Net Zero Energy / Water Residential

BPI - Building Professional Institute

May 22, 2017

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ZERO

My Hero

Appearance courtesy of Schoolhouse Rock

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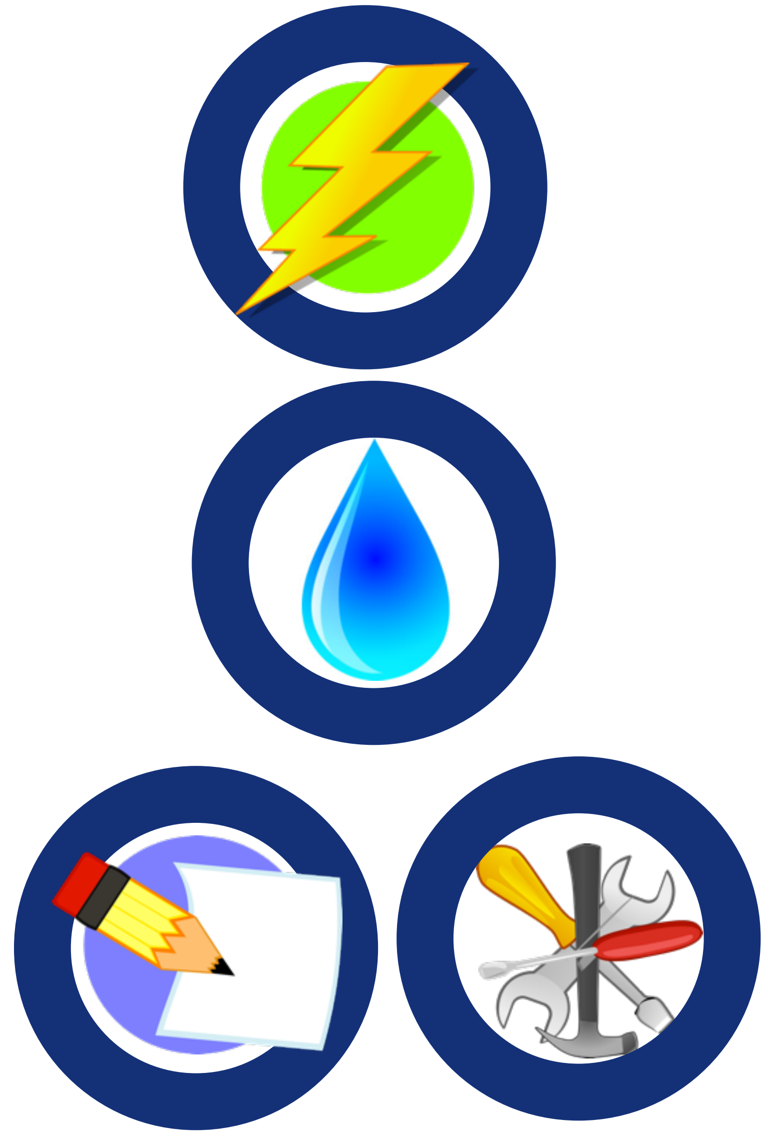
Agenda

- Energy Data
- Net Zero Energy
  - Define
  - Boundary
  - Rating Systems / Certifications
- Net Zero Water
  - Define
  - Rating Systems / Certifications
- Design / Implementation
  - Design Strategies
  - Construction
  - Operation
  - Case Studies



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Course

Architecture/Green Building

Moderators Cathy Boldt - AIA Dallas Chapter - Lewisville, TX
Zaida Basora-Adrian - Huitt Zollars - Dallas, TX

1601AP **Net Zero Energy/Water**

These overviews will explore the state of net zero energy and net zero water building design, define key terms for the design, construction and operations of net zero buildings, and identify current market limits of net zero project types.

Instructor: Paul Westbrook - Re:Source Design

Instructor: Craig Schiller - Rocky Mountain Institute

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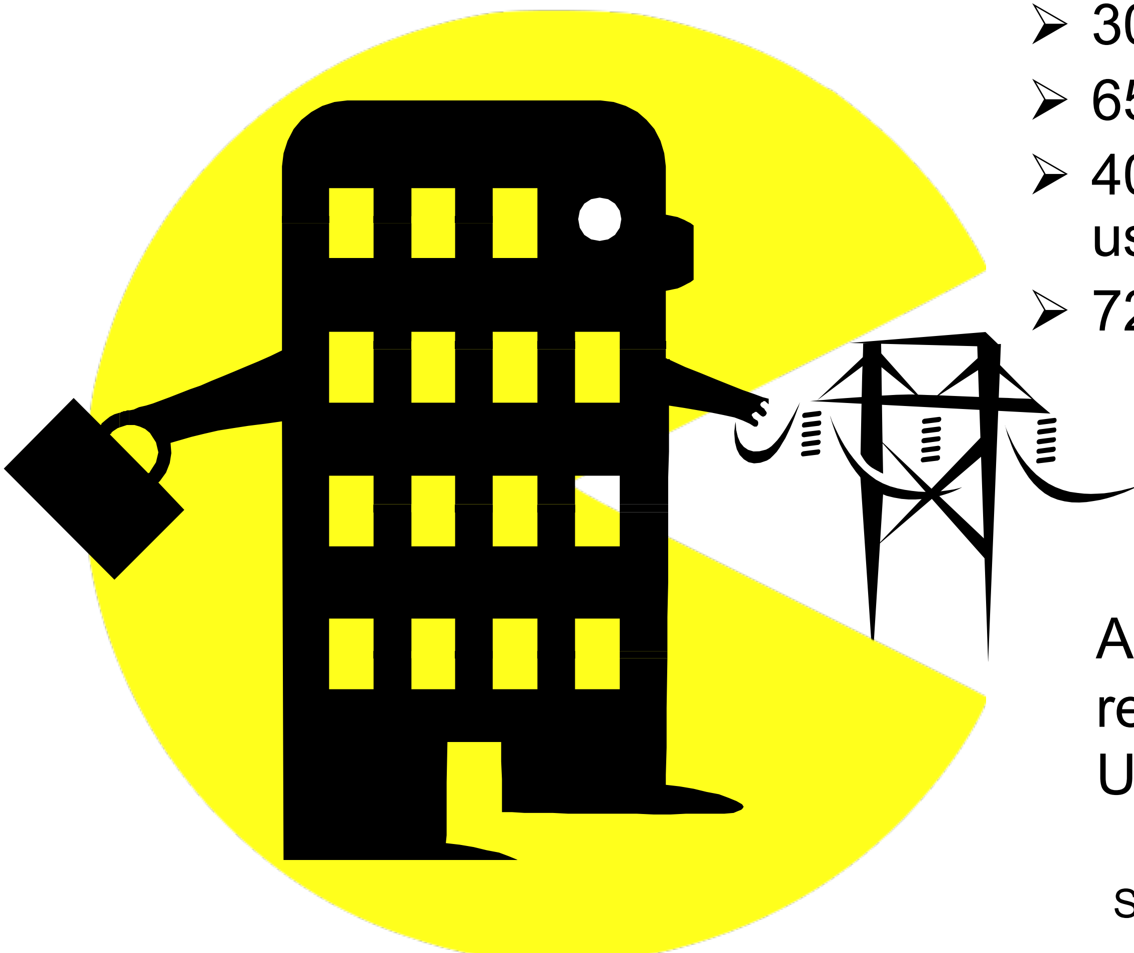
Buildings



Buildings consume:

- 14% of the potable water
- 30% of the raw materials
- 65% of the waste output
- 40% of all primary energy used in the US
- 72% of all U.S. electricity

And buildings are responsible for 39% of all U.S. carbon emissions

Source: USGBC

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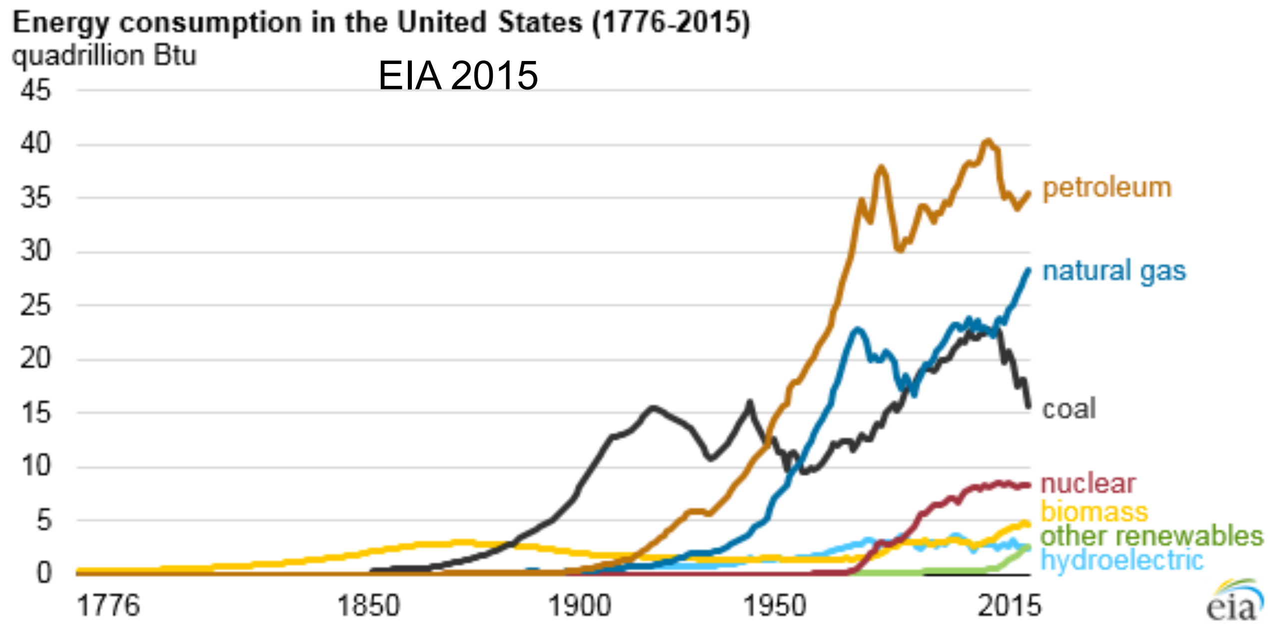
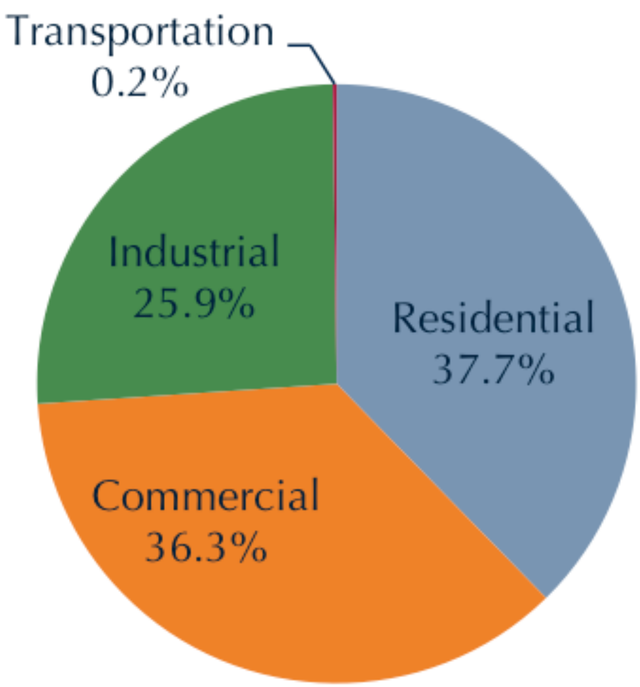
Energy Source and Consumption

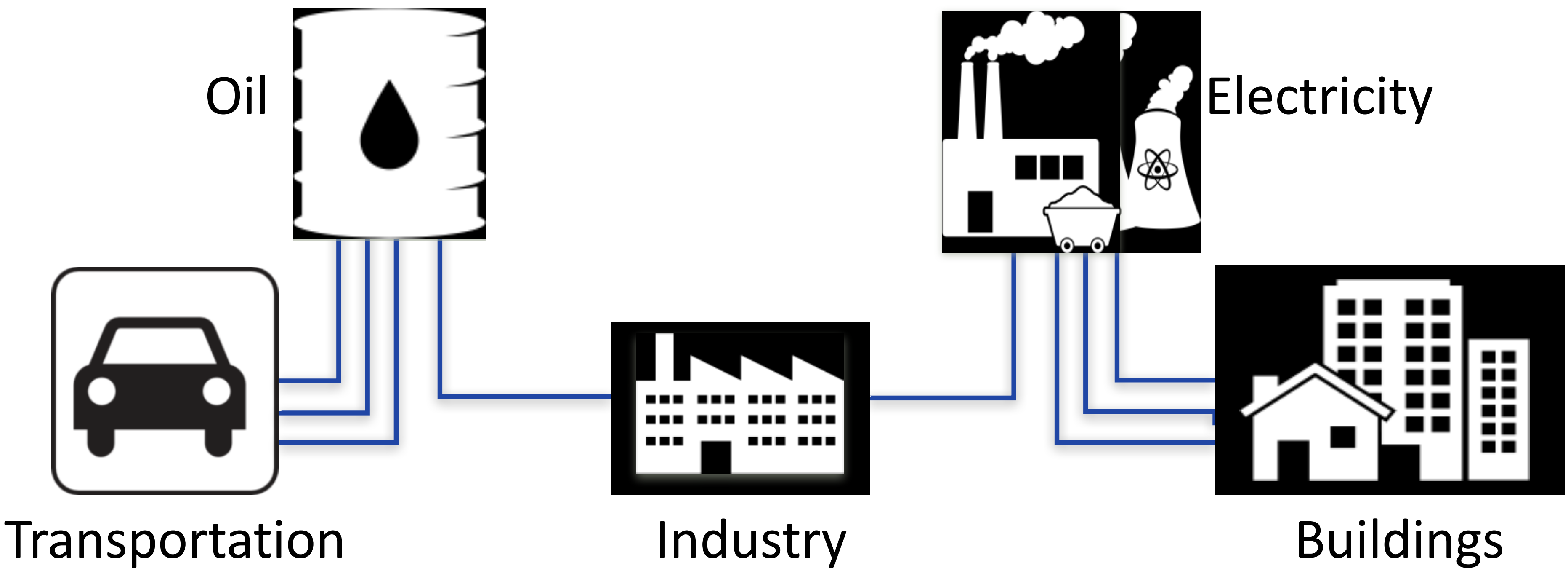


Retail sales of electricity to end customer



Source: U.S. Energy Information Administration (EIA), *Electric Power Monthly*, Table 5.1, September 2014

Oil vs Electricity

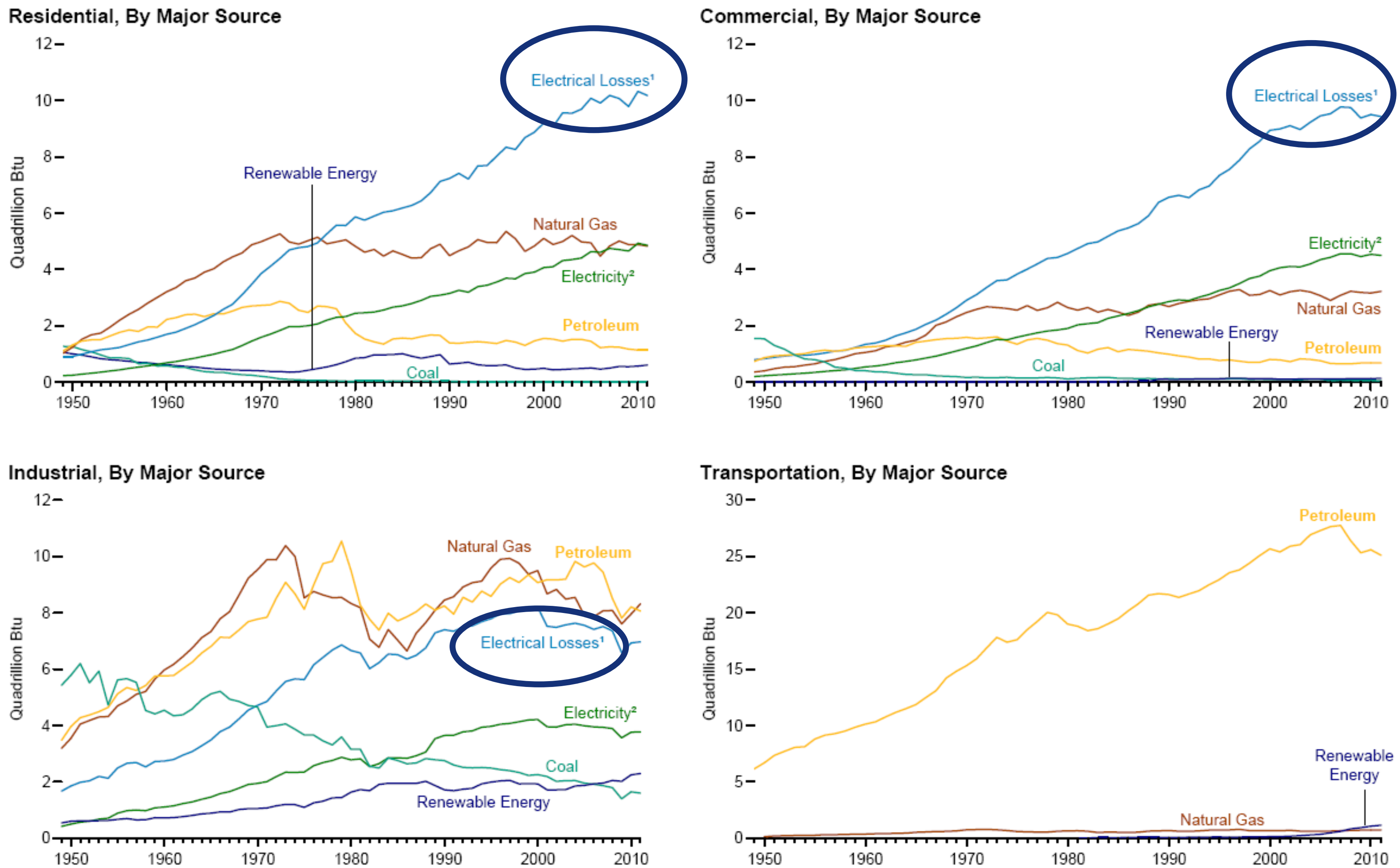


RMI Reinventing Fire

http://www.rmi.org/ReinventingFire

US Energy Use and Waste

Figure 2.1b Energy Consumption Estimates by End-Use Sector, 1949-2011

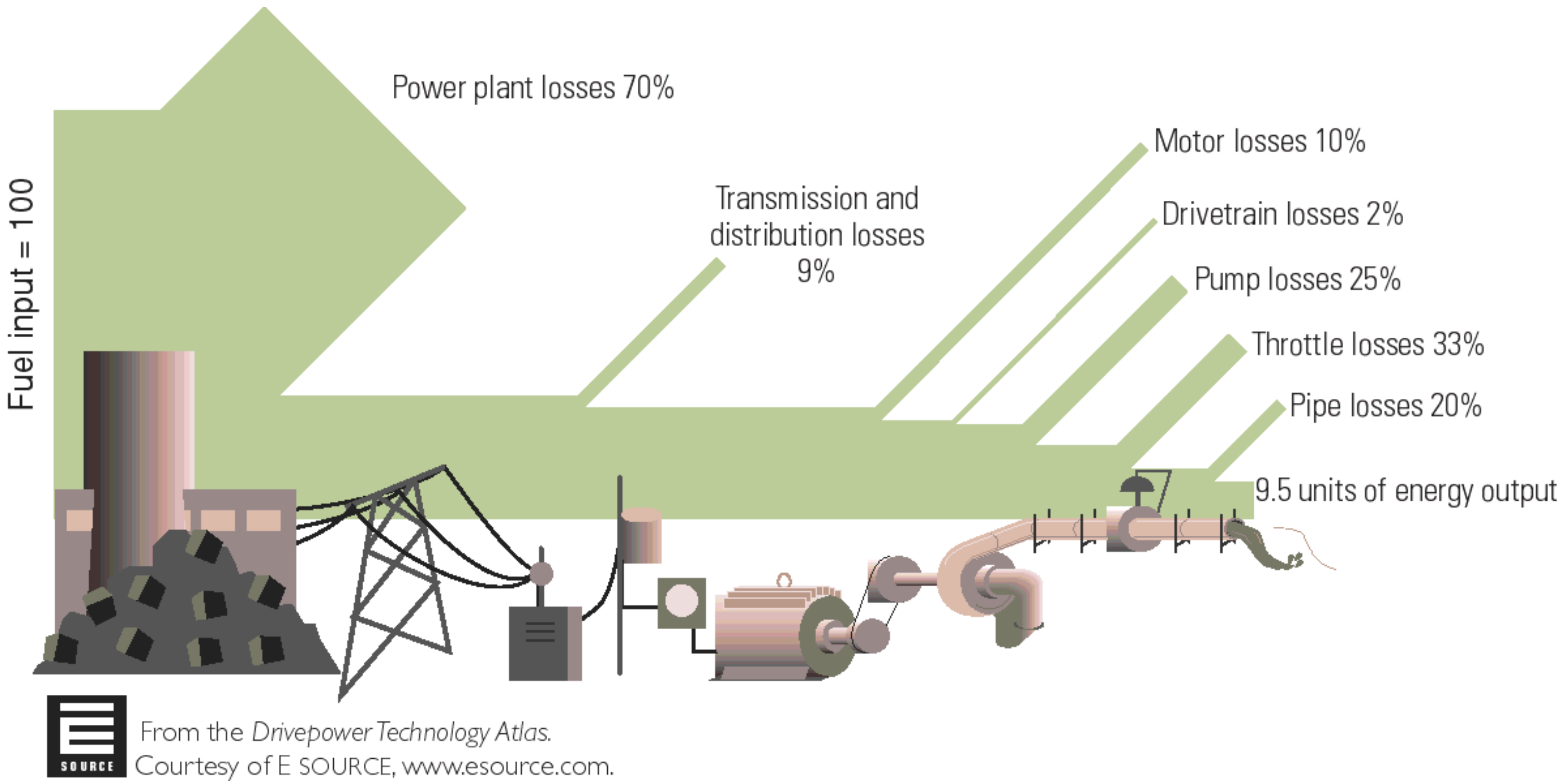


¹ Electrical system energy losses associated with the generation, transmission, and distribution of energy in the form of electricity.

² Electricity retail sales.
Sources: Tables 2.1b–2.1e.

Source: US EIA Annual Energy Review 2011

Energy Loss



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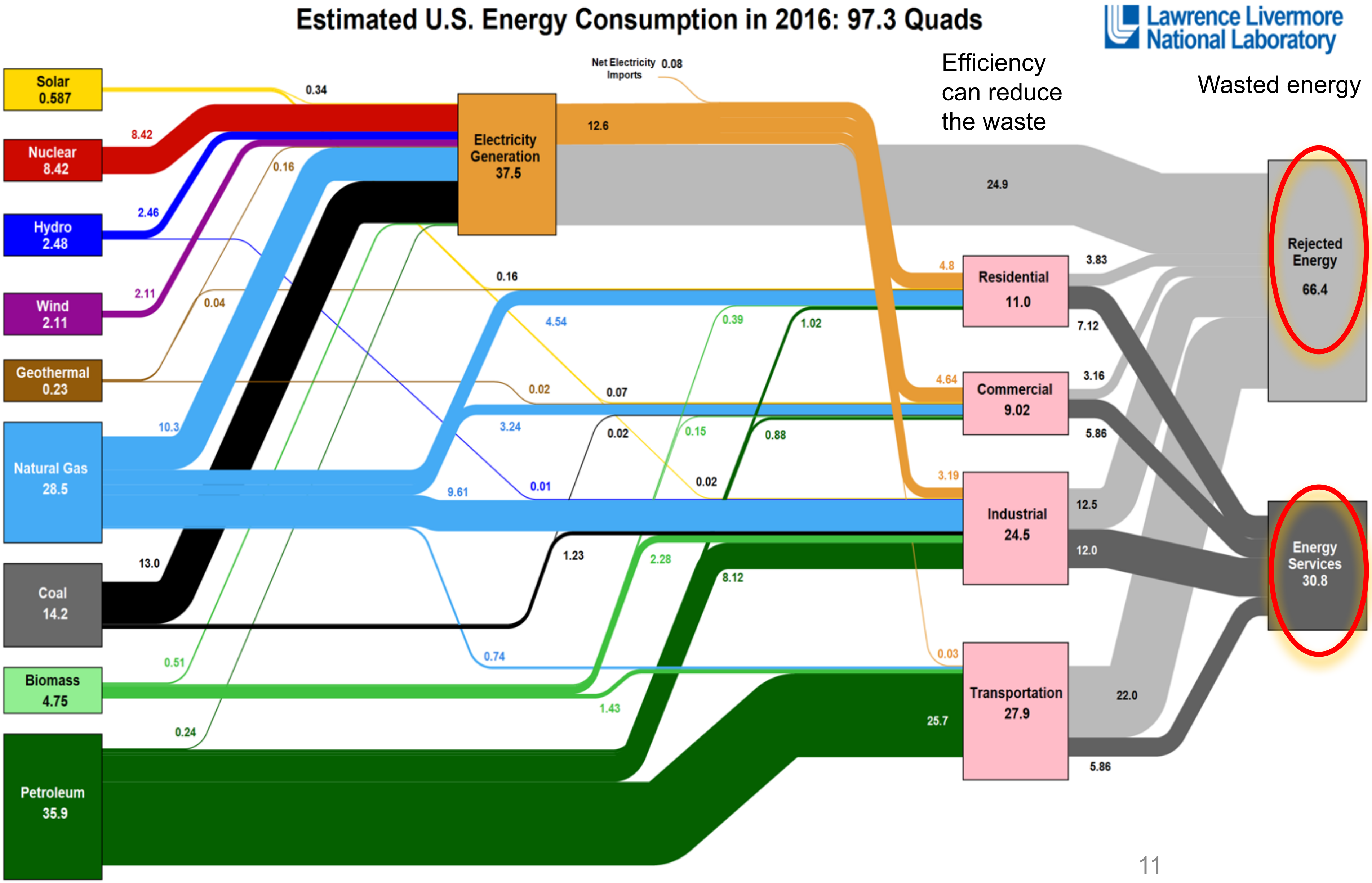
US Energy Map



Source: LLNL March, 2017. Data is based on DOE/EIA MER (2016). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. This chart was revised in 2017 to reflect changes made in mid-2016 to the Energy Information Administration's analysis methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector, and 49% for the industrial sector which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Energy Sources

US Energy Consumption by Source 2014

Renewable

biomass 4.9%
renewable
heating, electricity, transportation

hydropower 2.5%
renewable
electricity

geothermal 0.2%
renewable
heating, electricity

wind 1.8%
renewable
electricity

solar & other 0.4%
renewable
light, heating, electricity

Carrier - Hydrogen

Non-Renewable

Fossil

petroleum 35.4%
nonrenewable
transportation, manufacturing

natural gas 28%
nonrenewable
heating, manufacturing, electricity

coal 18.2%
nonrenewable
electricity, manufacturing

uranium 8.5%
nonrenewable
electricity

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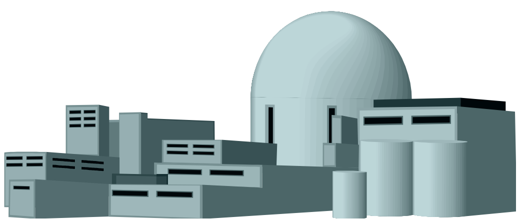
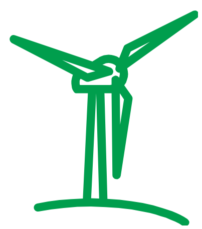
Common Language

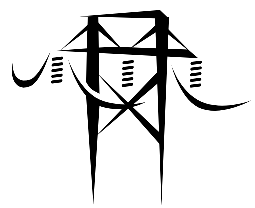
- Power
  - Power = Voltage (V) x Current (I)
  - Watts (W) or kiloWatts (KW) or megaWatts (MW)
- Energy = Power x Time
  - Watt-hours or kiloWatt-hours (KWh) or megaWatt-hours (MWh)



1,000 MW plant



3 MW turbine



kWh meter

- 1KWh = 3,412 BTU (British Thermal Units)

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Environmental Impact

- Environmental Impact of 1,000 kWh of fossil fuel produced electricity:
  - 400 gallons of water consumed
  - 1,200 pounds (lbs) of CO2 released
  - 0.713 lbs of Nitrous oxides (NOx) released
  - 2.24 lbs of Sulfur oxides (SOx) released
  - 23.4 mg of Mercury released
- An average house in north Texas uses 15,000 kWh/year

Emissions source: eGrid 2009

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Net Zero?

- Zero What? – energy, water, emissions, carbon, cost . .
  - **Energy**
- ZEB = Zero Energy Building
- ZNE = Zero Net Energy
- NZE = Net Zero Energy
- NZEB = Net-Zero Energy Building

General Definition: A building that uses no more energy over the course of a year than it produces from on-site renewable sources.

- ZER = Zero Energy Ready (50-70% lower use than code)

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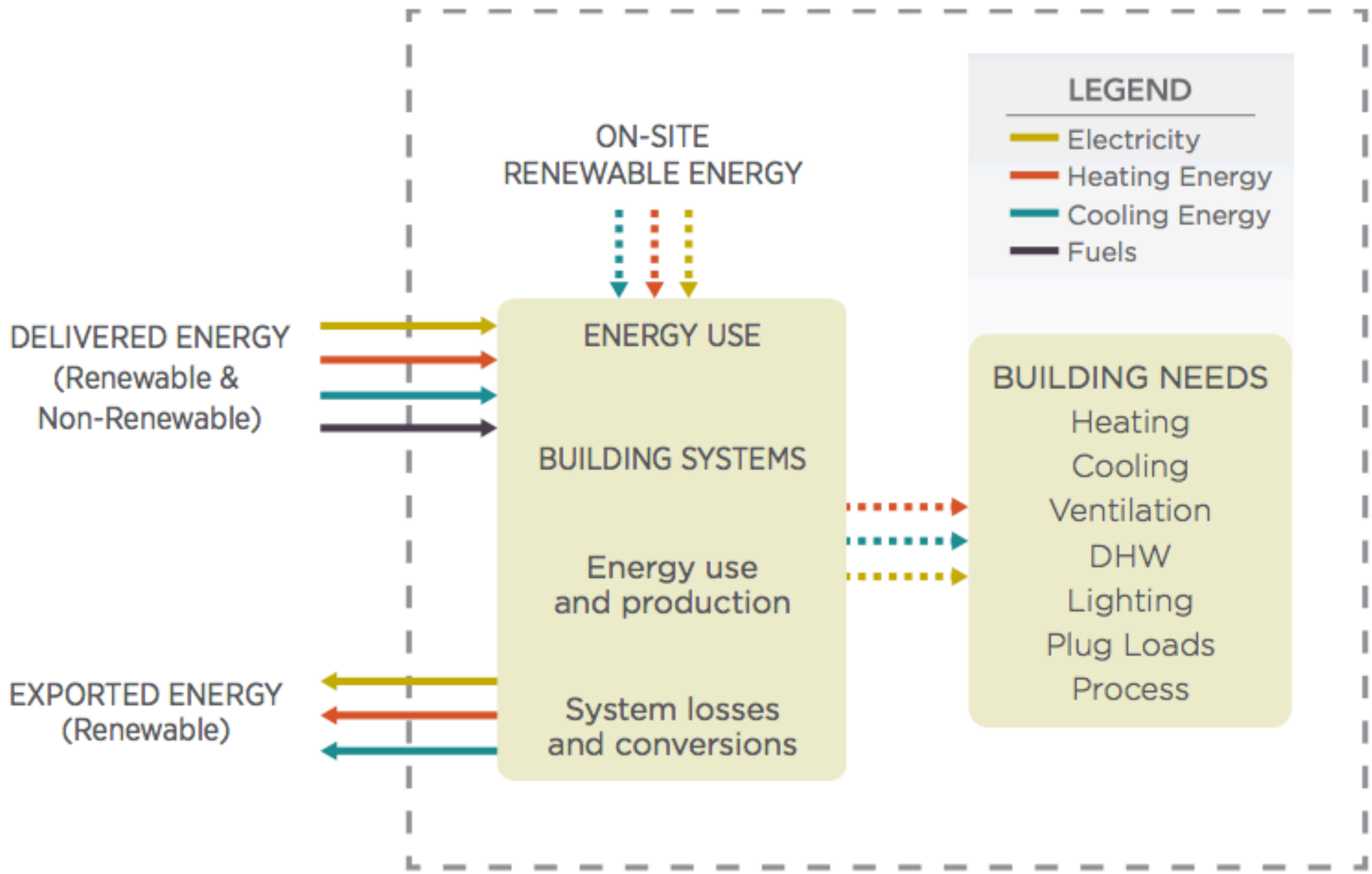
Net Zero Definition / Boundary

- Possible Zeros
  - Net Zero **Site** Energy
    - Energy consumed and generated at the site only
  - Net Zero **Source** Energy
    - Considers the source of the energy and the waste in generation (also called Primary Energy)
  - Net Zero Energy **Costs**
    - Considers energy cost over the year
  - Net Zero Energy **Emissions**
    - Considers offsetting emissions from energy production

Define Net Zero Boundary

- Site or Source Energy?

Figure 1 – Site Boundary of Energy Transfer for Zero Energy Accounting



Notes

1. The dashed lines represent energy transfer within the boundary
2. The solid lines represent energy transfer entering/leaving the boundary used for zero energy accounting

Source: “A Common Definition for Zero Energy Buildings”; Sep 2015; Prepared for the U.S. Department of Energy by The National Institute of Building Sciences.

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Define Net Zero Boundary

- Source Energy Conversion

Table 1 – National Average Source Energy Conversion Factors

Energy Form	Source Energy Conversion Factor (r)
Imported Electricity	3.15
Exported Renewable Electricity	3.15
Natural Gas	1.09
Fuel Oil (1,2,4,5,6,Diesel, Kerosene)	1.19
Propane & Liquid Propane	1.15
Steam	1.45
Hot Water	1.35
Chilled Water	1.04
Coal or Other	1.05

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Source Energy Example

- House Annual Use
  - 6,000 kWh from the electric grid
  - 4 MMBtu (40 therms, 4,000 cubic feet) of natural gas
- Use multiplier factors from table
  - 6,000kWh x 3.15 = 18,900 kWh
  - 4MMBtu x 1.09 = 4.36 MMBtu (converts to 1,278 kWh)
  - TOTAL = 20,178 kWh
- To offset all energy use you would need to produce:
  - 20,178 kWh / 3.15 = 6,406 kWh of on-site solar
- To size your solar system you find your local kWh/kW factor:
  - Assume 1,400 kWh/yr per kW (http://pvwatts.nrel.gov/)
  - 6,406 kWh / 1,400 = 4.6 kW solar array = (18) 260W panels

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Net Zero – Which One?

Definition	Pluses	Minuses	Other Issues
Site ZEB	• Easy to implement. • Verifiable through on-site measurements. • Conservative approach to achieving ZEB. • No externalities affect performance, can track success over time. • Easy for the building community to understand and communicate. • Encourages energy-efficient building designs.	• Requires more PV export to offset natural gas. • Does not consider all utility costs (can have a low load factor). • Not able to equate fuel types. • Does not account for nonenergy differences between fuel types (supply availability, pollution).	
Source ZEB	• Able to equate energy value of fuel types used at the site. • Better model for impact on national energy system. • Easier ZEB to reach.	• Does not account for nonenergy differences between fuel types (supply availability, pollution). • Source calculations too broad (do not account for regional or daily variations in electricity generation heat rates). • Source energy use accounting and fuel switching can have a larger impact than efficiency technologies. • Does not consider all energy costs (can have a low load factor).	• Need to develop site-to-source conversion factors, which require significant amounts of information to define.
Cost ZEB	• Easy to implement and measure. • Market forces result in a good balance between fuel types. • Allows for demand-responsive control. • Verifiable from utility bills.	• May not reflect impact to national grid for demand, as extra PV generation can be more valuable for reducing demand with on-site storage than exporting to the grid. • Requires net-metering agreements such that exported electricity can offset energy and nonenergy charges. • Highly volatile energy rates make for difficult tracking over time.	• Offsetting monthly service and infrastructure charges require going beyond ZEB. • Net metering is not well established, often with capacity limits and at buyback rates lower than retail rates.
Emissions ZEB	• Better model for green power. • Accounts for nonenergy differences between fuel types (pollution, greenhouse gases). • Easier ZEB to reach.		• Need appropriate emission factors.

Table from NREL "Zero Energy Buildings: A Critical Look at the Definition" P. Torcellini, S. Pless, and M. Deru National Renewable Energy Laboratory D. Crawley U.S. Department of Energy

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Net Zero Equation

- Energy Required = Energy Produced On Site

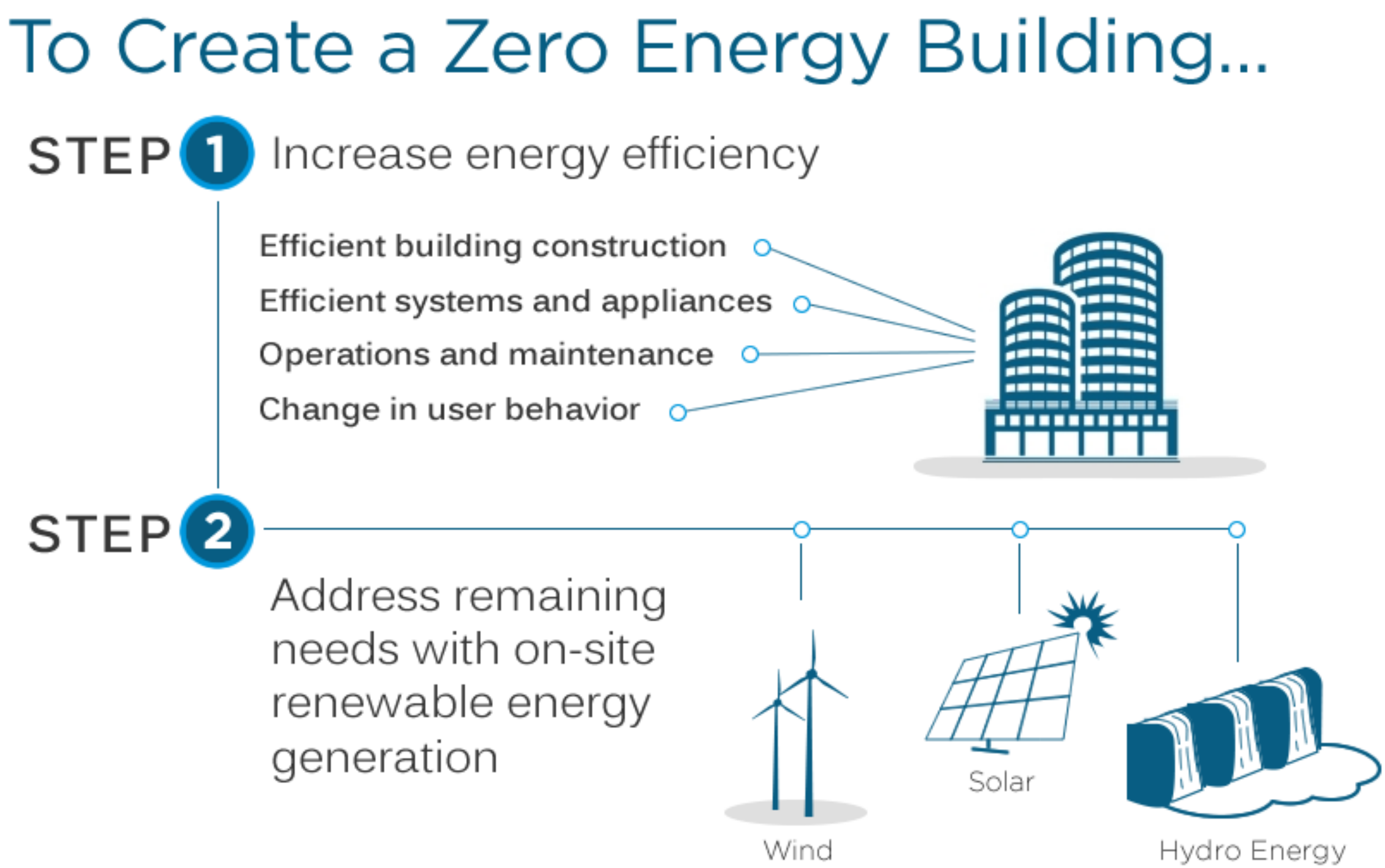
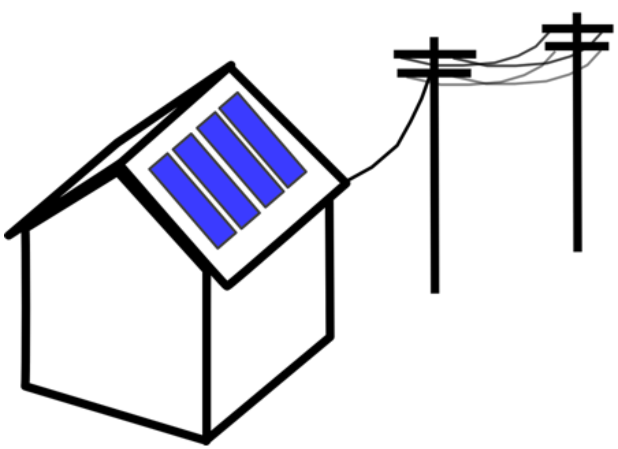


Image from Energy.gov Office of Energy Efficiency and Renewable Energy

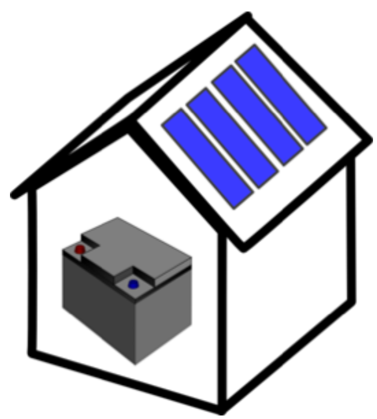
Net Zero Connection

- Most NZE buildings are connected to the electric grid
- The grid essentially functions as a big battery
  - Supplies energy to the house when needed
  - Allows for the transmission of excess energy back to the grid
  - Can also use on-site storage (battery) for stand alone or grid tied

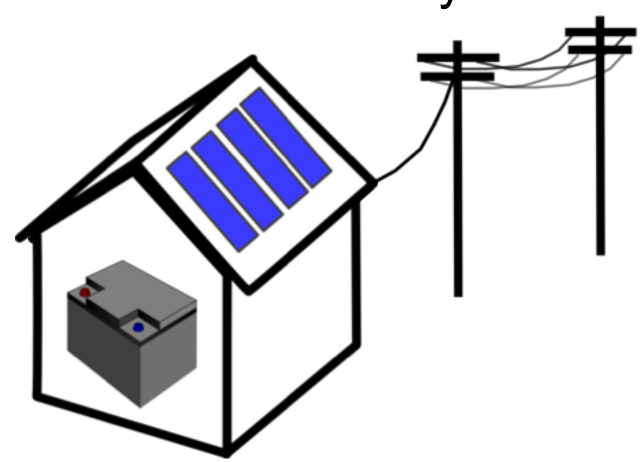
Grid tied



Battery storage – grid independent



Grid tied with battery



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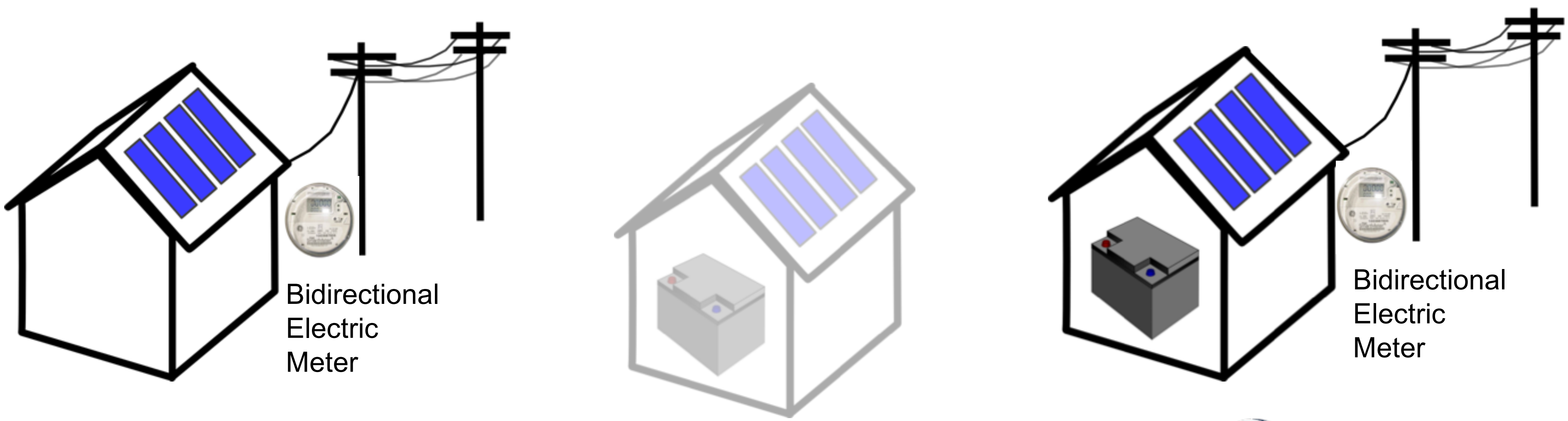
Net Zero Net Metering

- Buildings tied to the grid should be net metered
- State of Net Metering
  - No uniform standard in the US or most states
  - Varies greatly by utility provider
- Utilities might pay retail for exported energy, or wholesale, or nothing . . .
- There will still be base fees – or worse



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Net Zero Certifications

- The Living Building Challenge offers nationwide Net Zero Energy Building Certification.
- The Department of Energy has a Zero Energy Ready Certification.
- The Canadian Home Builders Association launched a Net Zero Energy Home Labeling Program that recognizes homes that reach zero energy ready status, too.
- Earth Advantage (Oregon based): Zero Energy and Zero Ready Home Certifications in locations where Earth Advantage green certification is offered.

Net Zero Energy Building Certification

- Certified under the ILFI Living Building Institute
  - https://living-future.org/net-zero/certification/
  - One hundred percent of the building's energy needs on a net annual basis must be supplied by on-site renewable energy. No combustion is allowed.
  - All certification documentation will be shared with the project's assigned third-party auditor, who is responsible for performing a document review once the 12 month performance period is complete.
    - Electricity from the grid (kWh)
    - Electricity sent to the grid (kWh)
    - Net usage or generation (kWh)
  - Limited exception for offsite renewable in rare cases

NET ZERO
ENERGY BUILDING
CERTIFICATION℠

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Zero Energy Ready Home Certification

- Comply with **ENERGY STAR for Homes** and the **Inspection Checklists** for
  - Thermal Enclosure; HVAC Quality Installation (Contractor and HERS Rater); Water Management; The target home/size adjustment factor used by ENERGY STAR
- Feature energy efficient appliances and fixtures that are ENERGY STAR qualified.
- Use high-performance windows that meet ENERGY STAR v5.0 and v6.0 specifications (depending on climate zone).
- Meet 2012 International Energy Conservation Code levels for insulation.
- Follow the latest proven research recommendations by installing ducts in conditioned space or using a high performance alternative as defined in the program specs.
- Conserve water and energy through an efficient hot water distribution system that provides rapid hot water to the homeowner. WaterSense program
- Provide comprehensive indoor air quality through full certification in EPA's Indoor airPlus Program
- Accomplish savings on the cost of future solar PV installations by following the PV-Ready checklist for climates with significant solar insolation.

ZERO
ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

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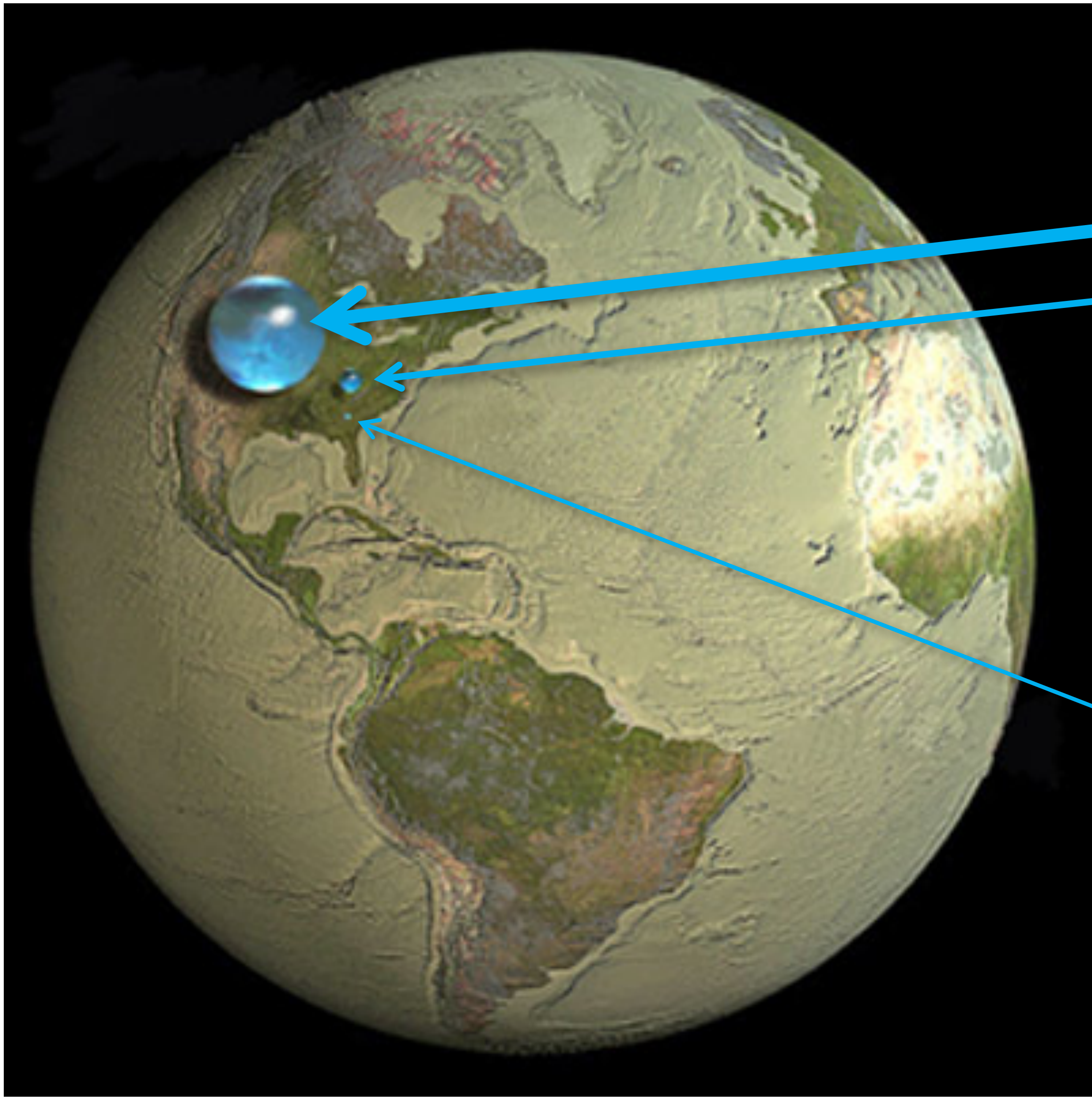
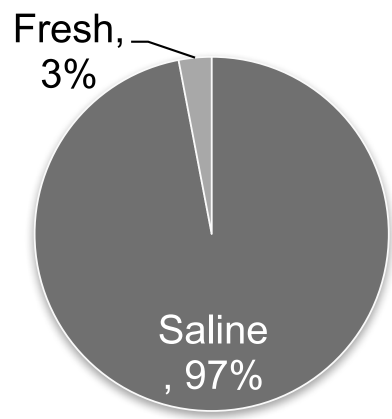
Earth Water Overview

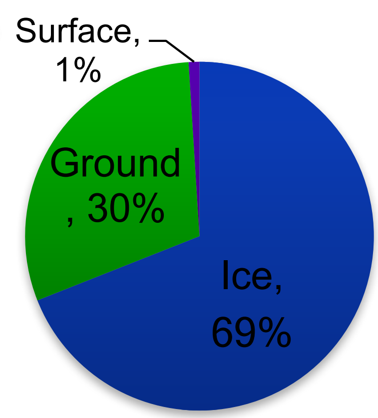


>70% of the earth's surface is covered by water

All the global water into a sphere



All water



Fresh water

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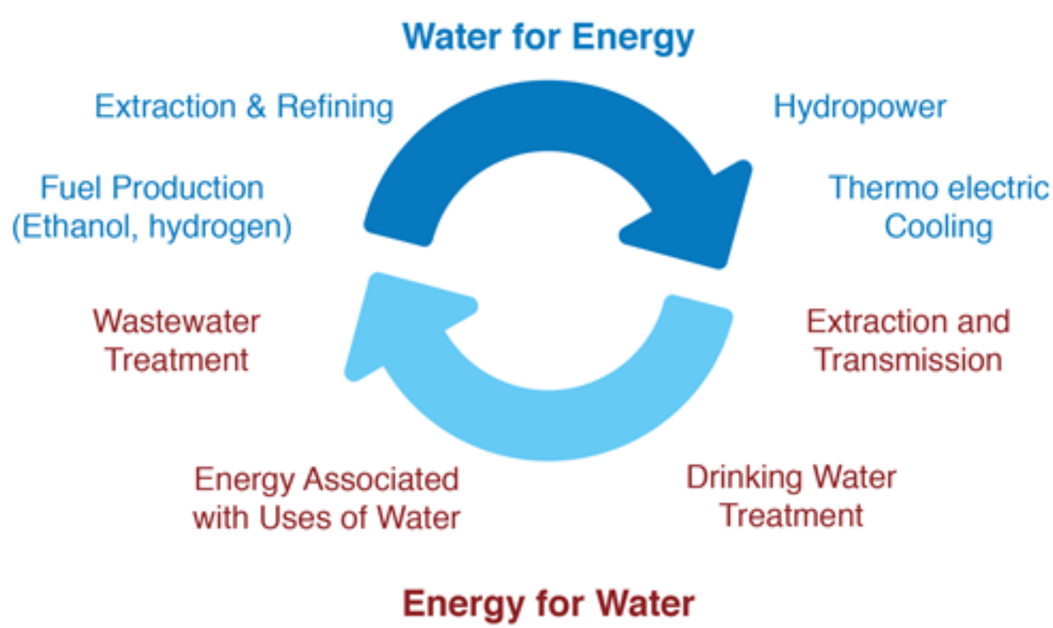
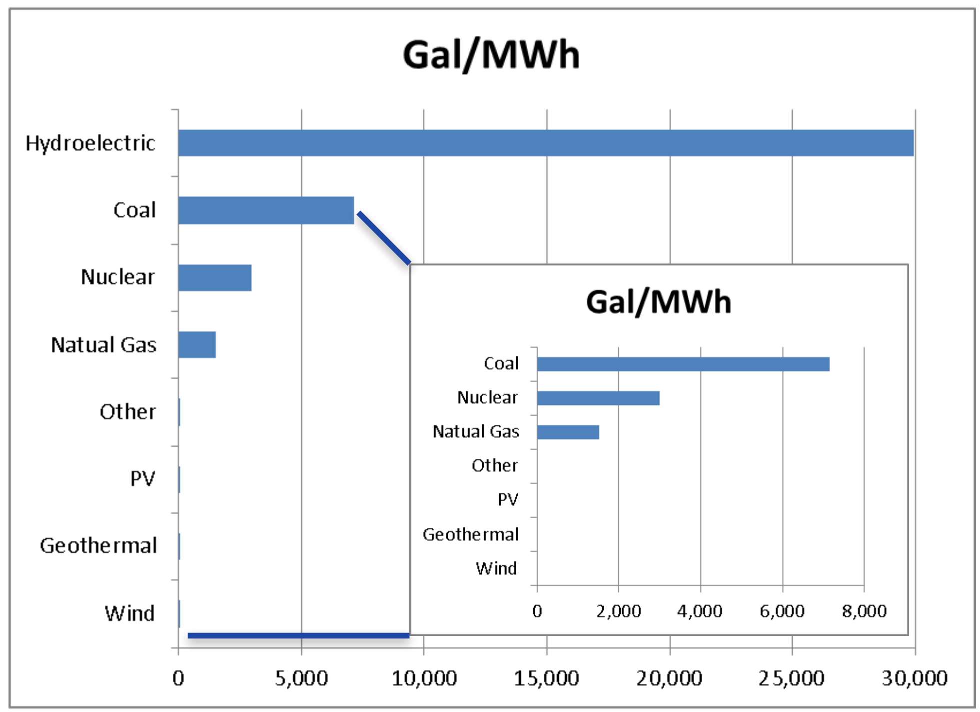
Water / Energy Nexus

- Water shortages result in
  - Hydroelectric power is at risk
  - Large fossil fuel power plants are at risk (steam production & cooling water)





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Net Zero Water

- Zero What? – energy, water, emissions, carbon, cost . .
  - **Water**
- NZW = Net Zero Water

- DOE: "Net zero water building" means a building that is designed, constructed, or renovated and operated to greatly reduce total water consumption, use non-potable sources as much as possible, and recycle and reuse water in order to return the equivalent amount of water as was withdrawn from all sources, including municipal supply, without compromising groundwater and surface water quantity or quality.

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Net Zero Water

- Most NZW residential buildings are not connected to the water utility or a well – they collect and store rainwater to meet their needs
- Larger buildings can treat and return the water to the source – perhaps supplemented with rainwater collection

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Net Zero Water Building Certification

- Living Building Institute Net Positive Water
  - Project water use and release must work in harmony with the natural water flows of the site and its surroundings.
  - One hundred percent of the project's water needs must be supplied by captured precipitation or other natural closed-loop water systems, and/or by recycling used project water, and must be purified as needed without the use of chemicals.
  - All stormwater and water discharge, including grey and black water, must be treated onsite and managed either through reuse, a closed loop system, or infiltration.
  - Excess stormwater can be released onto adjacent sites under certain conditions.

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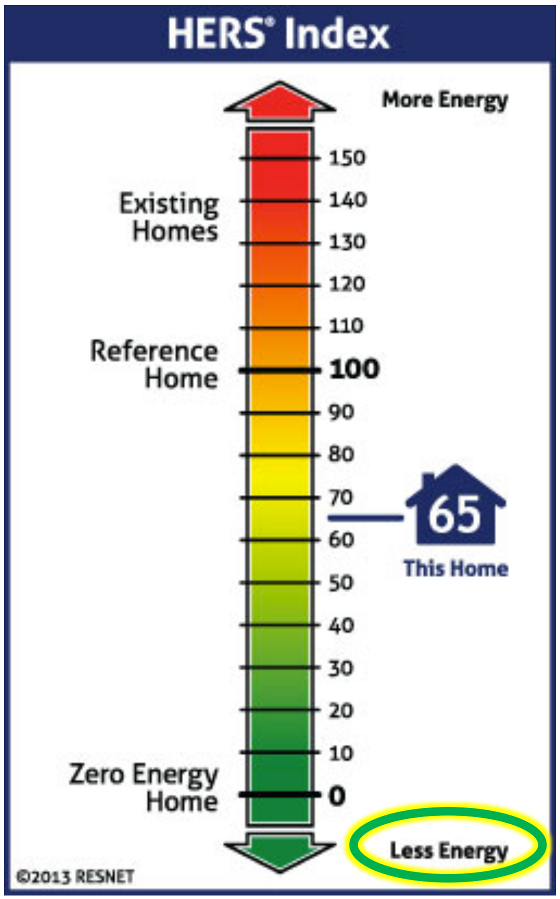
Home Energy Ratings

- Rating Systems
  - Home Energy Rating System – HERS Index
  - Energy Performance Score – EPS
  - Home Energy Score



The HERS Index is a measurement of a home's energy efficiency

Includes:

- All exterior walls (both above and below grade)
- Floors over unconditioned spaces (like garages or cellars)
- Ceilings and roofs
- Attics, foundations and crawlspaces
- Windows and doors, vents and ductwork
- HVAC system, water heating system, and your thermostat.
- Air leakage of the home
- Leakage in the heating and cooling distribution system

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Home Energy Ratings

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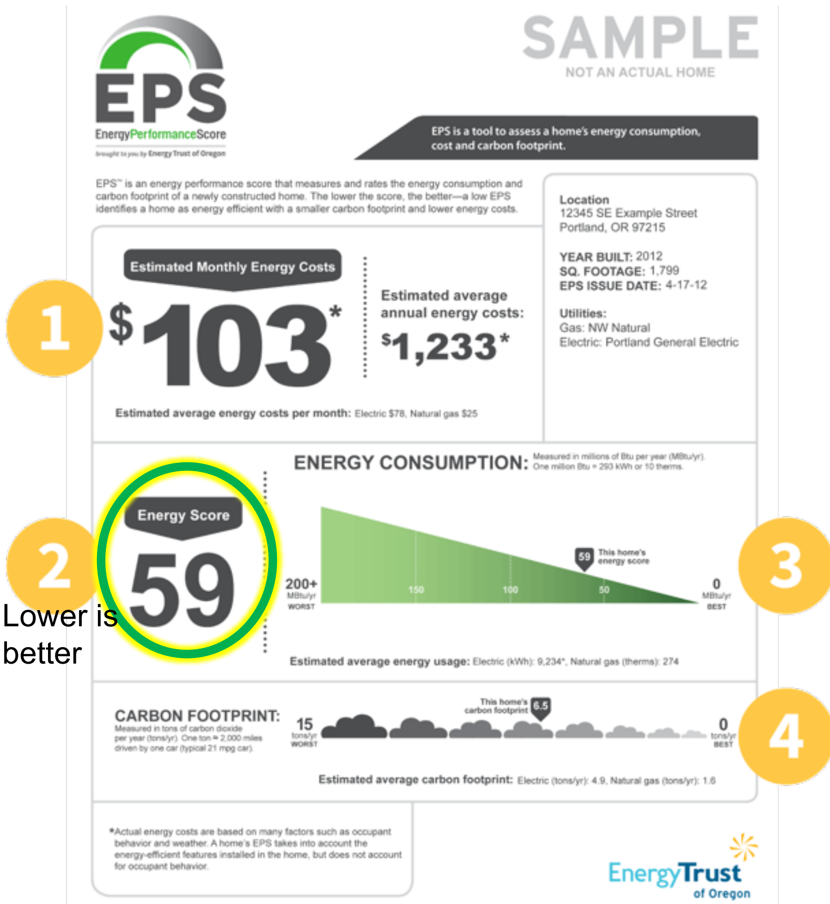

Lower is better

EPS is an energy performance rating tool for new and existing homes

Rewards space efficiency

Calculated based on the physical attributes of the home

- Insulation, air-tightness
- Lights, appliances
- Heating & cooling system

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Home Energy Ratings

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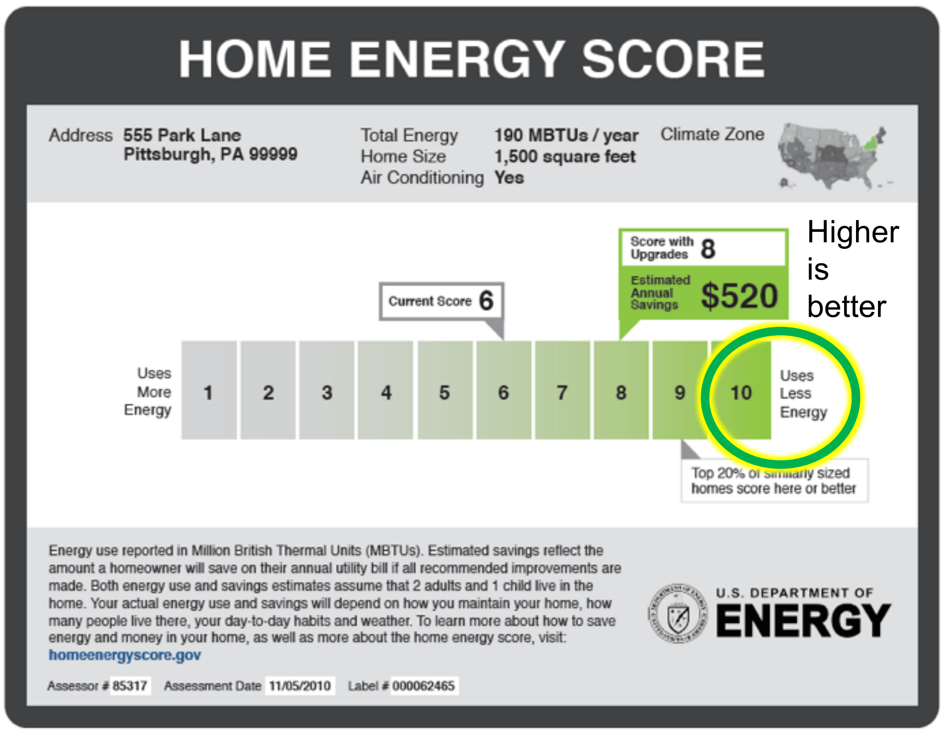

Home Energy Score

40 pieces of data and an energy use breakdown

Considers the home's fixed attributes (walls, windows, heating, cooling, and water heating systems) and applies standard assumptions about occupant behavior to all homes.

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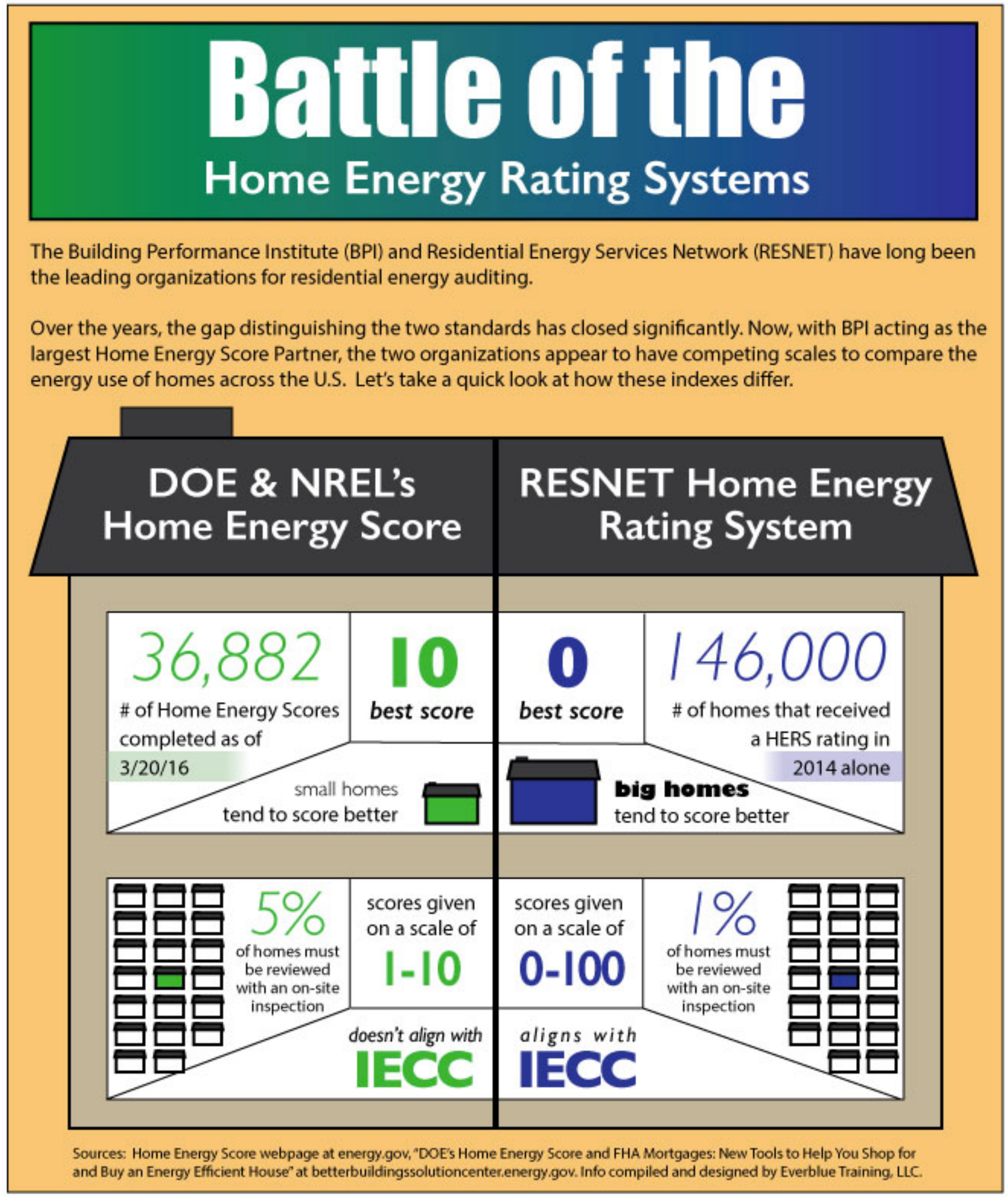
Home Energy Ratings Compared

- Home Energy Score vs HERS
- Excellent comparison article from Everblue http://www.everbluetraining.com/blog/home-energy-score-vs-hers-score



Home Rating Systems

Courtesy of Roger Taylor of DwellGreen Dallas

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Design

- “If you think good design is expensive, you should look at the cost of bad design.” – Ralf Speth
- “Everything is designed. Few things are designed well.” - Brian Reed
- “If I had asked people what they wanted, they would have said faster horses.” – Henry Ford
- “Only those who attempt the absurd will achieve the impossible.” – M.C. Escher

- “Nothing lasts longer than poor design” – Paul Westbrook

Right Things in the Right Order

- # Efficiency First

- Renewable Generation Second

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The Negawatt

Negawatt (n) - a measure of energy efficiency; a unit in watts of energy saved

Solar and wind may be sexy . . .





. . . but efficiency yields the best financial and environmental benefits

Negawatt term by Amory Lovins of the Rocky Mountain Institute (RMI)

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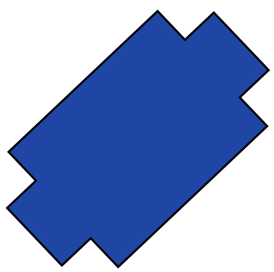
Integrated Design

An iterative, non-linear process

Non-ideal Linear Design Process

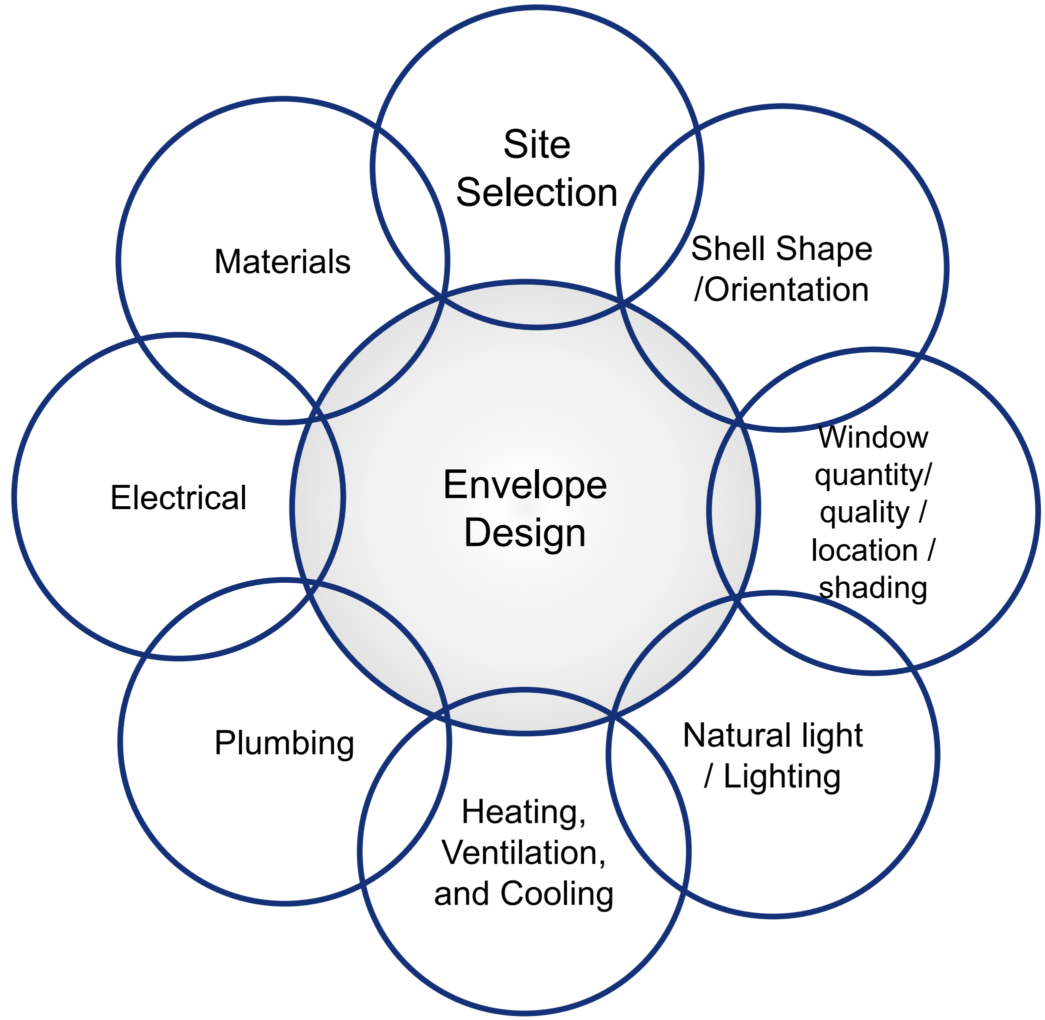
1. Bad architect draws up design



2. Everyone else makes it work:
- High cooling load window locations
- No room for ductwork
- Excessive materials use / waste
- Poor daylighting

. . . Over budget,
then “value engineering” occurs

Integrated Design Process



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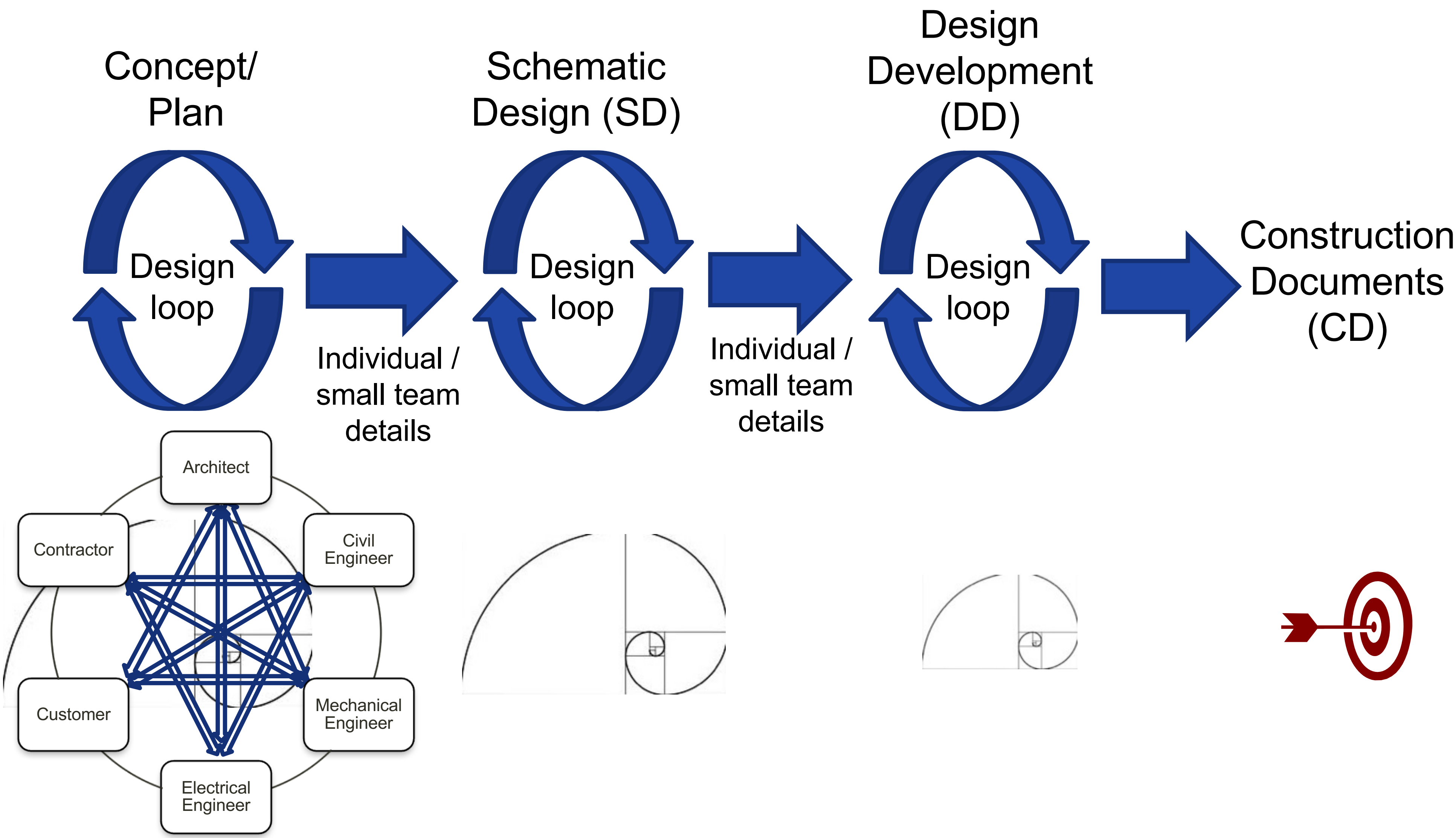
Value Engineering

Value Engineering is Neither

- Amory Lovins, RMI

Integrated Design: Loops



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Design Methodology

- Site Selection, Placement & Orientation
- Structure Size/Shape/Materials
- Window & Door Selection/Location/Placement
- Heating, Ventilation, and Air-Conditioning (HVAC)
- Water Heating / Water Efficiency
- All the Little Things
- Renewable Energy

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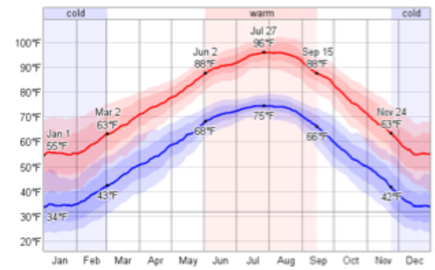
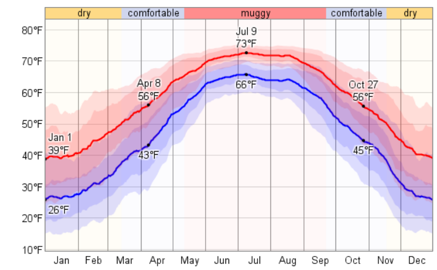
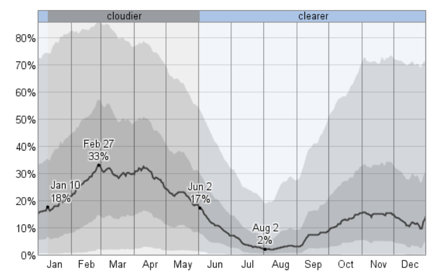
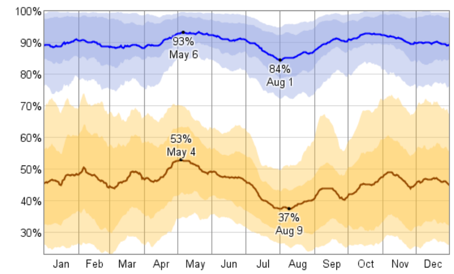
Location, Location, Location

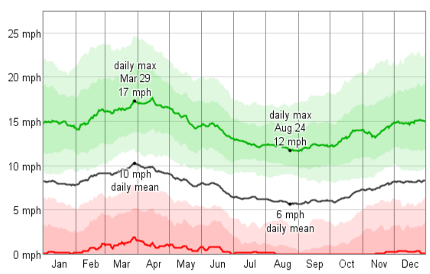
- Climate
  - Temperature
  - Humidity
  - Degree Days
  - Cloud Cover/Sun
  - Rain
  - Wind speed
  - Wind direction
  - Elevation
- Latitude
  - Sun path

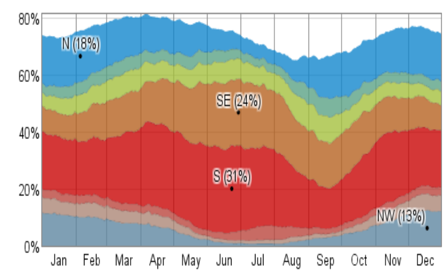


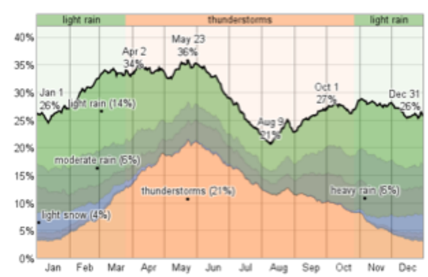












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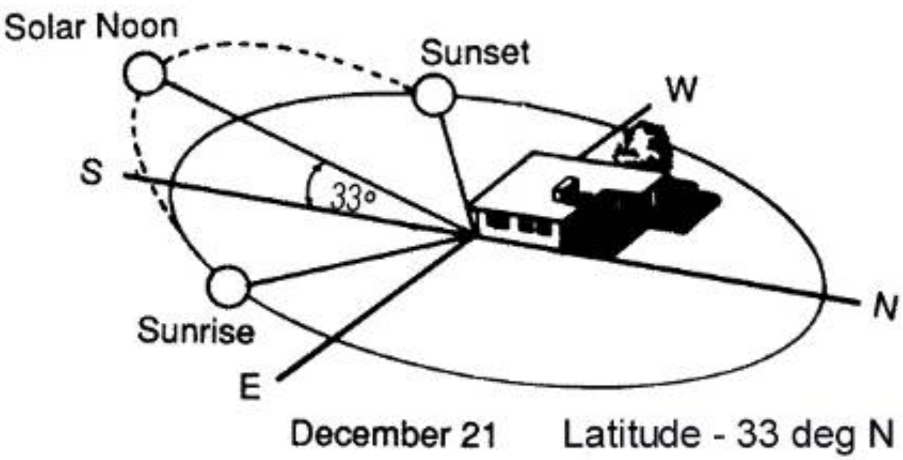
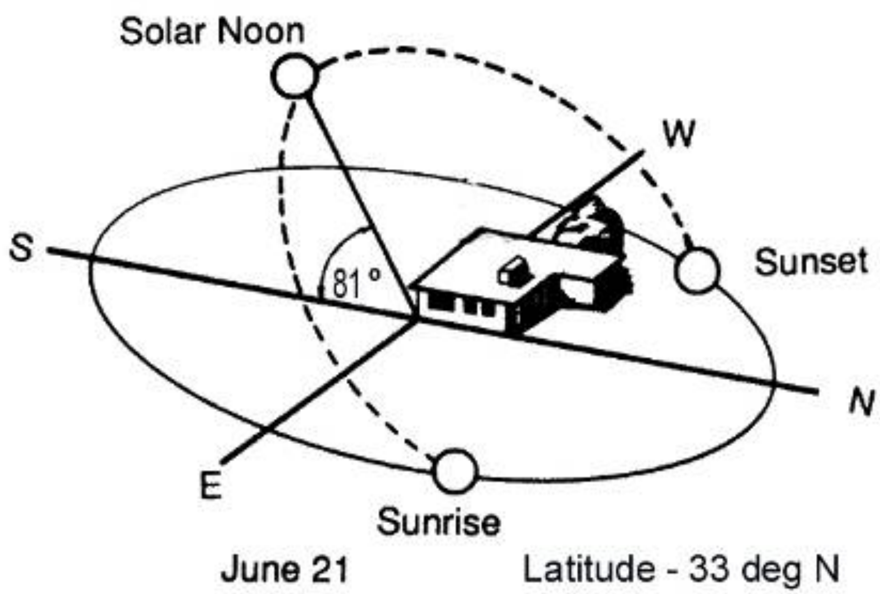
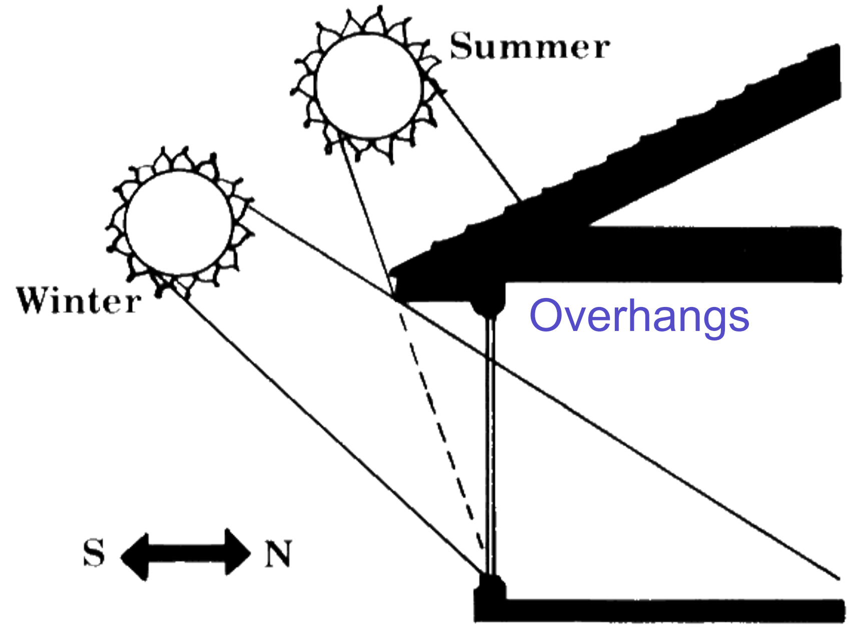
Sun Path





Minimize E & W windows

Reflective roof

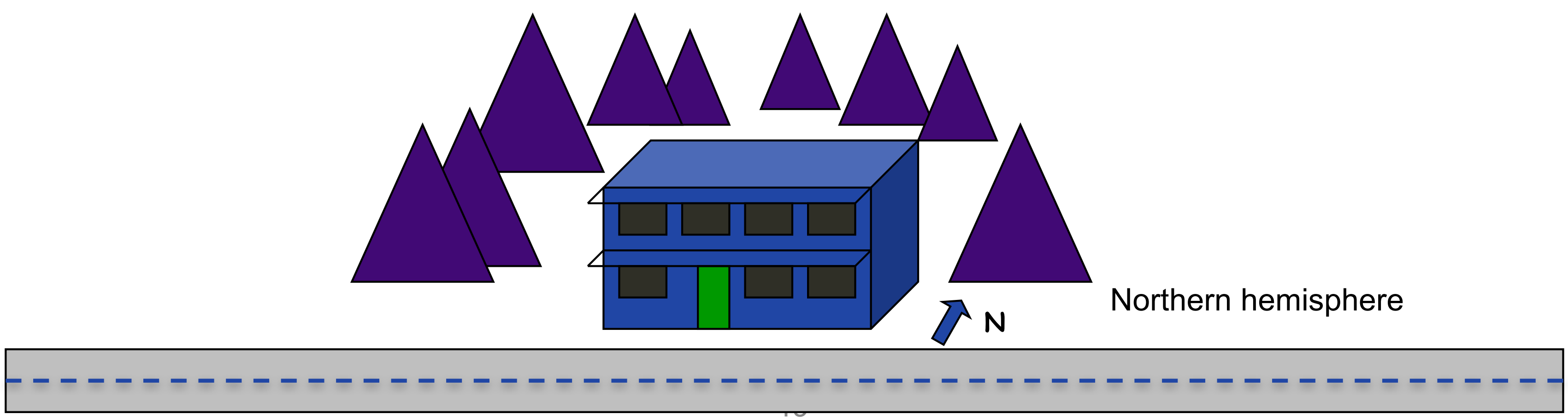


Overhangs

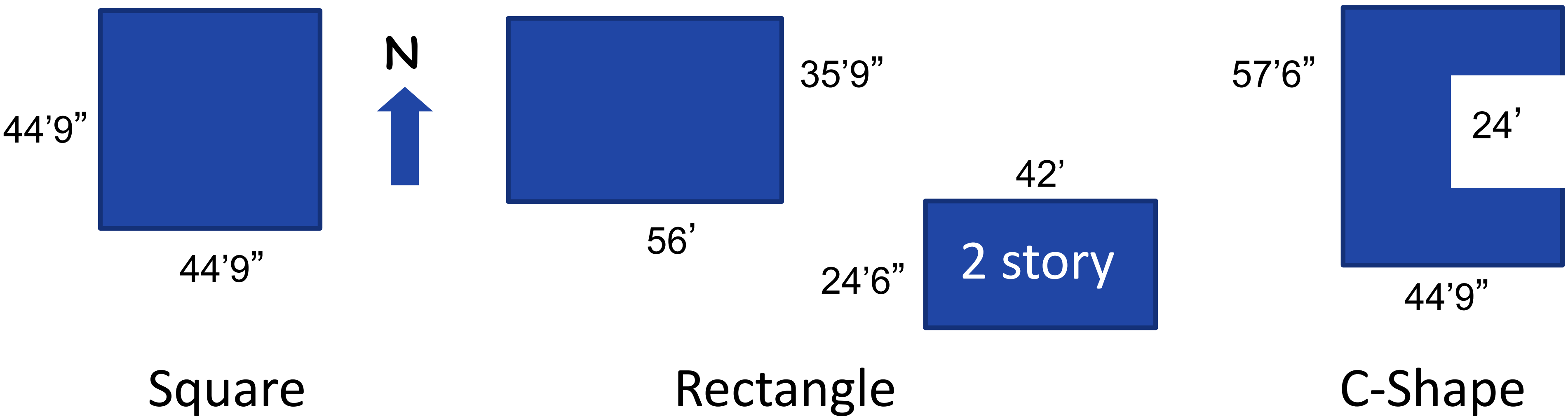
Northern Hemisphere

Site / Placement / Orientation

- Good southern exposure / evergreen trees to the north and west
- Preferably an east-west street (front of the building facing north or south)
- Long axis of the building running east-west
  - maximizes southern solar exposure
  - minimizes east and west solar exposure



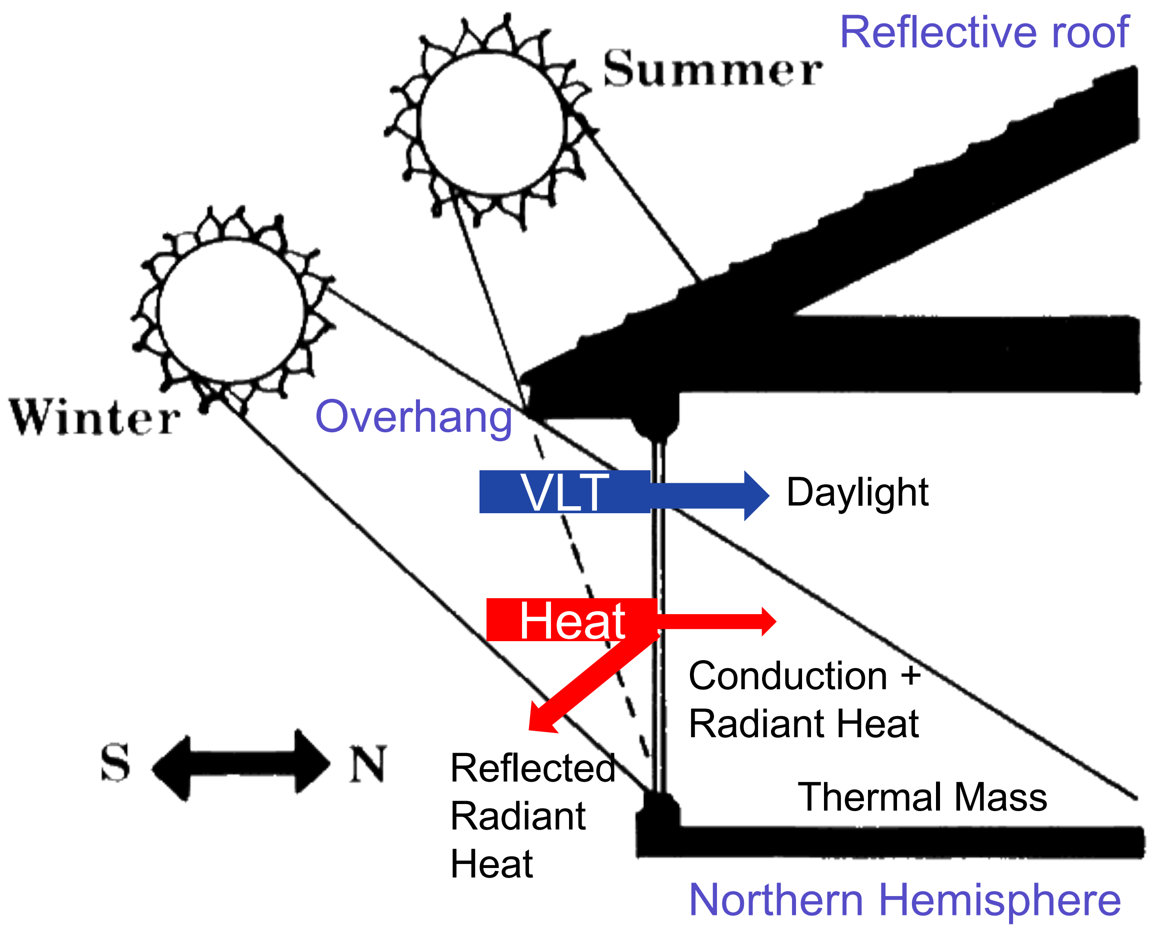
Envelope Design



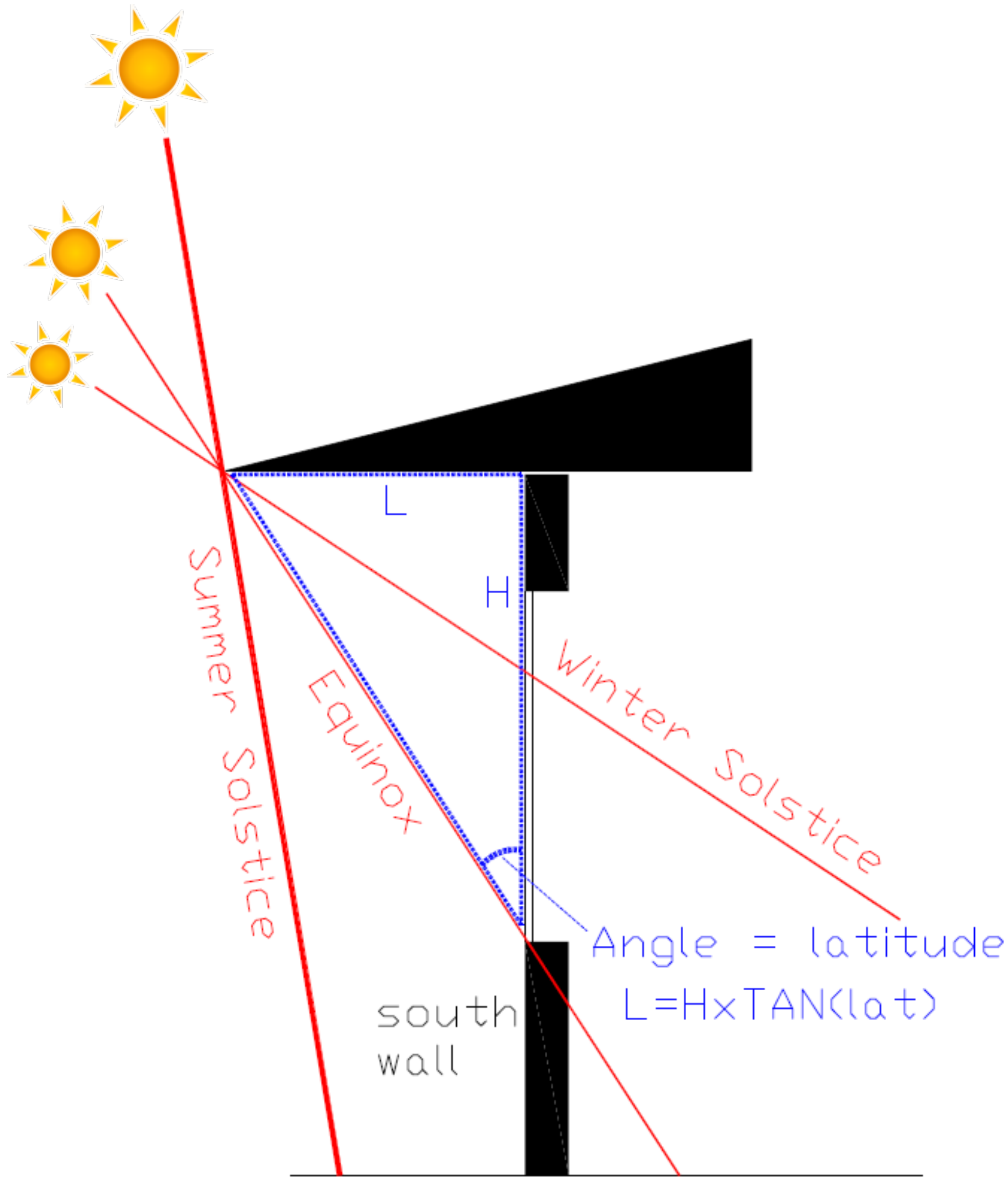
	Square	Rectangle	2 Story Rectangle	C-Shape	Goal
Floor Area (sf)	2,000	2,000	2,000	2,000	Same
Wall Area (sf)	1,432	1,468 (+3%)	2,261 (+58%)	2,020 (+41%)	Minimize
South Wall Area (sf)	358	448 (+25%)	714 (+99%)	358	Maximize
Roof or Slab Area	2,000	2,000	1,030 (-51%)	2,000	Minimize

The wrong shape increases initial cost and operating cost.

Passive Solar



Solar Shading



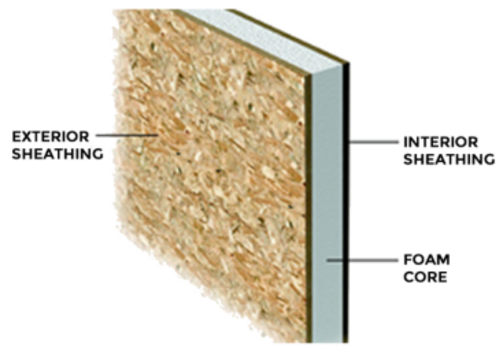
If lat = 33 deg N and H = 5.5 feet

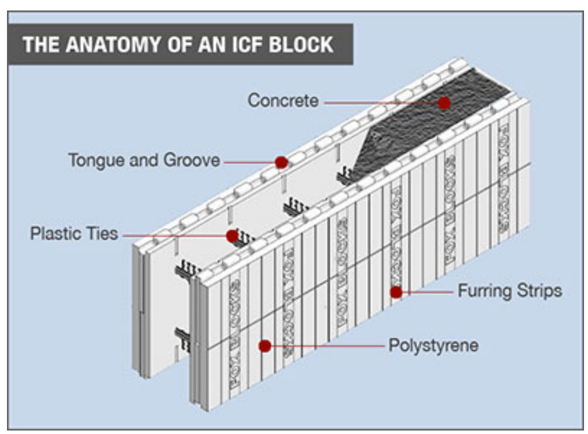
L = 5.5 x tan (33) = 5.5 x .65

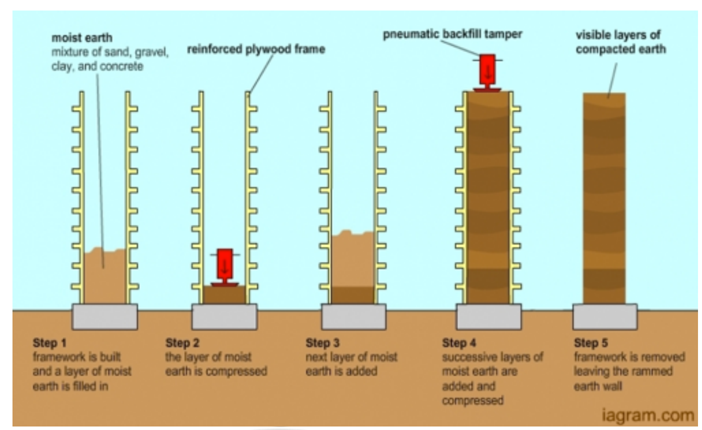
L = 3.6’

Structure Size/Shape/Material

- A 2-story rectangle is a space efficient and practical plan
- Using an advanced building system or advanced framing techniques is best
  - Structural Insulated Panels (SIP)
  - Insulated Concrete Form (ICF)
  - Earth Sheltered
  - Straw Bale
  - Advanced Framing
  - High Mass (Rammed Earth)

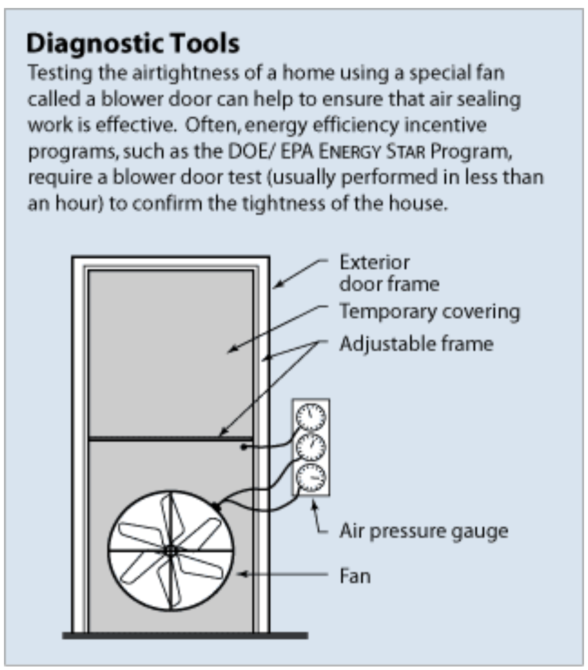






Structure Infiltration

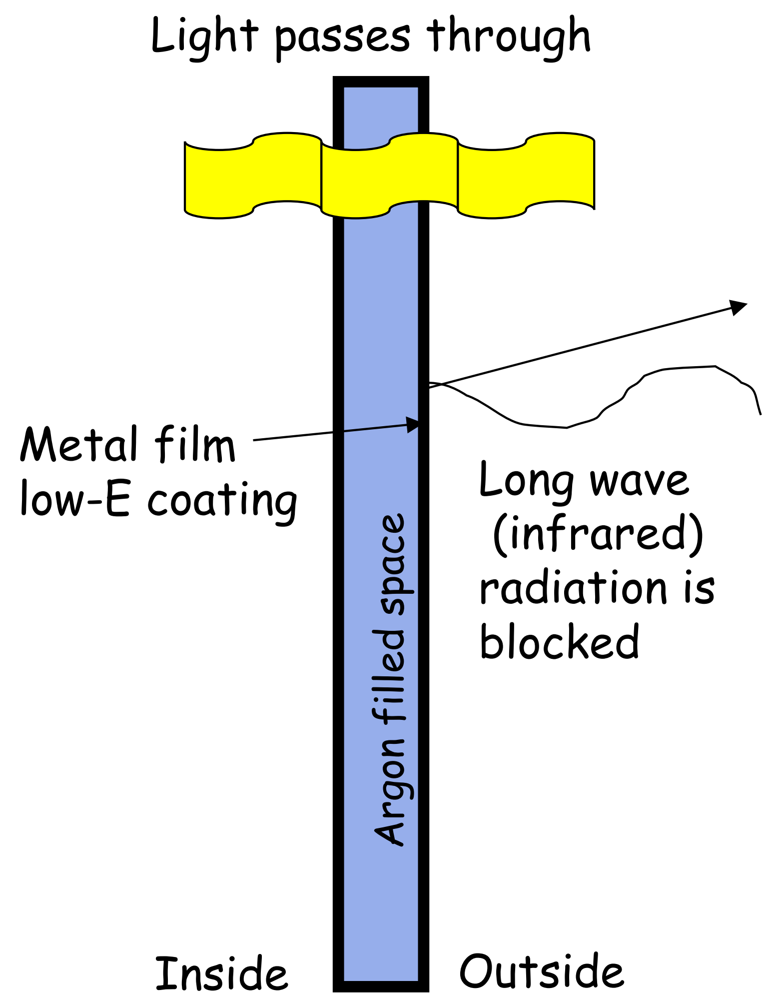
- Air tightness is as important as insulation
- Attention to detail needed to seal homes properly
- Blower door tests can evaluate the tightness and locate leaks – done at 50 Pascals (0.2 inches water gauge)
  - cfm50 is read off the flow gauge; ach50 is calculated using the house volume
  - Passivehaus standard is 0.6 ach50.



Infiltration inspector

Window Science

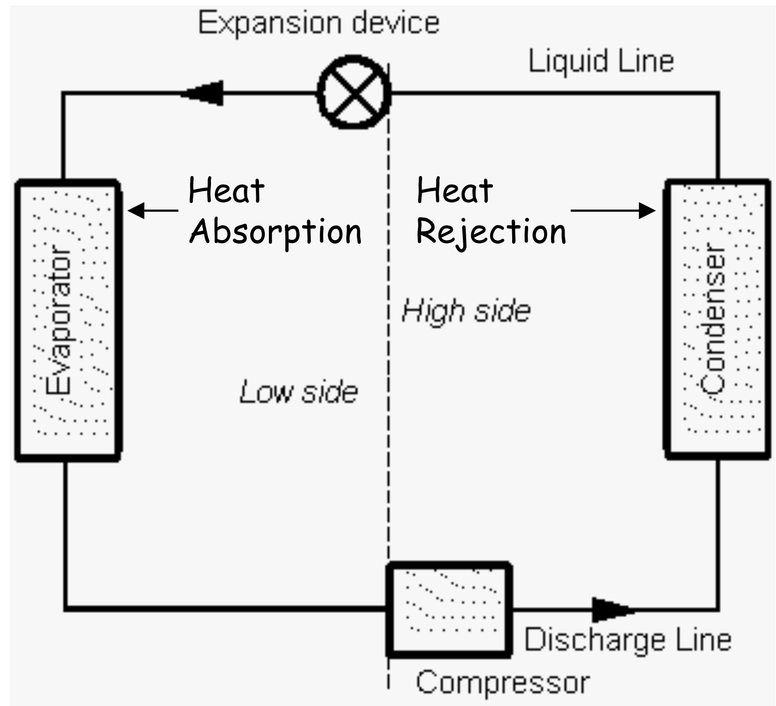
- Double pane provides an insulating air space
- Argon is denser than air (38% more), and does not conduct heat as readily (19% reduction)
- Low-E coatings block infrared (long wave) radiation and contribute to the comfort level of the home
- Radiation loss accounts for 2/3 of the losses by a window



RE:source

Heating / Cooling

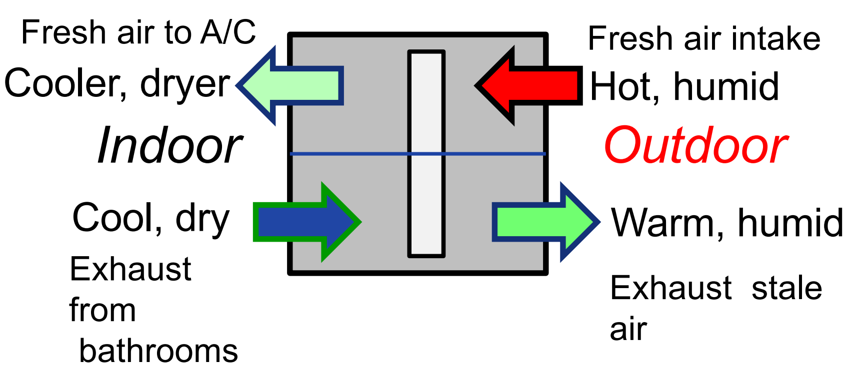
- Oversizing an HVAC system increases the initial cost and decreases the comfort. A short-cycling unit does not fully dehumidify.
- Two-speed units meet the variable loads more efficiently.
- Zoned duct is helpful in a two story home.
- Good design choices can greatly minimize the HVAC system size.



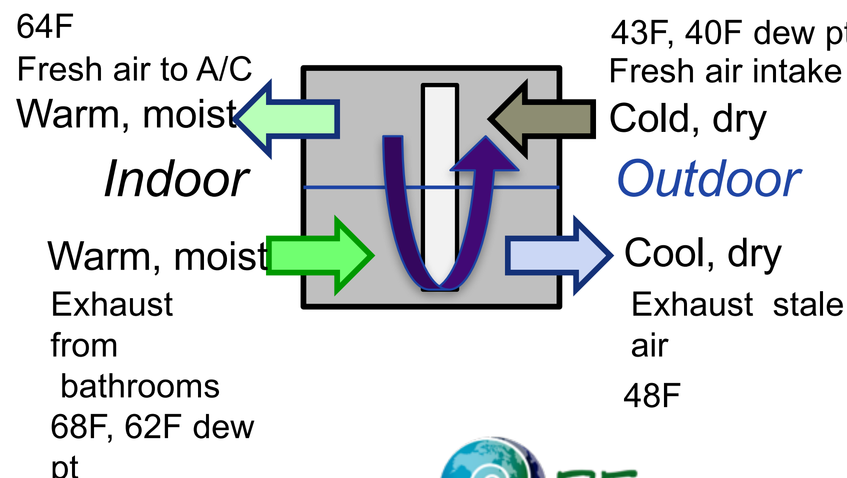
Energy Recovery Ventilator (ERV)

- The house is very air tight
  - GOOD: energy savings, minimal dust
  - BAD: not much fresh air
- An ERV brings in a steady stream of fresh air, but recovers much of the energy from the exhausted air
- Recovers over 70% of the total energy

Summer



Winter



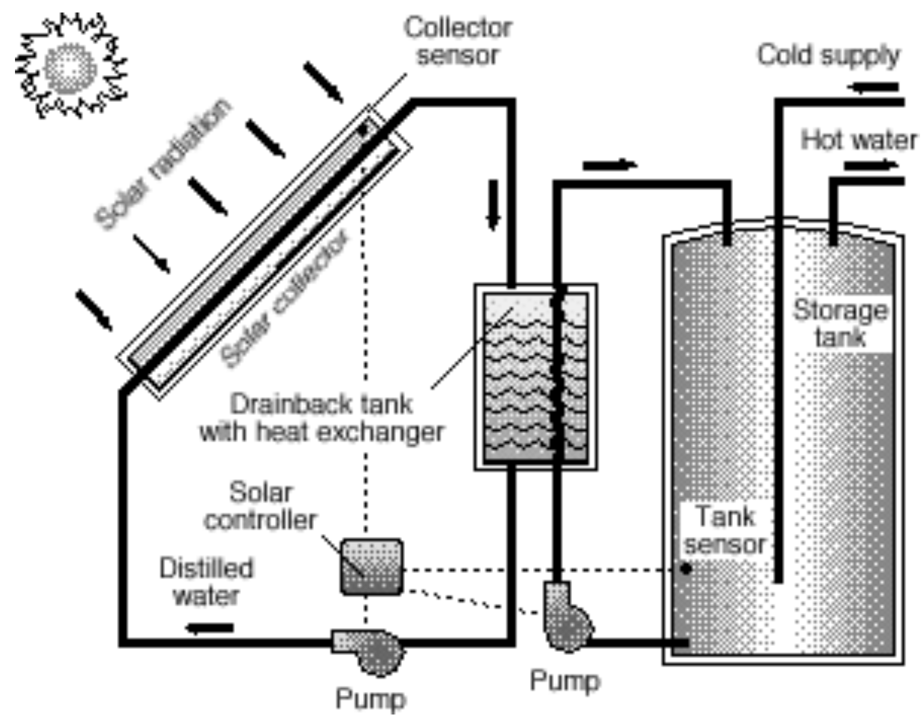
Efficient Lighting

- Passive solar design can result in good natural lighting, decreasing the need for daytime artificial lighting.
- Compact fluorescent (CF) lighting uses only 1/4th the energy of incandescent bulbs. LED's use even less than CF.
- Incandescent bulbs and halogen lights convert >90% of the electric energy to heat, which increases your air conditioning load.
- LED lights last significantly longer than incandescent bulbs - each LED has a higher initial price, but the energy savings and long life give each bulb a net $50+ savings.

RE:source

Water Heating

- Water heating can account for up to 30% of the electric use in a home.
- Solar Flat Plate water heating can be very cost effective.
- A side benefit of ground source heat pumps is a hot water recovery option which provides free hot water during the summer.
- Heat pump water heaters are improving fast.



Water Efficiency

- Rain water collection from the roof can be used to:
  - provide water for outdoor use.
  - reduce urban runoff.
  - lower your water bill.
- The first approach should be a native, low-maintenance lawn to reduce need.
- Rain water can also be used for human consumption.

1600 gallon rain water storage tank

RE:source

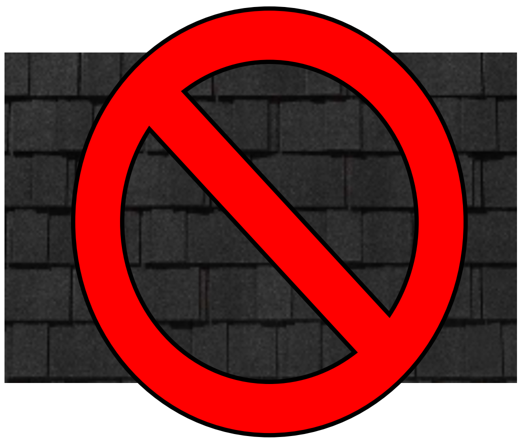
Water Efficiency

- House designed with all fixtures plumbed to a common water wall - no fixture is far from the water heater.
- Low flow fixtures - toilets, faucets, and shower heads all contribute.

RE:source

Roof

- In hot climates, exterior colors should be light for reflectivity.
- The roof material is a major heat absorber and should be light colored. Look for a roof material with high reflectance and high emissivity.
- A Galvalume metal roof reflects heat, provides a clean surface for rain collection, and reduces homeowners insurance rates (hail resistance). It also has a 50year + life.
- A coated metal roof is an even better reflector



RE:source

Construction

- A good design must be installed properly to function correctly
- “Cost, Schedule, Quality – pick two”
- Designer involvement
- Qualified subcontractors
- Contract language
- Certification requirements
- Quality control – commissioning of systems

RE:source

Operations & Maintenance

- The operation and maintenance of a home can have a large impact on the performance
- Behavioral issues are generally beyond the control of the designer, however:
- Complex systems are more likely to be used improperly or fail – and finding qualified repair people can be difficult

"Everything should be made as simple as possible, but not simpler."
– Albert Einstein

RE:source

Case Study - Westbrook House

- In the early 90's I designed my own passive solar home
- I was the architect, engineer, finance department, drafter, energy modeler, interior designer, ...
- I hired a small, local builder and obtained their input during the design phase
- We asked for input from suppliers during the design

"Quality, Cost, Schedule – Pick Two"

- We took the time to ensure the quality was there – from the design, through the construction
- We managed the budget by estimating and bidding the entire job during the design phase
  - And we did a few iterations as needed
- And because of all the detailed and integrated planning the construction schedule ran very well

RE:source

Disclaimer

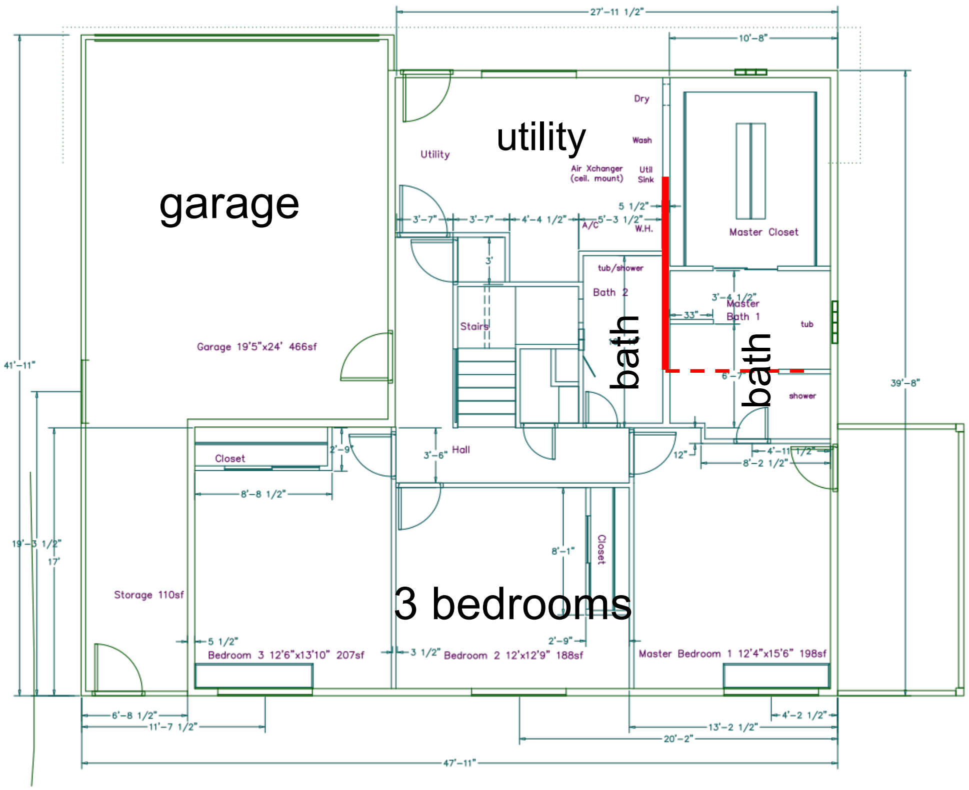
- The house is not an <u>annual</u> net zero house – yet
- We are net zero for some months
- We can be annual net zero by adding another ~2kW of solar panels
- The only thing holding us back is our electric co-op and their poor net metering policy (no compensation for excess energy sent to the grid and a monthly low energy use fee)

RE:source

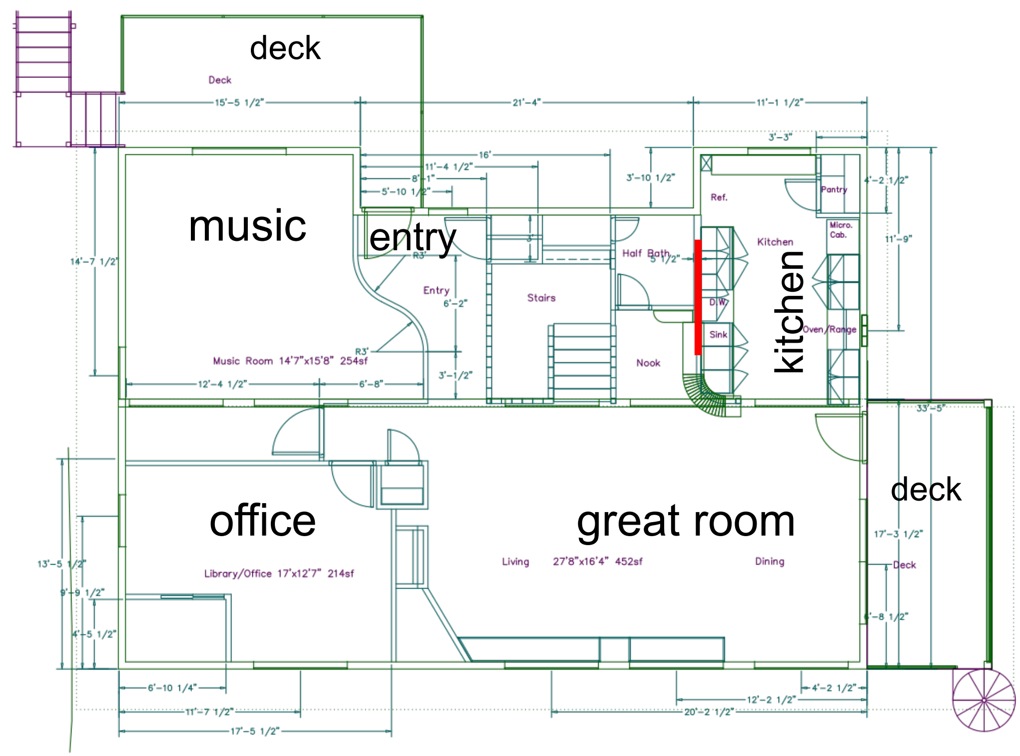
Floor Plan

Common plumbing wall

Living areas upstairs



1st Floor

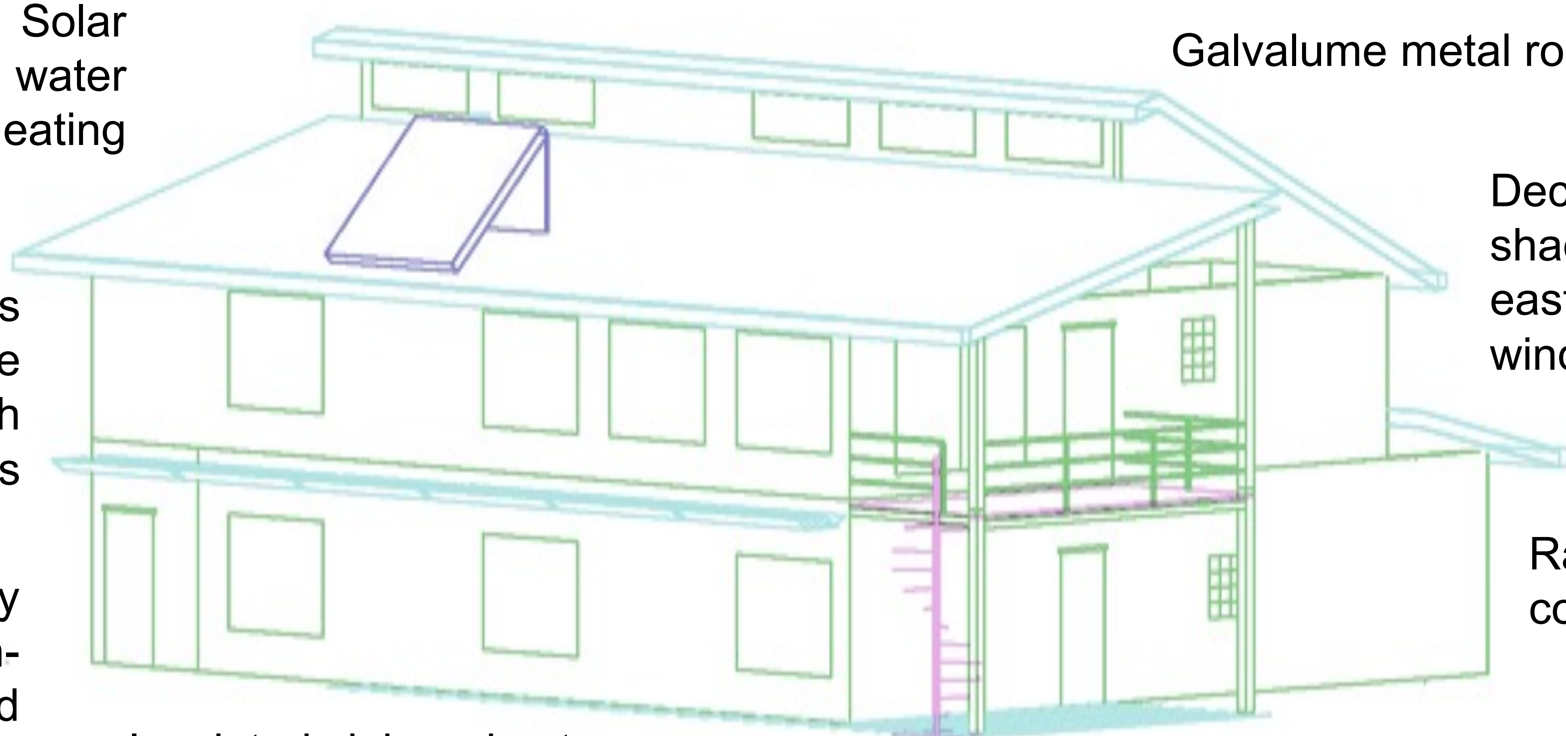


2nd Floor

Westbrook House - www.enerjazz.com/house

RE:source

Perspective



Westbrook House - www.enerjazz.com/house

RE:source

Aerial View

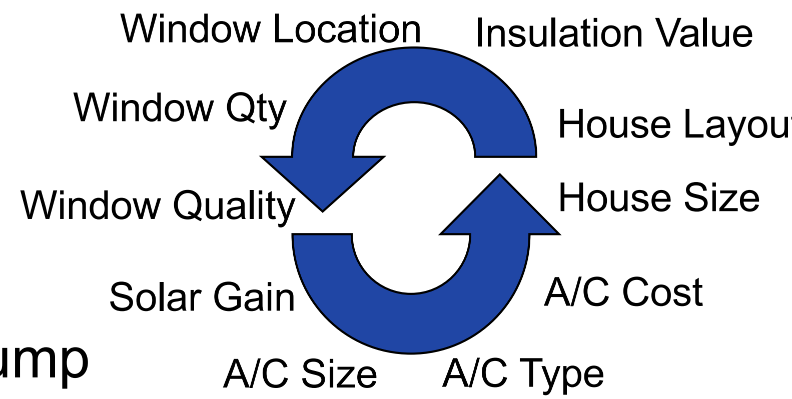
Westbrook House - www.enerjazz.com/house

RE:source

Integrated Design

- These items:
  - Proper orientation with respect to the sun path
  - The best glazing, in the right place, with the correct overhang
  - High levels of insulation and air tightness
  - A reflective metal roof
- Led to:
  - Reduced cooling/heating load
- Which resulted in:
  - A much smaller air conditioning system
- Which allowed me to afford:
  - A highly efficient ground source heat pump

Optimization Loop



All those items combine for better comfort at lower energy use and cost

Structure Size/Shape/Material

- A 2-story rectangle is a space efficient and practical plan
- Structural Insulated Panels (SIPs) for the walls and roof offer several advantages
  - Very little air infiltration
  - Good, consistent insulation value
  - Thermal bridging is underestimated in stick built construction
  - Cost effective
    - 6” wall=R26,
      8” roof=R33
    - Prefabricated in large sections off site, minimizing on-site erection time, crew size, and waste.

RE:source

Photos at solar noon:

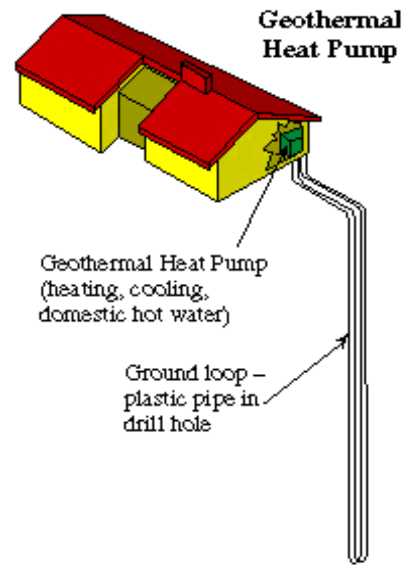
Winter solstice (left)

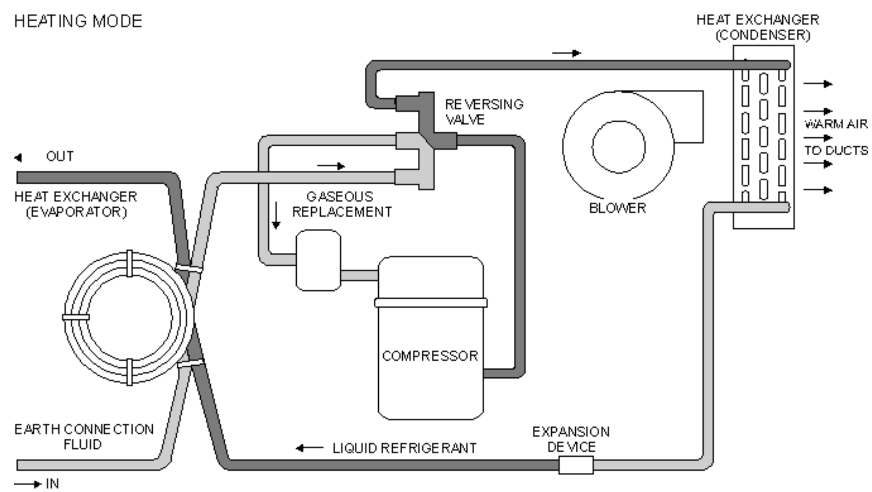
Equinox (lower left)

Summer solstice (below)

Ground Source Heat Pump (GSHP)

- The GSHP uses the relatively constant temperature of the earth as a heat sink or source.
- A GSHP can also be used as an efficient method of water heating.
- The minimum efficiency unit has a SEER of 13 (as of 2006). The Westbrook House GSHP has a SEER of 22.
- There is no noisy outdoor fan unit and we don’t reject heat to the already overheated air.





RE:source

Features

- Two story rectangle with ample south windows
- Proper orientation, passive solar design, efficient floor plan
- Well insulated and sealed house (Structural Insulated Panels – SIPS)
- High quality windows in the right place – with the right shading
- Efficient air conditioning – ground source heat pump
- Energy recovery ventilator
- Efficient lighting and appliances
- Solar water heating
- Galvalume standing seam metal roof
- Environmentally friendly products
- Minimal construction waste

RE:source

All the Little Things

- Insulated hot water lines in the walls
- Earth bermed the west wall of the attached garage and insulated it. Lowest garage winter temperature = 51 degrees F
- Used 100% recycled polypropylene carpet from Image
- Motorized operators on clerestory windows for ventilation
- Efficient indoor appliances (refrigerator) to reduce heat load
- Wood stove and outside air intake for combustion air
- Horizontal axis washing machine for efficient water use
- Insulated the concrete slab foundation perimeter
- Ceiling fans in almost every room
- Recycled plastic / waste cedar shavings for deck board
- Low VOC paints for better indoor air quality

RE:source

Energy Monitoring

- In 2013 I added real-time circuit level monitoring to my electric panel

RE:source

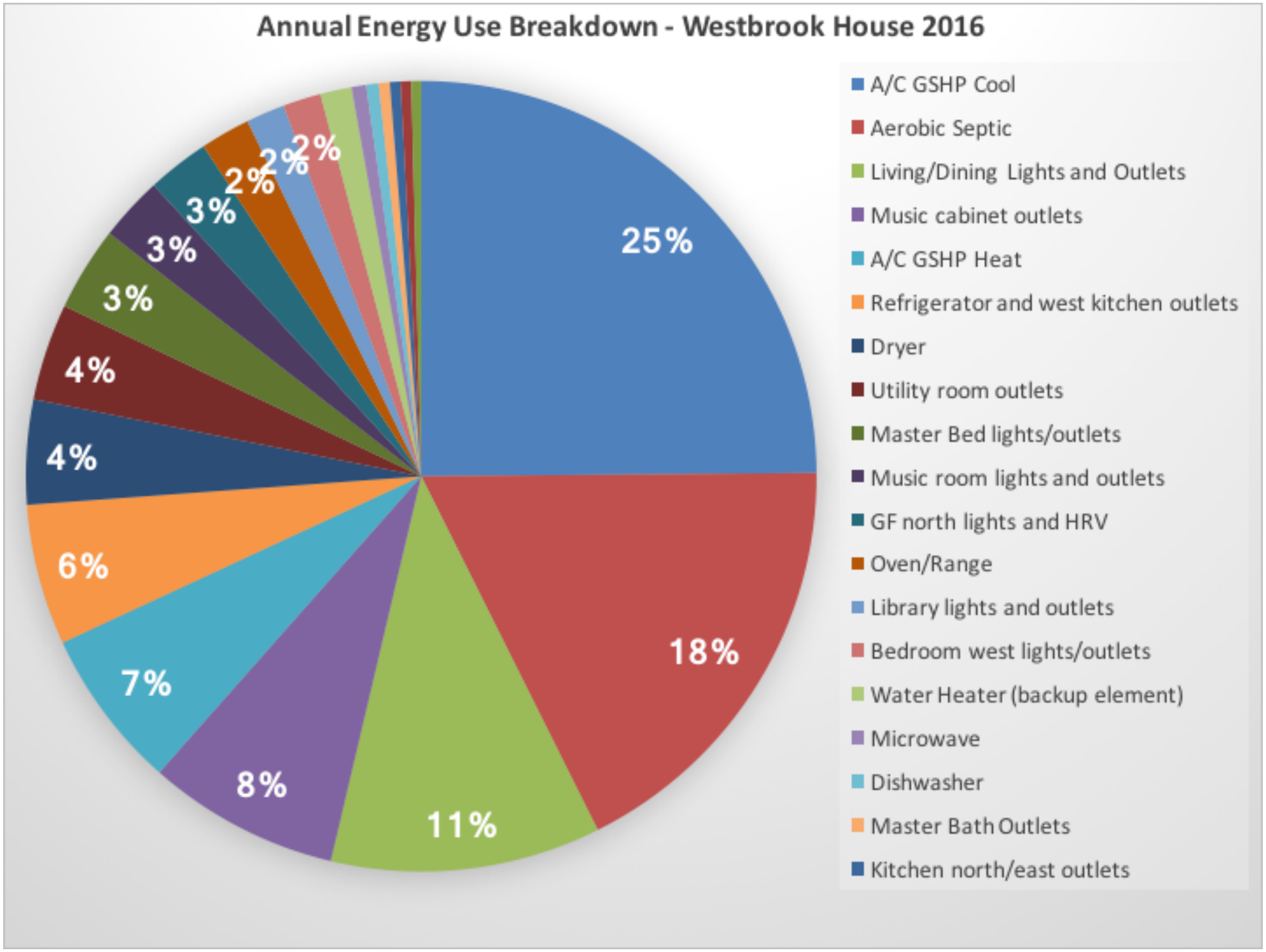
Energy Monitoring

- Summary Data from 2016

Circuit (**data in kWh**)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2016 Yr	Cost/Yr	Monthly Variation	18
A/C GSHP Cool				7.2	44	302	499	366	362	80			1,661	$ 183		
Aerobic Septic	138	129	150	161	149	166	90	40	39	40	43	41	1,187	$ 131		
Living/Dining Lights and Outlets	59	57	59	57	64	64	74	51	58	59	66	73	738	$ 81		
Music cabinet outlets	39	37	40	45	44	49	50	45	52	48	37	38	524	$ 58		
A/C GSHP Heat	162	57	5								16	198	438	$ 48		
Refrigerator and west kitchen o	25	26	29	30	34	37	40	37	35	34	30	29	385	$ 42		
Dryer	27	25	32	22	21	20	26	18	19	24	26	26	286	$ 31		
Utility room outlets	19	20	21	32	22	24	26	22	24	23	18	14	265	$ 29		
Master Bed lights/outlets	17	14	15	14	18	22	26	22	26	20	18	16	230	$ 25		
Music room lights and outlets	12	11	12	14	14	14	14	11	19	18	20	16	176	$ 19		
GF north lights and HRV	17	17	17	18	17	12	12	11	12	14	12	14	170	$ 19		
Oven/Range	10	11	10	10	11	10	12	9	10	10	17	14	136	$ 15		
Library lights and outlets	3	9	9	9	13	8	10	9	10	9	9	9	106	$ 12		
Bedroom west lights/outlets	8	7	8	8	8	7	8	10	10	10	10	10	104	$ 11		
Water Heater (backup element)	4	-	6	16	7	1	-	2	-	-	11	38	86	$ 9		
Microwave	3	3	3	2	4	2	3	2	3	4	5	4	40	$ 4		
Dishwasher	2	2	2	2	3	2	2	2	2	3	4	5	34	$ 4		
Master Bath Outlets	3	5	4	3	2	2	2	2	1	2	2	4	30	$ 3		
Kitchen north/east outlets	2	2	2	2	3	2	3	1	2	2	5	2	29	$ 3		
Garage Outlets	4	4	4	4	4	4	2	-	1	-	1	1	29	$ 3		
Washing Machine - Horizontal A	2	2	3	2	2	2	2	2	2	2	2	3	27	$ 3		
Bath / Half Bath Outlets - GFCI	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -		
Sum eMonitor Use	556	438	430	459	485	750	903	662	688	402	351	555	6,680	$ 735		

Energy Consumption

Public data view link



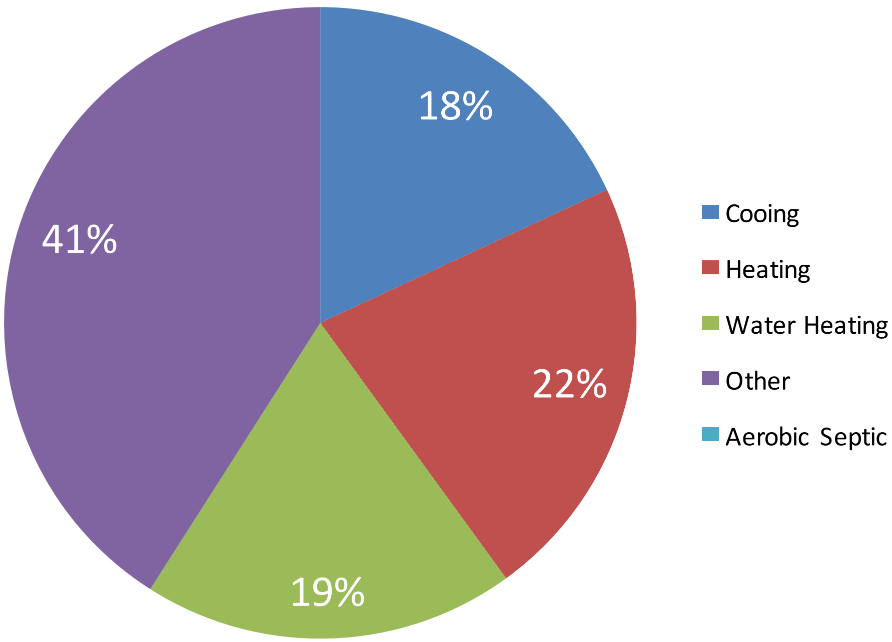
6,680 kWh/yr, 2,713 sf, 2 people, north Texas

8.6 kBtu/sf/yr (Texas EUI avg is in the 40’s)

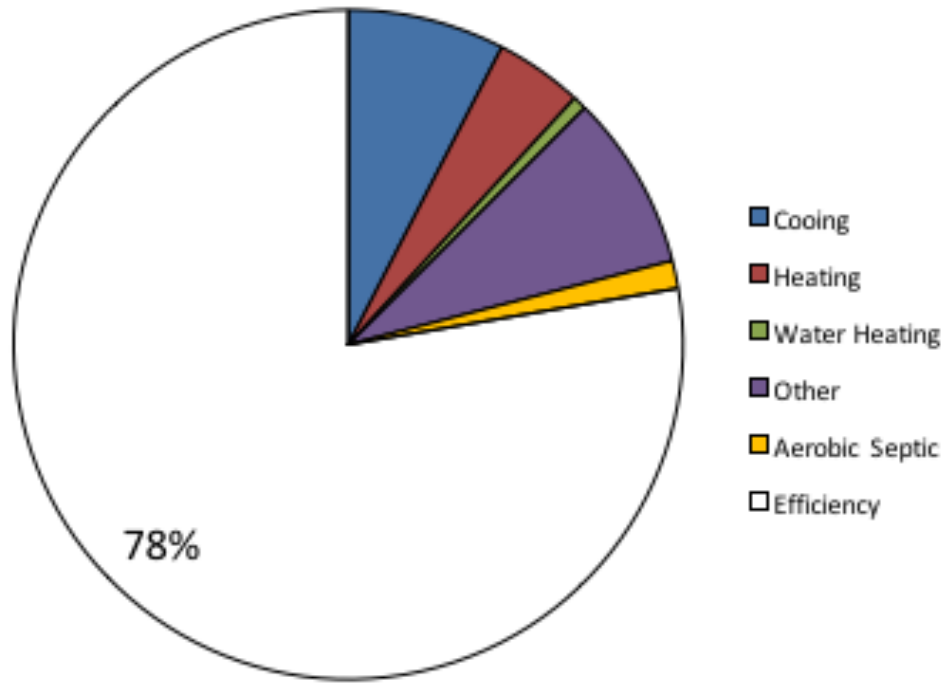
RE:source

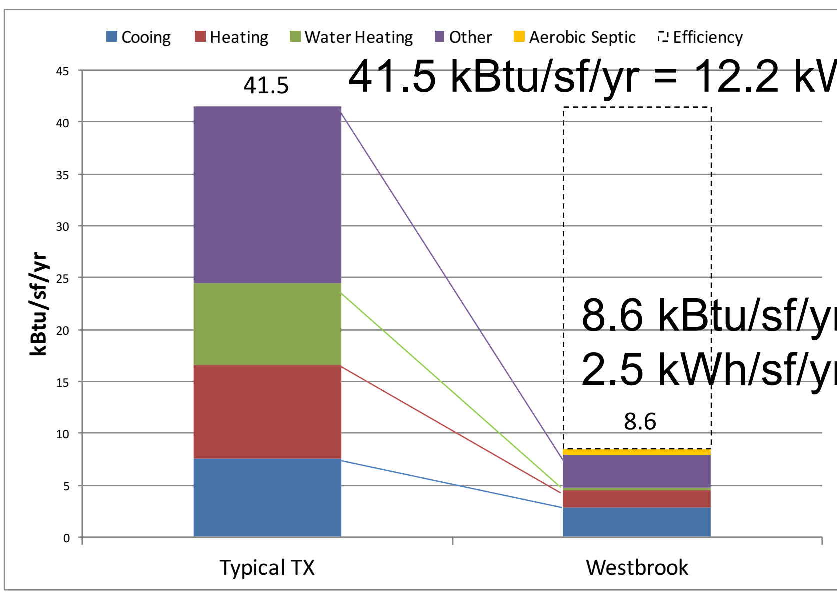
My Results – My House

Typical Texas Home



Westbrook House – 2016 year avg





Solar Generation Needed for Net Zero:

- Typical Home = 24kW solar ($50K)
- Westbrook House = 5kW solar ($12K)

www.enerjazz.com/house

RE:source

Economics of Efficiency

Design Goals		
Energy Efficiency		Environmental Sensitivity
Low Maintenance		Cost Effective Design / Construction
Logistics		
Construction Time:	6.5	months
Move In:	Sep-96	
Size (A/C):	2713	SF of A/C space
Size (gross):	3312	SF under roof
Electricity Savings (all electric home)		
Average Electric Bill:	$84.84	avg use: 840 kWh/month
Highest Electric Bill:	$170.71	Aug-06
Westbrook Electric Cost/Yr:	$1,018.08	826kWh/mo * $0.101/kWh over 14 year avg
Average Home Elec. Cost/Yr:	$2,951.12	Avg use south: 10.77 kWh/sf/yr @ .101/kWh
Annual Savings:	$1,933.04	
Monthly Savings:	$161.09	
Payback		
Cost for Energy Efficiency Items:	$ 13,000.00	Total cost of all energy efficiency upgrades
Added to a 15 year mortgage:	$99.22	/mo @ 5.5% int + tax deduct on mortgage
Added to a 30 year mortgage:	$74.94	/mo @ 6% int + tax deduct on mortgage
With a 15 year mortgage, you SAVE:	$61.87	/month - but get full payback faster.
With a 30 year mortgage, you SAVE:	$86.15	/month
After the mortgage is paid, you realize the full savings every month.		
Note that mortgage interest is tax deductible.		
Energy bills are not deductible. In fact, energy use is taxed.		
Payback occurred in the first month when we paid more to the mortgage co. but less to the utility.		

RE:source

Results

- Energy costs of about 1/3rd of my neighbors
- Water costs about 1/6th of my neighbors
- Low maintenance costs
- Won the 1996 NAHB Energy Value Housing Award for Innovative Design
- House was exactly on budget – no late VE required ($84/ AC sf in 1996 = $127/ AC sf in 2016)
- The builder and I are still speaking – in fact, we are friends
- Tour of my house by a TI VP sparked an idea to do this process on a very large scale which became the first LEED Gold semiconductor factory in the world.

RE:source



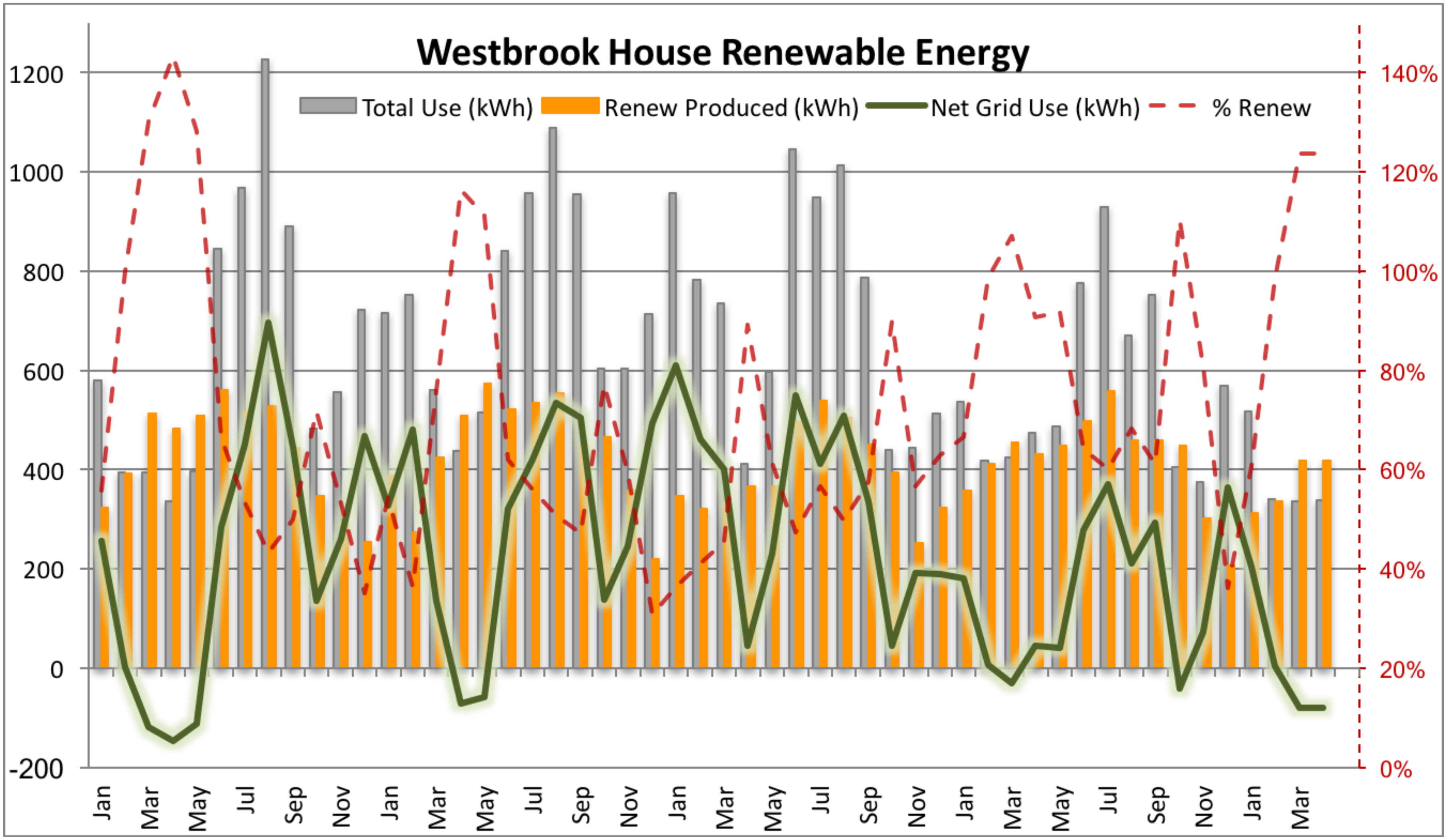

Energy Generation

- Reducing energy consumption meant that we would need a smaller on-site energy generation system
- When solar photovoltaic (PV) prices dropped in 2012 we installed a system
- Installed a 3.3kW array (expanded in 2014 to 3.75kW)
  - Produces more electricity than we need for 3-4 months a year
  - Produces > 60% of our electrical needs during the year

A ~6kW system would have made us an annual net zero site energy home, but our utility rate structure is poor – no payment for excess energy to the grid and a low-use fee penalty for not using enough energy each month.

RE:source

Energy Production Data



Solar PV installed for $2.63/W before federal tax credit. No local incentive.

RE:source

Latest Step – More Efficiency

- I replaced my aerobic septic aerator with a much more efficient model (units run 30 min of every hour)
  - Original model: 2 cfm, 550 Watts, 200 kWh/month
  - New model: 2 cfm, 80 Watts, 30 kWh/month
- Cost of replacement ~$400
  - <2 year payback, but aerator was failing anyway, so the delta cost is $0 = instant payback
- Equivalent solar panels needed to generate 2,040 kWh/year = 1.5kW = 6 ea 250W panel
  - At $3/W, the cost would be $4,500
- I am now >85% of the way to net zero

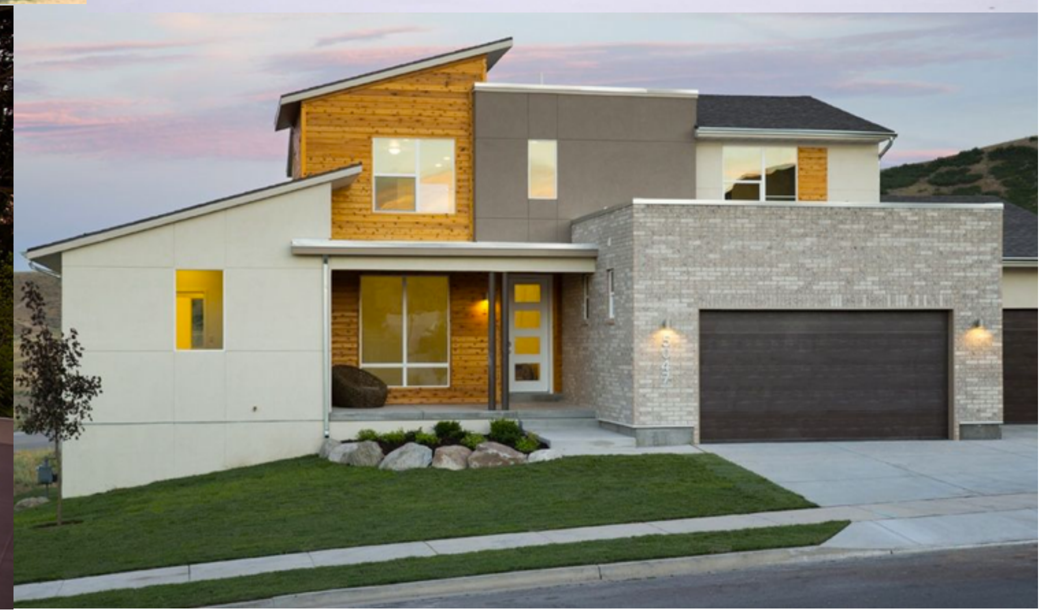
RE:source

What Would I Do Today?

- Less square footage
- Passive House type structure
  - Extremely well insulated and airtight
    - Walls ~R-40, Roof ~R-60
- Top quality windows (>R-8 available)
- Integrate small A/C unit into energy recovery ventilator (ERV)
- Consider PV driven heat pump water heater instead of solar water heater

RE:source

Net Zero Homes



A Few Homes

- Vandemusser Residence and Office - Link
  - North Carolina – climate zone 4
  - HERS Index of 44 before solar
  - LEED for Homes Platinum, ENERGY STAR, EPA Indoor AirPlus, NC Healthy Built Platinum
  - 5843 kWh consumed; 6147 kWh produced

RE:source

A Few Homes

- Volume Builder Home - Garbett - Link
  - Salt Lake City – climate zone 5
  - Purchased for $350K
  - 10.3kW solar

A Few Homes

- Ross Residence (retrofit) - Link
  - Massachusetts – climate zone 5
  - 120 year old house retrofit
  - 3,200 sf house
  - Produces 30% more energy than consumed

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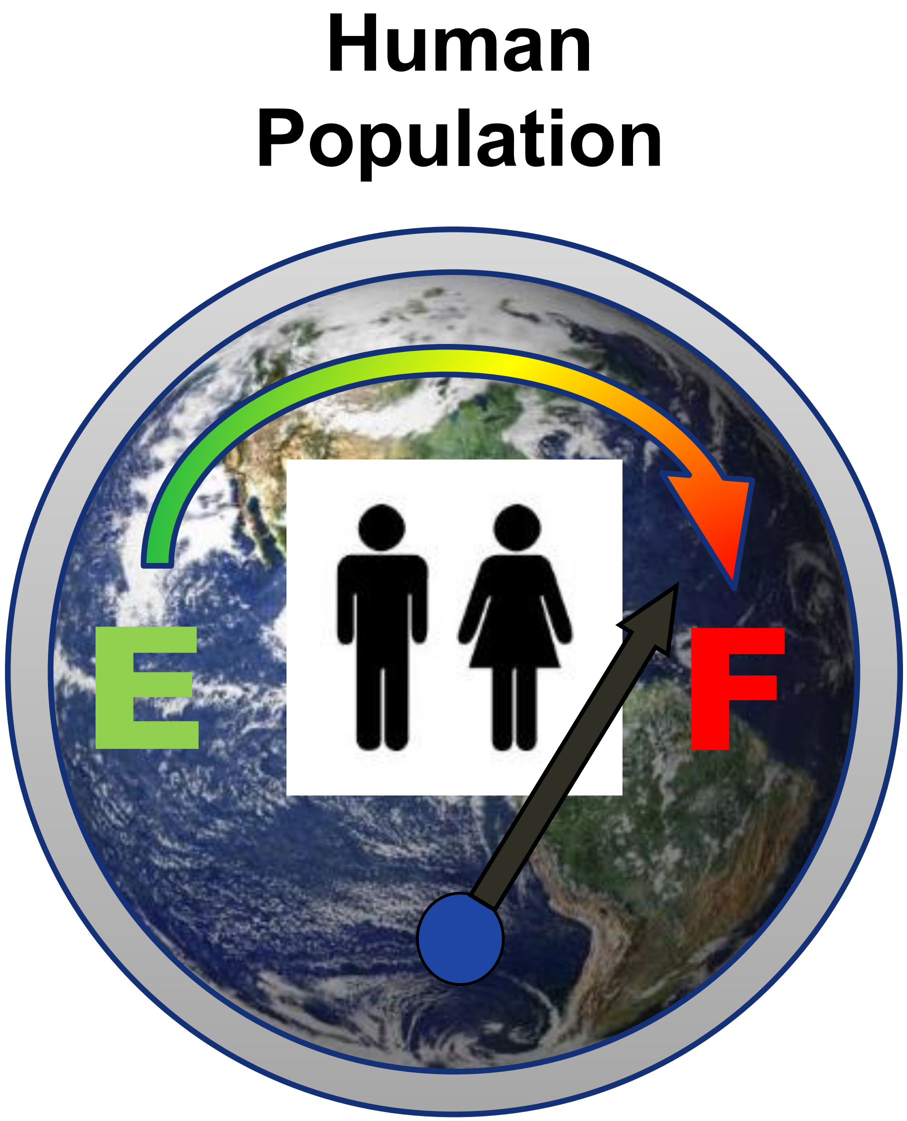
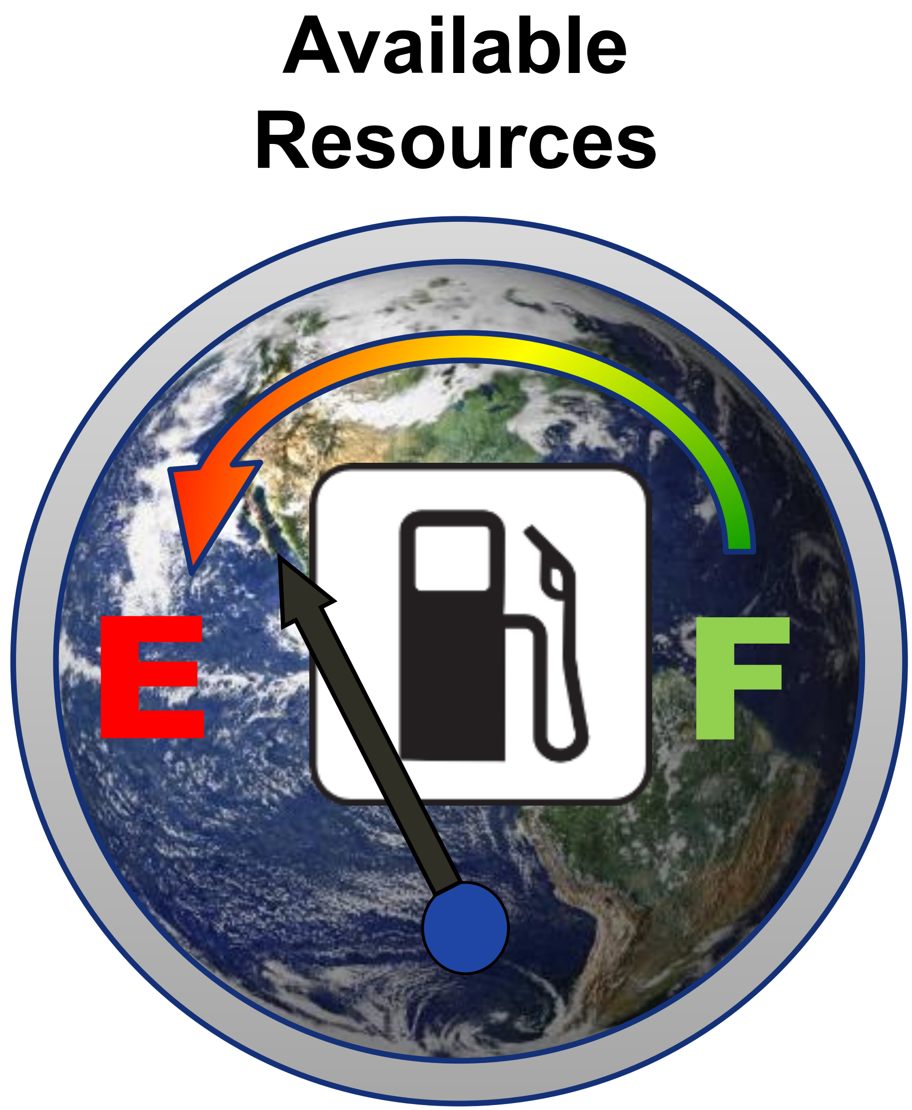
Planet Capacity





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Thank You

BPI - Building Professional Institute

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