

Equinox House

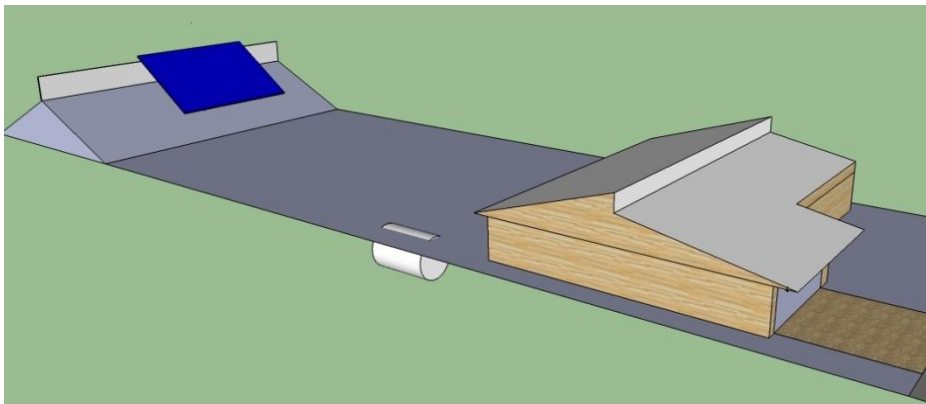
Solar Powered Living and Transportation

How and How Much?



Ben Newell and Ty Newell

ISPE/ASCE/SAME Banquet
February 26, 2010



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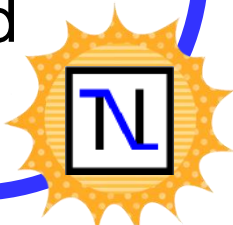
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Motivation and Objectives

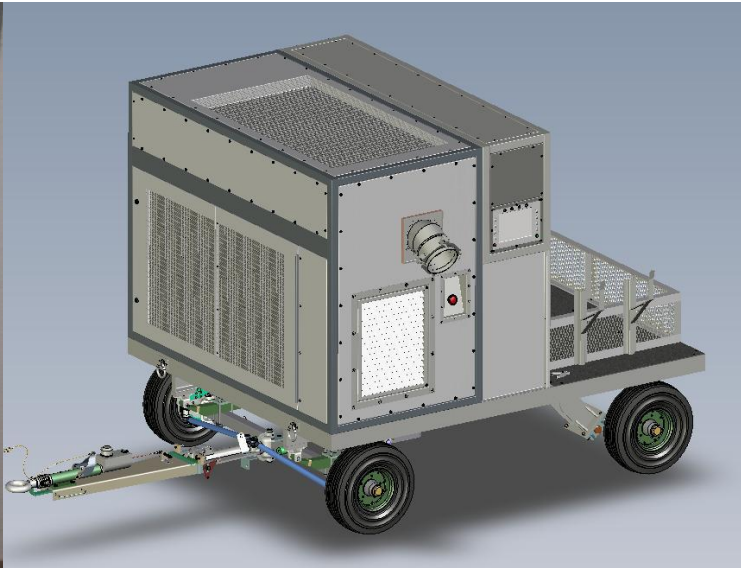
- Newell Instruments: Combine our knowledge of air conditioning and heating systems to create a product for meeting the energy needs of a super efficient home
 - Multi-function system developed that provides cooling, heating, fresh air, dehumidification and hot water
 - CERV (Conditioning Energy Recovery Ventilator, pronounced “serve”)
- Demonstrate that an energy efficient home can be fully powered (house and transportation) by solar energy in a cost effective manner ... even in central Illinois
- Learn home construction costs and processes firsthand



Newell Instruments



refrigerators



military cooling systems



automotive



NI Laboratory is
solar powered
We believe in solar!



Presentation Outline

- Equinox House Project
 - Features
 - Construction
- Energy and Cost

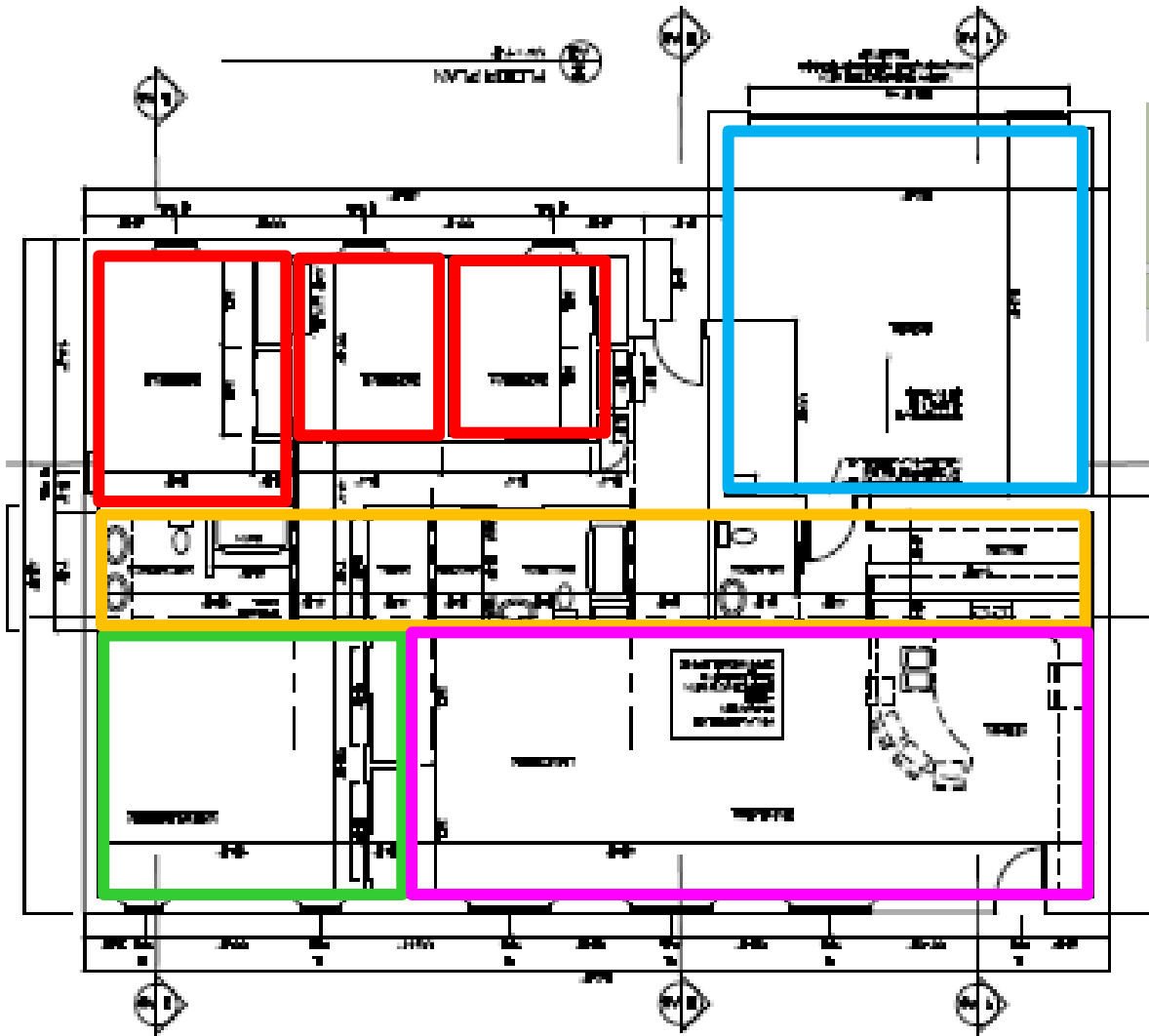


Equinox House Features

- Super-insulated / super-sealed envelope
- Passive solar design with window overhang
- CERV system for heating, cooling, dehum, fresh air, and water heating
- Barrier free (no steps!), ADA room and bathroom access
- “clean surface” interiors, low VOC furnishings and coatings
- LED lighting - efficient, long lasting, mercury free illumination.
- No natural gas connection
- 8.2kW solar pv array: provides all house energy + 6-8k miles driving
- Rainwater collection system: designed for 80% of needs
- Drought resistant gardens featuring native prairie plants
- Minimized construction waste and construction site materials recycling
- Popular features like granite countertops, Kitchen Aid appliances, etc



House Floor Plan – 2,100sqft Ranch



- Open Living
- Master Bedroom
- 3 Bedrooms
- Utility corridor (bathrooms, laundry, pantry)
- Garage



Equinox Construction Begins ...on the equinox...Sept 22, 2009



But, bank financing
delays actual
construction until
November and
December

Bank not sure about
professor as a general
contractor



Single Story, Slab Floor Construction

~2,100 sq ft Living ~500 sq ft Garage



- Easy-to-maintain design (accessible electric, plumbing, ductwork)
- 4 bedrooms (master and 3 small bedrooms)
- 2 ½ baths (modest size)
- Open living space floor plan



Insulated Foundation Walls



- Virtually no waste
- Up in one day



“**ICF**”, Insulated **C**oncrete **F**orm creates sealed foundation wall no concrete thermal bridge to floor



House Panels Arrive



- Three trucks
- Plastic wrap and banding recyclable



SIPs

Structural Insulated Panel



- 1st panel installed
- Walls and roof 1 foot thick, ~R44
- Follow the numbers, ~80 panels (walls and roof total)
- Heaviest panel (8' by 24') weighs ~400 pounds
- Again virtually no waste, whole house up in 1 week



Walls and Internal Structure

Two days to erects walls



One day to construct
internal structural wall

Utility chase/attic region

With lots of bad weather



SIPs Roof

Two more days to install roof



Civil Engineer
Jim French



Shell Completion



House wrap



Roof Paper



Windows



Shell Completion



North side windows
-Great view and light
-But, ~\$25/month per
100 sq ft of window
(\$15/mo for window and
\$10/mo for energy)

Equinox has ~75sqft of north window
for view and code requirements

Extra thick walls allow
double doors



Overhangs – Critical Feature



Overhangs or other exterior shading essential for net window energy benefit on south



“Equinox”
Overhang

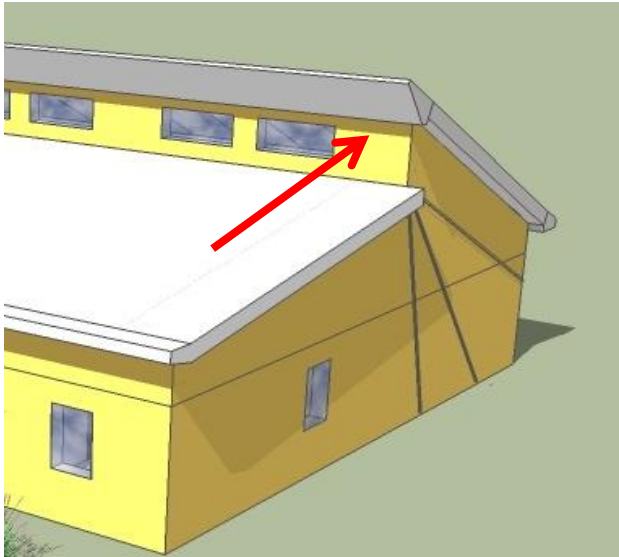


Lifetime window cost more than a wall, even with an energy benefit

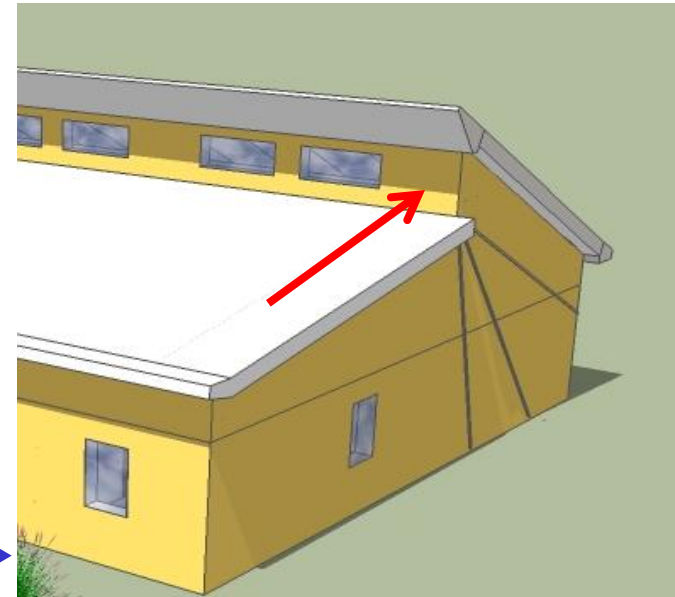


Outdoor Shading

For Illinois, equinox is a good time to shade & unshade



Clerestory shading on March 21
and September 22



Clerestory shading on April 14
and September 1

- ~ 80 sq ft of south facing clerestory, overhang shading
- ~24 sq ft of south casement, vegetative shading (hops)



Indoor Daylighting



Google “Sketchup” nice for examining light pattern design

Winter Solstice pattern
(~Dec 21)

Mid-January pattern

2-3 weeks after
spring equinox, no
direct sunlight



Ground Mount Solar

Proof that Engineers are good for something

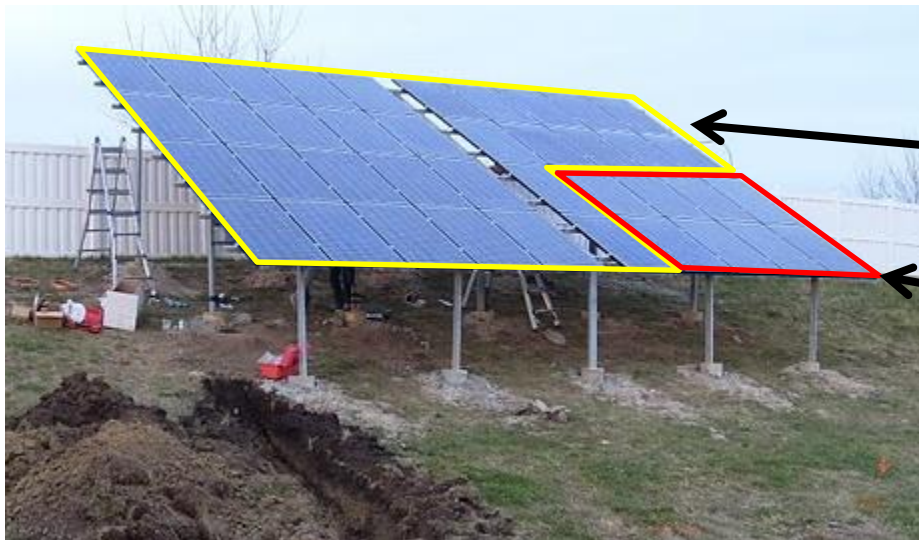


Either roof or ground mount good



Solar System Installation

8.2kW nominal system size
~4 days to install rack and panels
~600 to 700sqft (~25% roof area)
~10,000kW-hr per year
8000kW-hr for house
2000kW-hr for car



House panel area

Car panel area (6000
to 8000 miles per year)



Water



- Water is inexpensive in Illinois
- Aquifer levels are dropping
- Good time to learn about rainwater harvesting in Illinois
- 1700 gallon cistern
 - ~1" rainfall capacity
 - Rain garden to catch additional water (~2 to 3" rain capacity)
 - System cost ~\$3000
- Designed for 80% of house
 - Approved for toilets by State Dept of Public Health



Transportation



- “Good” electric vehicles (Chevy Volt, Nissan Leaf, Tesla Roadster) obtain 5 miles per kW-hr
- 2000kW-hr of Equinox solar system available for vehicles will provide 6000 to 8000 miles of transportation (including charging efficiency)
 - ~140 sq ft of solar PV



Current Status

- Shell commissioning underway (performance testing and leakage sealing)
- Electric service recently provided, and solar system online (as of this week; 2/23/2010)
- Internal electrical and plumbing underway
- Furnishings to begin
- Exterior when weather improves
- Completion planned for June 2010

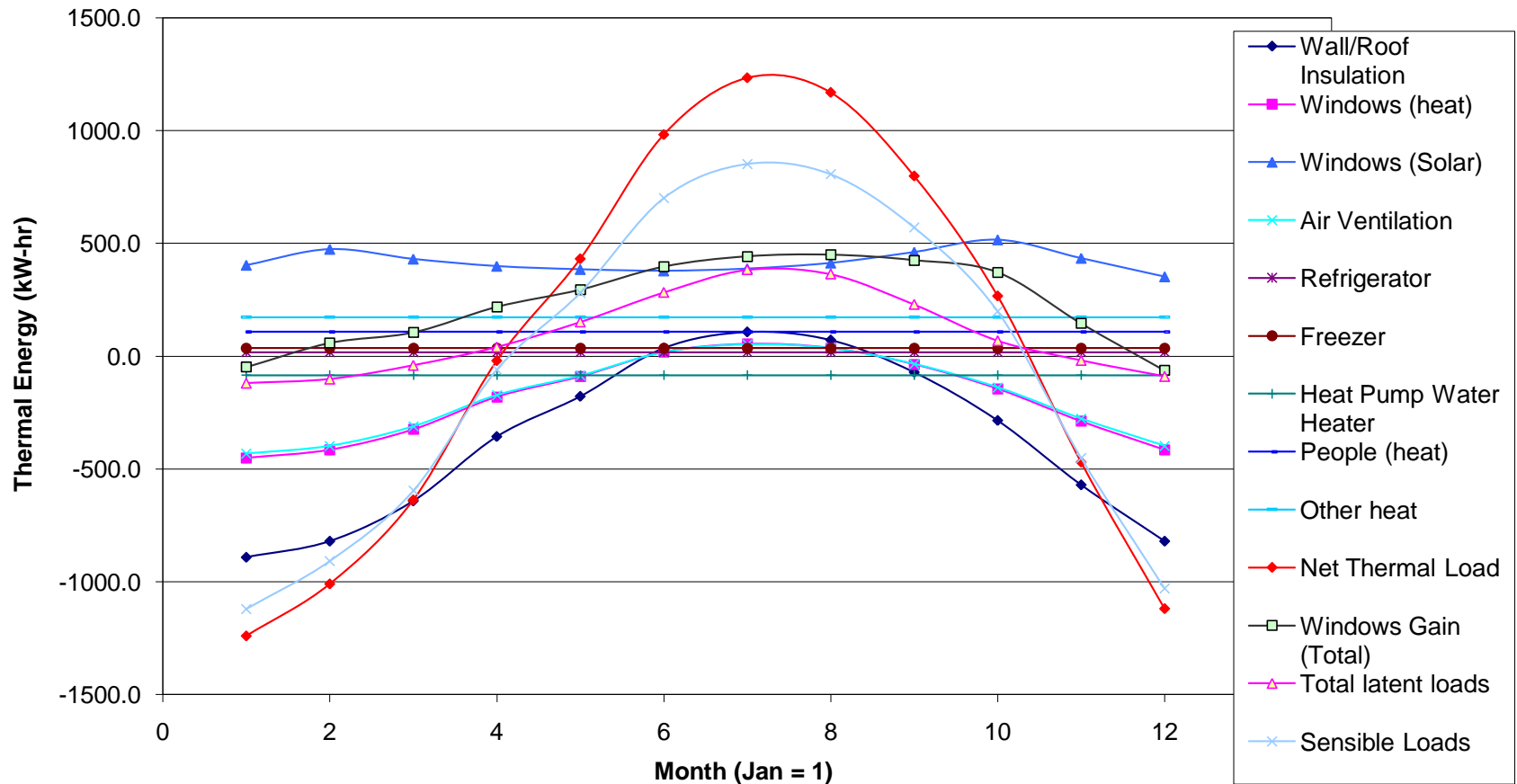


Equinox Energy and Cost

- So, is it worth it?
- What barriers are keeping solar powered homes and transportation from being common place?



Keeping Comfortable is Complicated



Lots to consider!



Conventional vs. Efficient

- Conventional homes are dominated by the exterior conditions
 - ~ 5 times energy requirement of Equinox
 - Leaky envelope means unwanted ventilation
 - Free exchange of conditioned/unconditioned air without recovery of energy
 - No moisture control



- Efficient homes dominated by interior loads
 - Ventilation and moisture are managed
 - Energy recovery



“Life Cycle” Cost (20 year) Net Zero and Conventional

- Assume a 2000 square foot home with 4 people
- Central Illinois weather
- Base house costs \$100/sq ft (\$200,000 for 2000 sq ft)
- “Conventional” energy assumed equivalent to \$0.10/kW-hr (no increase) and requires 5x energy of Equinox
- ~\$20,000 pv system for ~8000 kW-hr annual production needed for house

20 yr Net Zero Home Cost		20 yr Conv Home Cost	
House Cost (\$)	= 200000	House Cost (\$)	= 200000
Insulation Cost (\$)	= 20000	Insulation Cost (\$)	= 0
PV System Cost (\$)	= 20000	20 year Utility Cost (\$)	= 38000
Total House Cost (\$)	= 240,000	Total House Cost (\$)	= 238,000

Difference is less than the cost of granite counters



Monthly Cost – Net Zero vs Conventional

- Assume 6% loan over 20 years
- No escalation in utility price

Net Zero Monthly Cost

House Cost =	\$240,000
20% down=	48,000
Mortgage =	192,000
Monthly pay =	1,380
Monthly utility cost =	0
Total monthly cost =	\$1380

Conv Monthly Cost

House Cost =	\$200,000
20% down=	40,000
Mortgage =	160,000
Monthly pay =	1,150
Monthly utility cost =	160
Total monthly cost =	\$1310

Monthly mortgage payment difference ~ \$230/month
Net monthly payment difference ~ \$70/month
.... If utility rates don't increase



Some Big Issues

- Appraisers do not value insulation and solar system
 - Same cost per sq ft as “comparables”
- Bank loan based on appraisal
 - Lost financing opportunity for bank
 - Extra mortgage is money left in local economy rather than “exported” to utility company
 - “Extra” money spent on house goes to manufacturing and construction labor (jobs) rather than energy (no jobs)
- Without bank financing of extra insulation and solar panels, down payment of \$80,000 required....who has that?
 - Boomers
 - Community incentives/loans



Electric Vehicle (EV) Transportation

For an extra \$30 per month, you can add to your solar system and have 500 to 700 miles per month of transportation

A gasoline vehicle with 35mpg with \$3/gal gas cost \$40 to \$60 per month for 500 to 700 miles per month



After initial development costs are recovered (like flat screen TVs), EVs will cost no more than current vehicles and be easier to maintain (no oil!)

The Future Can Be Bright!

Because:

- 30 years ago, we could not have imagined a computer in every home
- 30 years ago, we could not have imagined communicating by cell phone, twittering, and e-mail
- 30 years ago, we could not have considered common, everyday usage of lasers, microprocessors, microsensors, and a wide array of new materials

•And, we cannot imagine 30 years from now, but we can help build the path taken.



Thank You!

Questions?

