All-Electric New Homes in PA

www.phrc.psu.edu

PennState College of Engineering | PENNSYLVANIA HOUSING RESEARCH CENTER

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Pennsylvania Housing Research Center

- The Pennsylvania Housing Research Center (PHRC) provides and facilitates education, training, innovation, research, and dissemination to the residential construction industry for the purpose of improving the quality and affordability of housing.
- Educational programs and publications by the PHRC address a wide range of topics relevant to the home building industry and are designed to reach a diverse audience: builders, code officials, remodelers, architects, developers, engineers, planners, landscape architects, local government officials, educators, etc. to provide professional development and continuing education.

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PHRC Webinars

- Always **FREE** to view
- **50+** recordings
- **Broad range** of topics

https://bit.ly/PHRCWebinars

Residential Structures and Building Code Requirements

5/11/2021
Air Sealing Tips, Tricks, and Details

4/13/2021
Healthy Homes: Insights for Existing Housing

2/25/2021
Structural Insulated Panels (SIPs) for Residential Construction

1/28/2021
Control Layers: Vapor Barriers & Retarders

10/13/2020
It's More than "Just a Deck"

9/24/2020
A Range of Rainscreens: An In-Depth Look at the Variety of Rainscreen Applications

8/11/2020
Why Housing is Long Overdue for Disruption

2/11/2020
Building Science 101 for Residential Buildings

10/8/2019
Wall Bracing in the UCC

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New! PHRC On-Demand Courses

Available Topics

- Slab Insulation: Finding the Right Details (1 hour)
- It's More than "Just a Deck" (1 hour)
- Solar PV in PA: Intro to the Design of New Construction and Retrofit Residential Systems (1 hour)
- Reducing Thermal Bridging with Continuous Exterior Insulation (1 hour)
- High-Performance Walls in Pennsylvania (1 hour)
- Control Layers: Vapor Barriers, Vapor Retarders, & Air Barriers (1 hour)
- The Do's and Don'ts of Crawlspace Design and Construction Revisited (1 hour)
- Healthy Homes: Insights for Existing Construction (1 hour)
- Wall Bracing in the UCC (1 hour)
- Air Sealing Tips, Tricks, & Details (1 hour)

Topics Coming in 2021-2022

- PA UCC Residential Code Update: Part 1
- PA UCC Residential Code Update: Part 2
- All-Electric New Homes in PA
- Adapting to Tighter Enclosures through Scopes of Work
- 2021 PA Alternative Residential Energy Provisions Update
- Adapting Stucco & Stone Assemblies to Changing Codes
- Building Envelope Fundamentals: Part 1
- Building Envelope Fundamentals: Part 2
- Moisture Control Layers & Materials

https://bit.ly/PHRC-On-Demand

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Description

With the advancement of heat pump technology, choosing all-electric systems for new construction homes is now much more feasible an option in cold climates like Pennsylvania. This webinar will describe the latest best practices in all-electric new home design, including the latest in cold climate heat pump technology for heating and water heating, and review occupant benefits of all-electric home design, such as improved indoor air quality and reduced environmental impact.

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Learning Objectives

1. Describe key features of an all-electric home design which improves a home's combustion safety.
2. Understand best practices for design and installation of cold climate heat pumps for overall system performance and energy efficiency.
3. Identify building industry standards such as ENERGY STAR for New Homes to aid in the design of an energy efficient all-electric home.
4. Describe a whole building systems approach for building envelope and HVAC system design to ensure a comfortable and healthy home.

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Outline

- **History**
- **Benefits**
- **Electric Features**
  - Heating & Cooling
  - Water Heating
  - Cooking
- **Next Steps**

1961, Oklahoma Home Builders Association Plan Book Advertisement

https://okcmod.com/2016/10/spring-festival-of-homes-brochure-1961-part-1/

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History

- **"Live Better Electrically"** campaign
  - 1950s - GE & Westinghouse
  - 900+ electric utilities & 180 manufacturers
  - Continued into 1970s
- **All-Electric "Medallion" Homes**
  - October 1957 - National Electrical Manufacturers Association
  - Heat, light, & power had to be 100% electric + additional appliance requirements
- Over **1,000,000 all-electric homes** built across the US in 1950s-1970s

www.liveauctioneers.com/item/95526258_tin-and-cardboard-retro-sign

https://dahp.wa.gov/historic-preservation/historic-buildings/historic-building-survey-and-inventory/live-better-electrically-the-gold-medallion-electric-home-campaign

History

1939, Illinois Rural Electrification Bulletin

https://americanhistory.si.edu/blog/cooking-electricity

1957, America's Independent Electric Light & Power Companies

https://envisioningthedream.com/2014/09/25/plugged-into-the-american-dream/

1958, "Live Better Electrically" Ad

History

"When you live better electrically, you lead a richer, fuller, more satisfying life."
Ronald Reagan, GE Electric Theater

https://slate.com/news-and-politics/2016/01/ronald-reagans-conservative-conversion-as-spokesman-for-general-electric-during-the-1950s.html

October 1958, Better Homes & Gardens Advertisement

https://www.smecc.org/live_better_electrically_medallion_home.htm

LIVING BETTER ELECTRICALLY

Lights On at the Reagans'

Writing to Eugene W. Commery, Large Lamp Department expert who was responsible for lighting in their all-electric home, Ronald and Nancy Reagan commented, "It wouldn't be the same house without the lighting, which is so unique and beautiful. . . . The real thrill comes with sundown when the lights come on."

The lighting—preplanned into the home scheme—gives a special air of luxury to a handsome four-bedroom dwelling.

In lighting-expert Commery's words: "the whole home reflects the related flow of light with living."

Speaking electrically, the General Electric Theater host and Mrs. Reagan have more than 19,710 kw of lighting in and around their newly occupied home, located in Pacific Palisades, Calif. The lighting alone requires 180-ampere wiring (total wiring 600 amps), as compared with the industry's current goal of 100 amperes for an entire home system.

THE REAGAN HOME; A PACIFIC PALISADES LANDMARK BY NIGHT; BELOW, FLUORESCENT PANELS BATHE DRESSING ROOM, LIVING ROOM IN SOFT LIGHT

WHAT GOES INTO AN ALL-ELECTRIC HOME?

Here's a list of General Electric products acquired by Nancy and Ronald Reagan to make their home all electric:

Master control-entrance, circuit breakers, remote-control switches, master switches, circuit servants, wall plates, relays, transformers, conduits, other wire and cable, watthour meter.

Two wall ovens, eight surface cooking units, wall refrigerator, refrigerator-freezer, freezer, four-cu-ft refrigerator, wine cellar room air conditioner.

Washer, drier, dishwasher, Disposall®, metal cabinets, Textolite® countertops.

Two Weathertrons (5 and 7½ hp), air-wall ducts, four water heaters.

Two mixers, speed kettle, Toast-R-Oven, electric skillet, four electric blankets, Roll-Easy cleaner, coffee-maker, steam iron, dry iron, seven clocks (one electronic).

Four radios (including one pocket transistor model); four television receivers (including one color receiver and one portable set), high-fidelity speakers, pre-amplifier, amplifier, magnetic pickup.

Fluorescent, reflector, and inside-frosted lamps, plus sun and heat lamp installation in baths; fluorescent lamp ballasts.

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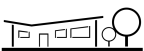
https://www.ge.com/news/taxonomy/term/5597

History



1950/60s Modern All-Electric Home
Icon created by Jonathan Li from Noun Project

ENVELOPE	
Insulation	**NONE TO LITTLE**
Air sealing	**NONE**
HVAC	
Heating	**ELECTRIC RESISTANCE**
Cooling	***HEAT PUMP (WINDOW UNITS)***
Water Heating	**ELECTRIC RESISTANCE**
Ventilation	**PASSIVE**
COOKING	
Cooktop	**ELECTRIC RESISTANCE**
Oven	**ELECTRIC RESISTANCE**
ENERGY	
Efficiency	**LOW**
Renewables	**NO OPTION**

https://envisioningtheamericandream.com/2014/09/25/plugged-into-the-american-dream/

Yesterday vs. Today

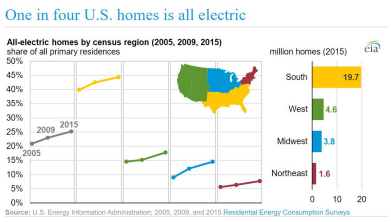
1950/60s Modern All-Electric Home
Icon created by Jonathan Li from Noun Project

ENVELOPE	
Insulation	**NONE TO LITTLE**
Air sealing	**NONE**
HVAC	
Heating	**ELECTRIC RESISTANCE**
Cooling	***HEAT PUMP (WINDOW UNITS)***
Water Heating	**ELECTRIC RESISTANCE**
Ventilation	**PASSIVE**
COOKING	
Cooktop	**ELECTRIC RESISTANCE**
Oven	**ELECTRIC RESISTANCE**
ENERGY	
Efficiency	**LOW**
Renewables	**NO OPTION**

2020s Modern All-Electric Home
Icon created by Martin LEBRETON from Noun Project

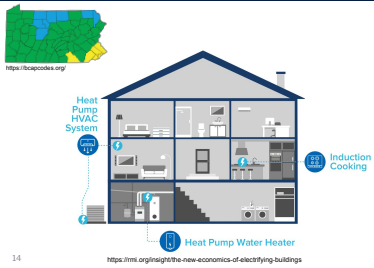
ENVELOPE	
Insulation	**GOOD TO GREAT**
Air sealing	**GOOD TO GREAT**
HVAC	
Heating	**HEAT PUMP**
Cooling	**HEAT PUMP**
Water Heating	**HEAT PUMP**
Ventilation	**ACTIVE**
COOKING	
Cooktop	**INDUCTION**
Oven	**CONVECTION OR E. RESIST.**
ENERGY	
Efficiency	**GOOD TO GREAT**
Renewables	**OPTIONAL**

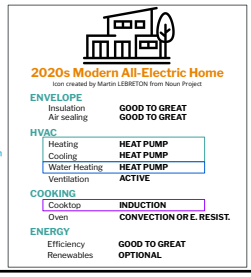
All-Electric Homes Today



https://www.eia.gov/todayinenergy/detail.php?id=39293

Today's Webinar Focus





Building Performance Institute (BPI) Healthy Housing Principles

1. *Keep it …* **Clean**
2. *Keep it …* **Dry**
3. *Keep it …* **Pest-Free**
4. *Keep it …* **Contaminant-Free**
5. *Keep it …* **Safe**
6. *Keep it …* **Ventilated**
7. *Keep it …* **Comfortable**
8. *Keep it …* **Maintained**

www.bpi.org/healthy-housing-principles

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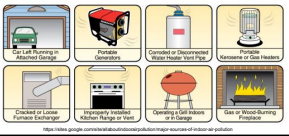
KEEP IT CONTAMINANT-FREE

4. Keep it … **Contaminant-Free**

Goal | Reduce exposure to:

- **combustion gas**, including **CO**
- **fine & ultrafine particulates**
- **volatile organic compounds** (VOCs), including formaldehyde
- lead
- tobacco smoke
- phthalates
- perfluorocarbons
- fire retardants
- pesticides

www.springtimebuilders.com/asheville-builders-blog/268/Reducing-Indoor-Air-Pollution



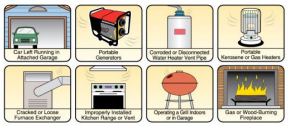
https://sites.google.com/site/allaboutindoorairpollution/major-sources-of-indoor-air-pollution

KEEP IT VENTILATED

6. Keep it … **Ventilated**

Goals | Reduce exposure to:

- **indoor pollutants**
- airborne chemicals
- dust particles



https://sites.google.com/site/allaboutindoorairpollution/major-sources-of-indoor-air-pollution

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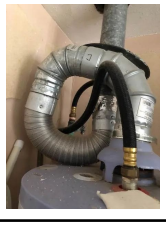
Benefits

- **Increased combustion safety**
- Improved indoor air quality
- Potential lower costs
- Pairs with renewables

➔ **Fuel leaks**
➔ **Combustion issues**
➔ **Venting problems**



www.energyvanguard.com/blog/combustion-safety-101-3-types-problems/

Cooking Pollutants

- Increased combustion safety
- **Improved indoor air quality**
- Potential lower costs
- Pairs with renewables

Cooking

CO_2 & H_2O

NO, NO_2, HONO, Formaldehyde

Ultrafine particles

Ultrafine particles, NO_x

Ultrafine particles
Formaldehyde
Acetaldehyde
Acrolein
$PM_{2.5}$
PAH

Source: Berkeley Labs

Gas Stoves: NO2

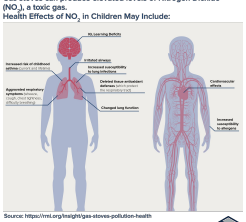
Gas Stoves Can Emit Elevated Indoor Nitrogen Dioxide (NO_2) Levels Often Exceeding Indoor Guidelines and Outdoor Standards

Outdoor Standards for NO_2	1-hr average (ppb)
US National Standard (EPA)	100
Canadian National Standard	60
California State Standard	180
Indoor Guidelines for NO_2	**1-hr average (ppb)**
Canada	90
World Health Organization	106

Measured NO_2 Emissions from Gas Stoves	Peak (ppb)
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop - no food	82–300
Gas oven - no food	130–546

Source: https://rmi.org/insight/gas-stoves-pollution-health

Gas stoves can produce elevated levels of Nitrogen Dioxide (NO_2), a toxic gas.
Health Effects of NO_2 in Children May Include:



Source: https://rmi.org/insight/gas-stoves-pollution-health

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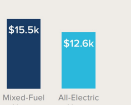
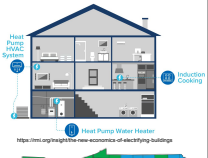
Columbus, OH - Rocky Mountain Institute Study

Equipment	Mixed-Fuel	All-Electric
Heating	Ducted central gas furnace (AFUE 95)	Ducted multi-zone air source heat pump (11 HSPF, SEER 19)
Cooling	Central air conditioner (SEER 14)	
Water Heating	Gas water heater 80 gallon storage (EF 0.68)	Hybrid electric heat pump water heater 80 gal storage (EF 1.6)
Cooking	Gas cooktop Gas oven	Induction cooktop Electric oven

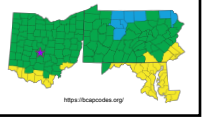
https://rmi.org/insight/the-new-economics-of-electrifying-buildings

Up-front Cost Comparison





https://rmi.org/insight/the-new-economics-of-electrifying-buildings



https://bcapcodes.org/

- Average gas hookup fee: **$2,100**
  - Could be $0 to $15,000+

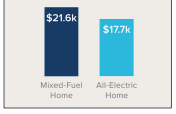
Columbus, OH - Rocky Mountain Institute Study

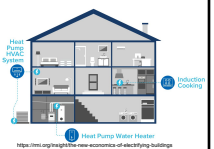
Annual Energy Usage and Utility Bill Impacts[ii]

	Mixed-Fuel	All-Electric	Difference
Annual Electricity & Gas Costs[iv]	$1,940	$1,830	-$110 (-6%)
Electricity Usage (kWh)	10,930	16,420	5,490 (+50%)
Gas Usage (kWh equiv.)	22,360 (760 therms)	n/a	-22,360 (-100%)

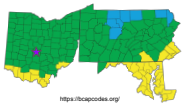
https://rmi.org/insight/the-new-economics-of-electrifying-buildings

15-Year Net Present Cost[i]





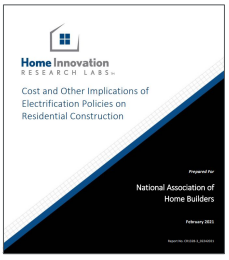
https://rmi.org/insight/the-new-economics-of-electrifying-buildings



https://bcapcodes.org/

i. Net present cost calculation incorporates up-front costs and bill impacts, discount rate of 7%, and 15-year assumed equipment lifetime.
iii. Results are rounded.
iv. Annual utility cost includes electricity and gas costs, where present. Standard 2020 residential tariffs were used.

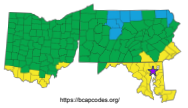
Baltimore, MD - NAHB / HIRL Study



Range of Construction Costs of Electrification relative to a Baseline Gas Reference House, $

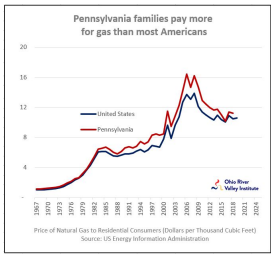
Electric Reference House Component	Houston		Baltimore		Denver		Minneapolis	
	Low	High	Low	High	Low	High	Low	High
Heat Pump	2,114	5,528	1,901	8,655	8,259	9,088	7,866	8,655
Heat Pump Water Heater	1,257	2,632	1,295	2,711	2,516	2,791	2,397	2,658
Electric Vehicle charger circuit(s)	617	2,040	635	2,102	65	2,163	623	2,060
Induction cooktop range	0	997	0	1,027	0	1,057	0	1,007
Total added construction cost, $	**3,988**	**11,196**	**3,832**	**14,495**	**11,430**	**15,100**	**10,886**	**14,381**
Electrical service upgrade or community electrical infrastructure	Varies by Utility Territory							
Community gas infrastructure cost savings	Varies by Utility Territory							

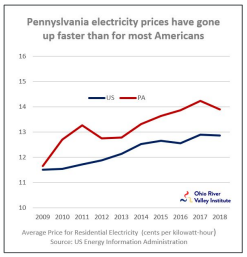
www.nahb.org/-/media/NAHB/nahb-community/docs/committees/construction-codes-and-standards-committee/home-innovation-electrification-report-2021.pdf



https://bcapcodes.org/

PA Energy Prices





https://ohiorivervalleyinstitute.org/pennsylvanian-families-pay-more-for-natural-gas-than-most-americans/

SHORT-TERM ENERGY OUTLOOK

Release Date: Oct. 13, 2021 | **Forecast Completed:** Oct. 7, 2021 | **Next Release Date:** Nov. 9, 2021

Forecast Highlights

Winter Fuels Outlook

- We forecast that average U.S. household expenditures for all major home heating fuels will increase significantly this winter primarily because of higher expected fuel costs as well as more consumption of energy due to a colder winter. Average increases vary by fuel, region, and weather assumptions. Compared with last winter, we forecast propane expenditures will rise by 54%, heating oil by 43%, natural gas by 30%, and electricity by 6%. We expect space heating demand to generally be higher this winter based on forecasts from the National Oceanic and Atmospheric Administration (NOAA) that U.S. average heating degree days will be 3% higher than last winter (*Winter Fuels Outlook*). Altering our assumptions for a 10% colder-than-expected winter significantly increases forecast expenditures, while a 10% warmer-than-expected winter still results in increased expenditures, because of price increases.

www.eia.gov/outlooks/steo/

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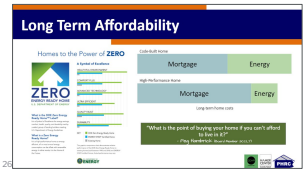
Net Zero Home (All Electric + Renewables)

- Increased combustion safety
- Improved indoor air quality
- **Potential lower costs**
- **Pairs with renewables**



2018 PHRC GreenBuild Webinar:
https://bit.ly/PHRCWebinar_GreenBuild

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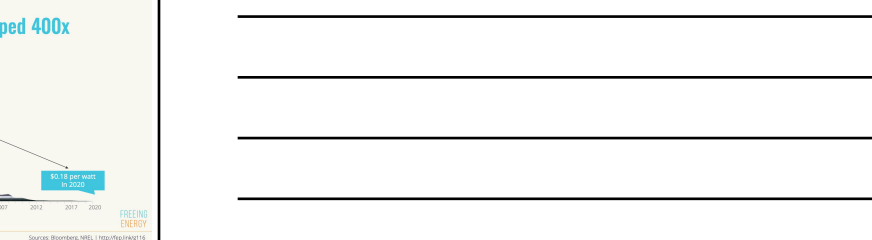
Renewable Costs

2019 | **Renewable Energy is Now the Cheapest Option -- Even Without Subsidies** *(Forbes, 2019)*

www.forbes.com/sites/jamesellsmoor/2019/06/15/renewable-energy-is-now-the-cheapest-option-even-without-subsidies/

2020 | **Solar is the cheapest electricity in history** *(International Energy Agency World Energy Outlook 2020)*

www.iea.org/reports/world-energy-outlook-2020



www.freeingenergy.com/why-does-the-cost-of-renewable-energy-continue-to-get-cheaper-and-cheaper/

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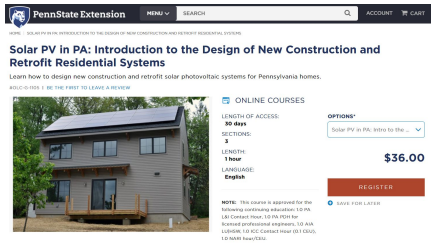
Solar PV in PA Webinar & Online Course

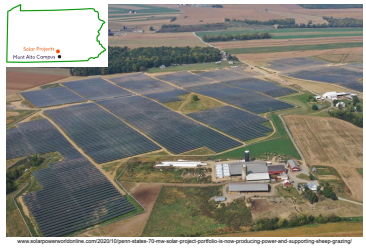


https://bit.ly/PHRC-On-Demand

Solar PV at Penn State

- **70 MW** solar PV system in **Franklin County, PA**
- **25%** of entire Penn State system's (23 campuses) electricity needs
- Year 1 cost savings *(2021)*: **$272,000**
- Predicted **$14 million in electricity cost savings** over next 25 years

www.lightsourcebp.com/us/projects/penn-state-powered-by-the-sun/



www.solarpowerworldonline.com/2020/10/penn-states-70-mw-solar-project-portfolio-is-now-producing-power-and-supporting-sheep-grazing/

SolarAPP+ by NREL

SolarAPP+ provides *automated plan review and approval* for standardized systems

- Uses yes/no questions & ranges to automate compliance checks
- Catches code issues, typos, and errors; returning corrections instantly
- Tough projects go through typical review. Stale applications require no action
- Produces an inspection checklist replicating permit details for verification

Current Support Parameters

- Residential Solar PV
- NRTL (UL) Approved equipment
- NEC 2017 / 2018 i-Codes
- Electric Panel Busbar <225A
- Electric Service <400A
- Residential Battery Storage

In Progress

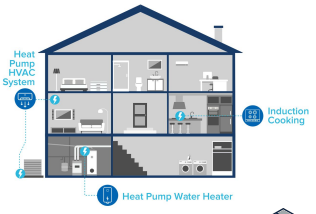
- NEC 2020, EV chargers, electric appliances

https://solarapp.nrel.gov/

Contact: Liz Robinson lizhrob2@gmail.com
Executive Director Philadelphia Solar Energy Association

Outline

- History
- Benefits
- **Electric Features**
  - Heating & Cooling
  - Water Heating
  - Cooking
- Next Steps



https://rmi.org/insight/the-new-economics-of-electrifying-buildings

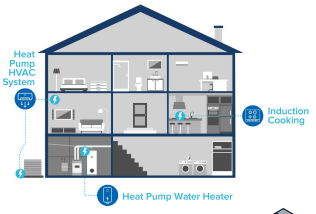
PHRC

Outline

2020s Modern All-Electric Home

Icon created by Martin LEBRETON from Noun Project

ENVELOPE	
Insulation	GOOD TO GREAT
Air sealing	GOOD TO GREAT
HVAC	
Heating	HEAT PUMP
Cooling	HEAT PUMP
Water Heating	HEAT PUMP
Ventilation	ACTIVE
COOKING	
Cooktop	INDUCTION
Oven	CONVECTION OR E. RESIST.
ENERGY	
Efficiency	GOOD TO GREAT
Renewables	OPTIONAL



https://rmi.org/insight/the-new-economics-of-electrifying-buildings

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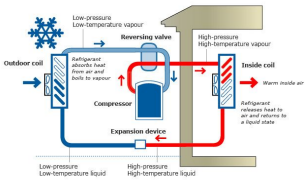
Heat Pump Introduction

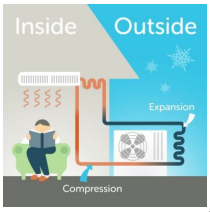
- **Moves heat** *vs.* creates heat
- Vapor compression cycle of a refrigerant



www.sciencelearn.org.nz/images/242-household-heat-pump-operation

Heat Pump Introduction

- **Air Conditioner**
  - Move heat outdoors in summer
- **Heat Pump**
  - Move heat outdoors in summer *and*
  - **Move heat indoors in winter**



https://aspencore.org/use-cold-air-to-heat-your-home/

PHRC

Types of Heat Pumps

Residential Heat Pumps *(5 tons or less)*

Heat source/sink
- **Air** Source
- **Ground** Source
- **Water** Source

Heat source/sink to **home's distribution** method
- Air to **Air**
- Air to **Water**

Separate indoor & outdoor units (split)
All-in-one equipment (packaged)
- **Split**
- **Packaged**

Air delivery method
- **Ducted**
- **Ductless**

Number of zones
- **Single**-zone
- **Multi**-zone

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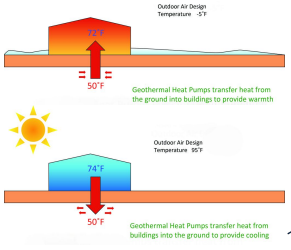
Heat Source/Sink

- **Geothermal** Heat Pumps
  - **Ground** Source Heat Pumps
  - **Water** Source Heat Pumps
- **Air** Source Heat Pumps



https://geothermalheatpumpconsortium.org/

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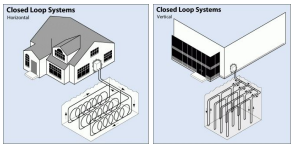

www.energy.gov/energysaver/geothermal-heat-pumps

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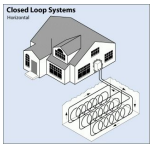

www.energy.gov/energysaver/geothermal-heat-pumps

www.rogerpany.net/professional/landowners-urged-to-consider-ground-source-heat-pumps/

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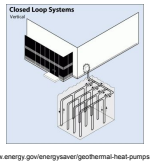

www.energy.gov/energysaver/geothermal-heat-pumps

https://elliswelldrilling.ie/geothermal/

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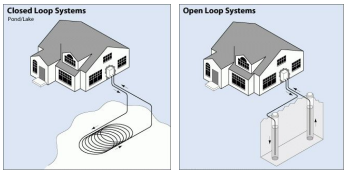

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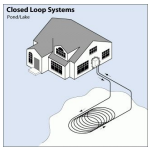

www.energy.gov/energysaver/geothermal-heat-pumps

www.resilience.org/stories/2021-06-16/the-jump-to-pumps-how-finland-found-an-answer-to-heating-homes/

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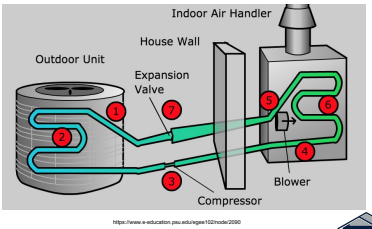
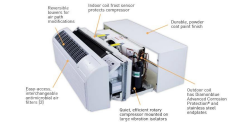


https://www.e-education.psu.edu/egee102/node/2090

Air Source Heat Pumps: Packaged

- **Packaged**
  - All-in-one
- **Split**
  - Outdoor unit & indoor unit
  - "Split system" *or* "Mini-splits"



https://learn.allergyandair.com/buying-ptac-units/

Air Source Heat Pumps: Split

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  - Outdoor unit & indoor unit
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www.energystar.gov/products/heating_cooling/ductless_heating_cooling

Air Delivery Method

- **Ducted**
  - Centrally ducted
  - Compact ducted
- **Ductless**

https://basc.pnnl.gov/images/ducted-mini-split-heat-pump-was-installed-unvented-conditioned-attic-and-ducted-short-duct

Compact ducted air handlers usually serve smaller areas such as one to three rooms. Their slim profile means they often fit in dropped ceilings, but leaving access for maintenance is important.

https://be-exchange.org/beexreport/heat-pump-planner/

Air Delivery Method

- **Ducted**
  - Centrally ducted
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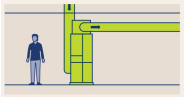
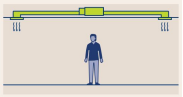


Conventional air handlers distribute air through larger ducts. They are often located in basements, attics, or utility closets. They can be installed to blow air upwards, downwards, or sideways to fit within your home.



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https://be-exchange.org/beexpert/heat-pump-planner/

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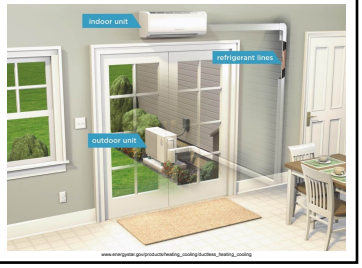
  - Compact ducted
- **Ductless**

www.familyhandyman.com/project/all-about-mini-split-systems/

Delivery

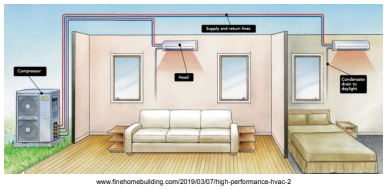
- **Single-Zone** Heat Pumps
- **Multi-Zone** Heat Pumps



www.energystar.gov/products/heating_cooling/ductless_heating_cooling

Delivery

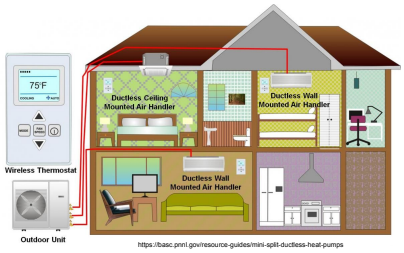
- Single-Zone Heat Pumps
- **Multi-Zone** Heat Pumps



www.finehomebuilding.com/2019/03/07/high-performance-hvac-2

Delivery

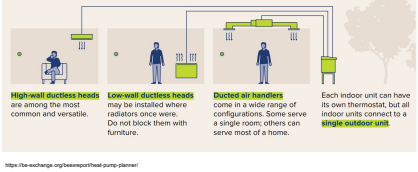
- Single-Zone Heat Pumps
- **Multi-Zone** Heat Pumps



https://basc.pnnl.gov/resource-guides/mini-split-ductless-heat-pumps

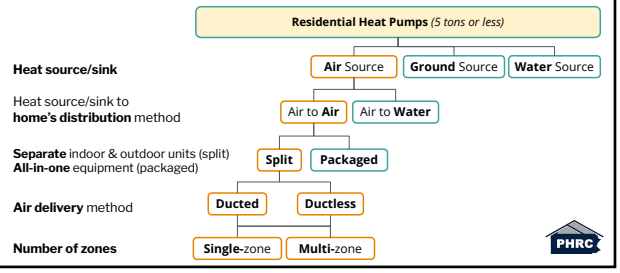
Delivery

- Single-Zone Heat Pumps
- **Multi-Zone** Heat Pumps



https://be-exchange.org/beexreport/heat-pump-planner/

Types of Heat Pumps



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Cold Climate Air Source Heat Pumps

- **Equipment** has significantly improved
  - Variable speed blowers
  - Better coils
  - Improved motor & compressor designs
- Equipment options that run at **outdoor temps of -10F to -15F**

www.washingtonenergy.com/idea-center/ac-vs-heat-pump-battle-cooling/

Year	SEER	HSPF
Before 1980	6 or less	5 or less
1992	10	6.8
2006	13	7.7
2015	14	8.2

www.goodmanmfg.com/resources/hvac-learning-center/before-you-buy/what-generation-is-your-heat-pump

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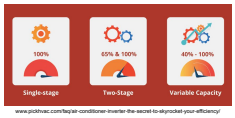
https://deltaairsystems.com/good-seer-rating-new-ac/



www.pickhvac.com/faq/air-conditioner-inverter-the-secret-to-skyrocket-your-efficiency/

Common Heat Pump Myths

- **"They don't work below freezing"**
  - We now have better heat pump technology, with options that run at -10F to -15F. So the heat pump can be installed and kept on throughout the winter.
- **"We must install a backup system for cold days"**
  - With a good envelope and a cold climate heat pump, no backup system is needed.

Common Heat Pump Myths

- **"They are expensive to operate"**
  - *Backup systems:* Older technology needed backup systems, like electric resistance, for cold days. We now have better heat pump technology and don't need the expensive-to-run backup system.
  - *Installation:* Many systems were also installed improperly. Well-sealed ducts, system commissioning and periodic tune-ups will ensure the system works as intended.

Common Heat Pump Myths

- **"They blow cold air"**
  - Older technology would turn on quickly and blow cold air as the system got running.
  - Older technology also didn't have the heating output for cold days, so it felt colder longer.
  - New technology has variable speed blowers, better controls, and appropriate heating output to avoid blowing cold air.

Cold Climate Air Source Heat Pumps

Northeast Energy Efficiency Partnerships

- **Specification** for Cold Climate Air Source Heat Pumps
- **List** of heat pumps that meet the specification
- **Resources** for installers & consumers

Cold Climate Air Source Heat Pump Specification (Version 3.1)
Effective August 1, 2021

Performance Requirements

- *For Non-Ducted systems:* HSPF ≥10
- *For Ducted systems:* HSPF ≥9
- COP @5°F ≥1.75 (at maximum capacity operation)
- SEER ≥ 15
- Lab testing results OR engineering data for each system must be reported through the attached "*Cold Climate Air-Source Heat Pump Performance Information Tables*". Incomplete tables will not be considered.
- Models rated under AHRI 210/240 with voluntary base pan heater engagement that do not meet the HSPF requirement shall qualify if the identical model without a base pan heater meets the HSPF requirement (and all other applicable requirements).

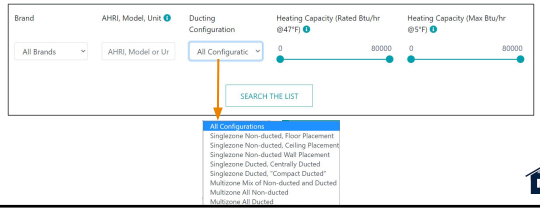
https://neep.org/sites/default/files/media-files/cold_climate_air-source_heat_pump_specification-version_3.1_update_.pdf

www.neep.org

Cold Climate Air Source Heat Pumps

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

https://ashp.neep.org/



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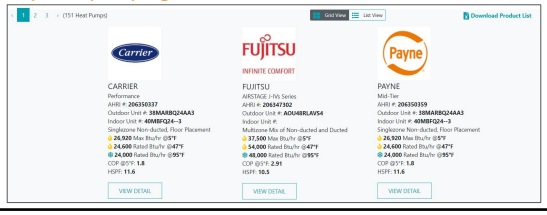
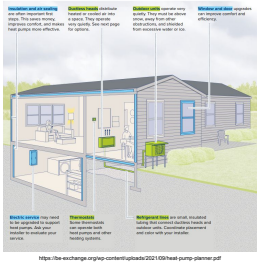
https://ashp.neep.org/



Best Practices

1. **Systems approach**
   a. Start with the envelope
   b. Explore balanced ventilation
2. Get **accurate load calculations**
3. **Don't oversize** the system
4. Remember access to **filters**
5. **Commissioning**



https://be-exchange.org/wp-content/uploads/2021/09/heat-pump-planner.pdf

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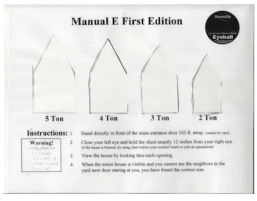

www.energyvanguard.com/blog/more-on-air-conditioner-sizing-rules-of-thumb/

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Substitute ductless cold climate heat pump for Climate Zones 4-6:
6-head system (4 on second floor, 1 on first floor, 1 in basement) 19 SEER 11 HSPF

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Heat Pump, 3-ton, SEER 14	EA	1,829.00	327.00	2,156.00	2,810.67	(1)	(2,810)
Air Handler, 3-ton coil	EA	988.00	195.00	1,183.00	1,404.26	(1)	(1,404)
Air Handler electric heat, 15 kW	EA	164.00	42.00	206.00	248.78	(1)	(249)
Refrigerant piping	EA	204.00	21.58	225.58	263.00	(1)	(263)
Duct distribution system, all metal	LB	0.56	3.65	3.99	6.38	(762)	(4,863)
Registers	EA	17.20	12.10	29.30	39.00	(16)	(624)
Grilles	EA	43.50	17.45	60.95	77.00	(1)	(154)
Ductless 4-zone system 19 SEER 11 HSPF	EA	5,644.00		5,644.00	6,208.40	1	6,208
Ductless 2-zone system	EA	4,466.00		4,466.00	4,912.60	1	4,913
Ductless, installation	EA	90.00	350.00	805.00	632.94	6	3,798
Ductless refrigerant piping/wiring kit	EA	279.50	90.00	309.50	356.29	6	2,138
Condensate piping, 3/4 PVC	LF	1.30	2.54	3.84	5.60	120	672
Heat Pump circuits: 40A & 100A breakers, disconnects, 60' #6/2 & 30' #3/2 NM	EA	520.00	267.00	777.00	986.69	(1)	(986)
Wire, add 30' #3/2 NM (AH)	LF	3.20	3.16	6.36	8.35	(30)	(251)
EFCI 30 amp 2 pole breaker (HP & AH)	EA	124.95		124.95	137.49	(2)	(275)
Standard 30/40-amp 2-pole breaker (HP)	EA	10.65		10.65	11.72	1	12
GFCI 50/60-amp 2-pole breaker (AH)	EA	149.00		149.00	163.90	(1)	(164)
Condenser circuit: disconnect, 40-amp 2-pole breaker, 40' #8/2 NM	EA	144.00	95.50	239.50	311.00	2	686
EFCI 30/40amp 2-pole breaker	EA	124.95		124.95	137.49	2	275
Standard 30/40-amp 2-pole breaker	EA	10.65		10.65	11.72	(0)	(0)
Wire, add #6/3 NM for HP	LF	1.17	2.57	3.74	5.45	40	216
	LF						
Total to Builder							**7,302**
Total to Consumer							**8,083**
Houston						0	0
Baltimore						1.02	8,852
Denver						1.05	9,117
Minneapolis						1.08	9,383

www.nahb.org/-/media/NAHB/nahb-community/docs/committees/construction-codes-and-standards-committee/home-innovation-electrification-report-2021.pdf

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1933, House Beautiful Advertisement

www.etsy.com/listing/527236080/1933-general-electric-humifilter-ad

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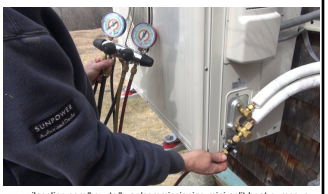
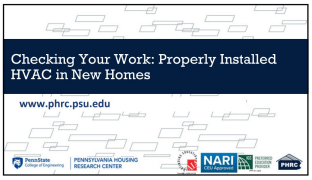


www.jlconline.com/how-to/hvac/commissioning-mini-split-heat-pumps_o

PHRC Webinar



http://bit.ly/PHRCWebinar_CheckingYourWork

Checking Your Work: Properly Installed HVAC in New Homes

4/29/2021 11:00 AM - 12:00 PM

Instructor: Dean Gamble (US EPA)

Handouts

Link to Webinar: http://bit.ly/PHRCWebinar_CheckingYourWork

Description

Many AC's and heat pumps are installed with faults that impact both their performance and efficiency. Come to this webinar to learn about a new RESNET/ACCA/ANSI standard with three simple field tests that can help a builder ensure they are getting what they have paid for. Not only can this make for happier homeowners, fewer service calls, and lower utility bills, it can also unlock new points for homes with a HERS/ERI rating.

Learning Objectives

1. Understand why HVAC installation faults are commonplace and how they can impact both the efficiency of the equipment and the comfort of occupants.
2. Learn about a new RESNET/ACCA/ANSI standard that addresses this problem, including three field tests that can help a builder ensure their HVAC systems are performing properly.
3. Learn how this standard is integrated into ANSI/RESNET/ICC 301, the standard that underlies HERS and ERI ratings, which was used to rate over 4,000 homes in Pennsylvania in 2019 alone.
4. Understand three ways that this new standard will improve the homes you build.

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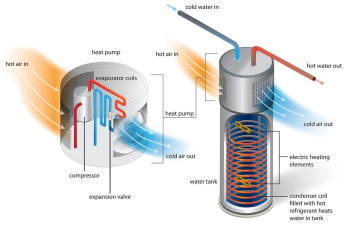
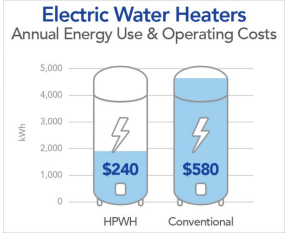
Water Heating | Heat Pump Water Heaters

- **Heat pump** water heater (HPWH)
- Also known as "**hybrid**" water heater
- All have **backup electric heating** elements



www.thisoldhouse.com/plumbing/21015567/all-about-heat-pump-water-heaters

Water Heating | Heat Pump Water Heaters



https://rpsc.energy.gov/tech-solutions/hpwh

Table 2: ENERGY STAR HPWH Savings Based on Household Size

Household Size	Annual Savings	Payback (Years)	Lifetime Savings
2	$160	4.9	$1,340
3	$250	3.2	$2,400
4	$330	2.4	$3,470

Assumes: Electricity Rate of 12 cents/kWh;
Incremental cost = $800; 13-year lifespan

www.energystar.gov/sites/default/files/asset/document/HPWHs_FactSheet_021518_0.pdf

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Sizing: First Hour Rating

California Prescriptive HPWH First Hour Rating Minimums

Number of bathrooms	1 to 1.5			2 to 2.5				3 to 3.5		
Number of bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating (gallons)	38	49	49	49	62	62	74	62	74	74	74

www.energy.ca.gov/sites/default/files/2020-07/JA13_Qualification_Requirement_HPWH_DM_ADA.pdf

Worksheet for Estimating Peak Hour Demand/First Hour Rating *

USE	AVERAGE GALLONS OF HOT WATER PER USAGE		TIMES USED DURING 1 HOUR		GALLONS USED IN 1 HOUR
Shower	20	×		=	
Shaving (.05 gallon per minute)	2	×		=	
Hand dishwashing or food prep (2 gallons per minute)	3	×		=	
Automatic dishwasher	7	×		=	
Clothes washer		×		=	
- Top-loader	25				
- H-Axis	15				
			Total Peak Hour Demand	*	

EXAMPLE

3 showers	20	×	3	=	60
1 shave	2	×	1	=	2
1 hand dishwashing	3	×	1	=	3
Peak Hour Demand				=	66

https://basc.pnnl.gov/resource-guides/heat-pump-water-heaters

www.energy.gov/energysaver/sizing-new-water-heater

Location: Heat Pump Water Heaters

www.biggshvac.com/plumbing/heat-pump-water-heaters/

Select Location.

Sufficient room volume (750 to 1000ft^3)	YES	NO
Adequate ambient temperature (> 50oF)	YES	NO
There is sufficient space to meet clearance requirements	YES	NO
Noise will not interfere with living spaces	YES	NO
Condensate can be removed effectively	YES	NO

https://basc.pnnl.gov/resource-guides/heat-pump-water-heaters

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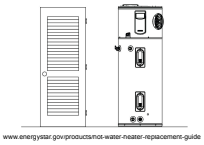
Water Heating | Heat Pump Water Heaters

Sufficient room volume (750 to 1000ft^3)	YES	NO

- Use a **louvered door** to ensure air volume



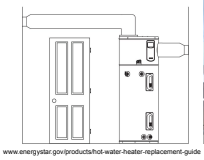
www.energystar.gov/products/hot-water-heater-repacement-guide

www.bobvila.com/articles/heat-pump-water-heaters/

Water Heating | Heat Pump Water Heaters

Sufficient room volume (750 to 1000ft^3)	YES	NO
Noise will not interfere with living spaces	YES	NO

- Using **ducting** for intake and exhaust air



www.energystar.gov/products/hot-water-heater-replacement-guide

www.nrdc.org/experts/pierre-delforge/very-cool-heat-pump-water-heaters-save-energy-and-money

Water Heating | Heat Pump Water Heaters

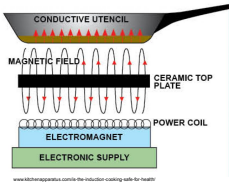
Sufficient room volume (750 to 1000ft³)	YES	NO
Noise will not interfere with living spaces	YES	NO

- **Split system** specifically for water heating

https://foursevenfive.com/sanco2/

Induction Cooktop

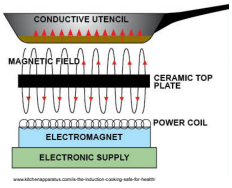
www.greenbuildingadvisor.com/article/an-induction-cooktop-for-our-kitchen



www.kitchenapparatus.com/is-the-induction-cooking-safe-for-health/

Induction Cooktop

https://cookerryspace.com/induction-cooking-safe/



www.kitchenapparatus.com/is-the-induction-cooking-safe-for-health/

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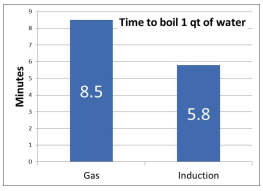

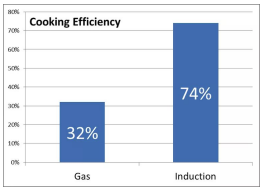

https://www.treehugger.com/which-more-energy-efficient-cooking-gas-or-induction-4858206

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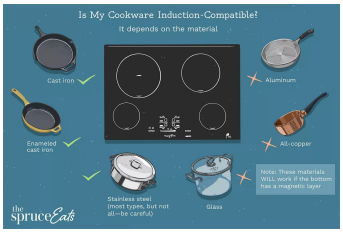
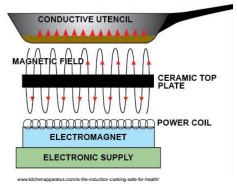
Induction Cooktop



https://www.thespruceeats.com/what-is-the-best-cookware-for-induction-cooktops-908920



www.kitchenapparatus.com/is-the-induction-cooking-safe-for-health/

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EEBA On-Demand Course

Plug In, Turn On & Cook Up: Electric Kitchens Have Arrived!

$ 10.00

Register Now

More Options

Already Registered?

Confusion about all-electric building codes and cooking options got you turned off? Get plugged in to an empowering event with code-clarifying, myth-busting details that will turn you on to electric cooking for life with better cooking performance, safer, healthier homes and a sustainable planet.

Instructors: Rochelle Stoutler, Karla Butterfield, & Aaron Smith

https://eeba.digitalchalk.com/learn/plug-in-turn-on-cook-up-electric-kitchens-have-arrived

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Outline

- **History**
- **Benefits**
- **Electric Features**
  - Heating & Cooling
  - Water Heating
  - Cooking
- **Resources**

July 1965, Life Magazine

www.flickr.com/photos/28153783@N08/3464560200

NAHB Webinar

NAHB National Association of Home Builders

The All-Electric Home is Coming – Are You Ready?

Council Member: $0.00
NAHB Member: $59.00
~~Non-member: $59.00~~

Quantity: – 1 + Add to cart

**** On Demand Recording Available Next Week ****

Wednesday, October 27, 2021 | 2:00 PM – 3:00 PM ET

The movement toward residential electrification continues to gain momentum, but there is no one-size-fits-all solution when it comes to new homes. Through case studies, this webinar will showcase cost-effective, systems-based strategies to meet new jurisdictional electrification requirements.

https://storefront.nahb.org/Catalogs/NAHB/NAHB-Events/37938

GreenBuild Documents

- ➔ **Construction Blog**
- ➔ **Design Documents**
- ➔ **Building Science Report**
- ➔ **Home Tour Posters**
- ➔ **and more!**

https://aiaes.psu.edu/aehr/projects/greenbuild/

GreenBuild Documents

- ➔ **Construction Blog**
  sites.psu.edu/eehr/greenbuild-construction-blog-2/
- ➔ **Design Documents**
- ➔ **Building Science Report**
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sites.psu.edu/eehr/greenbuild-construction-blog-2/

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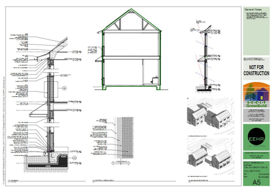
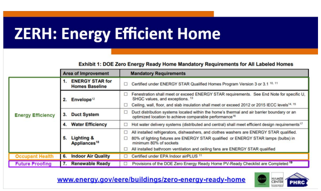
https://sites.psu.edu/eehr → Resources



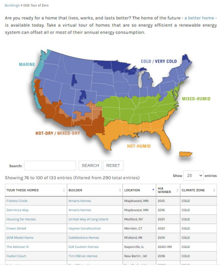
https://sites.psu.edu/eehr/recources/

GreenBuild Webinar



https://bit.ly/PHRCWebinar_GreenBuild

DOE Tour of Zero



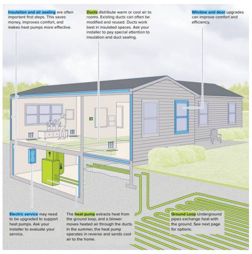
www1.eere.energy.gov/buildings/residential/pdfs/doe_ch_case_studies/2015hia winner_greenhill_100515.pdf

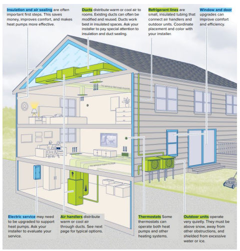
KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance.
- **Walls:** ICFs (R-22).
- **Roof:** Asphalt shingles; 130 MPH wind rating.
- **Attic:** #20: Sealed conditioned attic; 10" open-cell spray foam, 2.7" closed-cell spray foam (R-63). #26: Sealed conditioned attic; 11" open-cell spray foam (R-4); 2.75" closed-cell spray foam (R-7); total (R-69). #28: Sealed and conditioned; 10" open-cell spray foam; 2.7" closed-cell spray foam (R-68).
- **Foundation:** #20: ICF walls in basement (R-22); 42" below grade; 4.75" closed-cell spray foam under slab (R-30). #26": ICF walls (R-22); 42" below grade, 4.75" closed-cell spray foam under slab (R-29). #28: ICF basement walls (R-22); 42" below grade walls; 4.3" closed-cell spray foam under slab (R-27).
- **Windows:** Triple-pane; argon-filled; vinyl framed; U=0.20; SHGC=0.23; low-e.
- **Air Sealing:** 0.21 ACH 50.
- **Ventilation:** ERV; MERV 11 filters.
- **HVAC:** Geothermal heat pump; COP 5.7; EER 44.0; modulating condenser; variable speed ECM blower fan.
- **Hot Water:** Desuperheater; electric tank.

www.energy.gov/eere/buildings/maps/doe-tour-zero

Heat Pump Planner document





https://be-exchange.org/wp-content/uploads/2021/09/heat-pump-planner.pdf

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NEEP Resources

Northeast Energy Efficiency Partnerships

- → **Specification** for Cold Climate Air Source Heat Pumps
- → **List** of heat pumps that meet the specification
- → **Resources** for installers & consumers

www.neep.org

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Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

New Construction or Gut Rehab


Guide To Installing Air-Source Heat Pumps in Cold Climates

Introduction

www.neep.org

Outline

- **History**
- **Benefits**
- **Electric Features**
  - Heating & Cooling
  - Water Heating
  - Cooking
- **Resources**

2020s Modern All-Electric Home

Icon created by Martin LEBRETON from Noun Project

ENVELOPE	
Insulation	**GOOD TO GREAT**
Air sealing	**GOOD TO GREAT**
HVAC	
Heating	**HEAT PUMP**
Cooling	**HEAT PUMP**
Water Heating	**HEAT PUMP**
Ventilation	**ACTIVE**
COOKING	
Cooktop	**INDUCTION**
Oven	**CONVECTION OR E. RESIST.**
ENERGY	
Efficiency	**GOOD TO GREAT**
Renewables	**OPTIONAL**

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