

Cold-Climate Air Source Heat Pump

Case Study: Incorporating Weatherization



NYSERDA
New York State Energy Research
and Development Authority

Scenario

Homeowners of a 1950's single-family, two-story 1700 square foot Cape Cod style house in Saratoga County, NY are looking to get a full load cold-climate air source heat pump (ccASHP) system installed. The home's outdoor heating design temperature is 1° F. The building envelope is poorly insulated and leaky. The HVAC contractor runs an ACCA Manual J calculation based on following existing conditions and heating load:



Infiltration: 20,413 Btu/hour (30%)

Semi-loose

Ceiling: 9,632 Btu/hour (14%)

- Vented attic
- R-7 cavity insulation
- Asphalt shingles
- No roof deck insulation

Ducts: 15,514 Btu/hour (33%)

- Unsealed and uninsulated
- Located in an enclosed crawlspace

Walls: 9,835 Btu/hour (15%)

Above grade

- 2'x 4' wood stud framing
- R-13 cavity insulation
- No exterior board insulation
- Vinyl siding

Below grade

- Concrete masonry
- No insulation

Doors: 565 Btu/hour (1%)

Metal with fiberglass core

Floors: 6,302 Btu/hour (9%)

Above grade

- Wood frame
- R-19 cavity insulation
- Vented/leaky crawlspace

Below grade

- Concrete slab floor
- No insulation

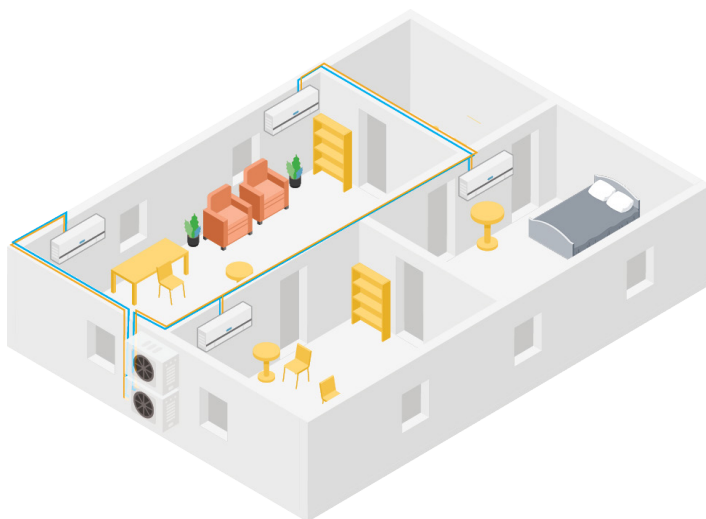
Windows: 5,203 Btu/hour (8%)

Clear low-e double pane operable windows with clad wood framing

The home currently has a 67,000 Btu/hr heating load and 25,000 Btu/hr cooling load. With the existing 77,000 Btu/hr natural gas, direct vent furnace with integrated 36,000 Btu/hr split system, **annual energy costs* are around \$3,414, or more than \$51,000 over 15 years.**

The HVAC contractor's **initial bid is to install four multi-zone ductless split heat pump systems** due to concerns that reusing the existing leaky ductwork will not meet the home's heating load. This initial bid **will require an estimated upfront cost of \$29,000 and annual energy cost of \$4,102, or more than \$61,000 over 15 years.** To reduce the load and needed system capacity, the HVAC contractor proposes three weatherization packages to upgrade the ducts and envelope. Potential weatherization and heat pump packages with estimated costs and savings are detailed on the next page.




Initial Bid Four Multi-Zone Ductless Split Systems



*Estimated and average costs are based on energy pricing as of November 2024, per the Energy Information Administration, and are specific to the unique home outlined above.

Four Package Options for Case Study Home:

The following shows various scenarios for how conducting envelope improvements to this example home leads to HVAC performance benefits, reduced heating and cooling loads, and reduced lifetime energy costs. Even simple upgrades, such as air sealing and installing attic insulation, will reduce the heating load enough to install a smaller heat pump, improve the homeowner's comfort, and lead to a higher satisfaction with their heat pump system. Although one of these scenarios increases upfront costs, it has the lowest annual and lifetime energy costs.

	Upgrade Packages & Heat Pump Install	Package Total	Heating Load	Cooling Load	*Estimated Annual Energy Costs	**Lifetime Energy Cost
Initial Bid	Weatherization Upgrades: None Heat Pump System: Four multi-zonal ductless split 66 kBtu/hr heat pump systems throughout the home	\$29,000	67 kBtu/hr	25 kBtu/hr	\$4,102	\$61,530
Option 1	 <p>Weatherization Upgrades: Sealing all ductwork and insulating exposed ducts in unconditioned spaces to R-8 wrap</p> <p>Heat Pump System: One 42 kBtu/hr central packaged heat pump for the main floor of the home & two 6 kBtu/hr mini-splits for the upstairs</p>	\$27,750	55 kBtu/hr	21 kBtu/hr	\$3,371	\$50,565
	Percent or amount change compared to initial bid.	↓ \$2,250	↓ 19%	↓ 17%	↓ \$731/yr	↓ \$10,965
Option 2	 <p>Weatherization Upgrades: Includes Option 1 Package, plus air sealing and insulating the small attic spaces and kneewalls with foam board and cellulose insulation</p> <p>Heat Pump System: One 42 kBtu/hr central packaged heat pump for the entire home</p>	\$25,800	42 kBtu/hr	17 kBtu/hr	\$2,591	\$38,865
	Percent or amount change compared to initial bid.	↓ \$4,200	↓ 38%	↓ 30%	↓ \$1,511/yr	↓ \$22,665
Option 3	 <p>Weatherization Upgrades: Includes Option 2 Package, plus installing R-19 below-grade interior wall and R-12 above-grade exterior foam board wall insulation and reusing siding</p> <p>Heat Pump System: One 36 kBtu/hr central packaged heat pump for the entire home</p>	\$34,400	37 kBtu/hr	15 kBtu/hr	\$2,268	\$34,020
	Percent or amount change compared to initial bid.	↑ \$5,400	↓ 47%	↓ 39%	↓ \$1,834/yr	↓ \$27,510

*Estimated energy costs are based on energy pricing as of November 2024, per the Energy Information Administration, and heat pump system pricing are based on market prices for R-410A equipment, and are specific to the unique home outlined above.

**Lifetime Energy Cost Savings, assuming a minimum 15 year expected useful life, compared to lifetime energy costs of initial bid for four multi-zone ductless mini splits systems for home with no weatherization envelope upgrades

Weatherization Works

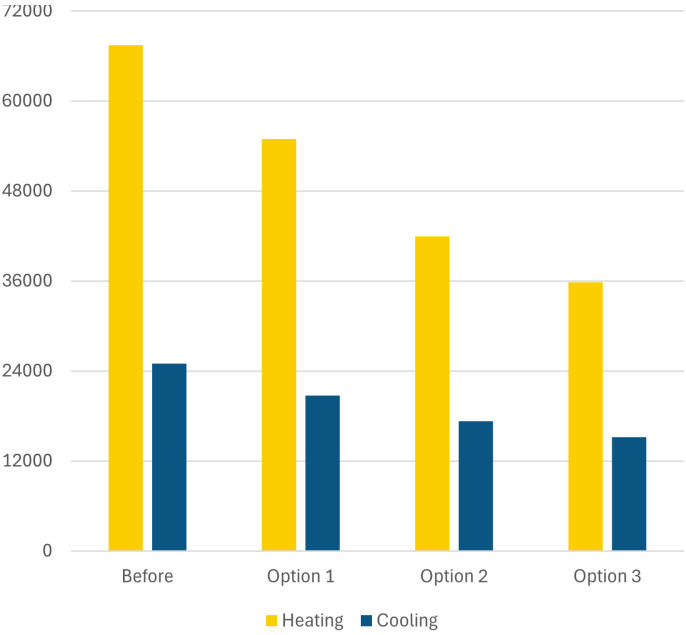
The three weatherization and heat pump packages focus progressively on sealing more of the home’s thermal envelope, starting with the ductwork, and then adding in the attic/roofline spaces, and finally the walls. ACCA Manual J calculations confirm that these **envelope improvements allow for smaller capacity heat pump systems** and, inherently, reduced energy costs.

For two of the three weatherization packages, the energy cost savings will more than pay for the envelope upgrades over the lifetime of the heat pump.

The upgrades will also reduce the cooling load by up to 45%, resulting in the **ratio of heating to cooling shrinking**, decreasing oversizing the cooling system and reducing incidences of short-cycling. With Option 3 package described above, **the cooling load reduces from roughly 25,000 Btu/hr to just over 15,000 Btu/hr.**

By reducing the design loads of the home, you will be able to **install a higher quality system** with a lower overall capacity while reducing installation and energy costs for the homeowner. Most importantly, for a similar installation cost to the customer, you can be confident in the customer’s **comfort and satisfaction** knowing **the new system will run more effectively and efficiently** than if the home’s envelope had not been improved.

Heating and Cooling Load Reduction with Weatherization Upgrades



Weatherization and Heat Pump Costs per Option

