# WHOLE-HOUSE ANALYSIS OF ENERGY EFFICIENCY UPGRADES FOR EXISTING HOMES

Residential buildings consume roughly 20% of energy used in the United States. With the advancement of modern energy codes and equipment standards, new residential buildings typically perform at a much higher energy performance level than older, existing buildings. Opportunities for increasing the energy performance of existing homes have attracted the attention of utilities and state and federal government, which have all responded by developing initiatives to spur residential "energy retrofits" across the country.

This study serves as a guide for homeowners, remodelers, trade contractors, and weatherization agencies by providing information on prioritizing energy upgrades for existing homes. This unique research evaluates dozens of energy efficiency measures (EEMs) for their energy, economic, and environmental performance at 10 locations across 5 climates zones. While many systems were evaluated in the study, special emphasis was given to the performance of propane systems. The categories of EEMs are shown in the table on the inside left page.

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| ENERGY EFFICIENCY MEASURES | | | |
|---|---|---|---|
| **Building Envelope** | Windows | **Appliances & Lighting** | Clothes Washers |
| | Air Sealing | | Clothes Dryers |
| | Ceiling Insulation | | Dishwashers |
| **Space Conditioning Systems** | Propane and Heating Oil Furnaces | | Refrigerators |
| | Dual Fuel Heating Equipment | | High Efficiency Bulbs |
| | Propane and Heating Oil Boilers | **Domestic Water Heating Systems** | Propane and Heating Oil Storage Tanks |
| | Electric Central Air Conditioners | | Propane Tankless |
| | Aerosolized Duct Sealing | | Solar Thermal System with Propane Tankless Backup |
| | Propane Fireplace Inserts | | Electric Storage Tank |
| **Renewable Energy** | Solar Photovoltaic | | Electric Tankless Units |
| | | | Heat Pump Water Heater |

## KEY FINDINGS

*The study's final report arranges findings by climate zone for each EEM evaluated. While there are numerous replacement scenarios with attractive paybacks and emissions savings covered in the final report, some highlights include the following:*

**Specifying a high efficiency propane furnace in lieu of a standard efficiency propane furnace offers a 1 year payback in mixed-humid, cold/very cold, and Northeast regions.** The associated annual emissions savings are 1.9-3.4 metric tons of $CO_2$ for this upgrade — higher emissions savings than any lighting or appliance EEM analyzed across all climate zones.

**The dual-fuel system — pairing a high efficiency ASHP with a high efficiency propane furnace — offers simple paybacks of 4-6 years.** The dual-fuel system also provides consistently high annual emissions savings — over 3.3 metric tons of $CO_2$. These savings were sufficient to offset the $CO_2$ emissions associated with the consumption of approximately 370 gallons of gasoline annually.

**Selection of a propane clothes dryer over an electric clothes dryer has a payback of 5-6 years in the cold/very cold and Northeast climates with annual emissions savings ranging from <0.1 to 0.3 metric tons of $CO_2$.** These simple paybacks are shorter than the Energy Star refrigerator which had a 7-9 year payback in all climates.

**Replacing incandescent bulbs with 100% fluorescent lighting (e.g. CFLs) has a payback of 1 year or less regardless of the climate.** Likewise, air sealing the building envelope was also a consistently attractive measure with expected to paybacks of 1 to 4 years.

**Replacing an existing heating oil furnace with a high efficiency propane furnace offers a 1 year payback in the Northeast.** The high efficiency propane furnace also reduces emissions dramatically, offering 10-times the $CO_2$ emissions savings when compared to a high efficiency heating oil replacement furnace which also had a short payback. These emissions savings were enough to offset 213 gallons of gasoline consumption every year.

**Specifying a propane tankless unit over an electric tank in the Northeast has a payback of 5 years.** This EEM also has among the highest annual emissions savings at 0.6 metric tons of $CO_2$. The propane tankless units offer additional benefits in comparison to electric storage water heaters in that they have a 50% longer life expectancy and deliver hot water at nearly triple the hourly rate.

**Replacing a standard efficiency propane furnace with a high efficiency propane furnace is an extremely attractive EEM with Savings to Investment Ratios (SIRs) ranging from 5 to 20 across all climates.** SIR is the metric used by weatherization assistant programs to evaluate the economic value of an energy efficiency measure. SIR is the ratio of the economic (energy) savings realized over the life of the measure relative to the initial cost of installing the measure. A SIR of > 1 is necessary for a measure to be selected. Additionally, the dual-fuel system has an SIR of 3 or higher across all climates.

## SIGNIFICANCE OF FINDINGS

*Careful selection of energy efficient propane space heating equipment, water heating equipment, and appliances can result in cost-effective energy and emissions savings in residential retrofits. Homeowners can use the results of this study to plan ahead and proactively replace targeted mechanical systems that are near the end of their life with high efficiency equipment that will yield good returns on investment. Remodelers, trade contractors, and weatherization agencies can use this study to help guide their customers in making retrofit and replacement decisions and to make informed decisions regarding energy improvements to reduce utility costs for affordable housing residents.*

## SUMMARY OF PAYBACKS AND SIRs OF TOP PERFORMING EEMs

| Simple Payback[1] (Years) | TOP ENERGY EFFICIENCY MEASURES (SIR[2]) | | | | |
|---|---|---|---|---|---|
| | Hot-Humid | Hot-Dry/Mixed-Dry | Mixed-Humid | Cold/Very Cold | Northeast |
| **≤ 1** | • Lighting† (14) | • Lighting† (11) | • Air Sealing (21)<br>• HE Propane Furnace (14)<br>• Lighting† (9) | • Air Sealing (25)<br>• Propane Furnace (17)<br>• Lighting† (9) | • HE Oil Boiler (48)<br>• Air Sealing (27)<br>• SE Oil Furnace (26)<br>• HE Propane Furnace (20)<br>• Lighting† (13) |
| **2–3** | N/A | • HE Propane Furnace (7) | • Ceiling Insulation (15)<br>• SE ASHP (5) | N/A | • HE Oil Furnace (9)<br>• SE Oil Tank (3) |
| **4–6** | • Ceiling Insulation (8)<br>• HE Propane Furnace (5)<br>• Air Sealing (5)<br>• SE ASHP (4)<br>• Dual-Fuel (3)<br>• Electric HE Tank (2) | • Ceiling Insulation (11)<br>• Air Sealing (8)<br>• SE ASHP (4)<br>• HE ASHP (4)<br>• Dual-Fuel (3)<br>• Aerosolized Duct Sealing (3)<br>• WH: Electric HE Tank (2) | • Aerosolized Duct Sealing (5)<br>• HE ASHP (4)<br>• Dual-Fuel (4)<br>• GSHP (3) | • Ceiling Insulation (11)<br>• Aerosolized Duct Sealing (5)<br>• HE Propane Boiler (4)<br>• Propane Clothes Dryer (3)<br>• Dual-Fuel (3) | • Ceiling Insulation (9)<br>• HE Propane Boiler (6)<br>• Dual-Fuel (5)<br>• WH: Propane Non-Condensing Tankless (4)<br>• WH: Propane Condensing Tankless (4)<br>• WH: Propane HE Non-Condensing Tank (3)<br>• WH: Electric HE Tank (3)<br>• Propane Fireplace Insert (3)<br>• Propane Clothes Dryer (2)<br>• WH: Propane HE Condensing Tank (2) |

1. For Simple Payback, the lower the number the better; Calculated as Annual Savings/First Cost
2. For SIR, the higher the number the better; Calculated as (1/Simple Payback) x Useful Life†Lighting = 100% high efficiency fluorescent lighting
Powered entirely or partially by propane
*Abbreviations:* HE = High Efficiency; SE = Standard Efficiency; WH = Water Heater

## ABOUT THE STUDY AUTHOR

Newport Partners LLC is a Maryland-based company focused on the building industry with special emphasis on training and research related to energy efficient design. They have authored studies for government agencies, associations, manufacturers, and other studies for PERC on related topics.

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## GLOSSARY OF TERMS

**Aerosolized duct-sealing** – this technology involves injecting aerosolized sealant particles into a pressurized duct system where the particles adhere to crack edges to effectively seal leaks.

**AFUE** – also known as Annual Fuel Utilization Efficiency, this is expressed as the relationship between the amount of fuel entering a furnace or boiler and the amount of space heat that fuel is converted into. It is commonly expressed as a percentage.

**AHRI** – this acronym stands for the Air-Conditioning, Heating, and Refrigeration Institute, which provides certification and performance information on heating, ventilation, air conditioning, and refrigeration equipment and components.

**ASHP** – also known as an air source heat pump, these systems are typically used in moderate climates to heat and cool a home by using a vapor compression cycle to "pump" heat from a low temperature source to a higher temperature sink.

**Btu** – also known as a British thermal unit, it is the amount of heat required to raise one pound of water one degree Fahrenheit.

**Condensing** – for purposes of this report, this is a characteristic of some water heaters that use the heat from exhaust gases to assist in heating the water. Condensing units typically operate at a higher efficiency than non-condensing units.

**COP** – this acronym stands for Coefficient of Performance, and is a heating efficiency metric for a GSHP that is computed by dividing the heat output of a heat pump by the energy input.

**EEM** – this acronym stands for Energy Efficiency Measures. The report delineates between elective and non-elective EEMs. For the purposes of this report, elective measures are upgrades to a home that do not require immediate action by the homeowner. On the other hand, non-elective measures are typically made in haste, based upon the loss of a critical function in the home's operation.

**EER** – also known as Energy Efficiency Ratio, it is the measure of how efficiently a cooling system will operate when the outside air is assumed to be a specific temperature. Higher values signify a more efficient system.

**EF** – also known as Energy Factor, this relates to the efficiency level of a water heater. Within groupings of water heater equipment operating with the same energy source, higher values indicate more efficient systems. On its own, EF is an inadequate measure for comparing energy costs across water heating equipment of differing fuel types.

**FHR** – also known as First-hour rating, this is the amount of hot water a water heater can provide on a per hour basis, when starting with a full tank of water.

**GSHP** – also known as a ground source heat pump, these units use the relatively constant temperature of the earth to regulate a home's indoor air temperature.

**HSPF** – also known as Heating Seasonal Performance Factor, this is a measure of the heating efficiency of a heat pump. Higher values indicate systems that are more efficient.

**IECC** – this acronym stands for the International Energy Conservation Code, which is the primary national model energy code.

**Manual J 8th Edition** – from the Air Conditioning Contractors of America (ACCA), this manual serves as the industry standard for estimating residential heating and cooling loads.

**MEF** – also known as Modified Energy Factor, is a metric for clothes washer energy performance. The higher the value, the more efficient the clothes washer is.

**Metric ton** – a unit of measure equal to 2,204.6 pounds.

**Non-condensing** – for purposes of this report, this characteristic refers to water heaters that do not extract heat from combustion gases to the point of condensation. In general, non-condensing units are less efficient than condensing units.

**R-value** – this provides a measure of a material's resistance to heat flow. The greater the value, the more resistant a material is to heat flow. It applies primarily to insulation.

**Return on Investment** – for purposes of this report, the monetary savings resulting from the implementation of an EEM divided by the cost of the EEM.

**SEER** – also known as Seasonal Energy Efficiency Ratio, it is the measure of the cooling efficiency of an air conditioner or heat pump. Higher values signify cooling systems that are more efficient.

**SHGC** – also known as the Solar Heat Gain Coefficient, is a measure of the fraction of the sun's heat that passes through a window. Expressed as a value between zero and one, a lower value signifies less transmission of solar heat.

**SIR** – Savings to Investment Ratio is the ratio of the monetary savings realized from a measure over its useful life to the cost of installing the measure. A SIR of 1 or greater is usually considered a good investment.

**U-factor** – similar to an R-value, this measures the rate of heat flow through a material. The lower the value, the better the material will be able to insulate. It is most often applied to windows.

**Weatherization Assisted Program (WAP)** – is a jointly administered DOE/HUD program to make energy and health and safety improvements to low income housing.

### FOR MORE INFORMATION

To learn more about the Propane Education & Research Council, visit **propanecouncil.org**.

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