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Replacing Residential Heating Oil with Heat Pumps in the US

Heating oil is one of the more expensive ways to heat homes in the US, requiring millions of households to spend more than $2,000 annually for heat. Replacing or supplementing oil powered heating equipment with modern two-way heat pumps can cut greenhouse gas emissions, reduce household heating and cooling costs and increase comfort.

Heating oil prices are expected to increase 28% year-over-year in 2022, compared to an increase of only 4% for electricity[1], making now the opportune time for homes and businesses to make the transition to heat pumps.

Key Stats

Average annual oil heating bills

$2,031

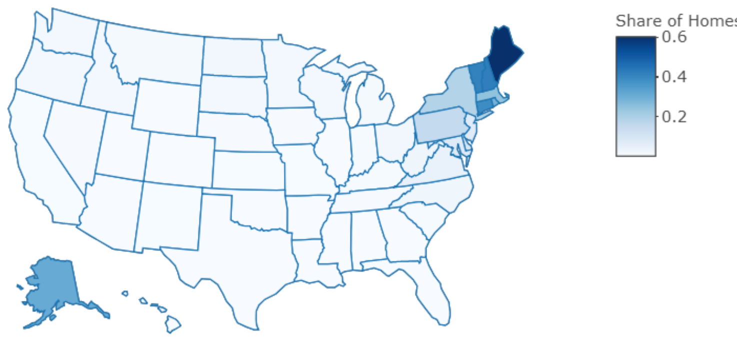
Average annual bill savings with heat pumps

$850 (42%)

Number of homes heated with oil (2019)[2]

5.4 million

Concentrated in the Northeast
(NY, PA, and MA have highest numbers of oil homes)



What is a heat pump?

Heat pumps are air conditioners that can run in reverse, collecting heat from outside a building—even when it is cold out—and concentrating it to heat the interior. This technology can run at an efficiency exceeding 400%, meaning that heat pumps use one unit of electricity to deliver four units of heat. In contrast, oil, gas, or electric resistance can never exceed 100% efficiency.

Like central air conditioners, heat pumps in the US consist of an outdoor heat exchanger or condenser, a refrigerant loop, and an indoor air handler (or multiple). The air handler can be hidden from view and use ducts to deliver conditioned air to multiple rooms in the house ("central" or "unitary"; the more common variety), or it can be mounted on the wall and deliver conditioned air primarily to a single room ("mini-split" or "multi-split"). There are also air-to-water heat pumps that work with radiators, but these are rare in the US.

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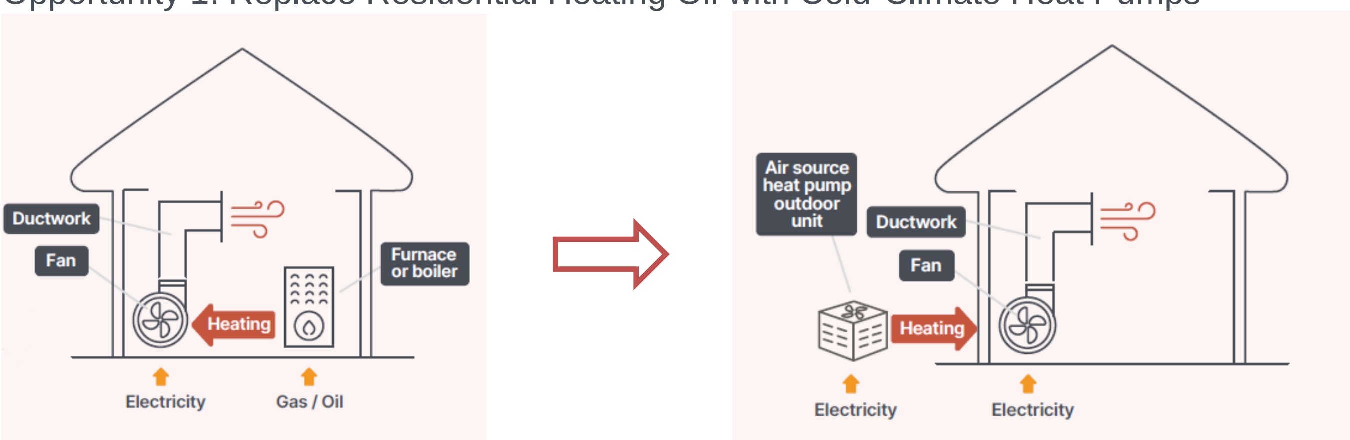
[1] U.S. Energy Information Administration, "Short Term Outlook", March 8, 2022. We used December 2021 prices, the latest month with available data for both heating oil and electricity, which will provide conservative results given the recent spike in heating oil prices.

[2] The rest of this paper refers to 2015 estimates, which include 6.2 million oil households, as that is the latest year for which the detailed census-tract-level data that our analysis depends on are available.

Left: "Mini-split" or "multi-split mounted air handler. Right: Outdoor heat condenser.

This paper explores two opportunities for heat pump retrofits for oil heating equipment and the costs and benefits of each based on a 2021 CLASP analysis,[3] with updates to reflect oil heat and December 2021 prices.

Opportunity 1: Replace Residential Heating Oil with Cold-Climate Heat Pumps



Fully electrifying oil heating in the states where it is widely used will require cold-climate heat pumps with electric resistance backup. Cold-climate heat pumps are more expensive than the average non-cold-climate versions typically found in the South; however, these high-powered pieced of equipment are able to maintain their heat output and efficiency well below freezing, keeping homes warm and bills low. For houses currently heated with oil boilers and radiators and lack ducting, mini-split heat pumps are typically more cost-effective as they do not require new ducting.

Below is the average coefficient of performance (COP) or efficiency used to model this opportunity[4], showing greater than 200% efficiency down to 5° Fahrenheit.

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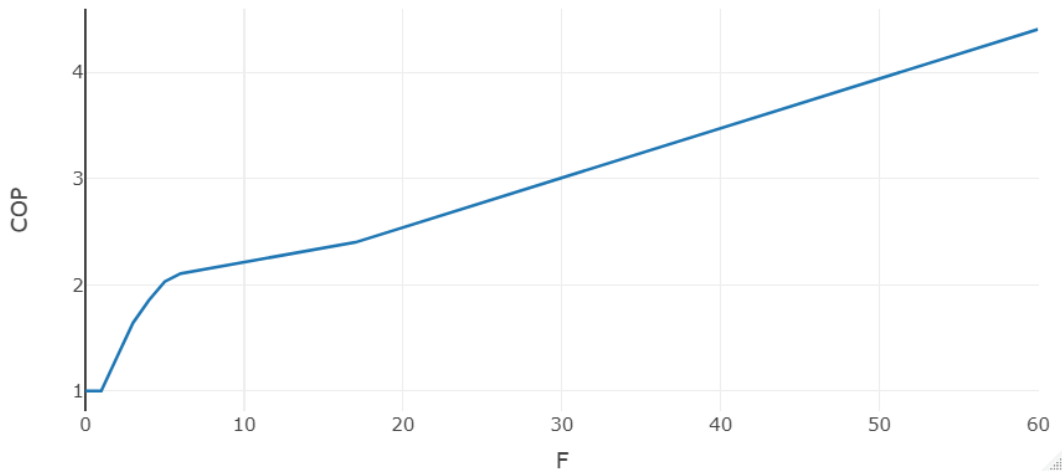
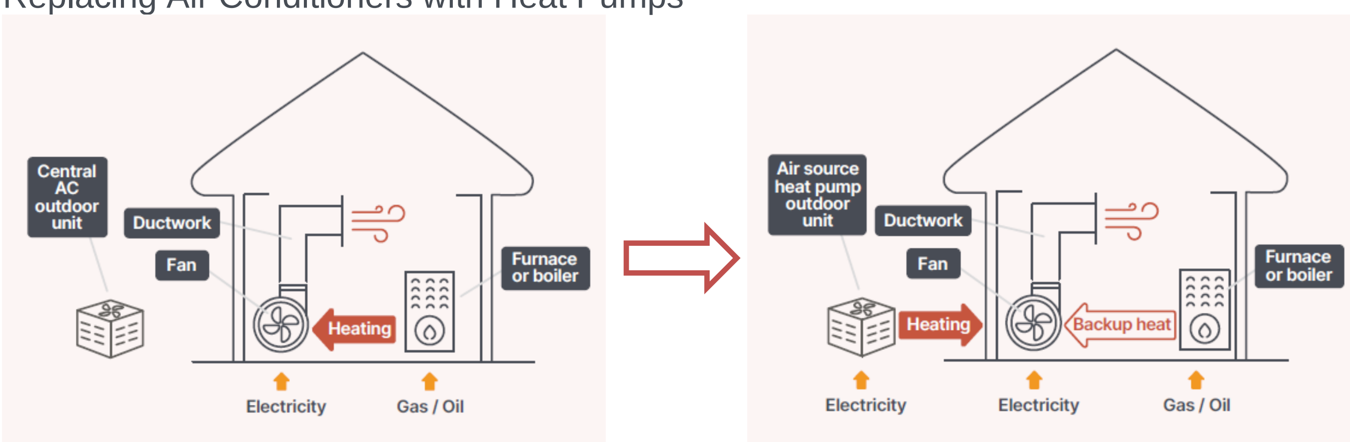
[3] Steve Pantano, Matt Malinowski, Alexander Gard-Murray, and Nate Adams, "3H Hybrid Heat Homes: An Incentive Program to Electrify Space Heating and Reduce Energy Bills in American Homes", May 2021.
[4] Average performance and overall model methodology from Michael Waite & Vijay Modi, "Electricity Load Implications of Space Heating Decarbonization Pathways", 2019, which estimated the median performance of models on NEEEP's Cold Climate Air Source Heat Pump List.



Replacing oil heat with cold-climate heat pumps would save consumers $850 in utility bills per household per year, and $5.2 billion across the nation (42% savings), while reducing CO_2 emissions from heating by 27 million metric tons per year (71% reduction).

Cold-climate heat pumps cost between $10,000-20,000[5], accounting for the equipment and labor to install. Prices can fluctuate depending on the size, temperature performance, and complexity of the installation. However, with average household bill savings of almost $1000 and equipment lifetimes between 10–20 years, heat pump replacements of oil systems are cost effective for consumers now and would be even more so with moderate incentives. An oil heat to heat pumps transition could be further accelerated through increased availability and contractor familiarity with the technology.

Opportunity 2: Displace 10% of Residential Heating Oil Quickly and Cheaply by Replacing Air Conditioners with Heat Pumps

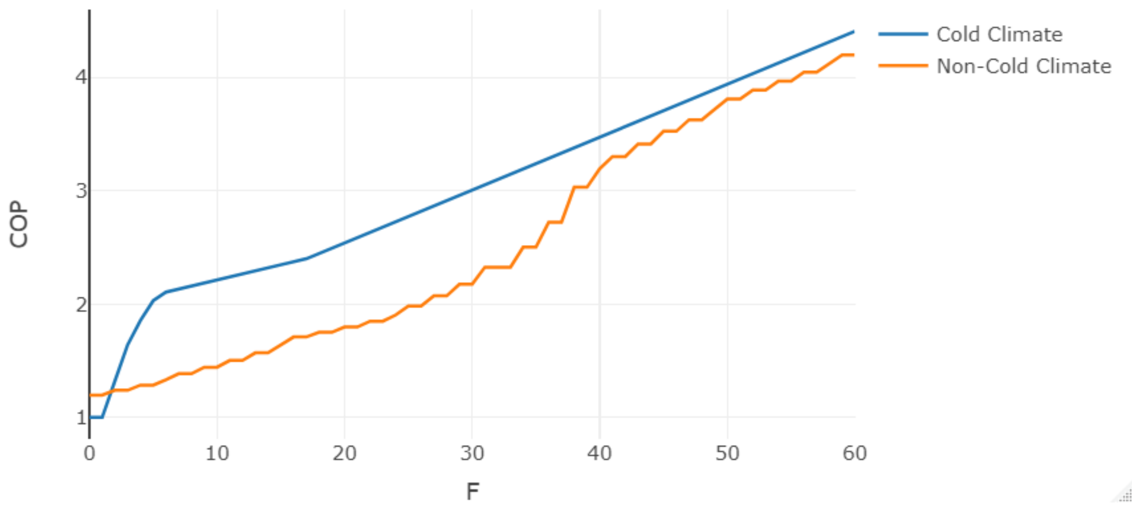


[5] Based on 2021 and 2022 interviews with VEIC and Center for Energy and Environment, though recent inflation may have increased these costs by as much as 40% to $12,000-$28,000.

There is an additional opportunity for electrification in homes that have or are considering central air conditioning (31% of homes with oil heat have central AC).[6] In this subset of homes, 34% of oil heating can be eliminated by installing a ducted heat pump instead of a new AC. An example of this situation would be if a household’s AC fails but the homeowner is not yet ready to replace the oil furnace or boiler.

Because the oil furnace or boiler remain as backups, providing heat on the coldest days, it is not necessary to install a cold-climate heat pump. Instead, manufacturers offer versions of their standard air conditioners that are reversible. As can be seen below, these heat pumps do not perform as well as the cold-climate variety at low temperatures, but provide equivalent efficiency and temperature control in milder weather.

To model this hybrid opportunity, we assumed that homeowners would only use these non-cold climate heat pumps at warmer temperatures: turning off the oil furnace or boiler and turning on the heat pump at or above 41° Fahrenheit. This is a conservative assumption and different switchover temperatures could potentially result in greater cost and CO_2 reductions depending on specific equipment performance, local oil and electricity prices, and electric grid emissions.



A non-cold climate heat pump costs $1,000-$2,000 more than an equivalent air conditioner[7] despite the difference in parts is only equating to $150[8]. A potential cost-effective solution to increasing adoption across the US would be to incentivize manufacturers to produce heat pumps so that customers can enjoy clean, comfortable heat for a part of the season, while also saving money over oil. Then, whenever they are ready, or the oil furnace or boiler fails, households can fully electrify as demonstrated in Opportunity 1.

Replacing one-way air conditioners with heat pumps in a hybrid system would save consumers $360 in utility bills per household per year, and $2.2 billion across the nation (18% savings), while reducing CO_2 emissions from heating by 3 million metric tons (8% reduction). However, it is important to keep in mind that this route only applies to 31% of oil households as the remainder do not have central AC (and may not have pre-existing ducts).

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[6] National average applied to each state. U.S. Energy Information Administration, “2015 RECS Survey Data”, 2015.
[7] Total installed cost is $2,000-$5,000, according to National Renewable Energy Laboratory.
[8] U.S. Department of Energy, “Technical Support Document: Energy Efficiency Program For Consumer Products: Residential Central Air Conditioners and Heat Pumps”, December 2016, pp. 5-21, 5-23.

Other Opportunities

Equivalent opportunities exist for propane, another expensive heating fuel (analysis by CLASP and the Regulatory Assistance Project (RAP) is forthcoming). For a review of the multi-billion-dollar benefits of electrifying electric resistance and partially electrifying natural gas through hybrid heat pump systems, see the CLASP report "3H Hybrid Heat Homes: An Incentive Program to Electrify Space Heating and Reduce Energy Bills in American Homes", May 2021.

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Results for Opportunity 1: Full Replacement of Oil Heat with Cold Climate Heat Pumps

State	Percentage of Oil Households	Number of Oil Households	Current Oil Heating Energy Consumption (mmBtu)	Current Oil CO2 Emissions (MtCO2)	Effective Electrification (Reduction in Oil Energy Use)	CO2 Emissions of Backup Oil Heating (MtCO2)	CO2 Emissions of Heat Pumps (MtCO2)	CO2 Emissions Reductions (MtCO2)	CO2 Emissions Reductions (%)
CT	44%	595,244	58,967,016	4.4	100%	-	1.0	3.4	77%
DC	2%	5,982	376,974	0.0	100%	-	0.0	0.0	70%
DE	14%	49,733	3,082,673	0.2	100%	-	0.1	0.2	70%
IL	0%	9,080	738,103	0.1	100%	-	0.0	0.0	36%
IN	1%	21,808	1,648,821	0.1	100%	-	0.1	0.1	49%
IA	1%	8,639	673,226	0.0	100%	-	0.0	0.0	39%
KY	1%	16,505	1,136,434	0.1	100%	-	0.0	0.0	55%
ME	65%	359,181	30,422,842	2.3	100%	-	0.6	1.7	74%
MD	10%	212,903	17,297,005	1.3	100%	-	0.4	0.8	66%
MA	29%	746,949	68,031,484	5.0	100%	-	1.2	3.9	77%
MI	1%	50,369	5,102,210	0.4	100%	-	0.2	0.1	40%
MN	2%	50,429	4,629,567	0.3	100%	-	0.2	0.1	30%
NH	46%	241,284	18,732,878	1.4	100%	-	0.3	1.0	75%
NJ	11%	336,160	28,475,340	2.1	100%	-	0.7	1.4	69%
NY	25%	1,819,152	138,440,028	10.2	100%	-	2.8	7.4	73%
NC	4%	149,443	10,550,180	0.8	100%	-	0.2	0.6	71%
OH	2%	113,025	8,681,270	0.6	100%	-	0.3	0.3	49%
PA	18%	899,357	74,556,033	5.5	100%	-	1.9	3.6	66%
RI	33%	137,451	13,655,400	1.0	100%	-	0.2	0.8	77%
VT	45%	114,826	10,387,936	0.8	100%	-	0.2	0.6	74%
VA	6%	171,679	12,953,991	1.0	100%	-	0.3	0.6	65%
WI	3%	63,988	5,173,944	0.4	100%	-	0.3	0.1	27%
Total		**6,173,187**	**513,713,354**	**38**	**100%**	**-**	**11**	**27**	**71%**

State	Percentage of Oil Households	Number of Oil Households	Electricity Price ($/kWh)	Oil Price ($/gal)	Ratio of Electricity to Oil Prices per Site Btu	Current Oil Household Annual Heating Bills	Oil Household Heating Annual Bill Under Program (HP + Oil Backup)	Household Annual Bill Savings ($)	Household Annual Bill Savings (%)
CT	48%	595,244	$0.21	$3.30	2.6	$2,367	$1,548	$819	35%
DC	3%	5,982	$0.13	$3.36	1.6	$1,535	$585	$950	62%
DE	17%	49,733	$0.13	$3.65	1.4	$1,639	$555	$1,085	66%
IL	0%	9,080	$0.14	$3.36	1.6	$1,980	$893	$1,088	55%
IN	1%	21,808	$0.14	$3.33	1.7	$1,822	$801	$1,021	56%
IA	1%	8,639	$0.12	$2.89	1.6	$1,634	$807	$827	51%
KY	1%	16,505	$0.12	$3.17	1.6	$1,579	$619	$960	61%
ME	70%	359,181	$0.18	$3.14	2.3	$1,930	$1,278	$652	34%
MD	11%	212,903	$0.14	$3.54	1.6	$2,085	$818	$1,267	61%
MA	32%	746,949	$0.24	$3.35	2.9	$2,211	$1,715	$496	22%
MI	2%	50,369	$0.17	$3.15	2.2	$2,309	$1,407	$902	39%
MN	3%	50,429	$0.13	$3.42	1.5	$2,275	$1,209	$1,066	47%
NH	49%	241,284	$0.21	$3.30	2.6	$1,854	$1,338	$516	28%
NJ	12%	336,160	$0.16	$3.54	1.8	$2,172	$987	$1,185	55%
NY	29%	1,819,152	$0.20	$3.54	2.2	$1,952	$1,109	$842	43%
NC	5%	149,443	$0.11	$3.30	1.4	$1,688	$561	$1,127	67%
OH	3%	113,025	$0.13	$3.28	1.6	$1,827	$752	$1,075	59%
PA	20%	899,357	$0.14	$3.21	1.8	$1,930	$890	$1,039	54%
RI	38%	137,451	$0.25	$3.34	3.0	$2,407	$1,863	$544	23%
VT	48%	114,826	$0.20	$3.20	2.5	$2,095	$1,515	$579	28%
VA	7%	171,679	$0.12	$3.39	1.4	$1,852	$639	$1,213	66%
WI	4%	63,988	$0.14	$2.95	1.9	$1,730	$1,053	$677	39%
Total		**6,173,187**				**$12,538,709,967**	**$7,290,397,509**	**$5,248,312,458**	**42%**
Average						**$2,031**	**$1,181**	**$850**	**42%**

Results for Opportunity 2: Replacement of Central AC with Hybrid Heat Pump with Oil Backup

State	Percentage of Oil Households	Number of Oil Households	Current Oil Heating Energy Consumption (mmBtu)	Current Oil CO2 Emissions (MtCO2)	Effective Electrification (Reduction in Oil Energy Use)	CO2 Emissions of Backup Oil Heating (MtCO2)	CO2 Emissions of Heat Pumps (MtCO2)	CO2 Emissions Reductions (MtCO2)	CO2 Emissions Reductions (%)
CT	44%	595,244	58,967,016	4.4	35%	3.9	0.1	0.4	9%
DC	2%	5,982	376,974	0.0	48%	0.0	0.0	0.0	11%
DE	14%	49,733	3,082,673	0.2	42%	0.2	0.0	0.0	9%
IL	0%	9,080	738,103	0.1	28%	0.0	0.0	0.0	4%
IN	1%	21,808	1,648,821	0.1	30%	0.1	0.0	0.0	5%
IA	1%	8,639	673,226	0.0	23%	0.0	0.0	0.0	4%
KY	1%	16,505	1,136,434	0.1	35%	0.1	0.0	0.0	7%
ME	65%	359,181	30,422,842	2.3	25%	2.1	0.0	0.1	6%
MD	10%	212,903	17,297,005	1.3	41%	1.1	0.0	0.1	9%
MA	29%	746,949	68,031,484	5.0	32%	4.5	0.1	0.4	8%
MI	1%	50,369	5,102,210	0.4	24%	0.3	0.0	0.0	4%
MN	2%	50,429	4,629,567	0.3	19%	0.3	0.0	0.0	3%
NH	46%	241,284	18,732,878	1.4	26%	1.3	0.0	0.1	7%
NJ	11%	336,160	28,475,340	2.1	37%	1.9	0.1	0.2	8%
NY	25%	1,819,152	138,440,028	10.2	37%	9.1	0.3	0.9	8%
NC	4%	149,443	10,550,180	0.8	43%	0.7	0.0	0.1	10%
OH	2%	113,025	8,681,270	0.6	29%	0.6	0.0	0.0	5%
PA	18%	899,357	74,556,033	5.5	33%	4.9	0.2	0.4	7%
RI	33%	137,451	13,655,400	1.0	37%	0.9	0.0	0.1	9%
VT	45%	114,826	10,387,936	0.8	23%	0.7	0.0	0.0	6%
VA	6%	171,679	12,953,991	1.0	41%	0.8	0.0	0.1	9%
WI	3%	63,988	5,173,944	0.4	22%	0.4	0.0	0.0	3%
Total		**6,173,187**	**513,713,354**	**38**	**34%**	**34**	**1**	**3**	**8%**

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State	Percentage of Oil Households	Number of Oil Households	Electricity Price ($/kWh)	Oil Price ($/gal)	Ratio of Electricity to Oil Prices per Site Btu	Current Oil Household Annual Heating Bills	Oil Household Heating Annual Bill Under Program (HP + Oil Backup)	Household Annual Bill Savings ($)
CT	44%	595,244	$0.21	$3.30	2.6	$2,367	$1,999	$367
DC	2%	5,982	$0.13	$3.36	1.6	$1,535	$1,060	$476
DE	14%	49,733	$0.13	$3.65	1.4	$1,639	$1,162	$478
IL	0%	9,080	$0.14	$3.36	1.6	$1,980	$1,625	$355
IN	1%	21,808	$0.14	$3.33	1.7	$1,822	$1,475	$346
IA	1%	8,639	$0.12	$2.89	1.6	$1,634	$1,389	$245
KY	1%	16,505	$0.12	$3.17	1.6	$1,579	$1,209	$370
ME	65%	359,181	$0.18	$3.14	2.3	$1,930	$1,687	$243
MD	10%	212,903	$0.14	$3.54	1.6	$2,085	$1,526	$558
MA	29%	746,949	$0.24	$3.35	2.9	$2,211	$1,958	$253
MI	1%	50,369	$0.17	$3.15	2.2	$2,309	$2,027	$282
MN	2%	50,429	$0.13	$3.42	1.5	$2,275	$1,989	$286
NH	46%	241,284	$0.21	$3.30	2.6	$1,854	$1,642	$212
NJ	11%	336,160	$0.16	$3.54	1.8	$2,172	$1,684	$487
NY	25%	1,819,152	$0.20	$3.54	2.2	$1,952	$1,578	$373
NC	4%	149,443	$0.11	$3.30	1.4	$1,688	$1,176	$512
OH	2%	113,025	$0.13	$3.28	1.6	$1,827	$1,481	$347
PA	18%	899,357	$0.14	$3.21	1.8	$1,930	$1,539	$391
RI	33%	137,451	$0.25	$3.34	3.0	$2,407	$2,109	$298
VT	45%	114,826	$0.20	$3.20	2.5	$2,095	$1,874	$220
VA	6%	171,679	$0.12	$3.39	1.4	$1,852	$1,322	$530
WI	3%	63,988	$0.14	$2.95	1.9	$1,730	$1,511	$219
Total		**6,173,187**				**$12,538,709,967**	**$10,317,926,388**	**$2,220,783,578**
Average						**$2,031**	**$1,671**	**$360**