Heat Pumps

An alternative to oil heat for the Northeast—input for planners and policy-makers

Ryan Matley | March 2013

ROCKY MOUNTAIN INSTITUTE | RMI.ORG

2317 Snowmass Creek Rd. Snowmass, CO 81654

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EXECUTIVE SUMMARY

Heating is the third largest end use for oil, accounting for 7% of U.S. consumption. Its use is concentrated in the Northeast (New England plus New York, New Jersey, and Pennsylvania).

Heating oil is an economic drain on the region, costing residents and businesses over $14 billion annually. Rural residents disproportionately bear those costs. Fifty-five percent of rural households in the Northeast use fuel oil or propane as a heating source, compared to only 25% of urban households.

Users of heating oil are at a crossroads as the fuel is increasingly untenable for long-term use. Pressure on crude oil costs from global demand will continue to drive up heating costs, while oil's emissions raise important climate concerns. There are two alternative paths available: natural gas and electric heat pumps.

Many states in the region are studying multi-billion dollar expansions of their natural gas distribution systems in response to the recent decline in natural gas prices. At today's prices, natural gas can offer compelling economics, particularly for customers on or near the existing distribution system. But states may be overlooking another heating technology whose economics can match or beat gas: heat pumps.

Over the long term, heat pumps have reduced exposure to volatile fossil fuel prices (particularly natural gas), and can be paired with renewable electricity generation. Entirely replacing oil heating with heat pumps can save the region $5.5–6.0 billion in fuel costs annually. Paired with a renewable grid, heat pumps can also put the region on track to meet the 80% greenhouse gas reduction target that the U.N. Intergovernmental Panel on Climate Change (IPCC) has declared necessary to avoid the most dramatic impacts of climate change.

A number of barriers historically stood in the way of heat pumps: high first cost, lack of awareness, and the difficulty of retrofitting homes and businesses.

Yet states can take numerous steps to address these barriers. In particular, focusing on reducing the upfront cost will drive the industry toward self-sufficiency and resolve many of the other barriers.

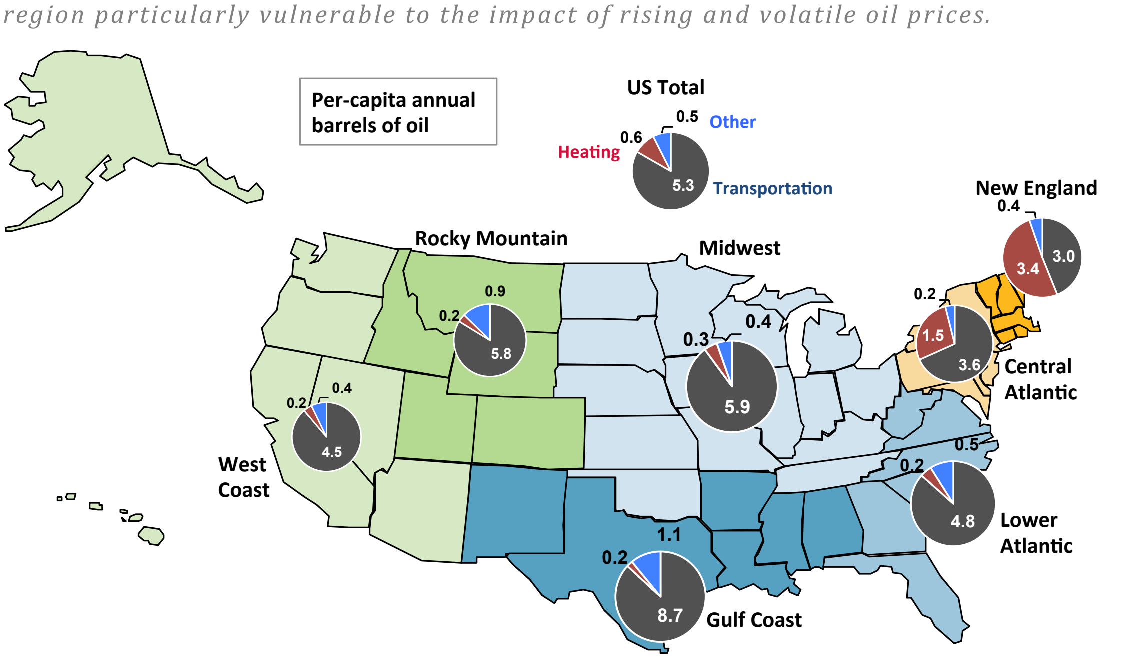
AN ECONOMIC AND ENVIRONMENTAL DRAIN ON THE NORTHEAST

The U.S. uses a lot of oil. This dependence underpins our way of life, has powered our rise to global superpower status, and increasingly threatens our environment, national security, and economic well being. In 2011, we consumed 18.8 million barrels of oil per day,[1] nearly twice as much per capita as Europe.[2]

The fact that we consume a lot of oil is not news, but our oil addiction is not simply a transportation issue. While nearly three quarters of our oil consumption powers on- and off-road vehicles, heating is the third largest contributor to our oil habit, comprising 7% of total demand.[3] Nearly 600 gallons of oil are consumed *per second* to heat our homes and buildings, even though there are many alternatives. Two-thirds of that heating oil use occurs in the Northeast U.S. (New England, New York, New Jersey, and Pennsylvania). So much heating oil is consumed in the region that it locally rivals or surpasses oil used for transportation (Figure 1).

Figure 1 – Regional and national per-capita oil, propane, and motor gasoline consumption by end use, 2010

More oil is consumed in New England for heating than transportation, making the region particularly vulnerable to the impact of rising and volatile oil prices.



Sources: U.S. EIA Sales of Fuel Oil, Propane, and Motor Gasoline by End-Use, U.S. Census Bureau Total Population by State

[1] U.S. Energy Information Administration (EIA)
[2] U.S. EIA, International Energy Outlook 2011
[3] U.S. EIA, Annual Energy Outlook 2013

Heating oil is therefore an economic drain on the Northeast. Its use costs the region's residents and businesses over $14 billion annually in fuel cost alone, roughly equivalent to the combined state budgets of New Hampshire, Vermont, and Maine.[4] That equates to $1,600 per household and $16,100 per business. Those averages obscure the fact that residents of northern New England, who have 35% greater heating requirements than the rest of the region, use and pay even more.[5]

Heating oil use is most common in rural areas. Fifty-five percent of rural households in the Northeast use fuel oil or propane as a heating source, compared to only 25% of urban households.[6] Residents of rural areas on average have lower annual incomes ($31,700) than residents of suburban ($35,200) and urban ($43,500) areas.[7] Therefore, the residents who can least afford it pay a substantial premium to heat their homes and businesses.

Table 1 – Heating oil in the Northeast by the numbers

Nearly 2 million of the 6.4 million households using fuel oil are in rural areas (defined as populations less than 2,500), while over half of the commercial buildings using fuel oil have less than 5 workers.

	Residential	Commercial	Total
Number of Households/Businesses	6,400,000	254,000	6,654,000
Energy Use (trillion BTU)	470	240	710
Total Annual Cost (million $)	$ 10,100	$ 4,100	$ 14,200
Annual Cost per Customer ($)	**$ 1,600**	**$ 16,100**	

Sources: U.S. EIA State Energy Data System (SEDS) 2010, U.S. EIA Commercial Building Energy Consumption Survey (CBECS) 2003, U.S. Census Bureau American Community Survey (ACS) 2011

Crude prices, which have risen substantially in recent years, directly drive heating oil prices and are unlikely to return to history's low levels. Rising U.S. oil production is not low-cost production.

The increasing cost of oil heat causes economic hardships, but fuel oil heating also raises environmental concerns. Heating oil combustion emits 43,000 tons of NO_x and 69,000 tons of SO_x annually into the atmosphere.[8] These common air pollutants (also know as criteria pollutants) are linked to increased rates of asthma, respiratory illness, heart attacks, strokes, and premature death.[9] They are also contributors to smog, acid rain, and nitrogen deposition that degrades our air, water, and ecosystems. In addition, burning oil for heat adds 57 million tons of CO_2

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4 Sunshine Review, accessed Jan. 28, 2013 at: http://sunshinereview.org/core/state-budgets/
5 U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Historical Climatology Series, State Heating Degree Days, 2009-10
6 U.S. Census Bureau, 2011 American Community Survey
7 U.S. Bureau of Labor Statistics, Per capita personal income by county, 2010. Rural defined as counties with <50,000 population, suburban with populations between 50,000 and 250,000, and urban with population greater than 250,000.
8 EPA Emission Factors, U.S. EIA State Energy Data System 2010
9 American Lung Association, "American Lung Association Energy Policy Development: Heating Background Document," Feb. 2011

emissions to the atmosphere (the emissions equivalent of over 10 million cars per year), accelerating climate change and its associated risks.[10]

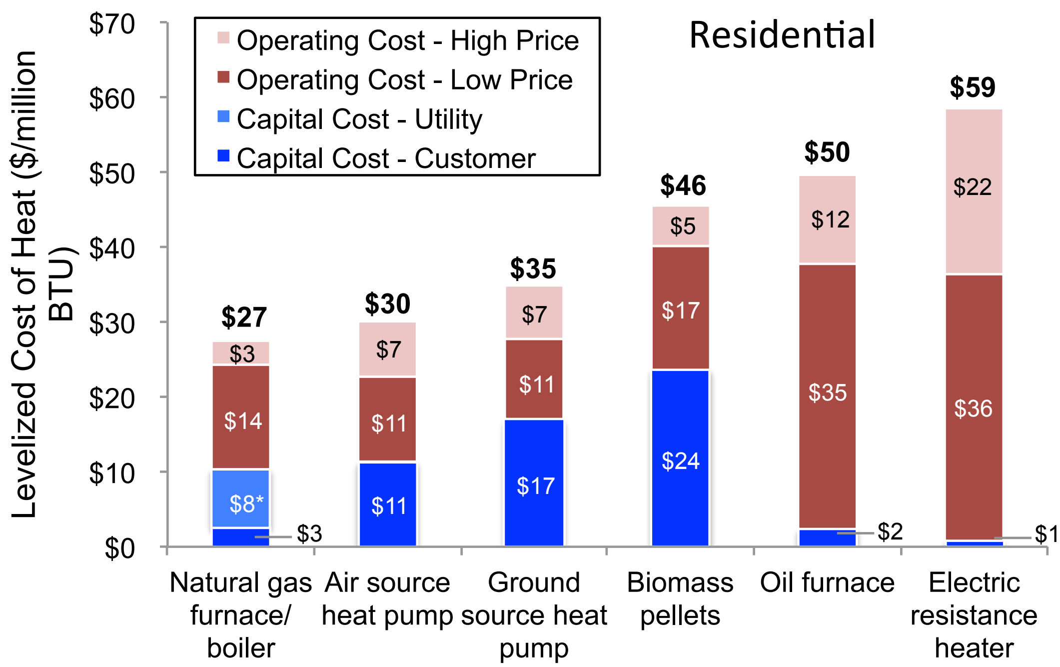
Oil use exacerbates global security issues as well. Many of the dollars spent on oil are exported overseas, supporting foreign countries often hostile to our interests. To secure this global supply chain, we fund and maintain one of the largest and most capable militaries in the world, and deploy soldiers across the globe.

ALTERNATIVES CAN SAVE MONEY AND REDUCE EMISSIONS

Fortunately, alternatives to oil heat exist that are both cheaper and less polluting. Alternative fuels available to heat buildings include primarily natural gas and electricity, but also biomass and in some cases solar. Each of the two primary sources can deliver heat in multiple ways. Natural gas can fuel a forced-air furnace or a boiler, while electricity can provide heat through electric resistance or heat pumps. Three fuel/technology options stand out as the most compelling due to their low cost: natural gas furnaces, natural gas boilers, and heat pumps (Figure 2).

Figure 2 – Levelized cost of residential space heating options

The levelized cost reflects the capital and operating cost of each million BTU of heat provided over the course of the technologies' lifetime under different price forecast scenarios.



**This is a per customer estimated cost of expanding the natural gas pipeline system to serve new customers, based on Connecticut's proposed expansion plan.*

[10] EPA Greenhouse Gas Equivalency Calculator, accessed Jan. 28, 2013 at: http://www.epa.gov/cleanenergy/energy-resources/calculator.html

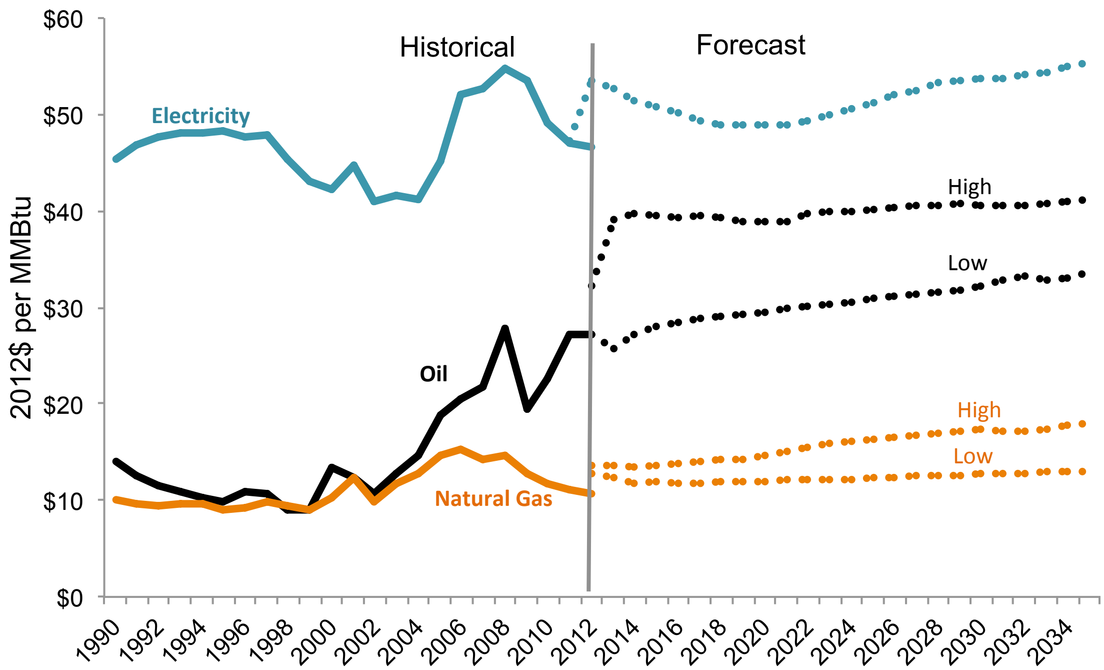
Natural Gas

Natural gas is cheap today, but it is both unlikely to stay that way and costly to expand its distribution system. Price volatility and emissions each bring mid- and long-term risks.

Traditionally, oil and natural gas prices moved in tandem since natural gas was a byproduct of oil production. New drilling techniques dramatically expanded available natural gas and caused natural gas prices to decouple—to fall relative to oil prices—resulting in a compelling economic opportunity to switch from oil heating (Figure 3). At today's prices, transitioning from fuel oil to natural gas offers the opportunity to reduce a residential customer's annual heating bill from $1,600 to $1,000.

Figure 3 – New England natural gas, electricity, and oil prices

While oil and natural gas prices have traditionally moved in tandem, fuel price forecasts expect the recent disparity between oil and natural gas prices to continue.



Source: EIA historical data and Annual Energy Outlook 2012

The growth in production from the Marcellus Shale, centered in western Pennsylvania but extending from West Virginia to New York, has turned interstate pipelines in the region on their heads. The system was designed to import natural gas from the Gulf Coast or off shore, but is now being re-engineered to also export or bring to market local gas production. Many states in the region are studying large expansions of their natural gas distribution systems in response to this expanded supply. Connecticut is considering a $5 billion expansion to its natural gas distribution system. New York and Pennsylvania are actively investigating and scoping similar opportunities.

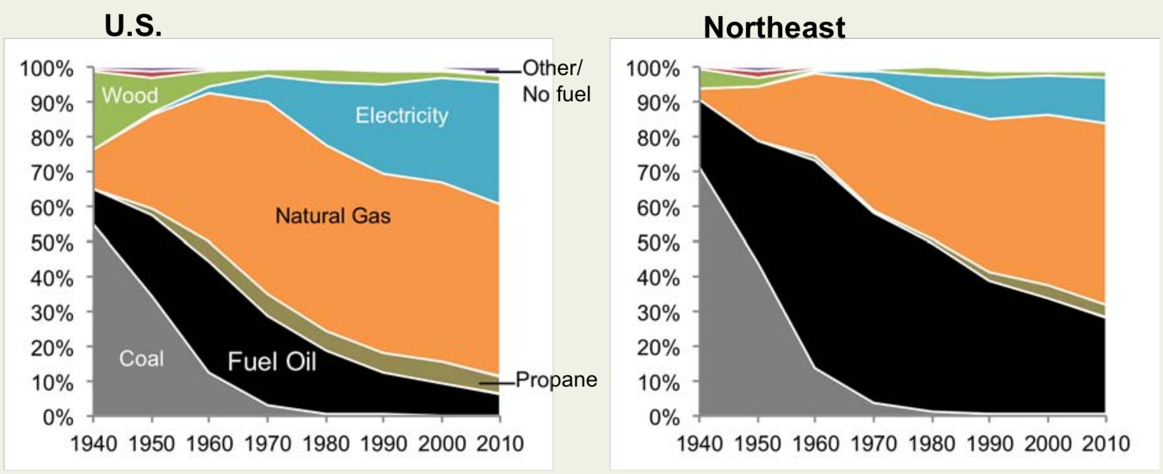
Despite these aggressive expansion plans, natural gas is not a near-term alternative for millions of rural homeowners and businesses in the Northeast. It is costly to expand the systems for distribution ($0.4–1.2 million per mile) and transmission ($1.5–2 million per mile or more), which makes the economics challenging for more sparsely populated areas of the Northeast. For example, the proposed total cost of a customer-purchased natural gas heating system plus the utility-funded system expansion in Connecticut ranges from $11,800 for each household already located within 150 feet of a distribution main to an average of $22,160 for those off the distribution main. Vermont Gas's $83 million Addison County expansion project will cost an average of $35,000 per customer connection in a county that has a population density less than a quarter of Connecticut's least populous county.

How did we get here?

Oil-fired boilers emerged in the 1920s and started replacing coal-fired heat en masse around World War II (Figure 4). Oil boilers were superior in two critical ways that drove their popularity. First, homeowners did not need to regularly shovel dusty coal to keep the heat going. Second, the temperature could be finely controlled with a thermostat rather than crudely through the size of the shovelful of coal used and the damper setting.

Figure 4 – Household heating fuel market share, 1940–2010

Compared to the U.S. as a whole, the dominant market position of fuel oil in the Northeast has slowed the growth of natural gas and electric heating.



Source: U.S. Census Bureau American Community Survey (ACS) 2011

While there were many benefits to replacing coal, the fact that oil was the primary fuel to supplant it in the Northeast is due to the intertwined relationship between geography and economics. The Northeast sits at the end of the natural gas pipeline system, making natural gas more expensive and less available there relative to the rest of the country. That pipeline system did not begin to serve New England until the mid-1950s, well after the oil transition was underway. The region is easily accessible to tankered heating oil shipments, making this fuel source readily available at a cost that has remained low until recent years. This constellation of forces has helped to embed fuel oil's physical and market infrastructure in the region.

Heat Pumps

Heat pumps are a low-cost alterative with low fuel price risk and better environmental attributes. Air source is the ideal retrofit technology, while ground source has a role in new construction.

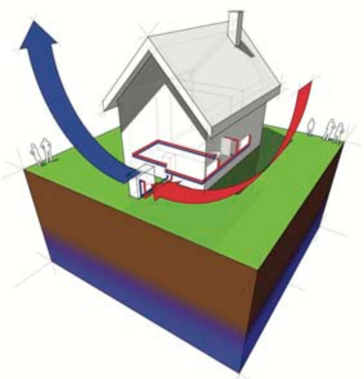
Fortunately, there is an under-used heating technology that can at least match and often beat the economics of natural gas expansion, and has the prospect of further cost reductions: heat pumps. This electrically powered heating technology operates much like a refrigerator run in reverse, extracting heat from the air or ground outside rather than creating it from fuel. It can also be operated in reverse to either provide cooling to households previously without air conditioning or provide it more efficiently than many existing window or central A/C units. (This paper focuses simply on heating economics.)

Heat pump systems have been available since the 1950s but have captured only a small share of the heating and cooling market. They are available in two types: air source and ground source. As their names imply they differ primarily in the portion outside the home, with ground-source heat pumps exchanging heat with the ground and air-source heat pumps exchanging heat with the air.

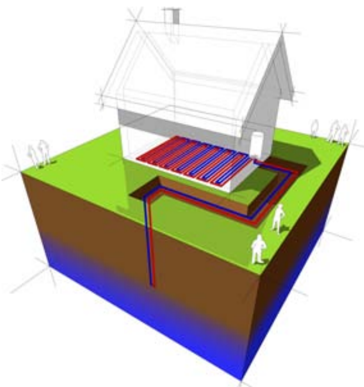
Ground-source heat pumps, also referred to as geothermal heat pumps, require the added expense of drilling or trenching to install a ground-loop heat exchanger, but allows for high operating efficiencies across all outside temperature ranges, and low operating costs. Such systems are in common use in the upper Midwest.

Air-source heat pumps are less expensive to install, since they do not require a ground loop. They were once a poor match for colder climates, such as the Northeast, because their operating efficiency degraded as outside temperatures dropped below freezing, making them expensive to operate and offering limited comfort on truly cold days. This has changed. New variable refrigerant flow (VRF) heat pump technology now offers high operating efficiencies down to very low outside air temperatures. These systems are just starting to penetrate the market and offer the potential of low upfront cost coupled with low operating cost.

Figure 5 – Heat pump configurations



Air-Source Heat Pumps



Ground-Source Heat Pumps

Credits (clockwise): Shutterstock/Slavo Valigursky, Shutterstock/Awisut Phrommakon, Shutterstock/Sinisa Botas, Wikimedia Commons/Marktj, Shutterstock/Slavo Valigursky

Heat pumps are available in a variety of configurations, allowing for a retrofit of every typical residential HVAC system. An air-source heat pump consists of an outdoor condensing unit, which captures ambient heat from outdoor air, and an indoor fan-coil unit that supplies tempered air to the building. Fan-coil units can fit within a duct (identical to typical "central air" configurations), or be installed in a ductless configuration (commonly seen in hotels). The range of available heat pump configurations means there is a retrofit opportunity for all common existing heating/cooling configurations (Table 2).

Table 2 – Heat pump configurations in common residential applications

Air-source heat pumps are best suited for retrofits, but the exact type depends on the existing heating configuration. Ground-source heat pumps are best matched for residential new construction projects.

Existing Heating System	Existing cooling system	Heat pump replacement
Electric resistance	None or window A/C	Ductless air-source heat pump
Fuel oil: hydronic	None or window A/C	Ductless air-source heat pump
Fuel oil: ducted forced air	Central A/C	Ducted air-source heat pump
New construction		Ground-source or air-source heat pump

In both commercial and residential applications, VRF air-source heat pumps offer superior operating efficiency. They pair a single outdoor condenser with either one or multiple indoor fan-coil units, either ducted or ductless. VRF systems utilize inverter-driven compressors that operate efficiently at all load profiles. This allows for optimal temperature and airflow control at each fan-coil, and enables innovative control strategies such as routing refrigerant between zones with simultaneous heating and cooling. This happens quite frequently in mild, shoulder seasons. Thus heat can be carried from a zone requiring cooling to a zone requiring heating without running a compressor, drastically reducing energy use. The technology has been popularly applied in Asia, Australia, and Hawaii for the past decade, but is just beginning to take hold in the mainland U.S. market.

Though ground-source heat pumps boast higher operating efficiencies (and therefore lower operating costs) than air-source heat pumps, their high capital cost because of drilling/excavation requirements are a challenge for retrofit applications, particularly at the residential scale. Large commercial and institutional retrofits can be good matches for ground source, where space is available, economies of scale can reduce costs, and capital is more accessible. They are also well suited for residential new construction, where the ground loop can be installed for much less during construction, and designs such as radiant floor heating can leverage the technology's unique characteristics.

Biomass may be an option in some regions
There is one additional alternative to oil heating gaining traction in northern New England: biomass pellet boilers. This technology is the next evolution for a centuries-old heating source: burning wood. These systems burn small wood pellets that are loaded into a storage bin and automatically fed into the boiler. The automation allows the biomass boiler to operate more similarly to an oil or natural gas boiler than a wood-burning stove or fireplace. These systems have become popular in areas of Europe and have begun to filter into the U.S. Capital costs are high—roughly $20,000 for a residential system—but operating costs are low, particularly in regions with a large biomass resource. This technology will likely play a niche role in the future portfolio of renewable heating sources.

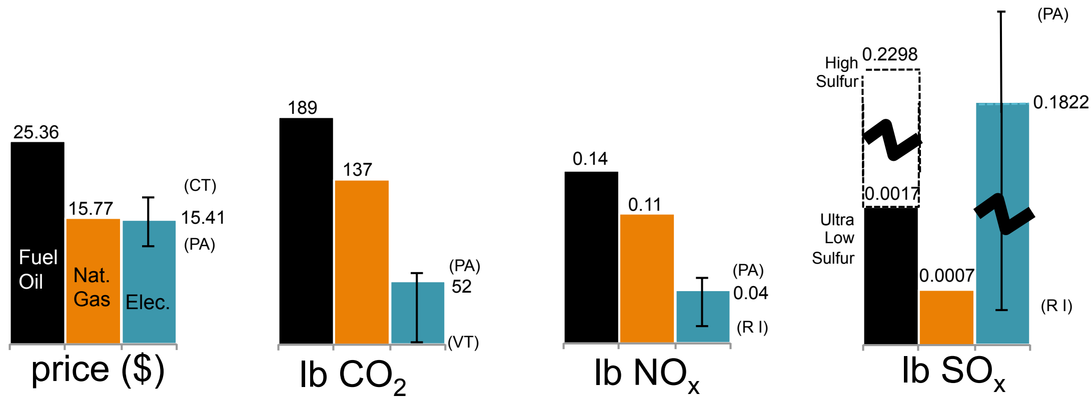
Entirely replacing oil heating with heat pumps can save the region $5.5–6.0 billion in fuel costs annually,[11] a roughly 40% savings over the region's existing $14 billion annual heating oil fuel bill. The average residential household would see their heating bill drop from $1,600 per year with oil to anywhere from $625–$950 depending on their electric rate.

The switch to heat pumps will reduce emissions of NOx, SOx, and CO_2 by 81%, 66%, and 81% respectively.[12] Those reductions are based upon the current generation mix in the Northeast grid, but will vary significantly in each state due to variations in electric generation (Figure 6). And because heat pumps are electrically powered, they offer a pathway—through a renewably powered grid—to very-low- or zero-carbon heating.

[11] RMI calculations based on data from U.S. EIA State Energy Data System, 2010
[12] EPA eGrid Data 2009, U.S. EIA State Energy Data System 2010

Figure 6 – Fuel characteristics per million BTUs of heat delivered

When adjusted for heating system conversion efficiency, oil emits more NO_x, SO_x, and CO_2 and costs more than natural gas and electricity. Electricity cost and emissions depend heavily on the generating resource mix in each state.



Source: EPA eGrid 2009

This cost- and emissions-saving opportunity will require investment in heat pumps. Air-source heat pumps can be installed for about $10,000 per household, or $4,000 per unit in a partial retrofit. That investment stacks up quite favorably compared to the $11,800–$35,000 per household needed to expand the natural gas system. Undoubtedly, there are some locations (particularly near or on the existing gas distribution system) where natural gas is the lowest-cost option. But heat pumps are easily the lowest-cost solution for rural areas, and likely so in many suburban and urban areas as well.

There is reason to believe that these advanced heat pump costs will fall as the market expands. Heat pump technology is relatively mature, but because it is still new to the U.S. there are limited distributors and skilled installers. Increased adoption will encourage equipment market entrants and increased competition can reduce prices. Even within the heat pump family, there has been differential scaling to date. Ground-source heat pumps ship one-tenth of the volume and command a 50–100% premium over functionally equivalent air-source heat pumps of similar capacity and component quality.[13] It stands to reason that much of the price disparity for the nearly identical pieces of equipment is an issue of market size and production volume.

Further, there is currently limited U.S. design and installation experience with heat pumps, and most HVAC contractors are not as familiar with the technology. This can make a huge difference. Ground-loop installation costs, for instance, can be 100–400% higher when an experienced and competitive installation infrastructure does

[13] ORNL, Geothermal Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers, Dec. 2008

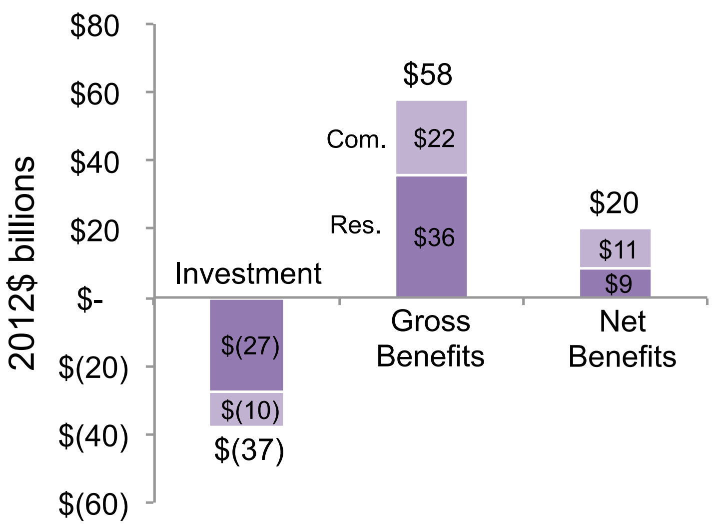
not exist.[14] Inexperienced contractors still often conservatively bid air-source projects to cover any unforeseen circumstances that might arise during installation.

Now is an opportune time to embark on a transition away from oil heating. Air-source systems can claim a federal tax credit of $300 per unit in 2013. Ground-source heat pump systems are eligible for the 30% federal investment tax credit though 2016. These discounts on the upfront cost, coupled with a dedicated effort at the state or regional level, could jump-start the market for this technology.

If 50% of current oil customers switch to heat pumps over the next twenty years, it would result in $37 billion in cumulative present value direct investment in the economy. That investment will save customers a cumulative present value of $58 billion ($20 billion net) over the next 40 years (Figure 7). That is a net present value of nearly $3,000 per resident and over $50,000 per business that converts.

Figure 7 – Net present value from heat pump adoption

Conversion of half of the region's oil customers to heat pumps can generate $20 billion in cumulative net present value savings, or $3,000 per house and $50,000 per business.



Converting from oil to heat pumps therefore amounts to a large economic opportunity for the region. Much of that $37 billion in direct investment will flow directly to the contractors installing these systems in the local economy, while the $20 billion in net benefits can improve the balance sheets of residents and businesses while also allowing for reinvestment that further spurs economic growth. Oil or gas systems leave a much lower share of the dollars in local hands, as payments for gas and oil end up in national or international hands, in some cases quite unfriendly ones.

[14] ORNL, Geothermal Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers, Dec. 2008

KEY BARRIERS HAVE PREVENTED THE MARKET FROM REACHING SCALE

Capturing this economic and environmental opportunity is a large challenge; over 6 million homes and 250,000 businesses would need to invest in a heat pump system to completely replace oil as a heating fuel in the region. Key barriers include:

1. Initial Cost

Heat pumps have very low operating costs, but **higher in-home upfront costs**. Many home or business owners do not have the capital available nor are willing to dedicate scarce capital. Even if they were willing to allocate scarce capital, some home and business owners are not confident they will remain in their building to realize the **payback** (5–10 years) common in heat pump projects.

These barriers reduce the size of the available market, which in turn limits cost reduction opportunities that come from economies of scale, increased competition, and equipment and installation learning curves. So while cost reduction opportunities are present, some type of market intervention is needed to help generate the scale required to put the industry firmly on the cost reduction path.

2. Lack of Knowledge

Upfront cost is not the only barrier standing in the way of increased heat pump adoption. There is a **limited awareness** of the technology and cost-saving opportunity among potential customers. Even if there were greater demand for heat pump systems, there is **a lack qualified installers and system designers**.

The configuration of a ductless air-source heat pump system for residential or small commercial buildings typically consists of one indoor "head" coupled to one outdoor heat exchanger. Such a configuration is commonly associated with motel rooms and window air conditioners. The stigma associated with these typically poorly performing units raises a **customer acceptance** barrier.

3. Difficulty of Retrofit

Installing a heat pump system, particularly as a retrofit, is **a significant project**. A ductless heat pump needs holes cut into the wall for refrigerant piping to the outdoor unit, and enough wall space to mount the air handler. Ground-source projects are far larger, involving either drilling wells 250–300 feet deep, or excavating and replacing a large horizontal area of earth to install the heat exchanger system. Many homeowners or business owners balk at such a project.

Similarly, the **timing of a retrofit project** can be challenging. Most customers don't think about a heating system replacement until their current system fails (often during cold spells when the heating system is needed the most), at which point it's too late to plan for a heat pump. The opportune time window for a heat pump retrofit is when the current oil system is near the end of its useful life but before it has stopped working. That is a narrow time window that is difficult for contractors or homeowners to identify.

Ductless air-source systems have a **different configuration** than the oil-fueled, boiler-based heating systems they replace. These distributed systems are best suited to heating and cooling the most commonly occupied area of the home as a retrofit, reducing a large portion of the heating load on the existing system. The ability for this technology to fully replace oil heating in residential or small commercial buildings is limited by the configuration of the building.

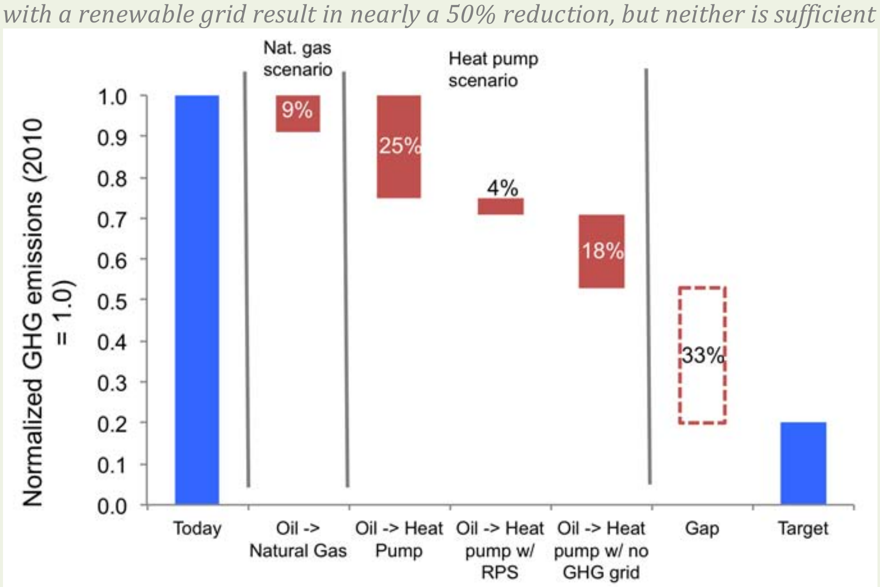
What about Climate Change?

Many states within the Northeast are actively trying to reduce greenhouse gas emissions through policies such as renewable portfolio standards and participation in market-based initiatives such as the Regional Greenhouse Gas Initiative. The consensus scientific target to avoid the most disastrous consequences of climate change is an 80% reduction in greenhouse gas emissions by 2050. Some states in the Northeast, such as Connecticut, have passed laws requiring this level of reduction.

Natural gas emits 27% less CO_2 than heating oil. Yet expanding the natural gas infrastructure in the Northeast to replace all existing oil heating only reduces overall heating emissions 9%. If all heating oil consumption were replaced with heat pumps instead, emissions would fall by 25% based on the current electric generation mix. After the region's renewable portfolio standards are implemented, emission would fall by 29%. Moving to an entirely renewable (or greenhouse-gas-free) electricity supply would result in emissions falling by 47%.

Figure 8 – GHG emissions reductions in two oil heating replacement scenarios

Replacing oil heating with natural gas only decreases heating GHG emissions 9%; heat pumps paired with a renewable grid result in nearly a 50% reduction, but neither is sufficient to meet future targets.



There is a strong case that heat pumps are the better strategic path to meeting the 80% reduction target. Replacing only one-third of current oil use with heat pumps (at today's electric emissions rates) would match the total emissions reductions achieved from a complete switch to natural gas. Two-thirds of the remaining oil use (along with existing natural gas) would be available for further switching to low-greenhouse-gas alternatives.

A low- or zero-emission replacement for natural gas heating is eventually needed for the region to reduce its greenhouse gas emission by 80%. Despite the allure of near-term emissions reductions, a broad expansion into long-lived natural gas infrastructure will pull the region further from its goals.

Best practices and technologies can jump-start the market

Despite these long-standing barriers, heat pumps' economic and environmental opportunities offer a large reward for the state or region that is able to craft effective solutions. There are numerous steps that can be taken to address these barriers, but focusing on reducing high upfront costs and long payback periods will drive the industry to self-sufficiency and solve many of the other barriers.

The average residential air-source system pays back its investment in 6–9 years, while the average commercial ground source system pays back in 5–8 years. That leaves ample opportunity for savings over the 20-year (or more) life of the system, but some home or business owners do not know if they will be in the same building or even own their business a few years from now.

There are a number of strategies a state can use to address this first-cost barrier, and many have been used before to increase the adoption of energy efficiency or distributed generation (particularly solar photovoltaics). These are in many cases alternatives to paying to extend the gas grid (if that is even possible) at much higher cost in almost all cases.

1. Incentives

A **state or local incentive** scheme can leverage federal tax credits to further reduce first costs. This incentive could be administered as part of existing efficiency programs (though oil-to-heat-pump projects are typically not covered by efficiency program incentives), or could be provided through a separate program with the explicit goal of bringing this technology to scale. The California Solar Initiative is an example of this type of program. It provided very large incentives for solar PV systems at its inception, then stepped down the incentives as the state met installation thresholds. The underlying assumption was that technology costs would fall at the same (or greater) pace as the incentive decline. So far, that logic has proven successful, and the solar market has its own momentum with very little in state incentives remaining.

States with renewable portfolio standards can allow heat pumps to earn **renewable energy credits**, creating an added revenue source. New Hampshire recently introduced a carve-out to its renewable portfolio standard for thermal technologies. Utilities now must procure a portion of the 23.8% renewable requirement from wood pellet boilers, solar water heaters, and ground-source heat pumps.

2. Financing

An alternative or complement to added incentives is to open up the market to **third-party financing** solutions.

Utilities can offer **on-bill financing**, pooling customers to get preferential interest rates while using customers' payment histories to reduce credit risk. The Plumas-Sierra Rural Electric Coop already provides a similar solution by offering a 30-year, zero percent financing ground-loop lease program. **Property tax financing** vehicles (such as PACE bonds[15]) is a way to offer low-cost public financing that is tied to the property rather than the tenant or owner. That way, even if a home or business owner is uncertain if they will remain in their building for a long period of time, they can still capture savings from a heat pump retrofit.

3. Leasing

The market can be opened to **third-party ownership**, in which an independent company owns the heat pump system and leases the heating or cooling output. This approach has unlocked the solar PV market in states across the country, a technology with a similar cost and savings profile to heat pumps.

States may need to change regulations that stand in the way, such as requiring those third parties to be treated as utilities, but many have already taken this step to open the market to solar photovoltaic third-party ownership structures. Specific to ground-source systems, states can allow for a **utility to own the ground loop** and sell its heating and cooling services. A ground loop will last 30–50 years, time horizons much better suited to a utility than a home or business owner. This approach could be particularly cost-effective to implement when new housing developments are constructed.

Strategies to **aggregate customers** can help create economies of scale by spreading fixed costs across a larger customer base. A state or municipal program to retrofit its own buildings can coordinate bulk purchases of the heat pump equipment, which can generate favorable pricing.

Efforts to reduce the first-cost will increase the size of the heat pump industry and yield further cost reductions through economies of scale, competition, and innovation.

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[15] PACE stands for Property Assessed Clean Energy, and is a financing vehicle where an energy retrofit loan repayment is tied to property taxes so that any remaining cost (as well as the benefits) from an energy retrofit transfer to the new owner upon sale of a property.

CONCLUSION

While the challenges to moving away from oil heating in the Northeast are great, this problem is worth solving. Using oil to heat 6 million homes and 450,000 businesses in the region is a drain on the economy and environment. However, heat pumps offer a compelling alternative that the region can support immediately. Heat pumps save money; shift dollars (otherwise exported to oil producers abroad) into the local economy, spurring economic growth and jobs; and dramatically reduce pollution, improving our health and climate.

There is precedent for this type of transition. Sweden has moved from being entirely dependent on oil heating in 1970 to using a mix of biomass, district heating, and ground-source heat pumps today (with only a small amount of oil heating remaining). Heat pumps now make up 40% of their heating market. This transition took Sweden 40 years, but technology improvements should enable a faster transition in the similar New England climate.

The time to start is now and targeted interventions by states can help speed the process.

This paper outlines a number of barriers and potential actions that individual states can take on their own or in coordination with other states in the region, but the exact pathway forward will depend on the specific policy, technical, and market landscape within each state. A targeted focus on reducing the first-cost barrier should be the first step. Once solutions are available, market growth will start to improve public awareness and acceptance, and attract more and better-skilled contractors, which will help to drive down costs.

The region must not keep burning oil for heat simply because it has always been done that way. Inaction is a choice, but the better choice is to take concrete steps to support heat pumps.

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