do you plan for a net zero energy house?

- **Minimise**
  the heating and electricity consumption of the house
  - The cheapest energy option

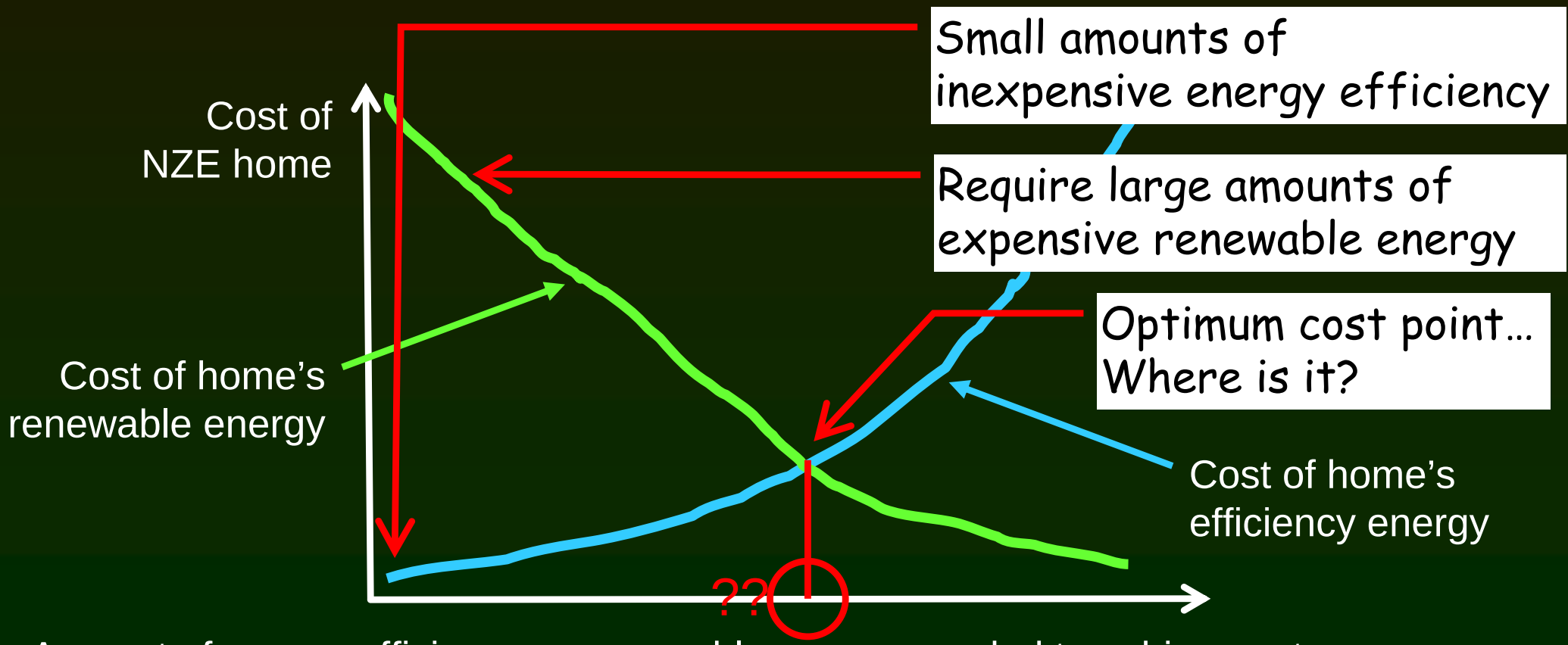
- **Maximise**
  solar energy contribution to the house's heating and electricity supply

Every great movement must experience three stages:
…ridicule, discussion, adoption.
John Stuart Mill

Design Challenge:

Where is the point where we decide between using more EE and using more RE?

- We know:
  - the goal is net zero energy…
  - we need large amounts of energy efficiency (EE) and large amounts of renewable energy (RE).



The Design Challenge:

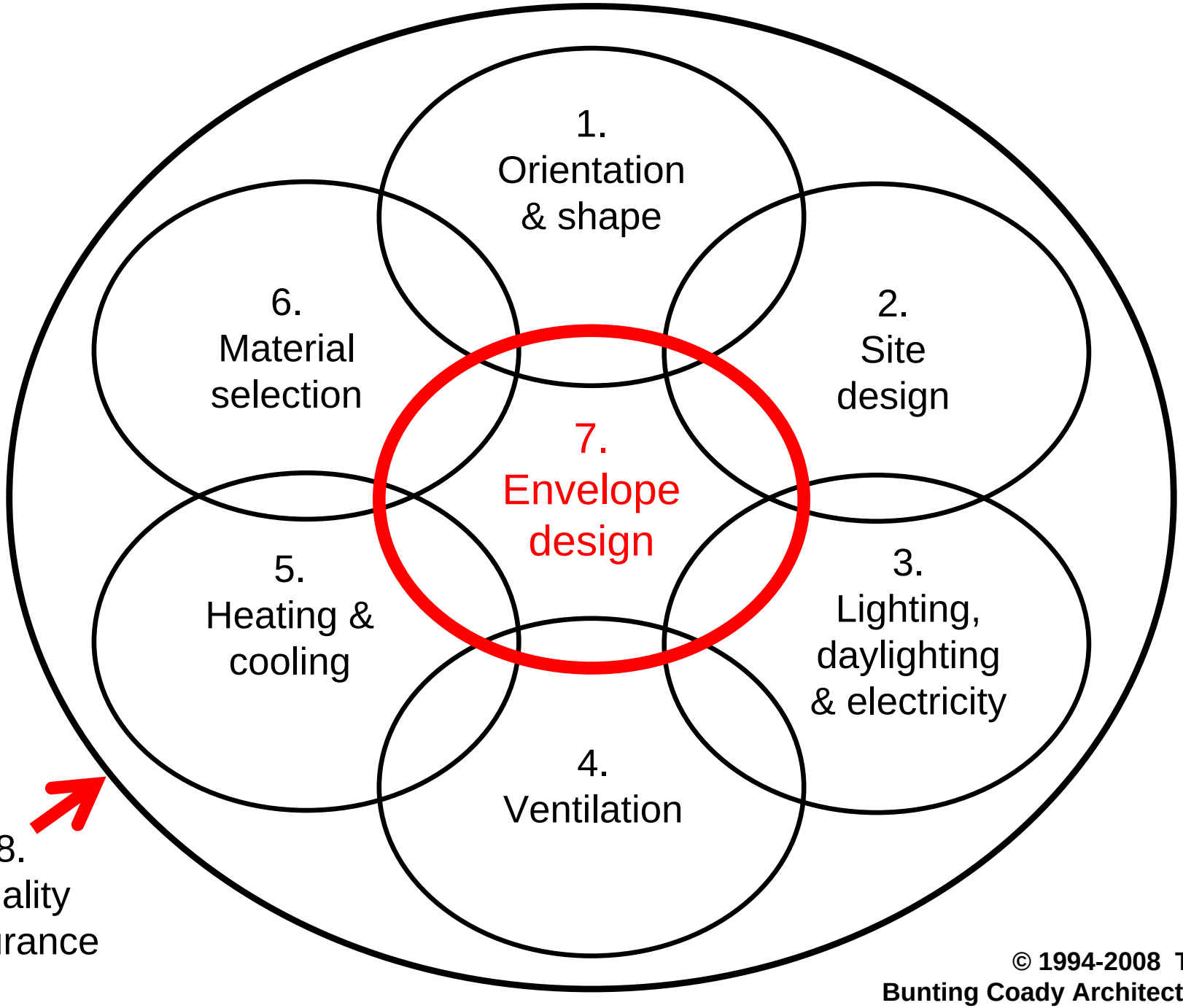
Is it possible to achieve NZ energy?

- An average house uses:
  - Around 6 times more heating fuel energy than electricity!
  - Biggest challenge is not in supplying household electricity…
  - Instead … it is in supplying home heating!

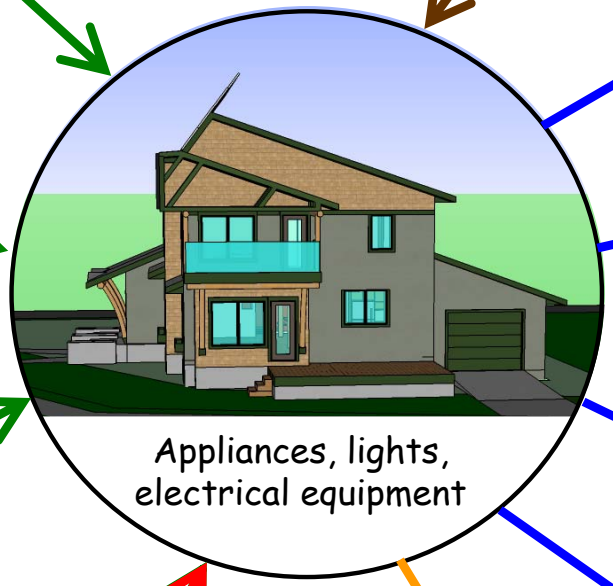
I'd put my money on the sun and solar energy. What a source of power!
I hope we don't have to wait 'til oil and coal run out before we tackle that.

Thomas Edison
(1847–1931)

Integrated Design Process



Energy Flows – Riverdale NetZero Home



Home's envelope
(walls, ceiling, floor, windows, doors)

Passive solar for home heating – all windows

Active solar heat for water and home

Solar photovoltaics (PV) for electricity

Heat loss through envelope

Heat loss from ventilation air
(forced plus natural ventilation)

Heat loss from waste water

Electricity used outside the home

Surplus solar electricity exported to grid

Coal and natural gas electricity imported from grid

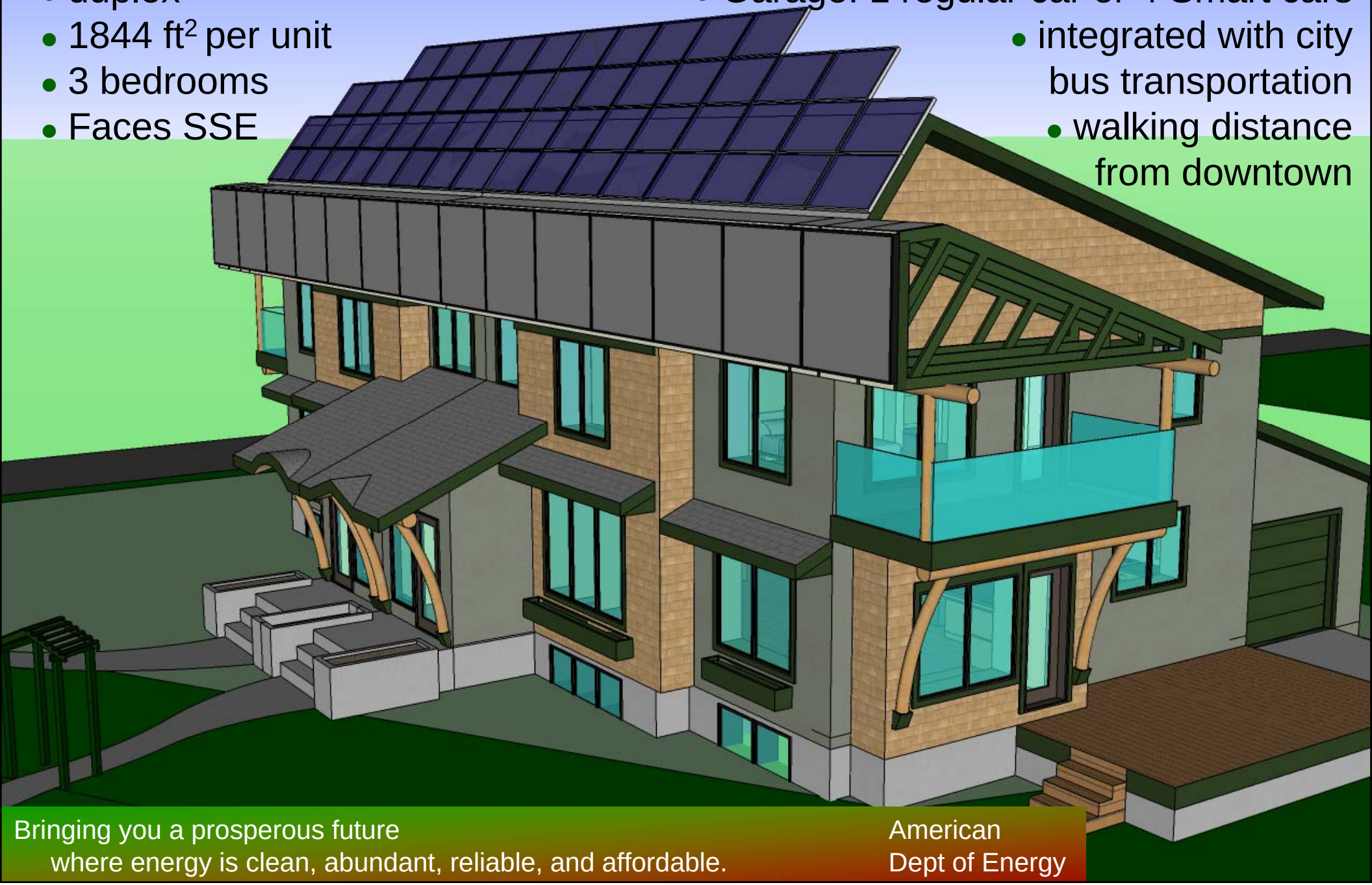
Net Zero Goal:
Electricity imported from grid
minus
Electricity exported to grid
=
Zero when added up over the year

Every revolution is about power!

Riverdale NetZero Energy Home

- duplex
- 1844 ft^2 per unit
- 3 bedrooms
- Faces SSE

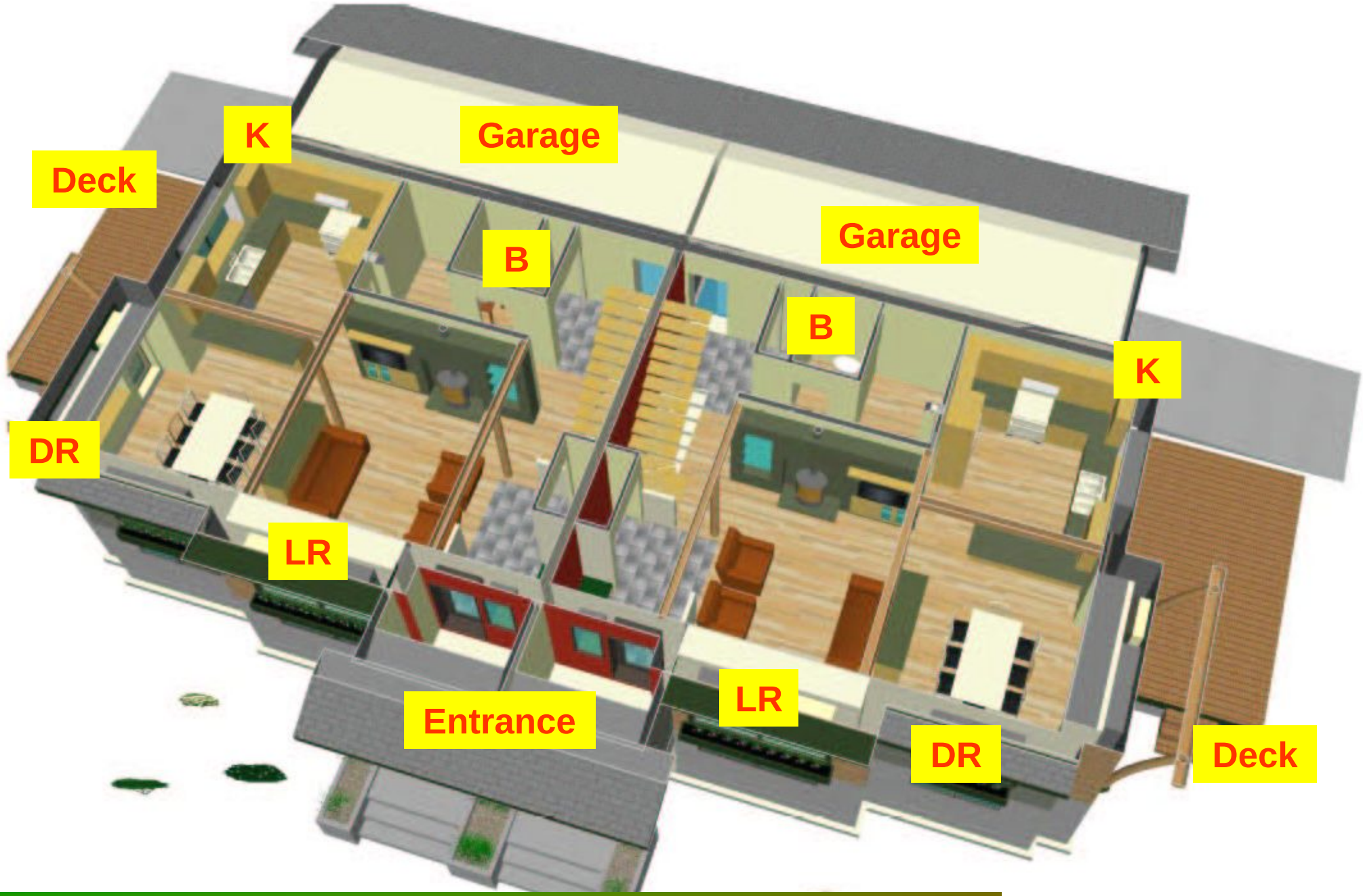
- Garage: 1 regular car or 4 Smart cars
- integrated with city bus transportation
- walking distance from downtown



Bringing you a prosperous future
where energy is clean, abundant, reliable, and affordable.

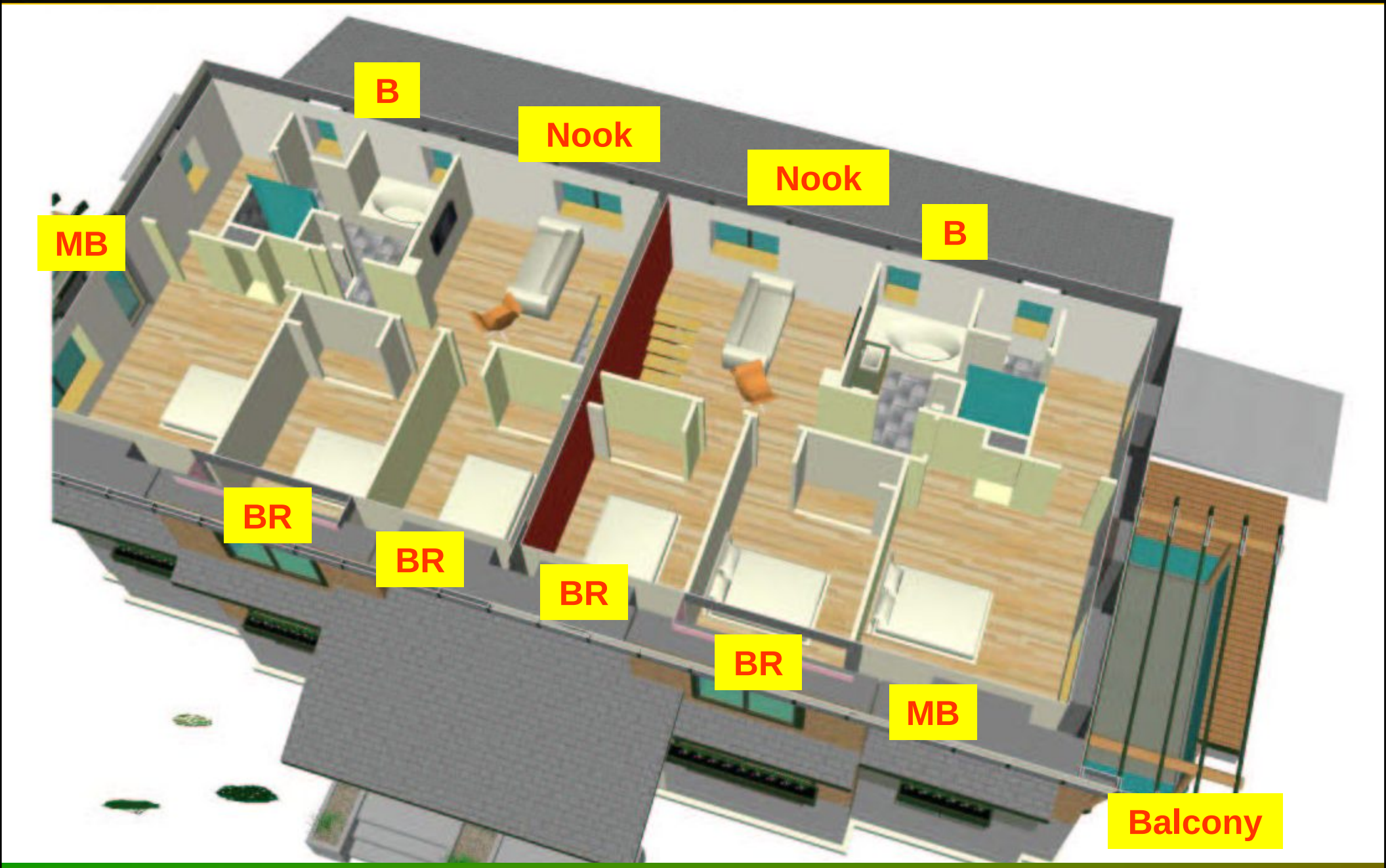
American
Dept of Energy

Main Floor



We've never lacked the means to solve our problems …only the will to do it.

Upper Floor



People who say it cannot be done … should not interrupt those who are doing it. George Bernard Shaw

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 thermal for household water heating…???
- Active solar thermal for home heating…???
- Solar air heating… ???
- Geothermal heat pump…???

} Heating technologies

- Solar photovoltaics…???
- Microwind…???

} Electricity technologies

Cities grow great… when old men plant trees in whose shade they know they will never sit in.

#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
- Uses only 4500 kWh (about $500 per year)
  (conventional is 9058 kWh, about $1000 per year)

Nobody is more blind, than one who does not want to see.

#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 litres of hot water per day
    - Low flow shower heads and faucets
    - Water conserving dishwasher
    - Water conserving clothes washer
- Drain water heat recovery
  - reduces water heating to equivalent of 90 L/d

The future does not belong to those who are content with today, fearful in the face of new ideas and bold projects. It will belong to those with a personal commitment.

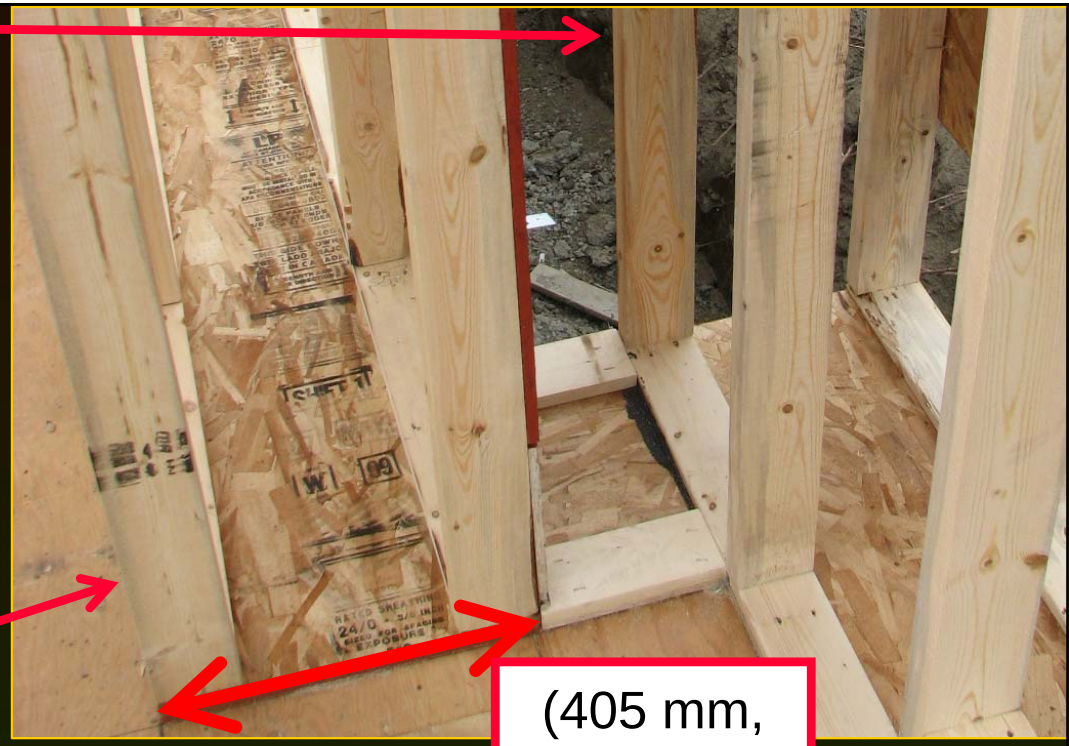
Robert Kennedy
1966

#3. Energy Efficiency
– most important

	Riverdale NZE	90s house	70s house
Wall construction:	double 2x4	single 2x6	single 2x4
Insulation:			
– ceiling:	R-100	R-28 to 34	R-12
– walls:	R-56	R-20	R-8
– basement walls:	R-54	R-8 (upper part)	nothing
– basement floor:	R-24	nothing	nothing
Windows:	3-glazed (S, E, W) 4-glazed (N) low-e, argon gas	2-glazed	2-glazed
Air leakage rate:	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
- Cellufibre insulation
  - Recycled newspapers
  - Low embodied energy
  - Locally produced
  - Sequestered carbon
  - Not a hydrocarbon product
  - Walls: 400 mm (R- 56)
  - Ceiling: 690 mm (R-100)



Going to a junkyard is a sobering experience…
There you can see the ultimate destination of almost everything we desire. Roger von Oech

High Performance Windows

South windows
3-glazings
R-7.3

East/west
windows
3-glazings
R-8.3

North windows
4-glazings
R-10

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

Results: Heat Loss at Winter Design Conditions

	Riverdale NZE	90s house	70s house
Floor area:	1844 ft^2	1500 to 1800	1500 to 1800
Heat loss at –32°C:	6.6 kW (22,400 BTU/h)	20 to 26 kW (70,000 to 90,000)	29 to 35 kW (100,000 to 120,000)
# of 4-slice toasters to heat the house at –32°C at night	4 (or 6 hair dryers)	12 to 15 (18 to 22)	17 to 21 (24 to 30)
EnerGuide rating: (building envelope efficiency)	86	62 to 65	55 to 58

The Earth provides enough to satisfy every man's need,
…but not every man's greed.

Mohandas Karamchand Gandhi (*Mahatma*) India

#4. Passive Solar Home Heating

- 16.9 m^2 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
- EnerGuide rating: 93
  (electricity efficiency, passive solar)

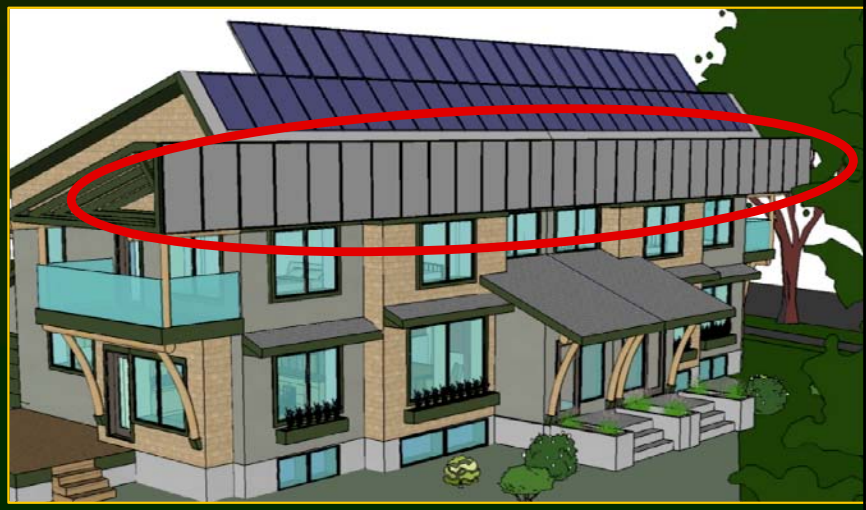
FAST – GOOD – CHEAP
… you are only allowed to choose two of them!

#5. Active Solar Water Heating

combined system

#6. Active Solar Home Heating

- 7 Zen collectors (21 m^2)
  - high-efficiency flat-plate collectors
  - mounted on a vertical tilt
    - to maximise winter solar gain
    - to eliminate snow cover
    - to maximise reflected solar energy
- 300 litres – hot water storage – water heating
  + 17 000 litres – warm water storage in basement – home heating
- Drainback system – water-based
  - does not use glycol
- Are including a very small solar-assist heat pump (3/4 T)
- EnerGuide rating: 96



Some men have thousands of reasons why they cannot do what they want to…
when all they need is one reason why they can.

Heating System

- Forced air
- Uses ventilation system that is already required by the house
- Low-speed fan – very quiet
- Gives uniform room temperatures

- Can do this because the walls and windows have such high R-values and so:
  - the walls and windows will be warmer; and
  - the rooms will need such little amounts of heat.

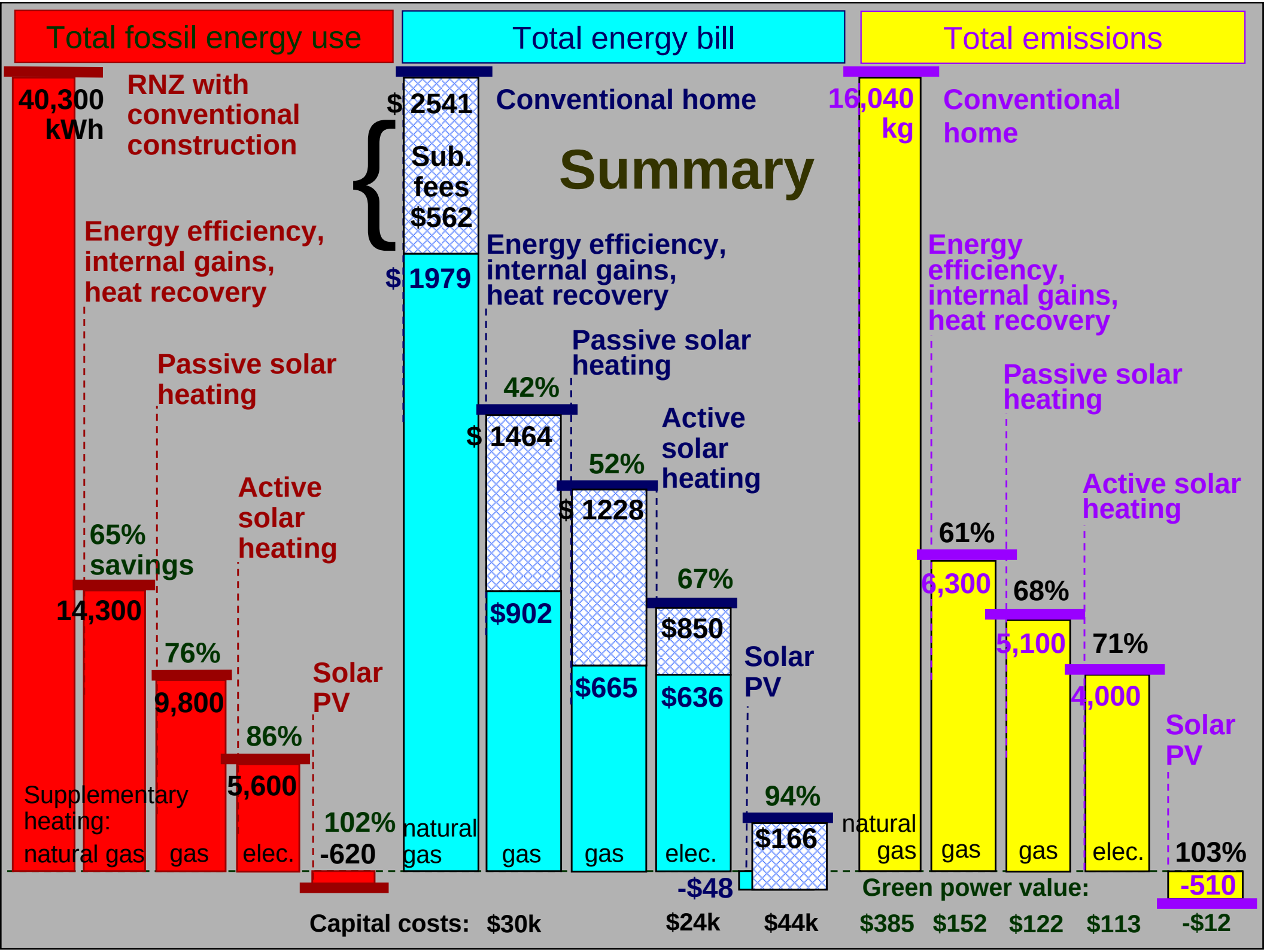
#7. Solar Electric Power System

called “photovoltaics” or PV

- 28 Sanyo high efficiency (17%) 200 W PV modules (Japan)
  - 33 m^2, 5600 W in bright sunshine
  - Solar array is mounted at 53°tilt to:
    - minimise 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)
- EnerGuide rating: 100.4

  (surplus of 620 kWh/year)

Those who make peaceful change impossible,
make violent change inevitable. John F. Kennedy, America


Total fossil energy use
Total energy bill
Total emissions
Summary
40,300 kWh
RNZ with conventional construction
Energy efficiency, internal gains, heat recovery
Passive solar heating
Active solar heating
Solar PV
65% savings
14,300
76%
9,800
86%
5,600
102%
-620
Supplementary heating:
natural gas
gas
elec.
$ 2541
Conventional home
Sub. fees $562
$ 1979
Energy efficiency, internal gains, heat recovery
42%
$ 1464
$902
Passive solar heating
52%
$ 1228
$665
Active solar heating
67%
$850
$636
Solar PV
94%
$166
-$48
natural gas
gas
gas
elec.
Capital costs:
$30k
$24k
$44k
16,040 kg
Conventional home
Energy efficiency, internal gains, heat recovery
61%
6,300
Passive solar heating
68%
5,100
Active solar heating
71%
4,000
Solar PV
103%
-510
natural gas
gas
gas
elec.
Green power value:
$385
$152
$122
$113
-$12

Preliminary Cost Numbers

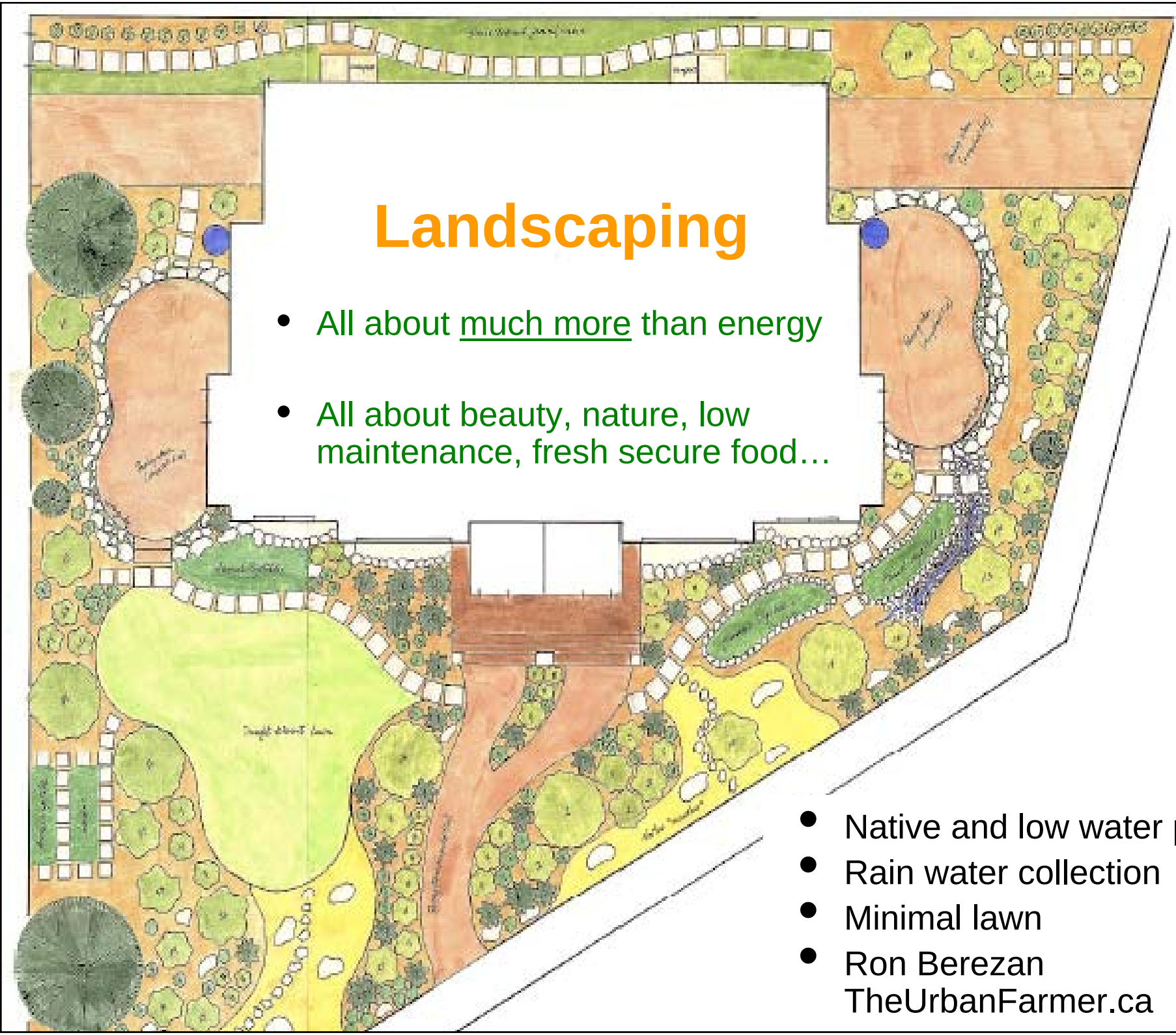
- Wall energy efficiency: $4 to 4.50 /ft2 extra

- Energy efficiency: $20k to $30k
- Solar thermal: $25k to $30k
- Solar electricity: $40k to $50k

- Total additional cost: ~$85k to $110k

  Total house cost: ~$244 /ft2

Socialism collapsed because it did not allow the market to tell the economic truth. Øystein Dahle
Capitalism may collapse because it does not allow the market to tell the ecological truth. Exxon Norway



Landscaping

- All about <u>much more</u> than energy
- All about beauty, nature, low maintenance, fresh secure food…

- Native and low water plants
- Rain water collection
- Minimal lawn
- Ron Berezan TheUrbanFarmer.ca

Sustainable Materials, Air Quality

- Use materials that:
  - Had low manufactured energy
  - Are cleanly manufactured
  - Have low transportation energy
  - Are highly durable
  - Have high recycled content, are recyclable
    - Uses feature beams recycled from liquor store
    - Uses siding from the old house for finish exterior around the windows
    - Recycled floor from a gym
    - Recycled window and door moldings
  - Have low off-gassing of VOC's (volatile organic compounds)

Sustainable materials database: GreenAlberta.ca

The superior man seeks what is right; the inferior one, what is profitable. Confucius

In designing and building the house, what have we learned so far?

- Likely we do not need to have a **heat distribution system**!
  - Standard ventilation system can be used to distribute any additional heat that the rooms need in addition to the house
- Make the house "**grey water ready**" so that when you want to add a grey water heat recovery system in the future, you will be ready for it.
- Use more **passive solar space heating** and make sure it is controlled well.
- The design, installation and control points for the **active solar space heating** system are quite complex.
- **Solar electric power** is a very easy and flexible technology, though expensive.

Barriers and Opportunities
– where policies need to facilitate change instead of blocking the changes…

- LOTS of work to be done here…
  - Re-organisation of society's energy and development priorities
- Green loans – interest rates easily block energy efficiency and renewable energy options
- Changes to fossil fuel energy tariff and subsidy structure:
  - Elimination of utility bill monthly connection charges
  - Full-cost accounting for fossil fuel health care and environmental costs
  - Remove substantial subsidies on fossil fuels
  - Remove industrial-scale fees and taxes on renewable energy

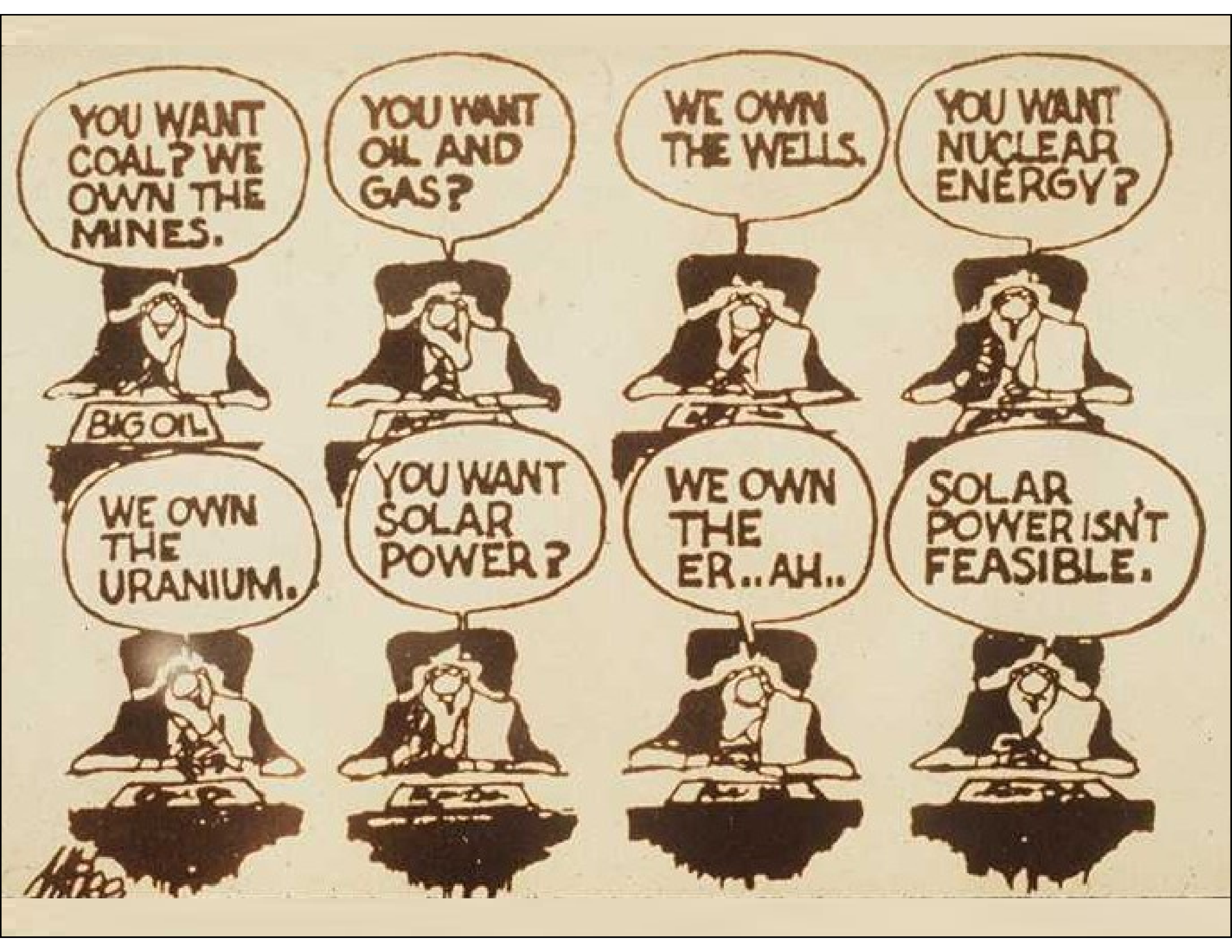
Anyone who thinks they are too small to make a difference… has never spent the night with a mosquito. African Proverb

Gordon Howell, P.Eng.
Howell-Mayhew Engineering

Edmonton
Phone: +1 780 484 0476
E-mail: ghowell@hme.ca

Photo credits: Gordon Howell, Peter Amerongen, Max Amerongen and several others

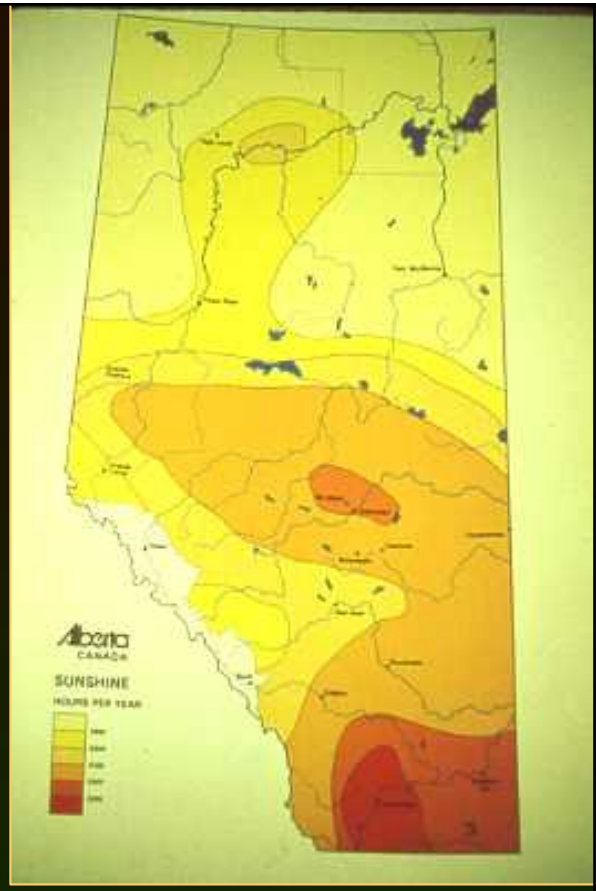
Download this presentation from
www.hme.ca/presentations/RiverdaleNetZero--AAPT.pdf


YOU WANT COAL? WE OWN THE MINES.
BIG OIL
WE OWN THE URANIUM.
YOU WANT OIL AND GAS?
YOU WANT SOLAR POWER?
WE OWN THE WELLS.
WE OWN THE ER.. AH..
YOU WANT NUCLEAR ENERGY?
SOLAR POWER ISN'T FEASIBLE.

Question: What is Alberta's most abundant energy resource?

Alberta: The Solar Province

– Our Most Abundant Energy Resource



- 14 hours of sunshine = all our fossil energy resources in 2001!
- Alberta's sunshine is over 300 times more than our fossil fuel resources.

What is the use of a house
...if you haven't got a tolerable planet to put it on?

Henry David Thoreau, America

Development of Alberta's Solar Resource

- Alberta's solar energy resource today is similar to the tar sands of several decades ago:
  - rich resource
  - currently expensive
  - not a lot of experience in Alberta
  - many barriers to utilization
  - many opportunities to develop jobs, products and markets for the world

- Key issues: how to store energy? – from day to night, from summer to winter

Government Response to our Solar Resource

	Alberta
Policies that facilitate	None
Policies that subsidize	None
Development programmes – industrial capacity, infrastructure, regulations, research, standards, issues…	None
Taxation policies	Solar power is treated like an industrial power generator – industrial taxes are 4x the value of the electricity generated!
Policies that subsidize competing energy sources	– Natural gas rebates in the winter – Low oil, gas, and coal royalty rates – Tax holidays for the tar sands – No environmental royalties !!

Policy Contrasts…

- In contrast to Canada and Alberta…

  billions are being spent in other industrialized countries to develop their solar energy sector:

- Industrial capacity
- Manufacturing processes
- Regulations
- Products
- Infrastructure integration
- World market development…
- Research
- Infrastructure
- Services
- Applications

"We don't know what to do about solar energy because we don't know how to tax it."

Alberta Energy in 2003 June

Political will arises from personal momentum

We need to be the leaders to our governments and corporations.