PHRC Webinar Series | Tuesday, May 16 @ 1pm

What does Net-Zero Energy Mean in PA?

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Description

The residential construction industry has been advancing in terms of energy efficiency for decades. The concept of achieving Net-Zero Energy is now a reality. But what does Net-Zero Energy actually look and feel like in Pennsylvania? This webinar will explore the basics of energy consumption in residential settings, as well as the history of energy efficient techniques, systems, and building codes in Pennsylvania. The discussion will focus on the specifics of Pennsylvania's climate, construction industry, and economy.

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Learning Objectives

- Examine the fundamentals of energy consumption as it relates to heating and cooling, occupancy, water heating, lighting, and other common residential uses.
- Understand the history of energy efficient construction techniques that have pushed the residential industry toward a higher standard through voluntary programs and minimum code requirements.
- Analyze the specific challenges that builders and designers in Pennsylvania may face when trying to achieve Net-Zero Energy and the impact those challenges have on cost and feasibility.
- Discuss various case studies that illustrate successful designs and executions as they relate to occupant comfort, utility bill reduction, mortgage feasibility, etc.

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Outline

- How do homes use energy?
- What is a net-zero energy home?
- How is zero-energy achieved?
- Overview of the DOE Zero Energy Ready Home Program

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How do homes use energy?

- **Interaction with the environment**
  - Heat gain/loss and the energy to condition the built environment
- **Basic services**
  - Water heating
  - Food storage
- **Occupant influence**
  - Plug loads
  - Occupant behavior

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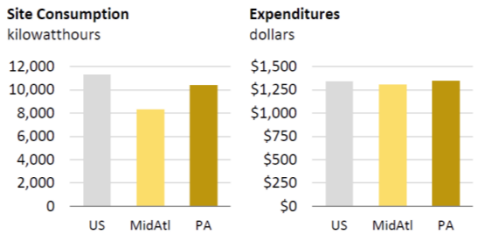
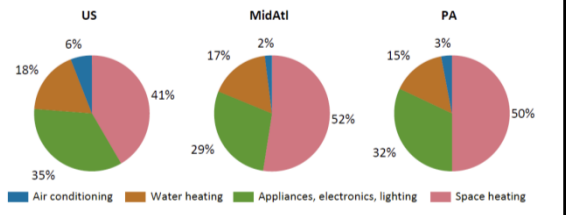
Consumption of Electricity



Source: 2009 EIA Residential Energy Consumption Survey

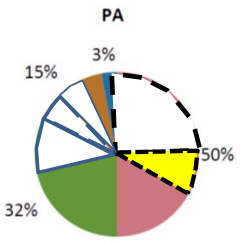
Consumption by End Use



Source: 2009 EIA Residential Energy Consumption Survey

Where builders & manufacturers can make a difference

- More insulation, tighter air sealing, energy recovery ventilator
- More windows toward south
- Low flow fixtures
- Energy-efficient appliances



Air conditioning Water heating Appliances, electronics, lighting Space heating

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What to call it?

Zero Net Energy = Net Zero Energy = Zero Energy

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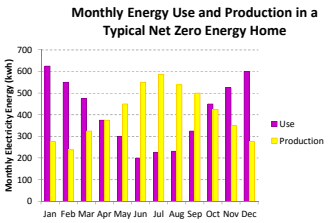
Zero Energy Building (ZEB)

An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

- A Common Definition for Zero Energy Buildings (DOE)



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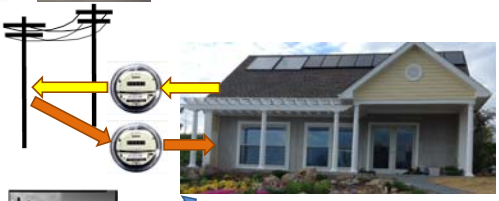
3.15

Based on source energy used to deliver a unit of energy



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National Average Source Energy Conversion Factors

Energy Form	Source Energy Conversion Factor
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

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Case Study 1: Production home built in 2014

- **3 bedroom, 2.5 bath, 1900 SF**
- **Fuel sources:**
  Electric (AC, appliances, lighting, plug loads, etc.)
  Natural gas (heating, cooking)
- **Estimated annual delivered energy:**
  Electric = 11,500 kWh (US avg 10,800 kwh) = 39,240 kBtu = $1,275/year
  Natural gas = 350 Thm = 35,000 kBtu = $600/year

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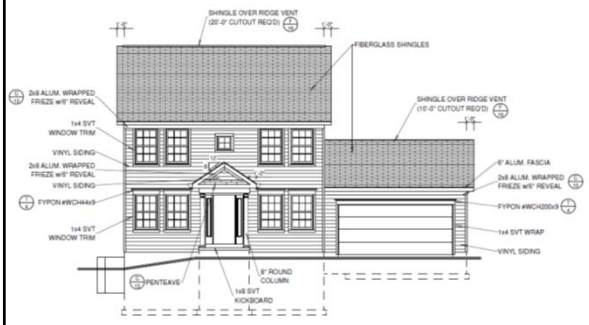

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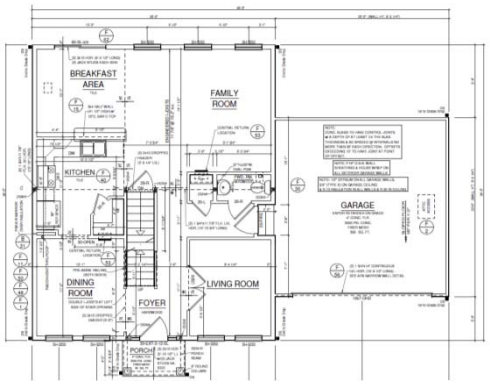

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Case Study 1: Production home built in 2014

How much renewable energy is needed to consider this home a zero energy building?

Σ_{source} = (39,240 kBtu x 3.15) + (35,000 kBtu x 1.09)
Σ_{source} = 123,606 + 38,150 = 161,756 kBtu

The amount of exported renewable electricity would have to equal this (with 3.15 conversion factor):
Annual renewable production = 161,756/3.15 = 51,351 kBtu =
15,045 kWh

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Case Study 1: Production home built in 2014

Key considerations:

- How much will the system cost?
- Do I have enough usable roof area for a system of this size

Producing 15,045 kwh would mean:

- an **11.5 kW** system,
- 700 SF of module area, (roof is 550 SF)
- cost of **$46,000** ($4/W)

Rules-of-thumb for solar electric in PA:

- Size: ~14 W/sf
- Production: ~120 Wh/sf per year;
- Production: ~1,300 kwh/yr per kw of capacity

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Case Study 1: Getting Ready for Zero

As-built:
Code Heat Pump
LED lighting
13.3 kW PV, 816 sf

Tighter with ERV
11.6 kW, 696 sf

Wall 1" ins. brd., R60 ceil.
10.2 kW, 612 sf

Hi-efficiency Heat Pump
9.1 kW, 546 sf

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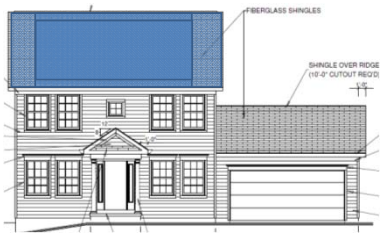
Case Study 1: Going Further



Heat Pump Water Heater
6.8 kW PV, 410 sf

Conserving behavior
5.4 kW, 326 sf

Solar size reduced to
$21,600

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How is Zero Energy Achieved?

1. **A consistent, system-wide emphasis on reducing energy use:**
   - Siting for passive solar heating and cooling
   - Beyond code insulation levels and air tightness
   - Energy-efficient appliances, HVAC, and fixtures
   - Conserving behavior
2. **Solar technologies (and maybe wind) to provide the reduced needs**
   - Solar water heater (or heat pump water heater) for domestic hot water
   - Photovoltaic (PV) system for the remainder

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Renewable Energy in PA

Solar water heating

- Domestic hot water energy use is 20-30% of total energy use in a super-efficient house
- A two-panel (60 sf) flat-plate collector system can provide 1/2 to 3/4 of annual energy use (10-15% of total)

Solar electricity (photovoltaic or PV)

- Each square foot of PV panels on a PA roof can produce about 14 Watts of peak power
- Each Watt of peak power can produce about 1.3 kilowatt-hours

Hundredfold Farm, Gettysburg, PA

HPWH Economics

- HPWH added installed cost is ~$1,000; Assuming that 90% of the cost is mortgaged at 30 year and 4% interest, the annual mortgage increase is $57 a year.
- Using 80 gal/day of hot water takes about 5,600 kwh a year (with 20% losses). At $0.10 / kwh that costs $560 a year.
- HPWH can save 50%+ of that, or $ 280 a year.

So at end of first year:

Down payment (10%)	$ (200)
Federal Tax credit ($300)	$ 300
Mortgage payment	$ (57)
Electricity savings	$ 280
NET	**$ 323**

+ $223 savings each year afterward

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PV Economics

- **Home value increases $20 for every $1 reduction in annual utility bills. (Appraisal Journal)**
- **Solar electricity systems now cost about $4 per installed Watt of capacity; a 5,000 W system would cost about $20,000.**
- **Annual savings in PA is about 1.3 kwh per installed watt; a 5,000 Watt system would save 6,500 kwh; at an electricity cost of $0.15 / kwh that's $975 per year.**
- **Home value would increase by $19,500.**
- **Federal tax credit reduces system cost by 30% or $6,000 in this case.**

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PV Economics - continued

FIRST YEAR:

Down payment (10%)	$(2,000)
Tax credit	$ 6,000
Mortgage pmt	$(1,031)
Interest tax reduction	$ 258
Electricity savings	$ 975
NET	**$ 4,202**

FOLLOWING YEARS:

Savings of about **$202** a year.

Other considerations: Future cost of electricity, Environmental benefits, Resale value

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DOE Zero Energy Ready Home

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

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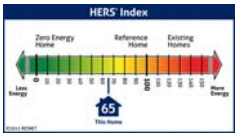
DOE Zero Energy Ready Home

- ***"A DOE Zero Energy Ready Home is a high performance home which is so energy efficient, that a renewable energy system can offset all or most of its annual energy consumption."***
  - https://energy.gov/eere/buildings/zero-energy-ready-home
- **A DOE Zero Energy Ready Home is ~40-50% more energy efficient than a standard new home**
  - HERS scores in the 50's



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ZERH Program Overview

- **DOE Zero Energy Ready Home National Program Requirements (Revision 5.0)**
- **Homes must:**
  - Meet minimum ZERH requirements
  - Be verified and field-tested in accordance with HERS Standards by an approved verifier
  - Meet all applicable codes

or **HUD Code**

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ZERH and ENERGY STAR

- **Prescriptive vs. performance path**
- **All ZER homes must meet ENERGY STAR version 3.1 as a baseline**

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ZERH Prescriptive Requirements

Exhibit 1: DOE Zero Energy Ready Home Mandatory Requirements for All Labeled Homes

Area of Improvement	Mandatory Requirements
1. ENERGY STAR for Homes Baseline	☐ Certified under ENERGY STAR Qualified Homes Version 3 or 3.1 [9, 10]
2. Envelope[11]	☐ Fenestration shall meet or exceed ENERGY STAR requirements [12, 13] ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 or 2015 IECC levels[14, 15]
3. Duct System	☐ Duct distribution systems located within the home's thermal and air barrier boundary or optimized to achieve comparable performance[16]
4. Water Efficiency	☐ Hot water delivery systems shall meet efficient design requirements[17]
5. Lighting & Appliances[18]	☐ All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified. ☐ 80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum 80% of sockets ☐ All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified
6. Indoor Air Quality	☐ Certified under EPA Indoor airPLUS [10]
7. Renewable Ready	☐ Provisions of the DOE Zero Energy Ready Home PV-Ready Checklist are Completed; (Solar Hot Water Ready provisions are encouraged but not required) [19]

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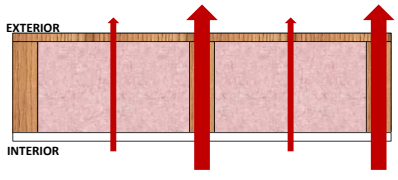
ZERH Envelope Requirements

- **Thermal bridging reduction (ENERGY STAR requirement)**
  - Exterior continuous insulation
  - SIPs, ICFs, or other panelized systems
  - Double stud walls
  - Advanced framing



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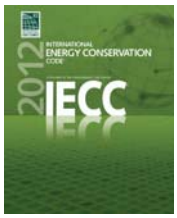
ZERH Envelope Requirements

- **Must meet prescriptive requirements in 2012 IECC for ceiling, wall, floor, and slab**
  - Ceiling = R-49
  - Wall = R-20 or 13+5
  - Floor = R-30
  - Slab = R-10 for 2 ft



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Infiltration

- **Blower door test required**
  - Must be less than 2.0 ACH50 in climate zone 5
  - Current requirement in PA is 7ACH50 (if blower door test is performed)

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ZERH Equipment Efficiency

Exhibit 2: DOE Zero Energy Ready Home Target Home [7, 20]

HVAC Equipment[21]			
	Hot Climates (2012 IECC Zones 1,2)[22]	**Mixed Climates** (2012 IECC Zones 3, 4 except Marine)	**Cold Climates** (2012 IECC Zones 4 Marine 5,6,7,8)
AFUE	80%	90%	94%
SEER	18	15	13
HSPF	8.2	9	10[23]
Geothermal Heat Pump	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House Mechanical Ventilation System	1.4 cfm/W; no heat exchange	1.4 cfm/W; no heat exchange	1.2 cfm/W; heat exchange with 60% SRE

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"Renewable Ready"

PV-Ready Checklist:

1. Designate proposed array location and square footage on architectural diagram
2. Identify orientation of proposed array location
3. Identify inclination of proposed array location
4. Ensure structural capacity of roof is adequate for proposed array
5. Provide drawing of solar PV system components
6. Install conduit for routing appropriate wiring between array and inverter
7. Install conduit for routing wiring between inverter and electrical service panel
8. Install blocking for inverter
9. Install 70-amp dual pole circuit breaker in electrical service panel

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DOE ZERH Summary

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

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ENERGY STAR

2012 IECC

EPA Indoor airPLUS QUALIFIED HOME

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Summary

- **Zero energy buildings are feasible**
- **In order to be economical, consumption must be reduced before generation is considered**
- **There are many above-code programs available for guidance along the path toward zero**

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