

Work From Home Energy Efficiency

Overview

- Energy End Uses (Where does energy get used in the home?)
- Your Utilities: Dominion Energy & Virginia Natural Gas
- Basic Energy Conservation Suggestions (You've probably heard of these before)
- Intermediate Home Energy Conservation (Some DIY)
- Advanced Home Energy Conservation (Professional Needed)
- Tracking Energy Savings
- Rebates, Incentives & Tax Credits

Introduction

Ian O'Connor, Certified Energy Manager

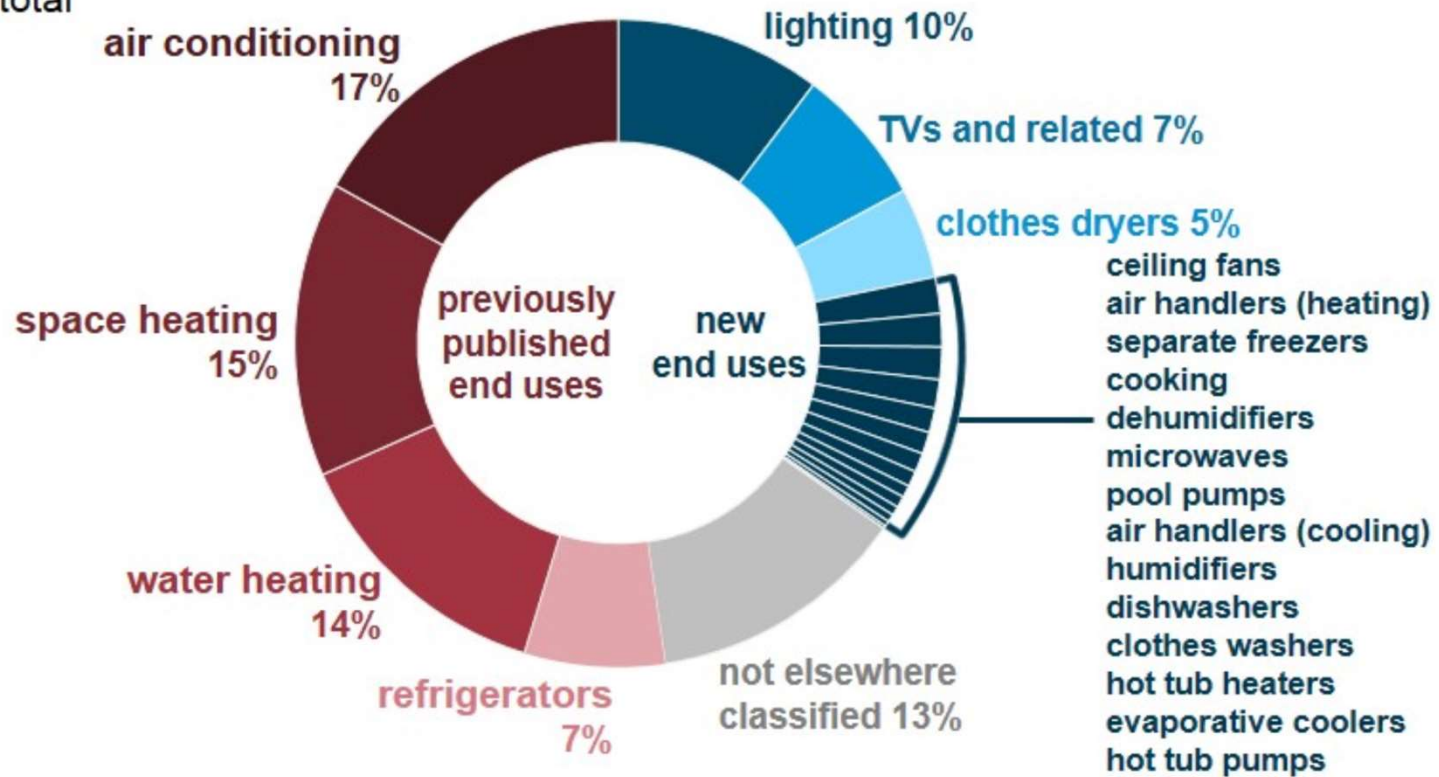
Contract Energy Analyst for LaRC Environmental Management Office (EMO)

5 years of experience in energy efficiency projects for large commercial, government and industrial customers.

Side effect: I've spent a lot of time making my home more energy efficient

Where energy is used at home

Residential electricity consumption by end use, 2015
percent of total

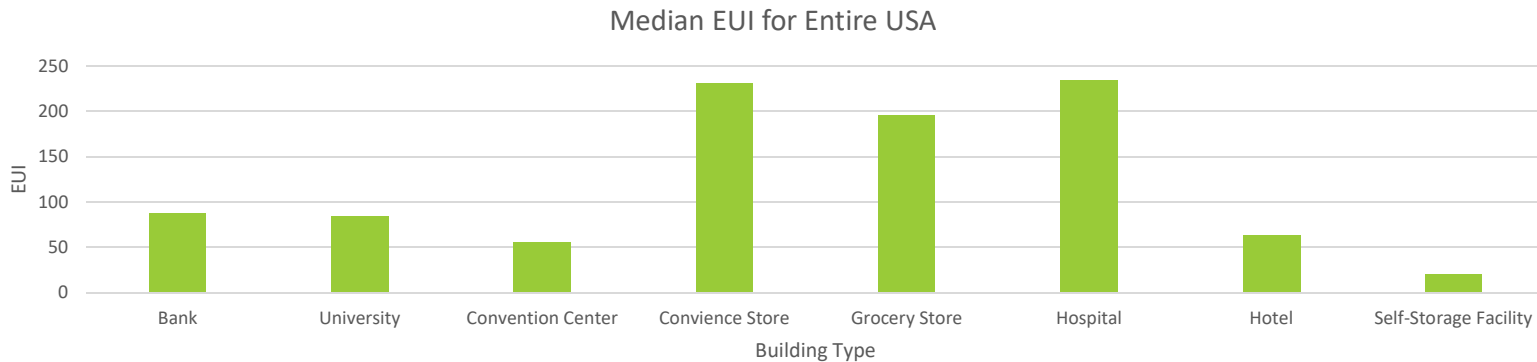


Utility Providers



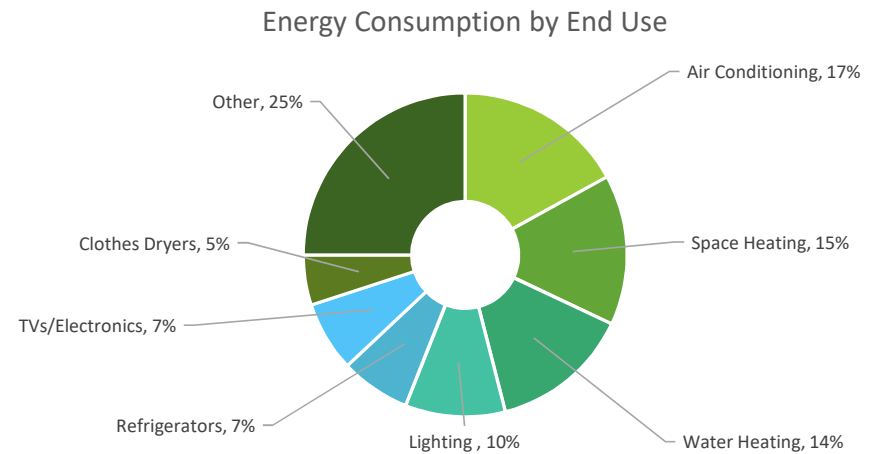
Some perspective

- ❑ Energy Use Index (EUI) - kBTU/SF/Year
- ❑ Varies depending on climate, construction, use
- ❑ Typical Mid-Atlantic Home EUI: 93.6 kBTU/SF/Year
- ❑ LaRC EUI: 138.1 kBTU/SF/Year



Theoretical Model Home

- ❑ Our model home in Hampton, VA
 - ❑ Typical Mid-Atlantic Home EUI: 93.6 kBTU/SF/Year
 - ❑ All-electric, Mid-2000's construction, 2,000 SF, 3 bed, 3 bath
 - ❑ 15,600 kWh annual consumption
 - ❑ \$990 annualized electric bill



Basic Energy Conservation

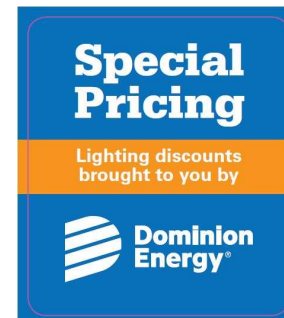
- Low-Cost, No-Cost Opportunities
- Quick and Easy – Do-It-Yourself
- Renter-friendly
- Marginal energy savings (Hard to measure savings)
- You probably already know some of these
- <https://www.directenergy.com/learning-center/25-energy-efficiency-tips>

Lighting

- ❑ Average 10% of home energy use
- ❑ Replace lamps with **Light Emitting Diode (LED)** lamps
 - ❑ Most cost savings from less frequent replacement
 - ❑ Incandescent: 1,000-3,000 hour life
 - ❑ Compact Fluorescent (CFL): 8,000-15,000 hour life
 - ❑ Light Emitting Diode (LED): 15,000-50,000 hour life
 - ❑ Replacement cost savings + energy savings justify switching all lamps to LED
 - ❑ 25 CFLs to LED: \$13.00 savings per year
 - ❑ 25 Incandescent to LED: \$110.00 savings per year
 - ❑ <https://www.bulbs.com/learning/energycalc.aspx>
 - ❑ Bonus – Reduces cooling load on home in summer
- ❑ Most important: lights **off** when not in use!

Lighting Facts Per Bulb	
Brightness	820 lumens
Estimated Yearly Energy Cost	\$7.23
Based on 3 hrs/day, 11¢/kWh	
Cost depends on rates and use	
Life	1.4 years
Based on 3 hrs/day	
Light Appearance	
Warm Cool	
2700 K	
Energy Used	60 watts

You pay about 6¢/kWh in VA



Lighting Facts Per Bulb	
Brightness	800 lumens
Estimated Yearly Energy Cost	\$1.57
Based on 3 hrs/day, 11¢/kWh	
Cost depends on rates and use	
Life	9 years
Based on 3 hrs/day	
Light Appearance	
Warm Cool	
2700 K	
Energy Used	13 watts

Heating & Air Conditioning (HVAC*)

- ❑ Average 32% of home energy use
- ❑ May be all electric or combination of electric and natural gas for heating
- ❑ Adjust thermostat to temperatures that are just tolerable
 - ❑ Save 1-3% of energy consumption per degree adjusted
 - ❑ Highly dependent on construction/insulation, climate, equipment and energy sources
- ❑ Install a **programmable or wifi-enabled** thermostat
 - ❑ Nest claims up to 15% cooling and 10-12% heating savings
 - ❑ Model home annual savings:
 - ❑ 1,250-1,350 kWh
 - ❑ \$80.00-\$85.00
 - ❑ <https://nest.com/thermostats/real-savings/>



\$150-\$300

*HVAC = Heating, Ventilating and Air Conditioning, but for our purposes, it just refers to heating and air conditioning.

Heating & Air Conditioning, Cont.

- ❑ Open windows when outdoor temps are 55-65° degrees
 - ❑ Be mindful of **humidity** – outdoor dewpoint should be < 60°
 - ❑ Don't forget to turn off A/C
 - ❑ Use a window fan to flush home with cool air
- ❑ Window treatments/coverings/curtains
 - ❑ Summer: Use white window treatments to block and reflect sunlight
 - ❑ Winter: Keep window treatments open to allow house to absorb sunlight



Water Heating

- ❑ Average 14% of home energy use
- ❑ Heated with electric or natural gas
- ❑ Adjust thermostat from 140° to 120°
 - ❑ Save 6-10% on water heating costs
 - ❑ Varies depending on natural gas or electric and water use
 - ❑ Model home annual savings:
 - ❑ 140-235 kWh
 - ❑ \$9.00-\$15.00
- ❑ Turn off water heater when away for more than 24 hours
 - ❑ Water heater uses no energy when off
 - ❑ Takes less than 60 minutes to heat up
- ❑ Use a showerhead with a “pause” button



Natural Gas



Electric

Kitchen

- ❑ Refrigerators: About 7% of home energy use
- ❑ Tune refrigerator temperatures using a thermometer
 - ❑ Keep refrigerator close to, but not above 40°
 - ❑ Keep freezer well below 32°, but not too cold (5°-15°)
 - ❑ Most freezers are way too cold (-10°).
- ❑ Use dishwasher heated dry seasonally
 - ❑ Do not use dishwasher heated dry in summer (air dry instead)
 - ❑ Only use heated dry in winter



Worthy Mentions

- ❑ Wash clothes in **cold water**
- ❑ Replace air filters regularly – Use high efficiency **MERV-10** or higher
- ❑ Reduce vampire loads by keeping electronics unplugged when not used
 - ❑ Use a timer plug or wifi-enabled plug
- ❑ Use **ceiling fans** to stay cool in summer
- ❑ Close **fireplace dampers** when not in use
- ❑ Use **bathroom fans** diligently when bathing
- ❑ Dress for the weather
- ❑ Questions???

Intermediate Energy Conservation

- Weekend projects
- Some Do-It-Yourself (depends on comfort level)
- Mostly renter-friendly
- More investment but greater energy savings

Lighting Controls

- ❑ Install a **photocell** or **timer** to control exterior lighting
 - ❑ Can reduce consumption of lighting by 50%
 - ❑ Requires some electrical skill
- ❑ Install LED lamps with photocell or timer built-in
 - ❑ Many Wifi-Enabled LED lamps can be programmed
 - ❑ Motion-controlled security lights



Air Conditioner Self-Diagnosis

- ❑ Air Conditioning Performance Evaluation
 - ❑ **Humid** indoor air or frequent “on-off” cycling may indicate a problem
 - ❑ Use a kitchen thermometer to measure supply air temperature
 - ❑ Supply air temperature should be **16°-22°** less than room temperature
 - ❑ Below or above that range indicates there might be a problem – contact HVAC contractor or property manager
 - ❑ Other things to note
 - ❑ **Large copper pipe** should be cold when running, condensation should form
 - ❑ **Small copper pipe** should be at room temperature or slightly warm



Air Conditioner Coil Cleaning

- ❑ Improve A/C and heat pump performance with **DIY coil cleaning**
 - ❑ Increases **heat transfer** between air and refrigerant coils
 - ❑ Can be applied to indoor and outdoor unit
 - ❑ Up to 10% cooling energy savings
 - ❑ Dependent on equipment and dirt buildup
 - ❑ Model home annual savings:
 - ❑ 265 kWh
 - ❑ \$17



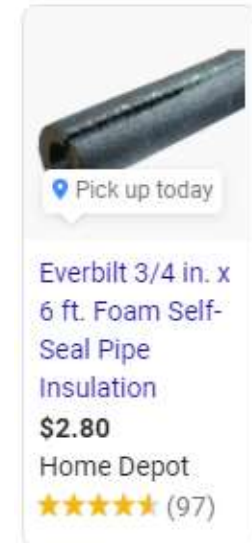
Air Conditioner Coil Cleaning

- ❑ Can also be **professionally cleaned** by HVAC contractor



Refrigerant Pipe Insulation

- ❑ **Reduces heat transfer** through air conditioner refrigerant piping
 - ❑ Outdoor refrigerant insulation deteriorates after a few years
 - ❑ Keeping this insulated improves A/C (and heat pump) efficiency and performance



Water Heating – Pipe Insulation

- ❑ **Reduce heat losses** in pipes by insulating them
 - ❑ Few houses have pipe insulation
 - ❑ Ideal for basement, attic or crawlspace-accessible piping
 - ❑ Contractor-installed insulation eligible for utility rebate
 - ❑ up to \$6.07/foot



Appliance Replacement

- ❑ Replace end-of-life appliances with **Energy Star** appliances
- ❑ Dominion Energy has rebates for ES Appliances
 - ❑ Refrigerator: \$50
 - ❑ Freezer: \$50
 - ❑ Dish Washer: \$50
 - ❑ Clothes Washer: \$50
 - ❑ Air Purifier: \$50
 - ❑ Dehumidifier: \$25
 - ❑ Heat pump clothes dryer: \$100



Other considerations

- ❑ Weathersealing: Replace **weathersealing** around leaky windows, doors and wall penetrations
 - ❑ Increase comfort & reduce load on HVAC
- ❑ Shade trees: Place around southern and western exposures
 - ❑ Long-term solution
- ❑ Repair **HVAC ducts**: Leaky or pinched ducts **reduce airflow** and increase energy consumption
 - ❑ Repair leaks with mastic or aluminum foil tape
 - ❑ Straighten tightly pinched ducts
- ❑ Questions???



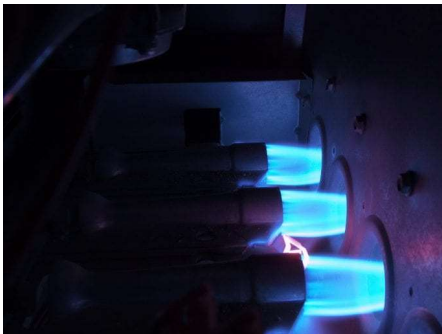
Advanced Energy Conservation

- Skilled contractor maybe required
- Only for homeowners
- Maximum energy savings but highest cost
- Many rebates available

Types of Heating & Cooling Equipment

A/C WITH FURNACE

- ❑ Air Conditioning systems have an inside (air handler) and outside component (condenser)
- ❑ Furnace is inside with heat provided by:
 - ❑ Natural gas furnace
 - ❑ Electric furnace (electric resistance heat)

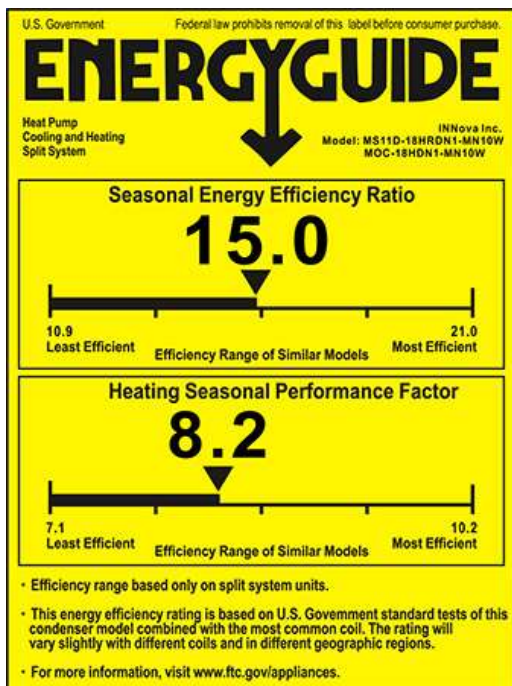


HEAT PUMP

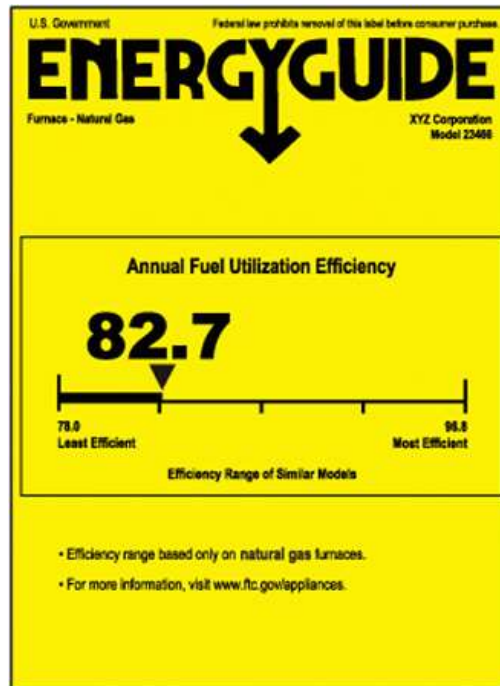
- ❑ Heat pump systems are air conditioning systems that can run in **reverse** to provide heating in winter.
- ❑ Same appearance as A/C system
- ❑ A heat pump takes the place of an A/C + furnace combo
- ❑ Just electric – no gas



HVAC Efficiency Primer



Heat Pump Label



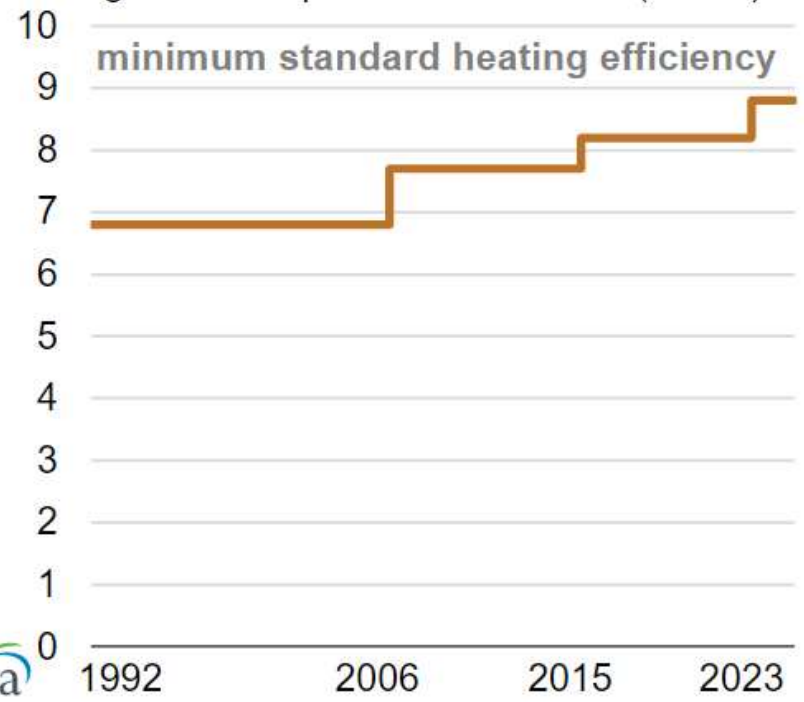
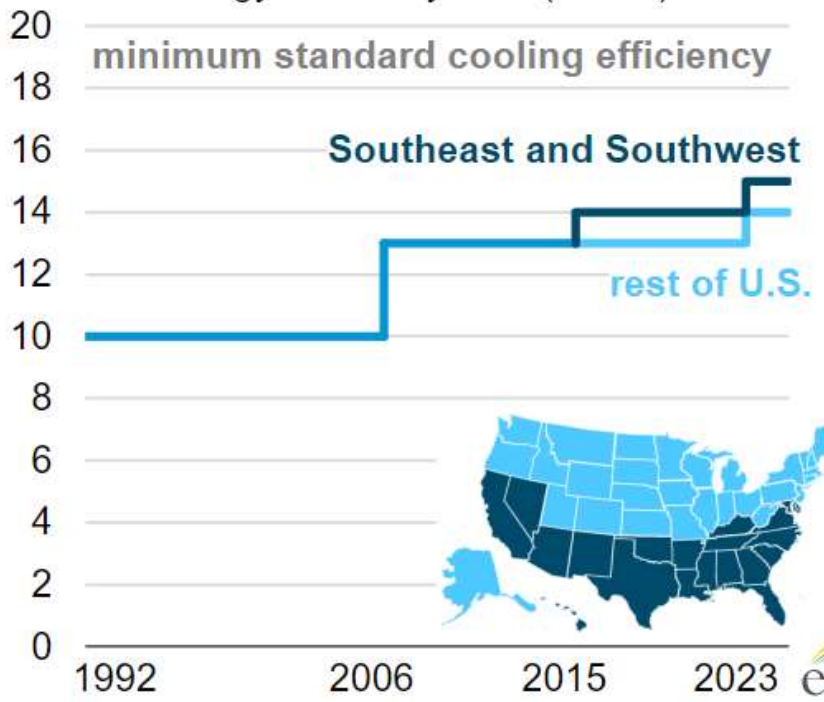
Furnace Label

- SEER – Seasonal Energy Efficiency Ratio
 - Cooling Output (kBTU) / Electricity Input (kWh)
 - Air conditioning performance
 - Average **cooling** performance over season
- HSPF – Heating Seasonal Performance Factor
 - Heating Output (kBTU) / Electricity Input (kWh)
 - Heat pump performance
 - Average **heating** performance over season
- AFUE – Annual Fuel Use Efficiency
 - Gas furnaces, oil furnaces, electric furnaces
 - Average efficiency of **heating** over season
- In short – higher is more efficient!

Performance standards for residential central air-conditioning equipment and heat pumps

seasonal energy efficiency ratio (SEER)

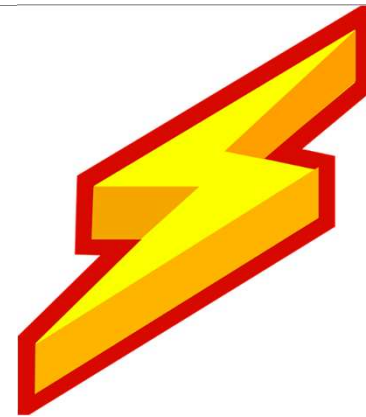
heating seasonal performance factor (HSPF)



Source: U.S. Energy Information Administration

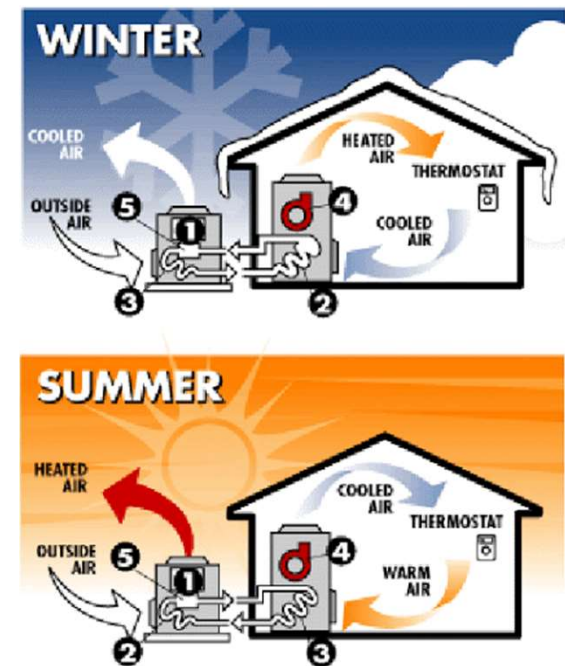
Consider Electrification

- ❑ Natural gas service is in about 35% of homes in the region
- ❑ Heating with natural gas:
 - ❑ is cheap, but subject to **cost fluctuations**
 - ❑ Requires having **additional** utility service
 - ❑ Carries combustion **safety risks** (carbon monoxide poisoning)
- ❑ Heat pump systems are **affordable** to own and run
- ❑ <https://www.energyvanguard.com/blog/1-reason-have-all-electric-home>
- ❑ <https://www.pecanstreet.org/2019/09/electrictexas/>



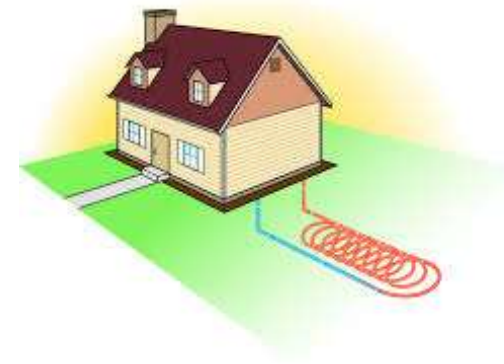
Heat Pumps

- ❑ Outdoor air is the **heat sink**
- ❑ Works like an A/C reverse - “pulls” heat from outdoors in the winter
- ❑ Works like a regular A/C in the summer – rejecting heat to outdoors
- ❑ Heating performance degrades in very cold weather
- ❑ Good performance for southern and coastal regions – does not get too cold



More About Heat Pumps

- ❑ Standard efficiency heat pump
 - ❑ 14 SEER, 8.2 HSPF
 - ❑ Single-stage
- ❑ High efficiency heat pump
 - ❑ Higher efficiency
 - ❑ May have 2-stage compressor or multi-speed
- ❑ Water-source (ground-source/geothermal) heat pump
 - ❑ Highest efficiency
 - ❑ Uses earth or groundwater as heat sink
 - ❑ May have 2-stage compressor or multi-speed
 - ❑ No performance degradation at low temperatures
 - ❑ Eligible for investment tax credit (26%)



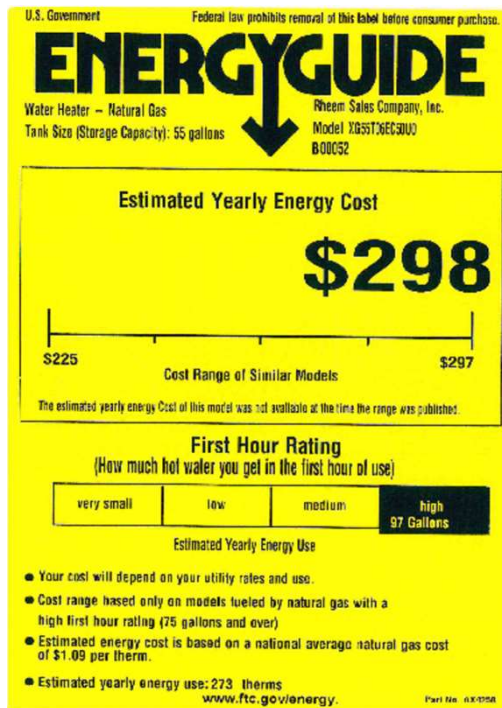
Heat Pump Appliances

- ❑ Heat pump technology has many applications
- ❑ Heat pump water heaters – 2-4 times more efficient than standard electric water heaters
 - ❑ Dehumidifies and cools surrounding air
 - ❑ Eligible for \$234 rebate from Dominion Energy
- ❑ Heat pump clothes dryers – 2 times more efficient than standard electric clothes dryers
 - ❑ No venting required
 - ❑ Gentler on clothes
 - ❑ Time tested – used in Europe for decades
 - ❑ Eligible for \$100 rebate from Dominion Energy



Water Heater Efficiency

Natural Gas – 55 Gal



Electric Conventional – 45 Gal



Heat Pump (Hybrid) – 45 Gal



Water Heater Replacement, Electric

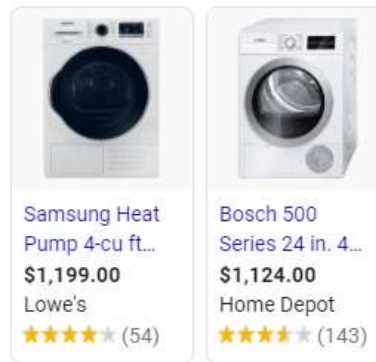
- ❑ Electric water heaters typically found in homes with no natural gas
- ❑ Recommended: Replace with a high efficiency heat pump water heater
- ❑ For our model home:
 - ❑ Existing water heater: 0.75 uniform energy factor (UEF)
 - ❑ Proposed water heater: 2.75 UEF
 - ❑ Expect annual savings of:
 - ❑ 1,588 kWh
 - ❑ \$100
- ❑ Cost: \$586
 - ❑ \$820 marginal cost, less \$234 rebate
- ❑ Roughly 5-6 year payback period
- ❑ Bonus: Lasts 50% longer than conventional electric

Product Name	Price	Rating
Rheem Performance Platinum 50 Gal. 10-Year Hybrid	\$1,199.00	4.5 (36)
Rheem ProTerra 40 Gal. 10-Year Hybrid High Efficiency Smart	\$1,349.99	5 (12)



Clothes Dryer Replacement, Electric

- ❑ Consider replacing a standard electric clothes dryer with a **heat pump** version that uses 50% less energy
- ❑ Eligible for a \$100 rebate through Dominion Energy
- ❑ For our model home:
 - ❑ Expect annual savings of:
 - ❑ 390 kWh
 - ❑ \$25
- ❑ Cost: \$200
 - ❑ \$300 marginal cost, less \$100 rebate
- ❑ Roughly 8 year payback



Model Home Energy Savings

- ❑ Before energy upgrades:
 - ❑ 15,600 kWh annual consumption
 - ❑ \$990 annualized electric bill

Measure	Measure Cost	Annual Savings (kWh)	Annual Cost Savings (\$)
Lighting - CFL to LED	\$ 125	195	\$ 13
HVAC - Thermostat	\$ 225	1,250	\$ 80
Water Heating - Thermostat	\$ -	140	\$ 9
HVAC - Coil Cleaning	\$ 10	265	\$ 17
Replace end of life Electric water heater w/ Heat Pump version	\$ 1,200	1,588	\$ 100
Replace end of life Electric dryer w/ Heat Pump version	\$ 1,200	390	\$ 25
Total	\$ 2,760	3,828	\$ 244

- ❑ After energy upgrades:
 - ❑ 11,772 kWh annual consumption
 - ❑ \$746 annualized electric bill
 - ❑ New EUI: 70.2 kBTU/SF/Year

25% energy savings

Other Considerations

- ❑ Replace or add insulation in attic
 - ❑ Insulation begins to compact and lose effectiveness after 10 years
- ❑ Solar electric (PV) & solar hot water: Eligible for investment tax credit
 - ❑ Installed in 2020: 26%
 - ❑ Installed in 2021: 22%
 - ❑ After 2021 Is subject to renewal
- ❑ Questions???



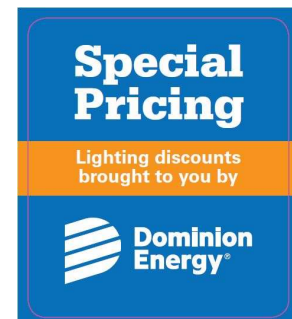
Dominion Energy Rebates

❑ Appliances

- ❑ Appliance recycling: \$20
- ❑ Refrigerator, Freezer, Clothes Washer, Air Purifier & Dishwasher: \$50
- ❑ Electric Clothes Dryer: \$100
- ❑ Dehumidifier: \$25
- ❑ <https://www.dominionenergy.com/virginia/save-energy/lighting-discounts-and-appliance-rebates>

❑ Lighting

- ❑ Instant rebate at home improvement stores or Dominion Energy Marketplace
- ❑ <https://www.poweredbyefi.org/dominionenergy/>



Dominion Energy Rebates, Cont.



- Contractor-Installed (Direct Install)
 - Heat pump tune-up: \$39
 - Heat pump upgrade: \$156 - \$273
 - HVAC duct sealing: \$109 - \$148
 - HVAC duct insulation: \$0.35/foot
 - Heat pump water heater replacement: \$234
 - ECM (high efficiency) HVAC fan motor replacement: \$39
 - Cool (reflective) roof: \$0.20/square foot
 - LED lamps & fixtures: \$7.16 - \$16.90 per lamp
 - For electric water heaters only:
 - Hot water pipe insulation: up to \$6.07/foot
 - 1.5 gallon per minute faucets & aerators: \$1.69 - \$22.87 per fixture
- <https://www.dominionenergy.com/virginia/save-energy/home-energy-assessment>



Dominion Energy Programs

- ❑ Home Energy Assessment
 - ❑ Free in-home consultation with an approved contractor
 - ❑ <https://www.dominionenergy.com/virginia/save-energy/home-energy-assessment>

- ❑ Smart Cooling Rewards
 - ❑ Demand-side management
 - ❑ Receive a \$40 credit annually
 - ❑ <https://www.dominionenergy.com/virginia/save-energy/smart-cooling-rewards>



Virginia Natural Gas Rebates

- Must be a Virginia Natural Gas Customer
- Wifi-Enabled Thermostat: \$50
- Natural gas tank water heater: \$70
 - Energy factor of 0.67 or greater
- Furnace: \$250
 - 90% AFUE or greater
- <https://www.virginianaturalgas.com/residential/ways-to-save/rebates.html>

Appendix



Your Electric Utility and Electric Rate

- ❑ Schedule 1 – Basic Residential Service
- ❑ \$6.58 flat fee per month
- ❑ Per kilowatt-hour (kWh) rate varies throughout year

Summer (June-Sept) - ¢/kWh		Winter (Oct-May) - ¢/kWh	
First 800 kWh	6.661	First 800 kWh	6.661
800 kWh and above	7.614	800 kWh and above	4.928

- ❑ kWh is unit of energy – 1 kWh = 60W light bulb running for 16 hours and 40 minutes



Your Natural Utility and Natural Gas Rate

- ❑ Schedule 1 or 1A – Basic Residential Service
- ❑ Monthly flat fee: \$10.18 (1) or \$3.33 (1A)
- ❑ 100 x cubic foot (ccf) of natural gas rate: \$0.964/ccf
- ❑ Ccf is unit of energy – 1 Ccf is:
 - ❑ Heat energy released from burning 100 cubic feet of natural gas

Advanced Energy Conservation – HVAC Replacement

- Skilled contractor required
- Only for homeowners
- Maximum energy savings but highest cost
- Many rebates available

HVAC Replacement, Heat Pump

- ❑ Found in newer homes (1990s and later) with no natural gas
- ❑ Older heat pump models **perform poorly** in cold weather
- ❑ Recommended: Replace end-of-life heat pump with a high efficiency heat pump
 - ❑ DoE minimum efficiency: 14 SEER, 8.2 HSPF
 - ❑ Energy Star efficiency: 15 SEER, 8.5 HSPF
- ❑ For our model home:
 - ❑ Existing unit installed in 2003, with 10 SEER and 6.8 HSPF



Install DoE Minimum Efficiency	Install Energy Star Efficiency
1,121 kWh	1,310 kWh
\$71	\$83

HVAC Replacement, A/C w/ Electric Heat

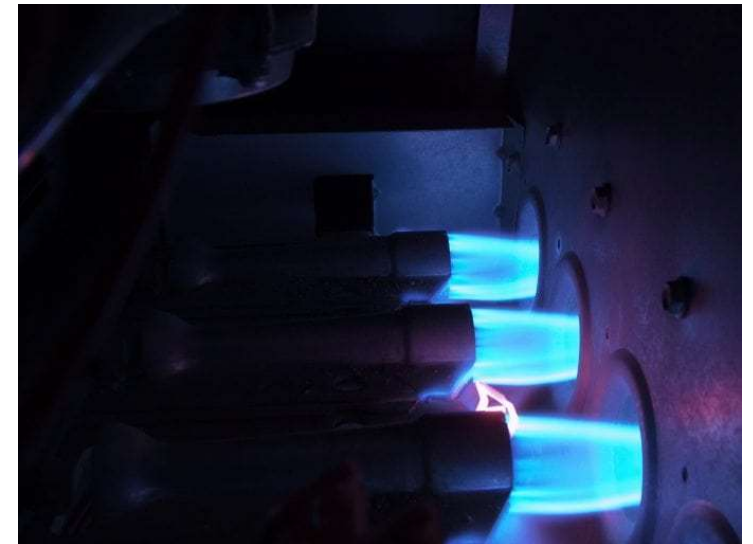
- ❑ Found in older homes w/o natural gas heat
- ❑ Electric furnaces (electric resistance heat) are very **reliable** but **inefficient**
- ❑ Recommended: Replace end-of-life A/C system with a high efficiency heat pump
 - ❑ DoE minimum efficiency: 14 SEER, 8.2 HSPF
 - ❑ Energy Star efficiency: 15 SEER, 8.5 HSPF
- ❑ For our model home:
 - ❑ Existing unit installed in 2003, with 10 SEER and 3.41 HSPF



Install DoE Minimum Efficiency	Install Energy Star Efficiency
2,218 kWh	2,368 kWh
\$141	\$150

HVAC Replacement, A/C w/ Gas Furnace

- ❑ Found in about 35% of homes in the region
- ❑ Most home with gas heating have an 80% AFUE efficiency
- ❑ Consider upgrading to a 90% AFUE efficiency
- ❑ Combine an end-of-life furnace replacement with A/C replacement
- ❑ Or, replace end-of-life furnace and A/C system with heat pump
- ❑ <https://www.pecanstreet.org/2019/09/electrictexas/>



Water Heater Efficiency

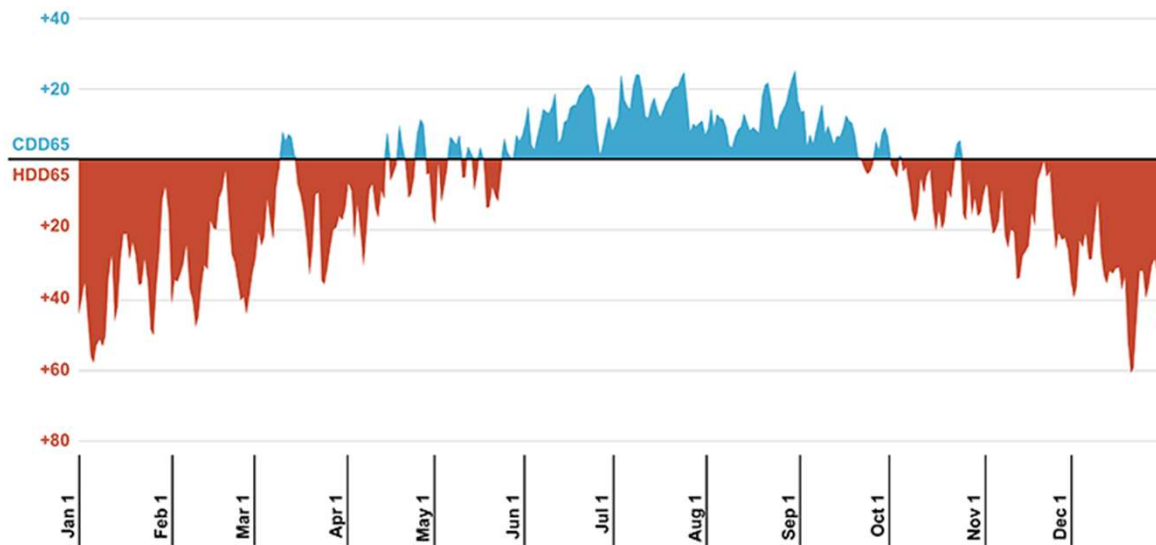
- ❑ Uniform Energy Factor - UEF
 - ❑ $\text{Delivered heat (kWh or BTU) / energy input (kWh or BTU)}$
- ❑ Gas tank: 0.58-0.69
- ❑ Gas tankless: 0.80-0.95
- ❑ Electric: 0.90-0.93
- ❑ Electric tankless: 0.93-0.95
- ❑ Electric Heat pump (hybrid): 2.75-4.00 UEF

Heating Degree Days and Cooling Degree Days (Base 65°F)

Location: St. Louis, Missouri

Average Annual HDD65: 4,817

Average Annual CDD65: 1,580

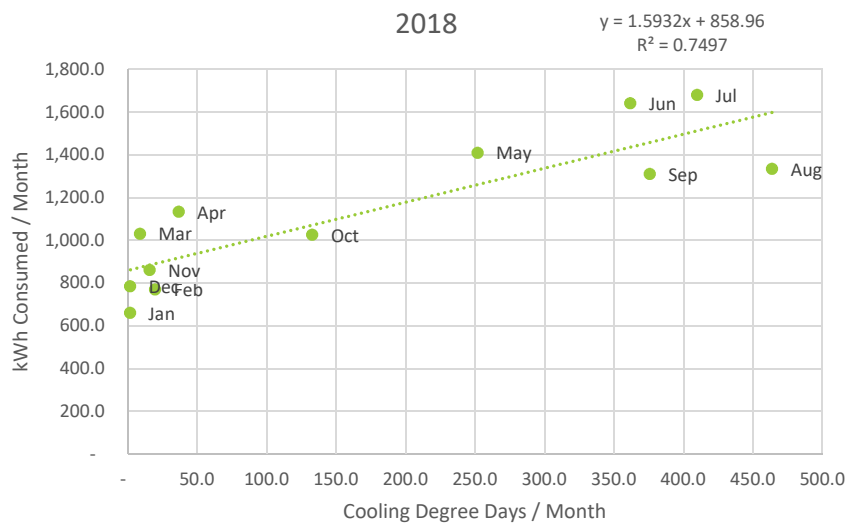


Source: Climate data from the National Climatic Data Center and accessed from the online EnergyPlus Weather Data resource provided by the National Renewable Energy Laboratory (NREL) via <https://energypius.net/weather> (accessed September 27, 2019).

Tracking Energy Savings

- Keep records of utility bills
- Normalize monthly utility consumption against weather data
 - Cooling degree days (CDD) / month
 - Heating degree days (HDD) / month

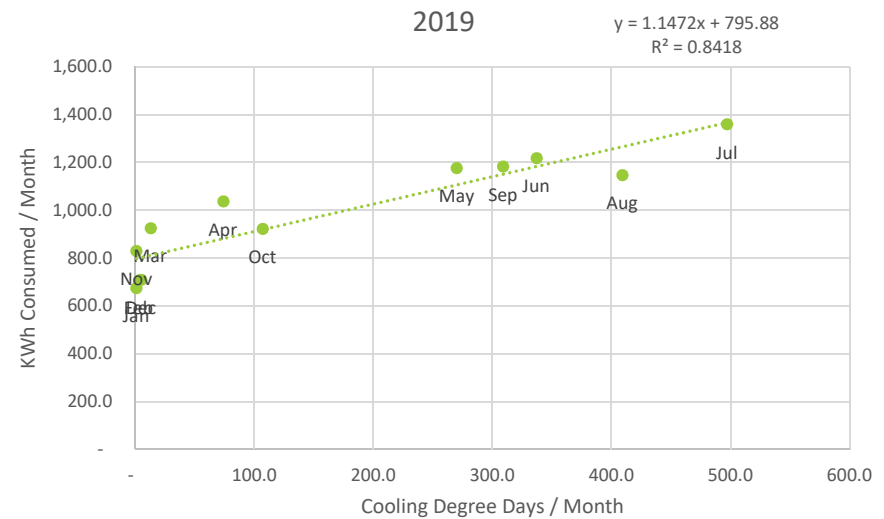
Tracking Energy Savings, Cont.



$$\text{Energy (kWh)} = 1.6 * \text{CDD} + 859$$

Monthly weather-related use: 1.6 kWh/CDD

Monthly non-weather use: 859 kWh



$$\text{Energy (kWh)} = 1.1 * \text{CDD} + 796$$

Monthly weather-related use: 1.1 kWh/CDD

Monthly non-weather use: 796 kWh

Additional Resources

- ❑ <https://michaelbluejay.com/electricity/>
- ❑ <https://www.energyvanguard.com/blog>
- ❑ lan.oconnor@nasa.gov