The Path to Net Zero Energy Houses – Introduction

Riverdale NZE

Belgravia NZE

Mill Creek NZE

South Windsor Park NZE

Alaska Centre for Appropriate Technology

Juneau, Fairbanks, Wasilla, Anchorage
2011 April 11-15

Gordon Howell, P.Eng.
howell-mayhew engineering, inc.

Peter Amerongen
Habitat Studio & Workshop Ltd

Edmonton, Canada

Workshop Outline

1. Introduction and Overview
2. Modelling
   – how do you determine how to achieve NZE?
3. Renewable Energy Options
   – the sizzle, but not the first thing to do…
4. Building Envelope
   – where the affordability happens
5. Mechanical Systems
   – what do you really need?
6. Renewable Materials
7. Marketing and Affordability
8. Logistics, Trades, Contractors
9. Verification – being real about net zero

Intro: Us, Our Work…

- I am a professional engineer (electrical)
  - solar energy since 1977 and solar electricity since 1984
- Howell-Mayhew Engineering is a solar-electric system developer
- We design, supply and commission solar electric systems
- We participate on provincial, national and international committees to write solar-electric standards
- We have no vested interests in any one solar-electric technology
- Our interest is that you choose wisely:
  - with your eyes **wide open**
  - based on the facts and whether it is right for **you** …or not.

howell-mayhew engineering,inc.

my house
Edmonton
20 m^2 (215 ft^2)
2.3 kW
12th one in Canada in 1995
100% solar electricity

…and others

- We also work with homebuilders who want solar-electric systems or who want to build net zero energy homes
  - Edmonton's first 6:

    Habitat Studio & Workshop Ltd
  - plus, under construction:
    - Effect Homes
    - Rosecrest Homes
    - Kensington Master Builder
    - and others…
  - total of around 12 houses now…

howell·mayhew engineering, inc.

Intent of Workshop

- To show you the path to take in order
  to achieve a net zero energy house

- With an actual example from Edmonton
  modelled for Juneau, Fairbanks, Wasilla and Anchorage

- This workshop shows the process and path
  - as real as we can make it in 1 day…

  - you will need to confirm various details
    (exact costs of equipment, prices of energy,
    incentives, politics)
    that are particular to your own city.

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

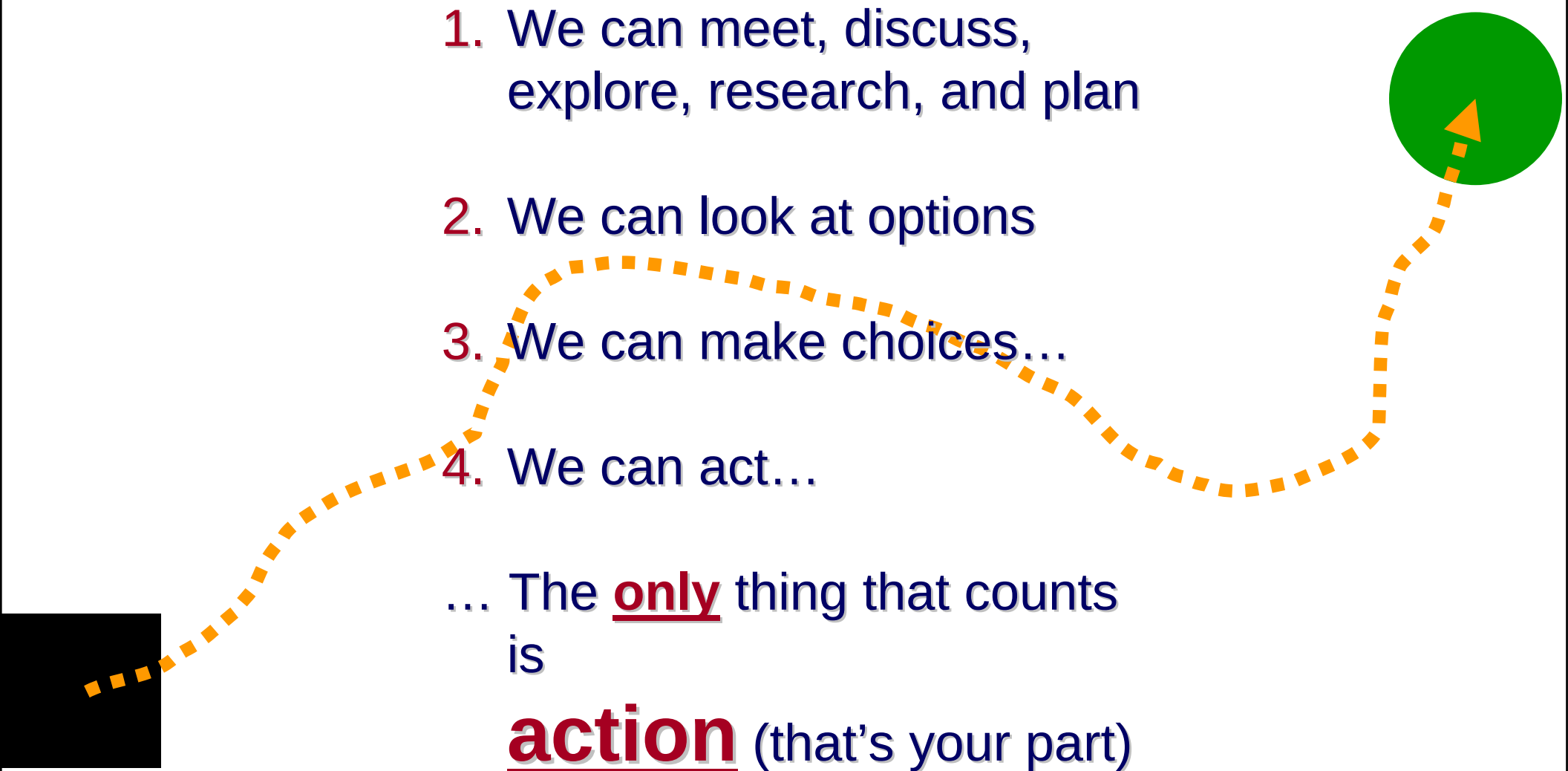
Mohandas Karamchand Gandhi
(*Mahatma*)
India

Taking steps… the only thing to do

1. We can meet, discuss, explore, research, and plan
2. We can look at options
3. We can make choices…
4. We can act…

… The **only** thing that counts is

action (that's your part)



Knowing is not enough… we must apply.
Willing is not enough… we must do.

Johann Wolfgang von Goethe

Canada's Precedents

Saskatchewan Conservation House (1977)
Regina, Saskatchewan
76 kWh /year /m^2 (24 BTU /year /ft^2)

Rob Dumont's House (1992)
Saskatoon, Saskatchewan
47 kWh /year /m^2 (15 BTU /year /ft^2)

Factor 9 House (2007)
Regina, Saskatchewan
33 kWh /year /m^2 (10.5 BTU /year /ft^2)

howell·mayhew engineering, inc.

Edmonton's Net Zero Energy Houses

- Riverdale

- 2 net zero houses completed
  - 6 under construction
    - 2 being planned
- 6 builders

- Mill Creek

Peter Amerongen

Habitat Studio & Workshop Ltd

www.habitat-studio.com

- Parkland

- Belgravia

- South Windsor Park

Status of NZE Housing Development

- Process of the development of any technology
  - prove the technical concept
  - increase its durability
  - reduce its costs (evaluate different options)
  - marketing, promotion, codes, standards (simultaneous)

- All equipment and components are off-the-shelf
  - They are combined together in a way not done before.
  - No new technologies need to be developed…

    but many new ones will be developed
    in order to help reach the NZE goal more cheaply.

howell·mayhew engineering, inc.

Why is it called a Net Zero Energy House?

- **A house that generates at least the same amount of energy as it uses on an annual basis…**

- **Net zero energy is just the dividing line between**
  - **net deficit energy** (where you need to purchase energy because your house doesn't generate sufficient on its own)
    and
  - **net surplus energy** (where the house is a benefit to the environment because it is operating)

- **It had never been done before in Canada until the government's Canada Mortgage and Housing Corporation (CMHC) developed their EQuilibrium Sustainable Housing Initiative.**

Key Concepts of Net Zero Energy

- only considers **operating energy**, not embodied energy
- is **assessed over the year**, not each day
- any off-site energy that is imported
  must be have an equivalent amount of
  on-site energy exported
  (other than wood heating, but only if it is sustainably harvested)
- is **always** connected to the electricity grid (so far)
  - doubtful that off-grid net-zero has yet been achieved on a practical house, though it is indeed technically possible
- typically is **not connected** to the natural gas grid
  (due to high cost of connecting to the natural gas grid)
- uses the electricity grid as an **energy storage** device
  - exports energy every second that generation > consumption
    if you have solar PV: any sunny second, more in the summer
  - imports energy every second that consumption > generation,
    more in the winter, less in summer

Canada

EQuilibrium HEALTHY HOUSING FOR A HEALTHY ENVIRONMENT

CMHC SCHL

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 about EQuilibrium Housing

- **Technology**
  - Products
  - Performance simulation
  - Design
  - Installation
  - Operation
  - Monitoring
- **Attributes of House**
  - Energy (house, food, transportation)
  - Indoor environment (air, water)
  - Outdoor environment (water, landscaping)
  - Sustainability, materials, recycling
  - Emissions (air, water, soil, land, waste)
  - Costs, economics
- **Technology Transfer**
  - Communication
  - Awareness
  - Education
  - Training
  - Demonstration
  - Marketing
- **Organisation of Society**
  - Policies and their goals and consequences
  - Infrastructure (energy, housing, transport)
  - Industrial capacity
  - Incentives, barriers and standards
  - Subsidies, green taxation
  - Removing competing subsidies

The Design Challenge: Is it possible to achieve NZ energy?

(after all, it's pretty cold and dark here in the winter…)

- In Edmonton, an average house uses:
  - Around 6 times more heating fuel energy than electricity! (ranging from 4 to 14 times)
  - Biggest challenge is <u>not</u> in supplying household electricity…
  - Instead … it is in supplying home heating! (likely the same as in all of Alaska)

howell·mayhew engineering, inc.

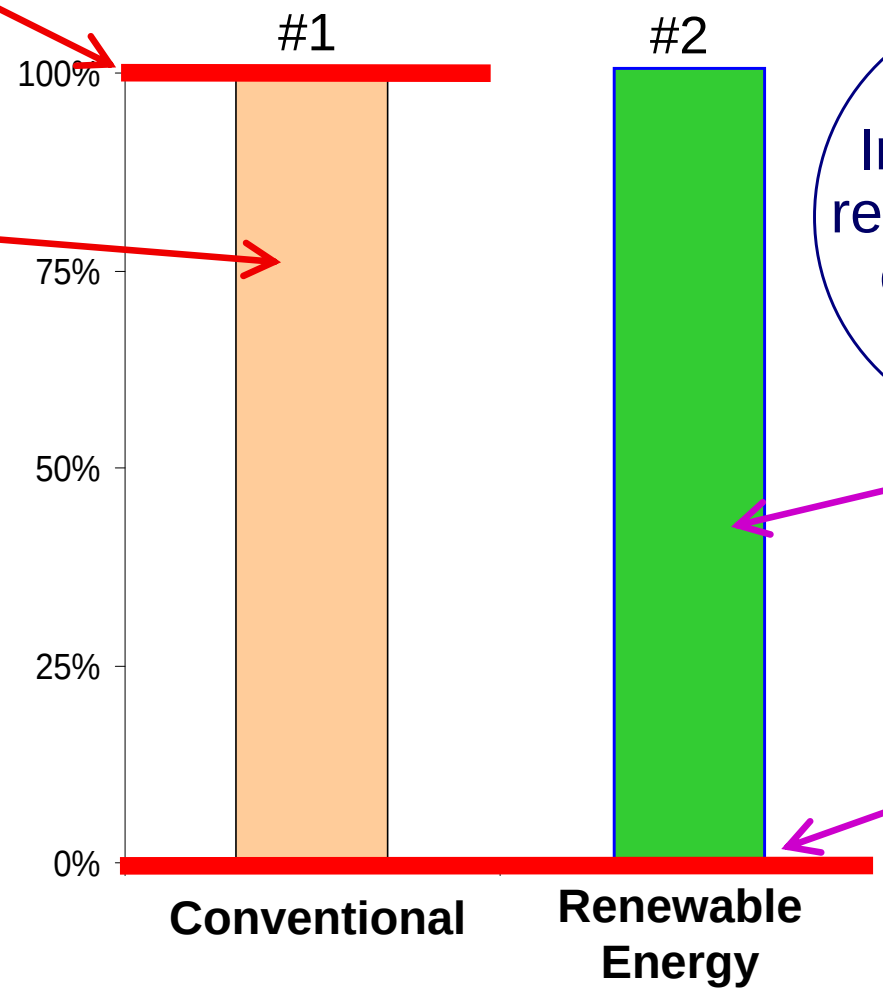
Beautiful home… as seen in visible light

Same home… as seen by its energy use

The most expensive way to achieve NZE…

Net Purchased Energy

Conventional Energy



Where is it?

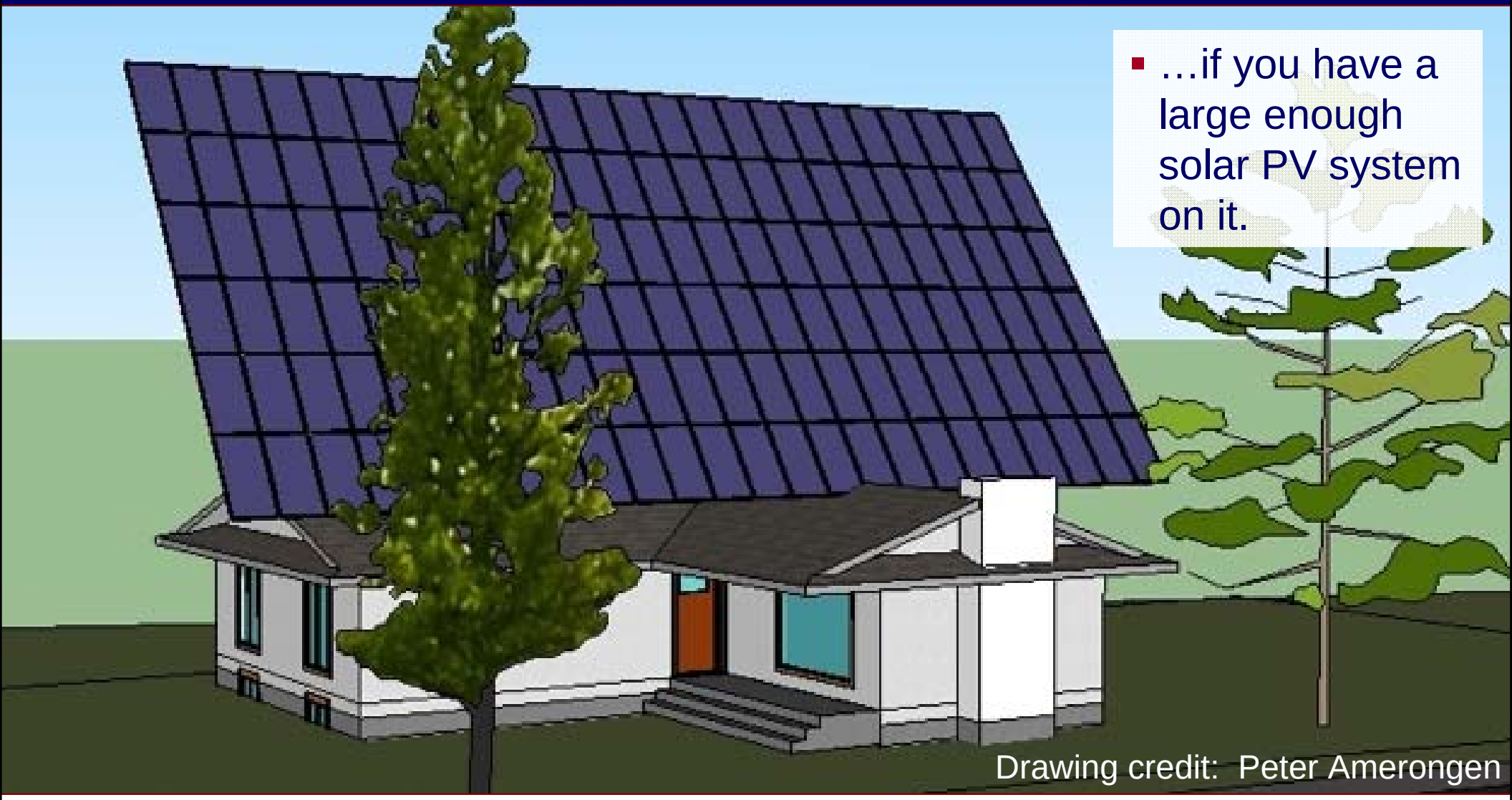
Inexpensive, reliable energy efficiency…

Add large amounts of expensive solar thermal, geothermal, solar PV or wind energy

Net zero energy home

Cost: $250k

Every House Can Achieve the NZE Goal…

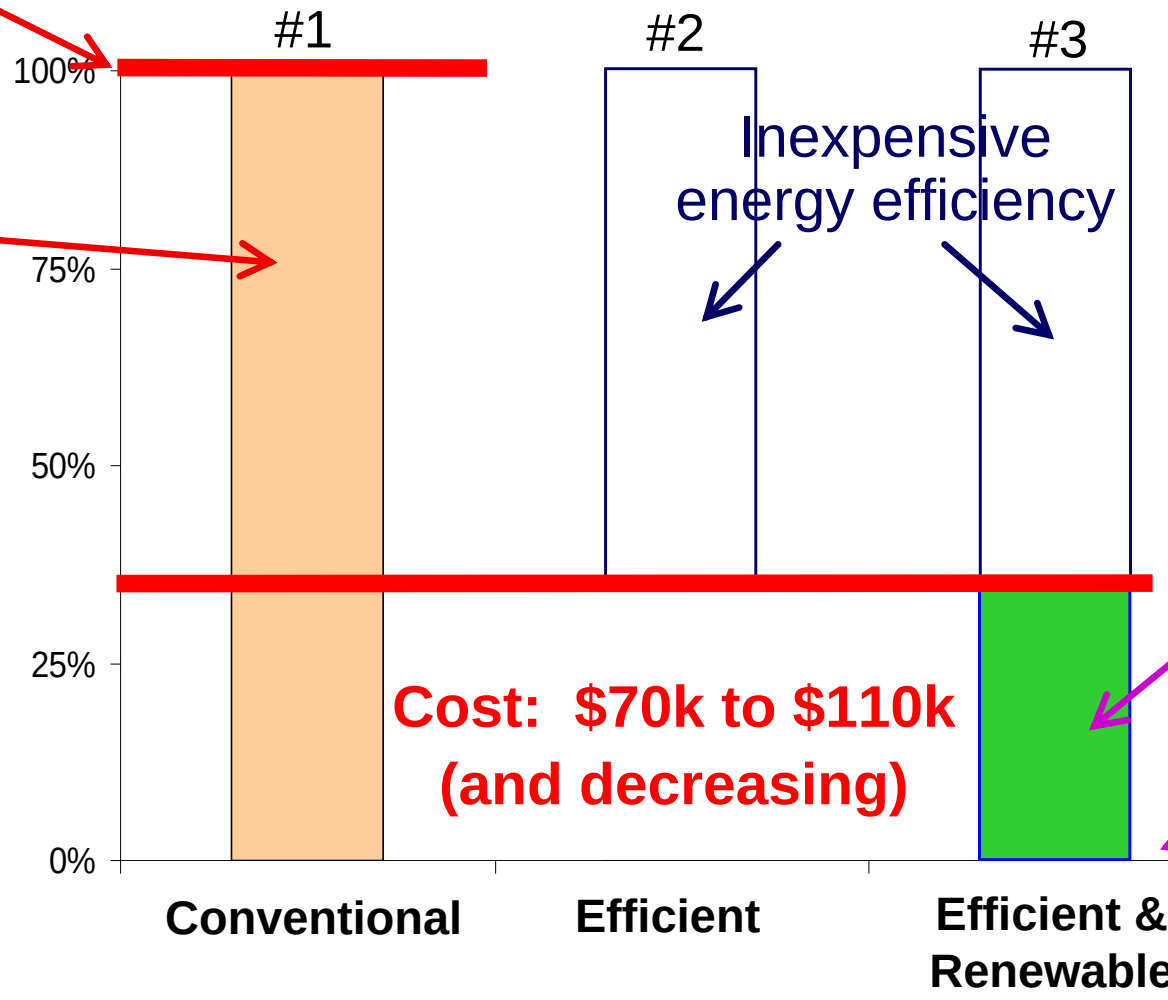


- But this will be the most expensive way to go…
- Making the house energy efficient is far cheaper than solar thermal, geothermal, solar PV, wind **and** energy from the grid.

The least expensive way to achieve NZE…

Net Purchased Energy

Conventional Energy



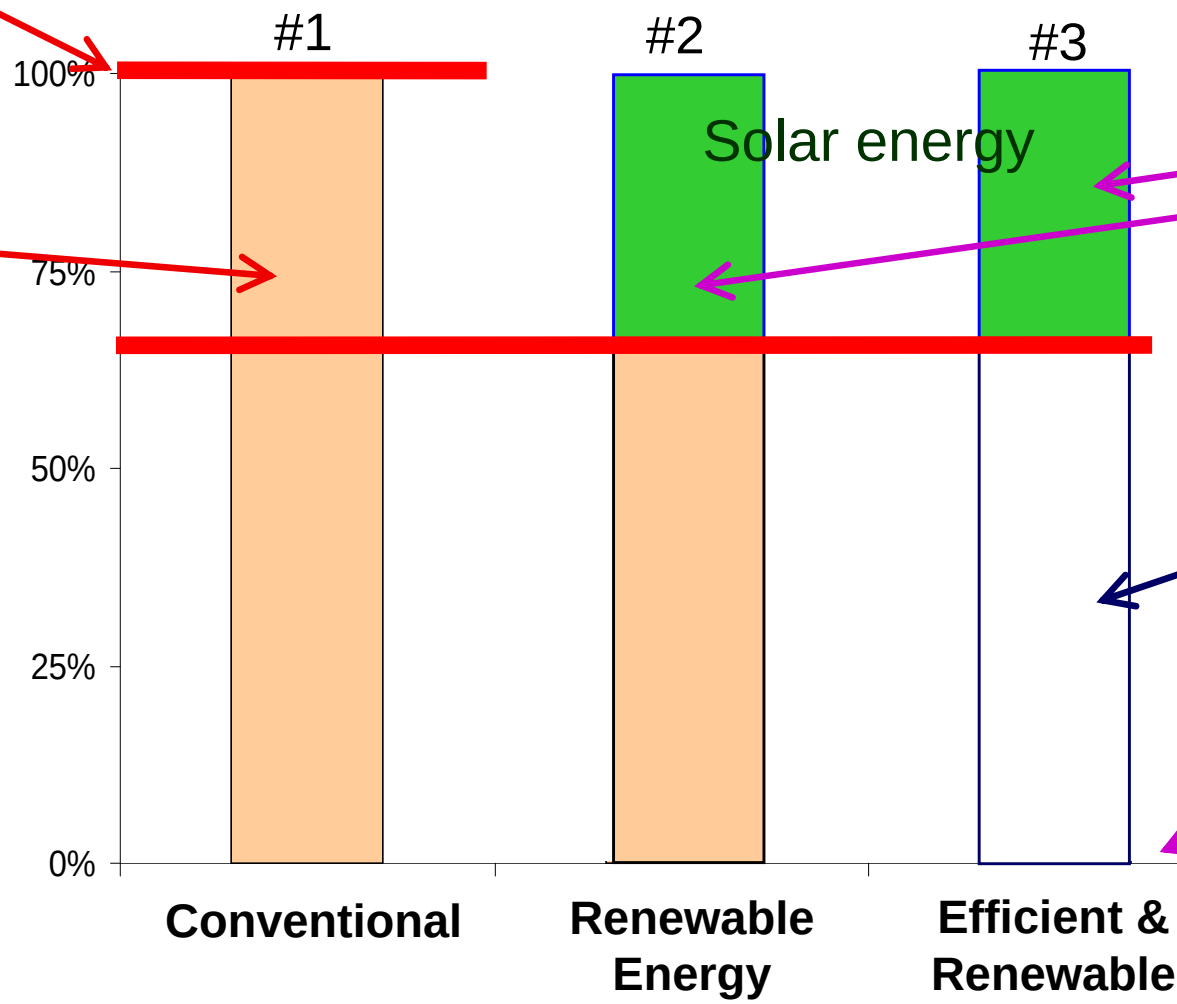
Add much smaller amounts of more expensive solar thermal, geothermal, solar PV or wind energy

Net zero energy home

The most exciting way to achieve NZE…

Net Purchased Energy

Conventional Energy



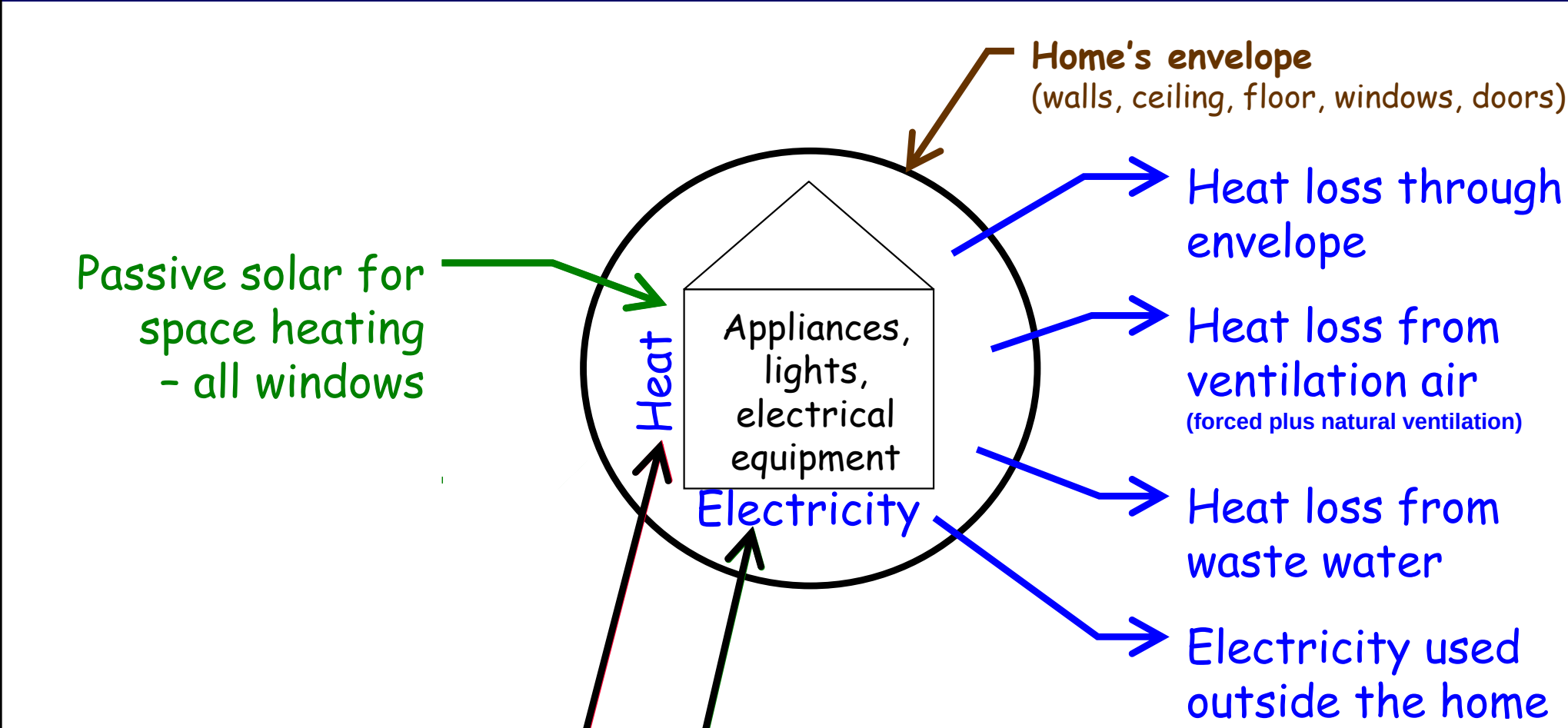
More expensive… yeah, but really exciting

Energy efficiency: most important, least expensive

Net zero energy home

howell·mayhew engineering, inc.

Energy Flows – Standard Home



Why does a home have an electricity bill and a natural gas bill?

Because its on-site production of electricity and heat is not sufficient to meet its electrical and heating requirements and so it needs to import energy from the grids.

Energy Flows – Any NetZero Home

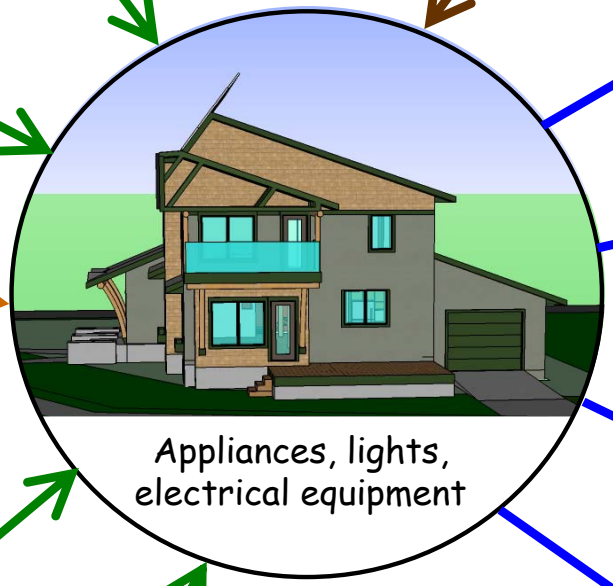
Passive solar for home heating – all windows

Active solar heat for water and space

Ground-, air- or water-source heat pump

Solar photovoltaics (PV) for electricity

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



Heat loss through envelope

Heat loss from ventilation air
(forced plus natural ventilation)

Heat loss from waste water

Electricity used outside the home

All electricity used inside the house goes to heat the house

==========

#3. The third key to a net zero energy house is to **maximise** and **control** the energy gains…

==========

#1. The first key to a net zero energy house is to **minimise** and **control** the electricity usage…

==========

#2. The second key to a net zero energy house is to **minimise** and **control** the house heat loss…

Energy Flows – Any NetZero Home

Passive solar for home heating – all windows

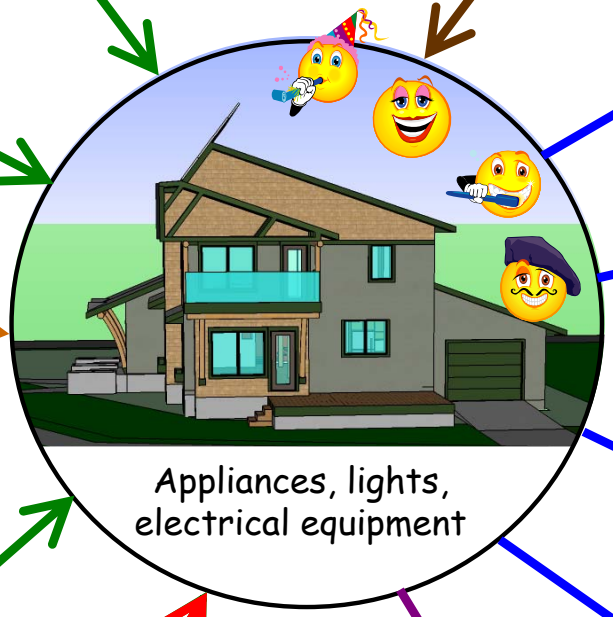
Active solar heat for water and space

Ground-, air- or water-source heat pump

Solar photovoltaics (PV) for electricity

Electricity from coal, natural gas, hydro and Diesel imported from grid

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



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

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

Net Zero Energy – a bunch of math

- The net zero energy goal is a simple bit of math
  - not a number of brownie points like LEED or Built Green
  - You either reach the NZE goal or you don't.

1. **Add** up the annual **consumption** of heat and electrical energy.
2. **Subtract** the annual **production** of heat energy and **generation** of electrical energy
3. If you **reach** 0 you are at net **zero** energy
4. If your net consumption is **> 0** you still have a **net energy deficit**
5. If your net consumption is **< 0** you have a **net energy surplus**

Net Zero Energy – almost…?

- Net zero energy is only a target…
  - It is not a be-all and end-all concept
- Net zero **ready**
  - You have designed the house
    so that heat and electricity generators could be easily added
    in the future without any design changes to the house
- **Near** net zero
  - You still have a net energy deficit, but are “close” to net zero
  - What does “close” mean? 10% away??? not defined yet…

The Journey to Net Zero Energy

– cheapest to most expensive

- **Electrical fixtures and appliances – electrical**
- **Water fixtures and appliances – water**
- **Building envelope – heating**

} **Ultra-high efficiency technologies**

- **Passive solar space heating…???**
- **Active solar liquid for domestic water heating…???**
- **Active solar liquid for space heating…???**
- **Active solar air for space heating…???**
- **Wood heating…???**
- **Heat pump: ground, air, water, solar…???**
- **Solar-electric heating: air circulation, electricity…???**

} **Heating technologies**

- **Solar photovoltaics…???**
- **Microwind…??? (likely not in urban settings)**
- **Microhydro…??? (likely in rural settings)**

} **Electricity technologies**

Many Energy Options

Energy Technology	Consumes	Supplies
Electrical fixtures and appliances	++	0
Water fixtures and appliances	++	0
Building envelope	++++++++++++	0
Passive solar space heating	+++	++++++
Active solar liquid domestic water heating	+	+++++
Active solar liquid space heating	+	++++++++++
Active solar air space heating	+	++++++
Wood heating	++	++++++++++
Heat pump: ground, air, water, solar	++++	++++++++++
Solar photovoltaic heating from air circulation	+	++???
Solar photovoltaic heating using its electricity	0	++++++++++
Solar photovoltaics	+	++++++++++
Microwind	+	++++++++++
Microhydro	+	++++++++++

How do you plan for a net zero energy house?

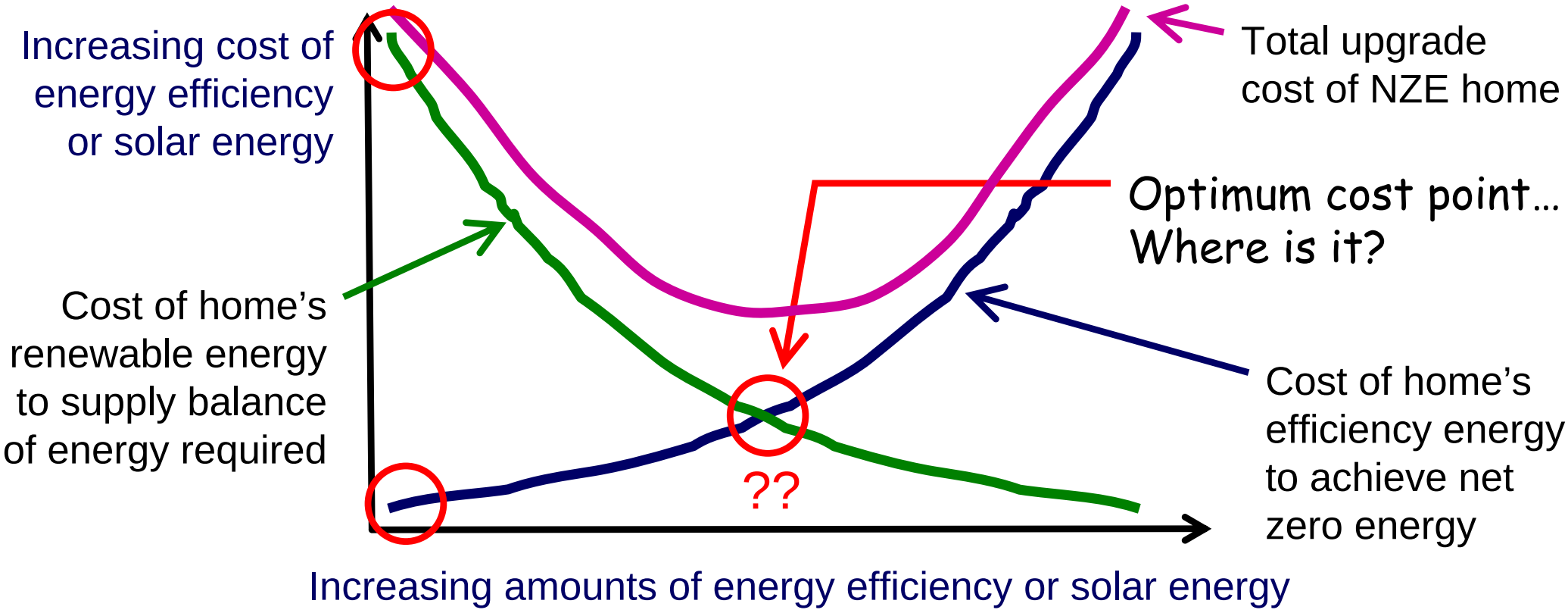
- First and most important:
  - **Minimise** heat and electrical energy consumption
  - **Reduce** by ***65%+*** through energy efficient and water efficient design, construction and appliances
  - This is the cheapest-cost option
  - Cost range: $15,000 to $25,000

- Second:
  - **Maximise and control** the contribution of energy sources
  - **Supply** ***35%-*** balance of heat and electrical energy
  - Cost range: $50,000 to $90,000
    and dropping in cost…

Design Challenge

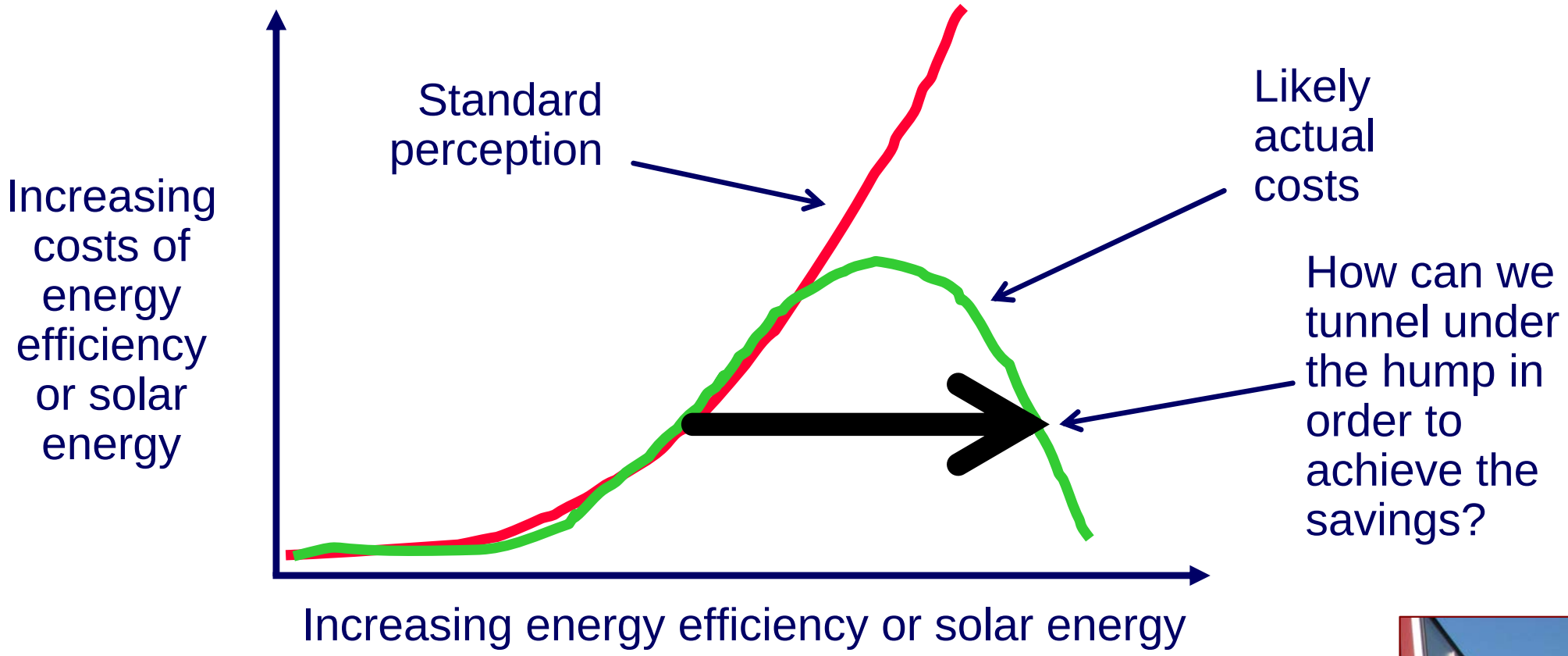
Where do we find the minimum construction cost to achieve net zero?

- We need large amounts of energy efficiency and large amounts of solar energy



Economic Challenge – "Tunnelling Through the Threshold"…

- Diminishing returns… yes,
  but… there are cost reduction opportunities too…



Concept courtesy of Amory Lovins

Net Zero Energy Housing

… can we really afford anything less?

Download this presentation and others from

www.hme.ca /presentations

www.riverdalenetzero.ca

www.greenedmonton.ca

www.habitat-studio.com

www.solaralberta.ca

Alberta Emerald Foundation

Gordon Howell, P.Eng.
Howell-Mayhew Engineering
Edmonton
Phone: +1 780 484 0476
E-mail: ghowell@hme.ca

We welcome any feedback, questions, suggestions, comments and challenges to anything we present.

Photo credits: Gordon Howell and several others