ESC Energy Solutions Center

ENERGY SOLUTIONS CENTER

Track: Residential Natural Gas
Unit # 9: High Efficiency Technologies
Programmable Thermostats, Saving Water, Reduced Infiltration

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Presentation Outline

- Average Home Energy Use
- Areas of Energy Waste
- Improving Building Envelope Efficiency
- HVAC System Sizing, Operation, & EE
- Programmable Thermostats & Zoning
- Hot Water Efficiency
- Kitchen/Laundry Appliances
- Home Energy Monitoring

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Total U.S. energy consumption per capita has decreased since the 1970s

Although total annual U.S. energy consumption has trended upward over time and the U.S. population has increased, the amount of energy consumption per capita (per person) peaked in the late 1970s. Annual per capita energy consumption was relatively flat from the late-1980s through 2000 and has generally decreased each year since then.

Factors contributing to lower U.S. energy consumption since the 1980s include:

- Increases in efficiency of appliances, electrical equipment, and building insulation, largely the result of establishing energy efficiency standards and improving building energy codes
- Increases in the average fuel efficiency of vehicles as a result of establishing Corporate Average Fuel Economy (CAFE) standards
- Availability of financial incentives for energy efficiency investments
- Increases in utility-scale electricity generation using higher efficiency natural gas-fired, combined-cycle and combined-heat-and-power plants

https://www.eia.gov/energyexplained/use-of-energy/

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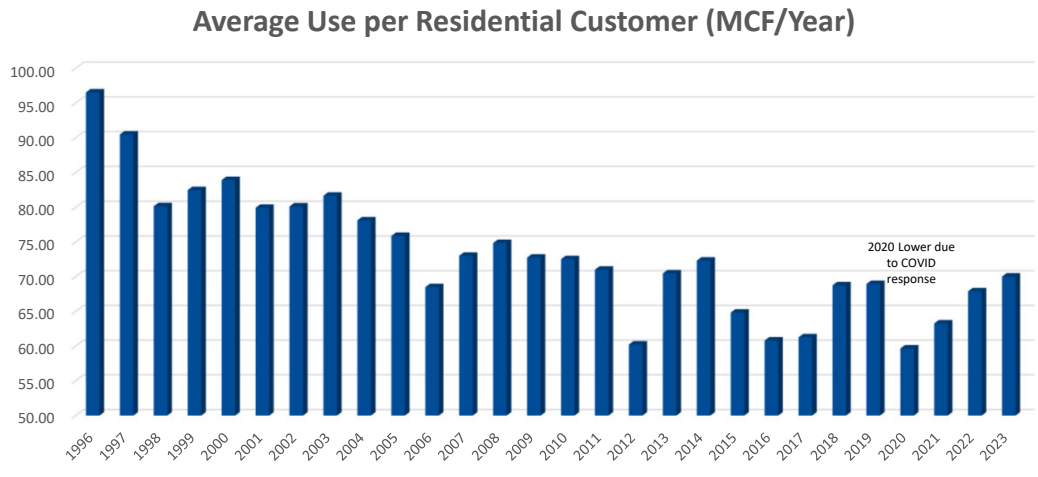
Residential Gas Use has Decreased



* AGA Gas Facts historical data

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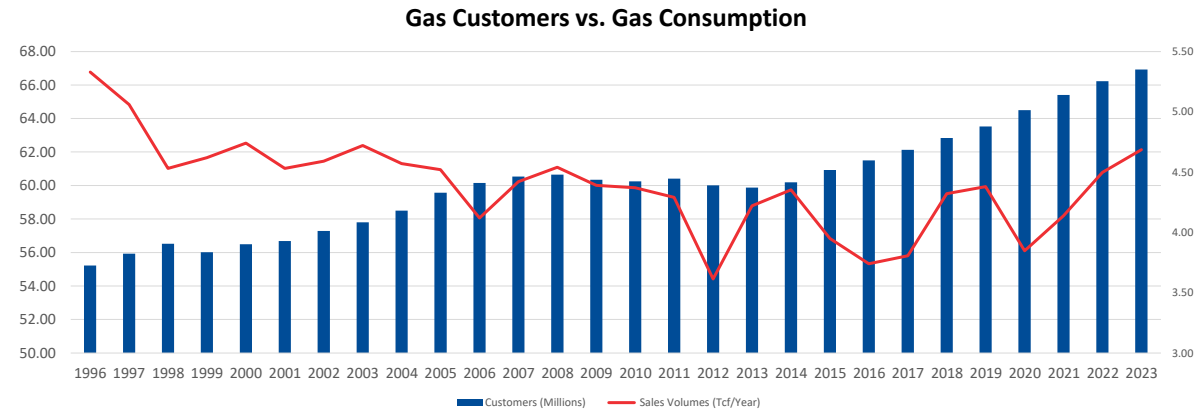
Gas Use Dropped While Customer Counts Increased Due to Efficiency Improvements



* AGA Gas Facts historical data

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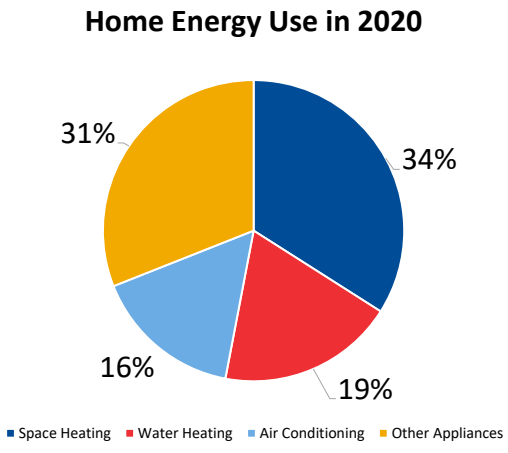
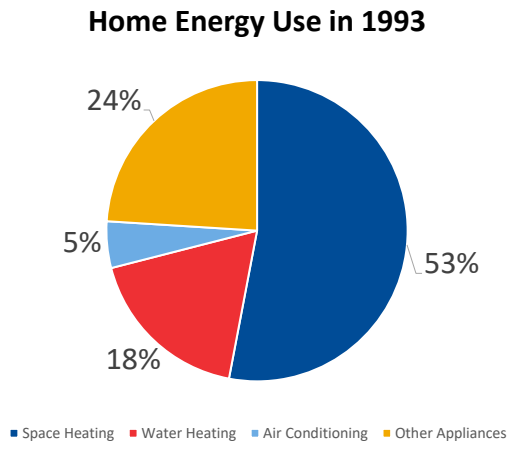
27+ Years of Residential Energy Use





https://www.eia.gov/consumption/residential/data/2020/index.php?view=characteristics

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Areas of Energy Waste

Building Envelope
Heating & Cooling Systems
Lighting
Appliances
Electronics
Hot Water

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Building Envelope

- Assess efficiency of the envelope to identify areas of heat loss/gain
- Thermographic Inspections
- Blower Door Test

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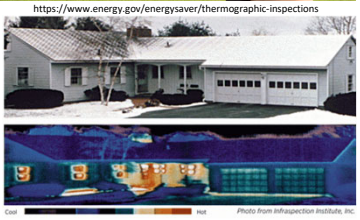
Thermographic Inspection

- Done with an infrared video or still camera
- Done from interior or exterior
- Tools see light in the heat spectrum
- Variations of the building's skin (red = hot, blue = cold)
- Good for checking for proper insulation installation

https://www.energy.gov/energysaver/thermographic-inspections



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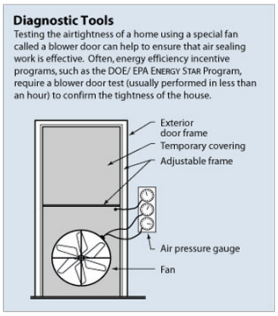
Blower Door Test

- Locates air leaks by using a special fan to depressurize a house
- Tests are conducted before and after air sealing to measure effectiveness of the work
- The average home has enough air leakage to add up to a 2 ft2 (.18 m2) hole



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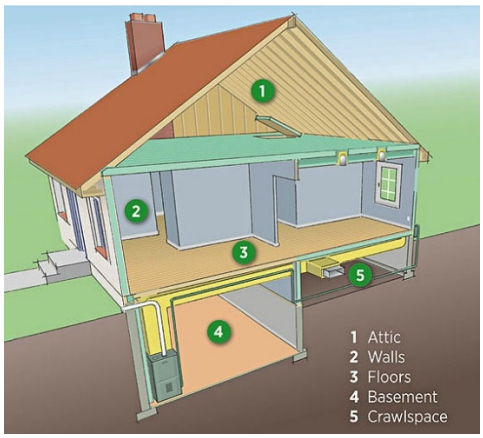
Building Envelope

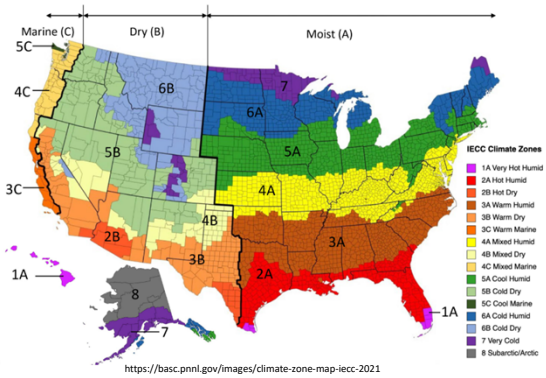
- Insufficient insulation
- Attic
- Walls
- Foundation
- Basement or Crawl Space



Insulation - Attic

- The attic is the easiest place to add insulation
- Check what is there and add insulation to get to minimum amount needed

Climate Zone	Recommended R Values (Uninsulated Attic)
Zones 1-3 (Warmer Climates)	R30–R49
Zone 4 (Moderate Climate, e.g., Pacific Northwest)	R49-R60
Zones 5-8 (Colder Climates)	R49–R60



https://basc.pnnl.gov/images/climate-zone-map-iecc-2021

https://www.energystar.gov/saveathome/seal_insulate/identify-problems-you-want-fix/diy-checks-inspections/insulation-r-values#:~:text=Table_title:%20Recommended%20insulation%20levels%20for%20retrofitting%20existing,to%20Attic:%20R49%20%7C%20:%20R38%20%7C

Insulation - Walls

- Harder to add to existing homes
- Add if remodeling and exposing exterior studs
- Add if replacing exterior siding material
- Options include:
- Batt material
- Blown in
- Spray foam
- Insulating wall sheathing

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Insulation - Foundation

- Adding insulation can reduce heat loss and help control moisture, insect and radon infiltration
- Easy to add to unfinished basement and prior to finishing
- Options include:
- Batt material
- Foam board
- Spray foam
- Loose fill

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Insulation – Crawl Space

- Many conditions to be considered
- Ventilated or unventilated
- Animal access/prevention
- Moisture control
- Other utilities within the crawl space
- Water
- Waste
- Electric, phone, cable
- Ductwork

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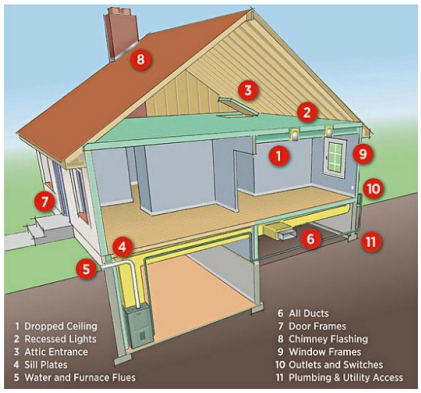
Building Envelope - Infiltration

- Infiltration (air coming in from outside)
- Conduct blower door or smoke pen test
- Address leakage areas
- Caulk
- Weather stripping
- Foam gaskets
- Spray foam
- Assess windows, doors and skylights



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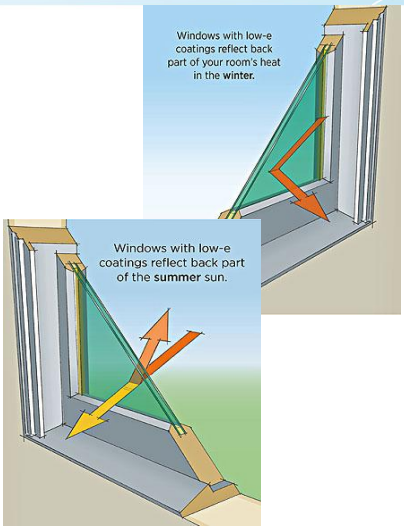
Building Envelope
Windows, Doors & Skylights

- Windows
  - Replace with more energy efficient
  - Add interior or exterior storm windows
  - Add film to reduce solar heat gain
  - Consider different window treatments
  - Check for and fix leaks
  - Caulking
  - Weather stripping



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Building Envelope
Windows, Doors & Skylights

- Doors
  - Replace with more energy efficient
  - Add an exterior storm door
  - Consider different window treatments for large patio doors
  - Check for and fix leaks
  - Caulking
  - Weather stripping

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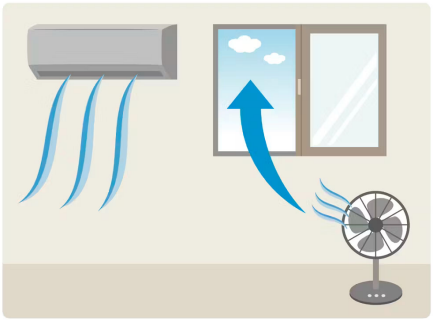
Building Envelope
Windows, Doors & Skylights

- Skylights
  - Replace with more energy efficient
  - Consider the cost benefit of the skylight
  - More light, but much more heat gain
  - Check for proper location and installation
  - Check for and fix leaks

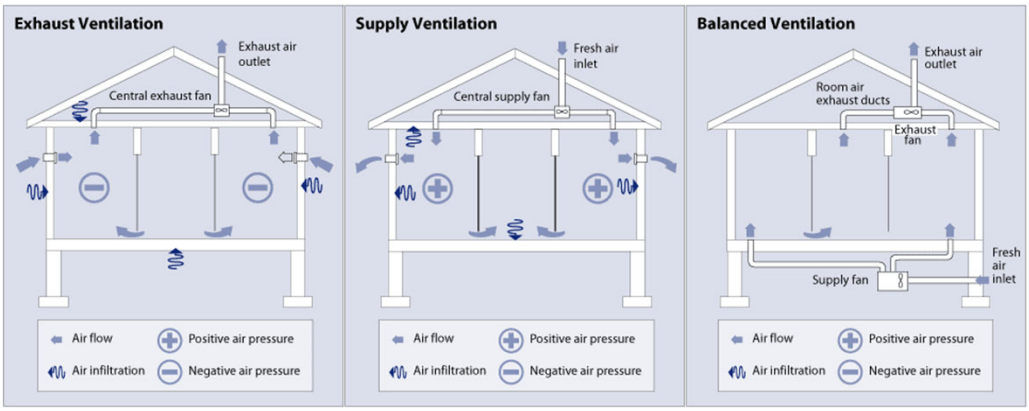
Ventilation

- Insulating and tightening up the home
- Positives
- Reduce conductive heat loss/gain
- Reduces infiltration heat loss/gain
- Reduces natural ventilation (air changes)
- Concerns
- Moisture levels increase
- Indoor air pollutants are trapped inside



Ventilation

- There are many different ways to achieve proper ventilation.



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Heating & Cooling Equipment

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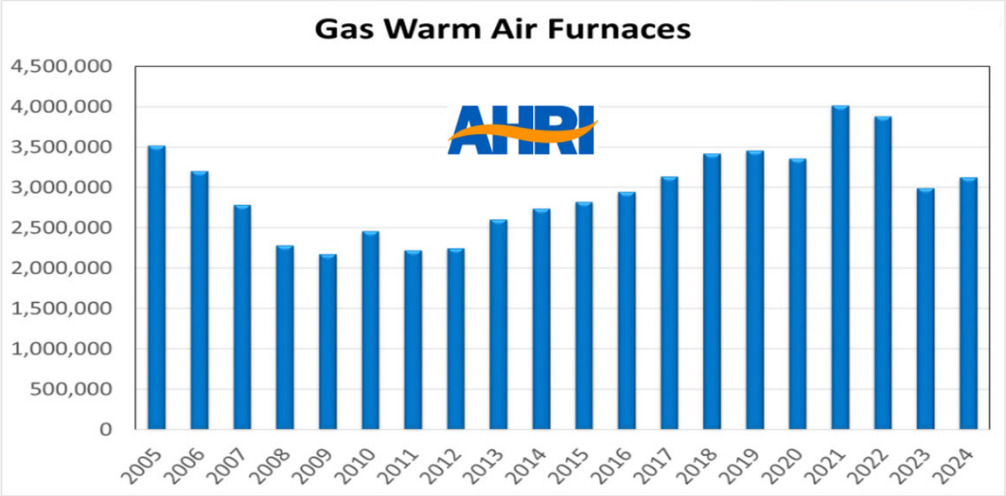
Gas Furnace Shipments



https://www.ahrinet.org/analytics/statistics/historical-data/furnaces-historical-data

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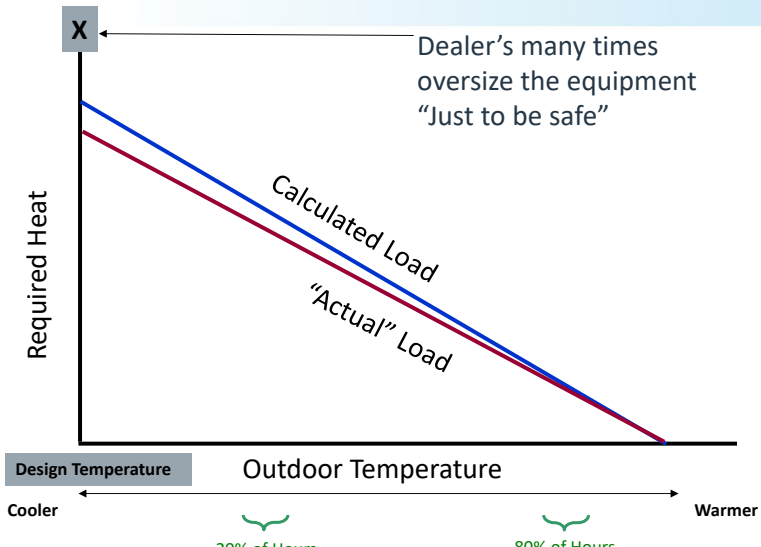
Heating Load



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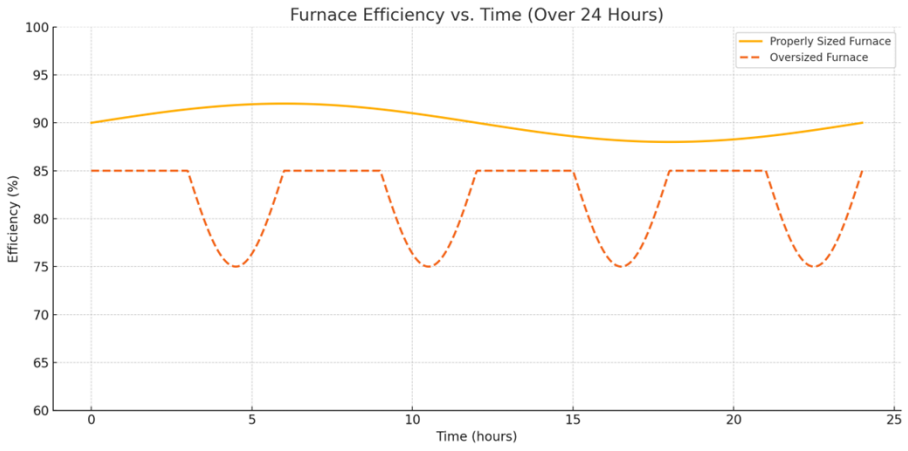
Properly vs. Oversized Furnace



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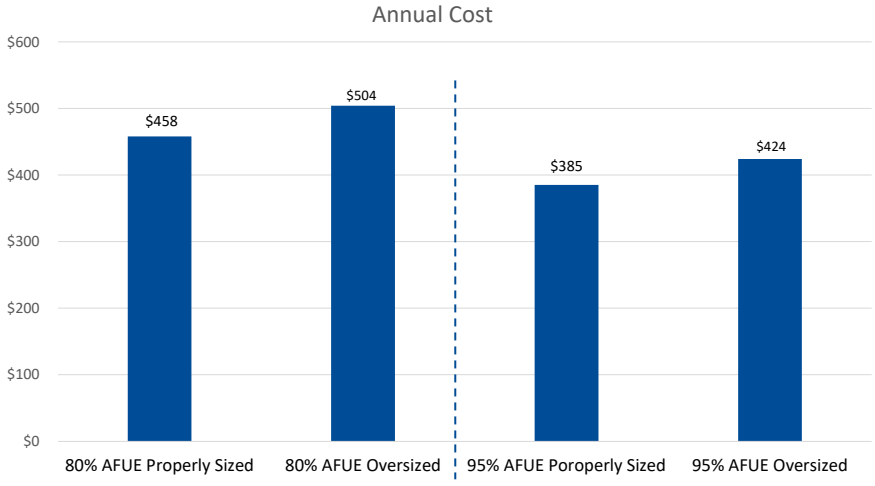
Cost of Over Sizing - Example



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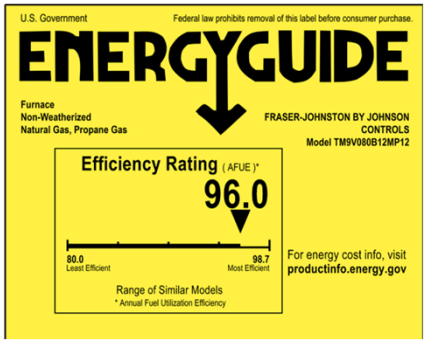
Heating System Efficiency

- Each furnace model is assigned an Annual Fuel Utilization Efficiency (AFUE number)
- The AFUE indicates for each dollar you spend on heating energy, how much of that dollar shows up inside the occupied space of your home as heat
- The higher the AFUE the better



Energy Star Criteria

Appliance Type	Energy Star AFUE
Gas Furnace	≥ 90% AFUE for U.S. South ≥ 95% AFUE for U.S. North
Gas Boiler	≥ 90% AFUE
Air-Source Heat Pump	≥ 8.0 HSPF2 (split systems)

Minimum Federal AFUE for Gas Furnace is 80%

https://www.energystar.gov/products/furnaces/key_product_criteria
https://www.energystar.gov/products/boilers#:~:text=ENERGY%20STAR%20certified%20boilers%20have,measure%20of%20heating%20equipment%20efficiency
https://www.energystar.gov/sites/default/files/2024-12/Final%20ASHP%20ENERGY%20STAR%20Most%20Efficient%202025%20Criteria.pdf

Heating System Efficiency

- AFUE is not the whole story of heating cost efficiency
- A high-efficiency heating system that has not been cleaned and serviced may be running poorly and wasting money
- An 95% AFUE heating furnace that has not been cleaned might be running at an efficiency much lower – perhaps 80%

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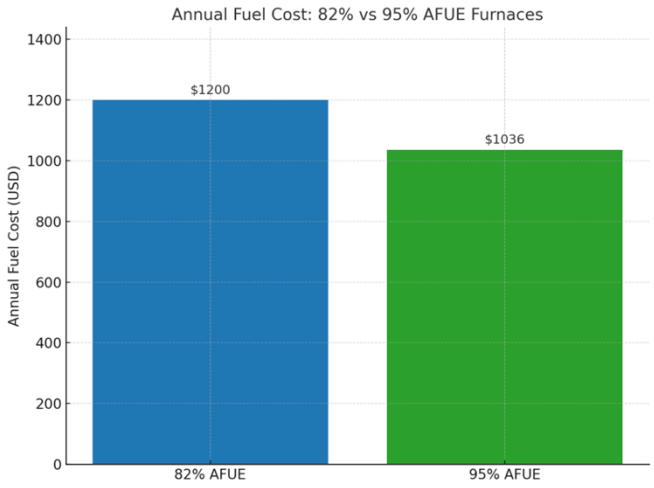
Efficiency and Savings



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Standard Warm Air Furnace

- Offer a seasonal efficiency of at least 80%
- Most have naturally aspirated burners
- Newer furnaces have electric ignition systems
  - Can consume from 3 to 5 percent less energy than a furnace with a conventional standing pilot light

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High Efficiency Gas Furnace

- Criteria to be ENERGY STAR:
  - Northern U.S.: ≥95% AFUE
  - Southern U.S.: ≥90% AFUE
  - Required to have high-efficiency electronically commutated fan motors and ≤ 2% cabinet air leakage
  - A new Version 5.0, proposing 97% AFUE in the North and 95% in the South, will take effect by July 31, 2026

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High Efficiency Condensing Furnaces

- Uses a second heat exchanger
- Hot flue gasses are cooled to the point where the water vapor condenses
- Allows the furnace to extract more heat from the combustion process
- Flue gases are cool and can be vented outside horizontally with a plastic PVC pipe
- Condensed water is run to a floor drain

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High Efficiency Condensing Furnaces

- Condensing furnaces are high efficiency with an AFUE of 90% and above and use variable speed or modulating burners & ECM blowers.
- Highest efficiency available is 99% AFUE achieved by High-end models, such as Lennox's SLP99UH series.

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Furnace Efficiency Improvements

- Electronic Ignition

- VFDs

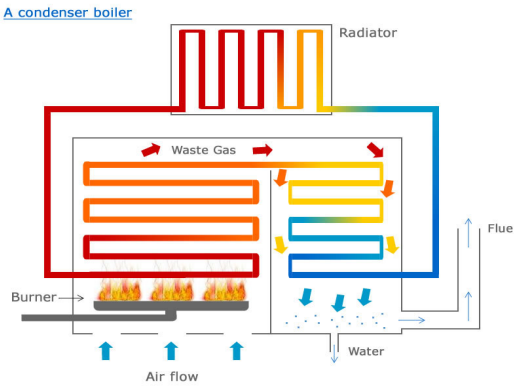
- Condensing furnaces

Condensing & Wall Hung Boilers

- Condensing boiler
- Higher efficiency than conventional boilers
- >= 90% AFUE
- Controls essential to running the system efficiently
- High-efficiency combi and condensing boilers commonly achieve 95%+ AFUE

Condensing Boilers

- Condensing boilers reuse the heat from water vapors created by the boiler's combustion
- Return water temperature is critical with this type of boiler system
- The boiler extracts additional heat from the waste gases by condensing this water vapor to liquid water, thus recovering its latent heat



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Radiators

- New models are more energy efficient
- Range of BTUH outputs to match area heat loss
- Radiator reflectors

Novitherm Reflective Panel

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Gas Absorption Heat Pump Comparison

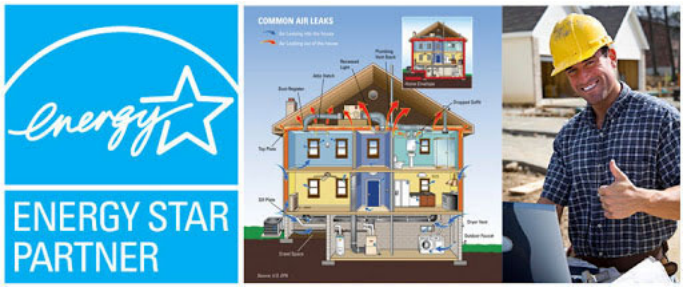
Feature	Robur GAHP-A	SMTI Anesi GAHP
Gas Input	96,000 BTU/Hr	55,000 BTU/Hr
Heat Output	125,000 BTU/Hr	78,000 BTU/Hr
Heating Efficiency	129%	140%
Electric Input	0.9 kW	0.6-0.7 kW

Save Cooling Energy

- Install a programmable thermostat
- Use a ceiling fan
- Insulate attic and walls – seal leaks
- Insulate and seal ducts
- Use outdoor grill instead of oven in Summer
- Install window coverings
- Install an Energy Star AC unit
- Replace the air filter

High Performance Homes

Energy Star – ENERGY STAR certified homes have been designed, built, inspected, tested and verified to standards set by the EPA to deliver energy efficiency savings of up to 20% when compared to typical new homes



https://www.epa.gov/statelocalenergy/local-residential-energy-efficiency?utm_source=chatgpt.com

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Programmable Thermostat

- Reduces energy consumption and costs when home is unoccupied and at night
- Save about 8-10% annually on heating/cooling cost by allowing the thermostat to adjust temperatures automatically throughout the day
- Allows participation in time of use or demand response programs
- Not recommended for heat pumps

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Set Back with Heat Pumps

- Using a standard programmable thermostat is not recommended for heat pump applications
- Setting back by more than 2°F (1.1°C) in heating mode will result in resistance heat being energized when the setback period is over
- That situation is expensive and negates the setback savings
- There are some programmable thermostats specifically made for heat pumps but the reheat time would be longer

Zone Controls

- Allows for control of air volume to individual rooms or areas
- **Options for Creating or Expanding Zone Control:**
  - Motorized dampers + zoning panels: Required for physical zone separation in ducted systems.
  - Room sensors: Used by Ecobee and Honeywell to balance comfort (not true zoning, but helpful).
  - Smart vents (e.g., Flair, Keen Home): Add-on devices that open/close individual vents to manage airflow per room.

Hot Water Efficiency

- Reduce consumption
- Decrease standby heat loss
- Drain heat recovery
- Reduce flue loss
- Lower the water temperature
- Improve Water Heater Efficiencies

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Reduce Hot Water Consumption

- Fix leaks in faucets, showerheads and pipes
- Install low flow fixtures & shower heads
- Less than 2.5 GPM (9.4 LPM)at 80 psi
- Install aerators on faucets – down to 1.0 GPM (3.7 LPM)
- Purchase energy efficient clothes washer and dishwasher
- Emerging “smart” water heater controllers use model-predictive control (MPC) to optimize heating based on energy prices, time-of-use rates, and household demand, cutting costs by 12–42% compared to standard thermostatic systems

https://www.epa.gov/watersense/fix-leak-week?utm_source

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Decrease Standby Loss

- Add insulation to the water heater (follow instructions) cost ~$20 with 1 year payback
- Insulating hot water piping can save ~$10 per year
- Replace tank heater with on demand heater
- Smart Water Heaters with Demand Response Capabilities

https://www.energy.gov/energysaver/do-it-yourself-savings-project-insulate-water-heater-tank?utm_source

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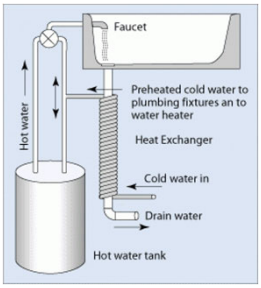
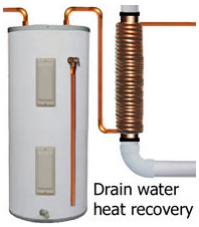
Drain Heat Recovery

- Transfers heat from drain water to cold water inlet to water heater
- $300 - $500 cost and 2.5 – 7 year payback
- Residential systems typically recover **20–40% of drain-water heat**—with some lab and real-world units achieving up to **60%** recovery during simultaneous flow (e.g., showers)

https://www.energy.gov/energysaver/drain-water-heat-recovery?utm_source





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Lower the Water Temperature

- Reducing temperature to 120°F (48.8°C) max.
- Reduces mineral build-up and corrosion
- Reduces scalding hazard
- Saves energy & money $30 - $60/ yr.
- Prolonged lifespan of the heater

https://www.energy.gov/energysaver/do-it-yourself-savings-project-lower-water-heating-temperature?utm_source

Water Heater – Uniform Energy Factor

New formulas (V equals volume of storage)

	Volume (Gal)	Medium UEF Example	Very Small Draw (UEF)	Low Draw (UEF)	Medium Draw (UEF)	High Draw (UEF)
Electric Storage	≥20 and ≤55 gal	**40 Gal = .92**	.8808-.0008V	.9254-.0003V	.9307-.0002V	.9349-.0001V
Electric Storage	>55 and ≤120 gal	**80 gal = 2.03**	1.9236-.0011V	2.0440-.0011V	2.1171-.0011V	2.2418-.0011V
Electric Tankless	<2 gal	**.91**	.91	.91	.91	.92
Gas Storage	≥20 and ≤55	**40 Gal = .58**	.3456-.0020V	.5982-.0019V	.6483-.0017V	.6920-.0013V
Gas Storage	>55 and ≤100	**80 gal = .76**	.6470-.0006V	.7689-.0005V	.7897-.0004V	.8072-.0003V
Gas Tankless	<2 gal and >50,000 Btu/h	**.81**	0.80	0.81	0.81	0.81
Oil Storage	≤50 gal	**40 Gal = .54**	.2509-.0012V	.5330-.0016V	.6078-.0016V	.6815-.0014V
Grid Enabled	>75 gal	**80 gal = .91**	1.0136-.0028V	.9984-.0014V	.9853-.0010V	.9720-.0007V

https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

High Efficiency Condensing Tank Style Water Heaters

- UEF ≥ 0.81 (medium draw), ≥ 0.86 (high draw)
- ENERGY STAR requirement includes sealed combustion + condensing heat exchanger
- More compatible with existing plumbing than tankless units
- Steady hot water supply for simultaneous users

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High Efficiency Condensing Tankless Water Heaters

- Most efficient gas option for domestic water heating only
- UEF ratings of 0.95–0.98+
- ENERGY STAR certified
- Saves 8–34% more energy than storage heaters (per DOE)
- Up to $100+ per year savings over conventional gas units
- Rebate eligible under many state and federal programs (including IRA)

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Gas Combination Boilers (Combi Units)

- Provide space heating + domestic hot water in a single system
- Higher overall system efficiency when used in cold climates
- ENERGY STAR units can exceed 90% AFUE + good DHW recovery rates
- Not strictly a water heater, but a highly efficient multi-function option

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Pool & Spa Heating Energy Savings

- Use a cover
- Reduces heat loss
- Cuts down on chemicals
- Some help heat the pool
- Reduce water temperature
- Clean the filters
- Optimize backwash frequency

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Improve Appliance Efficiency

- Replacement is the path to increased efficiency
- Keep appliances clean and in good working order
- Top 5 energy users excluding water heater
  - Appliances & Electronics
  - Lighting
  - Pool Pump
  - Refrigerator/Freezer
  - Cooking

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Kitchen/Laundry Appliances

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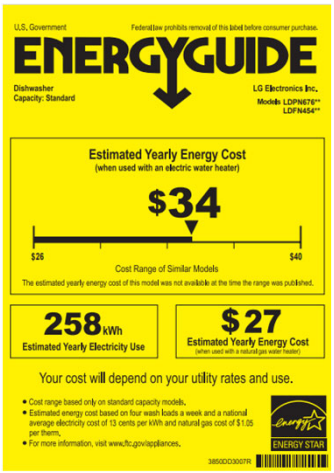
Kitchen Appliances- Dishwasher

- Skip Pre-Rinsing — Scrape, Don't Rinse
- Run Full Loads Only
- Use the Air-Dry or "Eco" Option - some models can cut 15% of energy per load by avoiding heat-dry
- Time Runs During Off-Peak Hours - Can reduce energy cost by up to 50% on time-of-use (TOU) rate
- Choose ENERGY STAR-Certified Models with Soil Sensors- These units use ~12% less energy and 30% less water than standard models, per DOE.



Kitchen Appliances- Range

- Replace standing pilot with electronic ignition
- Look for the blue flame – yellow flames indicate inefficient burning
- Match the pan to the burner size
- Keep burners and oven clean
- Only preheat when needed
- Make sure there is proper ventilation

Clothes Washer

- Energy Star washer uses 33% less water and 25% less energy than a standard washer
- Use cooler or cold water
- Switching from hot to warm setting cuts energy use in half
- Wash full loads
- EE Washers reduce Dryer energy use

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Clothes Dryer

- Energy Star dryers use 20% less energy than a conventional dryer
- Use the drying sensor
- Don't over dry
- Dry heavy cottons separately
- Run full loads
- Clean lint screen and periodically vacuum
- Start run during off peak hours

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Home Energy Monitoring

- Smart Grids/Meters
  - Smart meters enable two-way communication between the meter and the utility
  - Unlike home energy monitors, smart meters can gather data for remote reporting
  - Consumer benefits will depend on people actively changing their energy use and monitoring energy use profiles
  - Allows participation in demand response programs.

Home Energy Monitoring

- Many “commercial” electric systems available
  - Whole House Monitors track and display electricity usage in your home directly from your meter or electric panel
  - Individual appliance monitors
    - Monitor designed to measure the AMPS, KILOWATTS and DOLLARS of individual appliances
    - Allows you track aging appliances or compare against ENERGY STAR benchmarks.
- Devices like Curb, Eyedro, or Sense Flex (with add-ons) now offer natural gas usage monitoring
- Monitoring gas appliances is more challenging and not widely used

Electric Smart Meters are Readily Available

- Electric meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes
- Owners can access profile files to determine hourly energy use
- Demand Response compatibility
- Outage detection and restoration

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Gas "Advanced" Meters

- Usage is automatically and securely transmitted to utility billing center
- Can view up-to-date hourly and daily usage information and estimated costs online
- Set and achieve savings and conservation goals
- Significant cost to utilities with long term benefits – reduced errors and manpower
- Can add to analog meters

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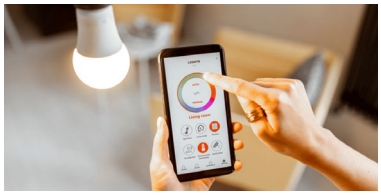
A Bit on Lighting

- Traditional incandescent no longer manufactured
- Energy Star certified LED bulbs use 90% less energy compared to incandescent bulbs and last 15-25x times longer with a lifespan of 25,000 hours
- Smart lighting controls allow for automatic dimming and remote scheduling
- Energy Star certified occupancy sensors can decrease energy usage associated to lighting by 30%



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Energy Use of Electronics

- Electronics account for 7-10% of home energy use
- Energy Star electronics are significantly more efficient compared to standard:
  - TVs are 25% more efficient
  - Computers and laptops are 25-40% more efficient
  - External Power Supplies are 30% more efficient
  - Monitors are 20-30% more efficient

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Learn More

- ESC – www.escenter.org
- US Energy Information Administration – www.eia.gov
- Energy Department – www.energy.gov
- Energy Star – www.energystar.gov

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Thank You

Consider taking the on-line test while course material is fresh in your mind

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