Benefits of Heat Pumps for Homes in the Southwest

By Neil Kolwey and Howard Geller

June 2018

SWEEP
SOUTHWEST ENERGY EFFICIENCY PROJECT

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EXECUTIVE SUMMARY

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Acknowledgements

We would like to thank Kenji Takahashi of Synapse Energy Economics for his very valuable help with the analysis. We thank two HVAC contractors for their very helpful equipment and installation cost estimates: Jesse Pridmore of Comfort Air Distributing, Denver, CO, and Rich Morgan of Magic Touch Mechanical, Phoenix, AZ. We thank Stacy Tellinghuisen of Western Resource Advocates for her help with the projections of GHG emission factors for the four electric utilities included in the study.

Finally, we thank the following people for reviewing and providing comments on a draft of the report:

Jamie Howland, Acadia Center
Steve Nadel, American Council for an Energy-Efficient Economy
Jeff Deason, Lawrence Berkeley National Laboratory
Eric Wilson, National Renewable Energy Laboratory
Jeff Mitchell, Northwest Energy Efficiency Alliance
Kenji Takahashi, Synapse Energy Economics
Mark Modera, Western Cooling Efficiency Center

The authors assume responsibility for any errors or omissions that remain in the report.

About SWEEP

The Southwest Energy Efficiency Project is a public interest organization dedicated to advancing energy efficiency in Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming. For more information, visit: www.swenergy.org

About the authors

Neil Kolwey is the Industrial Program Director at the Southwest Energy Efficiency Project (SWEEP), where he leads programs to advance energy efficiency in the industrial sector. Neil promotes best practices in utility energy efficiency programs for industrial customers throughout the region and promotes policies to support combined heat and power. Neil also manages the Colorado Industrial Energy Challenge, a voluntary program encouraging industrial facilities in Colorado to share energy efficiency and energy management best practices.

Howard Geller is the Executive Director of the Southwest Energy Efficiency Project (SWEEP), a public interest venture he founded in 2001. Howard also leads SWEEP's work on utility energy efficiency policy and programs. Dr. Geller is the former Executive Director of the American Council for an Energy-Efficient Economy (ACEEE).

I. EXECUTIVE SUMMARY

Heat pumps are a mature but still improving technology for energy-efficient space and water heating. In the past five years, the cold-weather performance of air-source heat pumps for residential applications has improved dramatically, allowing heat pumps to be more practical and cost-effective in more areas of the U.S. than was the case previously. Heat pumps can reduce heating costs compared to electric-resistance or fossil fuel-based heating, and can also reduce energy consumption and carbon dioxide (CO_2) emissions compared to these other heat sources.

Previous heat pump studies have mainly focused on analyzing the benefits of heat pumps compared to electric resistance, propane, and fuel oil heating sources. These expensive heating sources are good targets for cost-effective replacement with heat pumps, especially at the time of furnace, boiler, or air-conditioning (AC) system replacement. Using this targeted approach, the Northwest and Northeast regions have developed comprehensive strategies to encourage installation of heat pumps, including state and utility incentives for heat pumps, and education of home owners and mechanical contractors.

In the Southwest states, natural gas is the most common fuel used for home heating. In this study, we focus on whether heat pumps can be cost-effective and reduce energy consumption and greenhouse gas (GHG) emissions compared to heating with gas furnaces, in homes that also have central AC. The study examines these issues for five major southwestern cities (Denver, Salt Lake City, Phoenix, Las Vegas, and Reno). We analyze the potential benefits of installing heat pumps in new homes, as well as in existing homes at the time of needing to replace either the gas furnace or the AC system. We also examine the cost effectiveness and impact on GHG emissions of replacing natural gas water heaters with heat pump water heaters (HPWHs). Our cost effectiveness analyses consider the life-cycle costs from the consumer's perspective.

Main findings

For new homes, our study shows that duct-less mini-split heat pumps are cost-effective in all areas of the Southwest, mainly because of slightly lower installed costs compared to separate gas furnace and central AC systems. New homes with both mini-split heat pumps and HPWHs (and without any other gas appliances) also eliminate the need for natural gas service to the home, which further improves the overall cost-effectiveness, by eliminating the monthly fixed natural gas cost and the cost of the natural gas service connection to the home.

For new homes, ductless mini-split heat pumps also reduce primary energy consumption by an average of 31 percent, and reduce GHG emissions by 19-46 percent, depending on the electric utility's GHG emission factor. (See Table ES-1.)

Table ES-1. Heat Pump Energy Savings and GHG Benefits

	New homes		Existing homes	
City	Primary Energy Savings	GHG Emission Reductions	Primary Energy Savings	GHG Emission Reductions
Denver	31%	32%	16%	18%
Salt Lake City	32%	19%	18%	2%
Reno	32%	46%	17%	35%
Las Vegas	32%	42%	10%	22%
Phoenix	29%	36%	3%	14%

For existing homes, the picture is less clear. Heat pumps are cost-effective in Phoenix, at the time of replacement of the existing AC system or gas furnace. Heat pumps are not cost-effective in the retrofit scenarios in Denver, Salt Lake City, Reno, or Las Vegas, due to slightly higher initial costs for a cold-climate heat pump, and/or higher annual heating costs for heat pumps because of relatively low natural gas prices in these cities.

Despite the cost-effectiveness challenges, our study shows that heat pumps reduce source energy consumption in the retrofit scenarios by an average of 13 percent across the five cities, and reduce GHG emissions by a range of 2 percent (Salt Lake City) to 35 percent (Reno) (see Table ES-1).

Our study revealed two useful rules of thumb regarding heat pumps compared to natural gas furnaces:

1. We estimate that for heat pumps to reduce annual heating costs, the ratio of the residential electricity price to natural gas price (the variable components, in equivalent units) must be no more than about 3.2. This assumes an average coefficient of performance (COP) for the heat pump of 2.7 and annual efficiency of the gas furnace of 95 percent.
2. Our analysis shows that for heat pumps to reduce GHG emissions, a heat pump system with a seasonal average COP of at least 2.7 requires a regional or utility GHG emission factor of no more than 1,200 lb CO_2/MWh. All of the utilities serving the cities we analyzed are expected to have an average emission factor below this value over the lifetime of a heat pump, with the exception of Rocky Mountain Power in Utah. And for the United States generally, 37 states already have average emission factors below this threshold. More states are likely to pass this threshold in the future, as utilities continue to retire coal plants and replace them with renewable generation (or some combination of renewable and natural gas combined-cycle generation).

Heat pump water heaters (HPWHs) are cost-effective compared to natural gas water heaters in Phoenix, with a simple payback period of 6.2 years. HPWHs reduce annual energy costs in all cities except Denver and Reno. In addition, ENERGY STAR HPWHs significantly reduce primary energy consumption (by about 52 percent) and GHG emissions (by 38-64 percent) compared to ENERGY STAR natural gas water heaters, as shown in Table ES-2 below.

Table ES-2. Benefits of Heat Pump Water Heaters

City	Energy Cost Savings (%)	Total NPV Cost Savings; % Savings		Primary Energy Savings (%)	GHG Emission Reductions (%)
Denver	-18%	-$820	-32%	50%	52%
Salt Lake City	25%	-$275	-9%	50%	38%
Reno	-5%	-$703	-27%	52%	63%
Las Vegas	1%	-$644	-22%	54%	64%
Phoenix	41%	$289	7%	52%	66%

Note: Values in red indicate the HPWH has higher energy or total costs.

Recommendations

SWEEP recommends that state policy-makers, utilities, and local governments work together in the four main areas highlighted below.

Incentives and Financing. Electric utilities should develop, and obtain approval from regulators as necessary, incentives for heat pumps and HPWHs in the following areas and applications:

- Incentives for heat pumps for homes currently using electric resistance heating. For colder climates, the incentives should specify the Northeast Energy Efficiency Partnership (NEEP) cold-climate heat pump specification.
- Incentives for ENERGY STAR-rated ductless heat pumps for new construction (new homes or new additions).
- Incentives for ENERGY STAR-rated HPWHs in any home based on the significant energy and GHG emissions benefits.
- For existing homes, we recommend that electric utilities be allowed to promote and offer incentives to consumers who are willing to replace a gas furnace (or propane or fuel oil heating system) with a heat pump, based on the energy savings and GHG emissions benefits. However, we suggest that utilities focus these incentives on the more cost-effective retrofit options, namely homes with electric resistance or propane heating, or homes with gas furnaces in Phoenix and Las Vegas.

We also recommend that energy efficiency loan programs in the region include ENERGY STAR heat pumps and HPWHs as eligible measures, based on the potential energy savings and GHG emission reductions of these technologies.

Electric Rates. A number of utilities in the Southwest employ inverted block rates (IBRs) for residential customers, under which the variable electricity price (price per kWh) increases in tiers as electricity use increases. IBRs are a disincentive to heat pump and HPWH adoption because the incremental electricity use is likely to be in the highest, most-costly consumption tier.

To overcome this barrier, electric utilities should offer a time-of-use (TOU) rate option for residential customers, if this type of rate is not already available. TOU rates can improve the cost-effectiveness of heat pumps and HPWHs. Heat pumps would be used for heating in the winter

months, when rates would be lower. And HPWHs can be programmed to operate outside of the on-peak, high rate times, during all months.

Education. In addition to higher initial costs, heat pumps face challenges including lack of awareness on the part of home owners and some HVAC contractors, especially with respect to newer technologies such as ductless heat pumps and HPWHs. To overcome this barrier, utilities, states, and local governments in the Southwest should consider the following activities either individually or in partnership:

- Promote best practices in air-source HP installation, as well as the cold-climate specifications and product lists for both heat pumps and HPWHs.
- Increase consumer awareness of the benefits of heat pumps, through developing case studies of successful applications and other educational materials.
- Increase confidence of heat pump performance and benefits among HVAC equipment installers and home builders, through expanded training and education.
- Promote awareness and training in advanced control technologies to allow automated coordination among multiple heating systems (when backup heating systems are employed along with heat pumps).

Regional Market Transformation. The successful heat pump and HPWH initiatives in the Pacific Northwest and Northeast employ a comprehensive market transformation approach. This approach includes upstream incentives to increase availability of qualifying products in the marketplace and in some cases financial incentives for consumers as well as consumer education; training and education to create an engaged network of contractors and installers; and collaboration with equipment manufacturers to reduce upfront costs. The overall effort is planned and coordinated at the regional level by the Northwest Energy Efficiency Alliance (NEEA) in the Northwest and NEEP in the Northeast.

We recommend establishing a similar heat pump market transformation initiative in the Southwest, targeting new homes, HPWHs, and the more cost-effective retrofit options. Utilities can and should play a key role in this initiative, but experience in the Northwest and Northeast shows that a more comprehensive effort is needed to move the marketplace in a substantial way. The regional market transformation initiative should include interested state and local governments, trade groups, and equipment manufacturers. A Southwest heat pump initiative, if established, should also seek to collaborate with NEEA and NEEP in order to learn from their experience promoting heat pumps and HPWHs, and to facilitate a larger market impact.