EnergyIdeas Clearinghouse

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Product & Technology Review

Acadia™ Heat Pump

An air source heat pump optimized for use in cold weather areas.

Photograph courtesy of Hallowell International.

Product

Acadia™ Heat Pump Models:

- 36C/35H is approximately 36,000 Btu for Cooling and 35,000 Btu for Heating
- 42C/46H is approximately 42,000 Btu for Cooling and 46,000 Btu for Heating

Manufacturer

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Product History

The first version of this low temperature heat pump was available for a short time in the fall of 2004 as the *Cold Climate Heat Pump*™, manufactured by Nyle Special Products, LLC (Nyle). Nyle retained rights to the name – *Cold Climate Heat Pump*™ – and is developing a heat pump that is very similar to the Acadia, but uses different technologies to address the colder temperatures (this is not yet available).

The product became available again in the spring of 2007 as the *All Climate Heat Pump* from Hallowell. In the fall of 2007 Hallowell renamed it the *Acadia*™.

Product Function and Application

The following information was provided primarily by the manufacturer and is not evaluated here.

The Acadia uses a combination of technologies

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coordinated by the control system to enhance performance. It uses R-410a, an azeotropic[1] refrigerant designed to replace R-22, and a unique two-cylinder compressor. The compressor operates on one cylinder during mild weather. When outside temperatures drop to approximately 42°F, the compressor reverses rotation and both cylinders operate to increase the displacement and volumetric flow. As outside temperature continues to fall, below about 30°F, a booster compressor comes on to further increase capacity. An economizer is provided to sub-cool the warm liquid from the condenser before it reaches the evaporator, which increases the ability of the refrigerant to absorb energy from the cold outside air Lastly, sophisticated controls and a three-stage programmable thermostat are provided to control the compressors and backup resistance heat. The user can switch off the backup heat completely with a toggle switch.

The Acadia also uses a patented outdoor coil that reduces the rate of moisture buildup on its surface. The manufacturer claims that the patented outdoor coil, when combined with the proprietary defrost logic, reduces defrost losses by reducing to a fraction the number of defrost cycles usually required by a standard air source heat pump.

The heat pump uses a relatively sophisticated four-part defrost strategy to minimize losses and optimize annual coefficient of performance (COP). The strategy uses:

1. Demand defrost: the flash liquid refrigerant temperature is monitored with the outdoor temperature to determine the defrost timing.
2. An accumulated runtime timer initiates defrost as a backup to the demand defrost.
3. A short-cycle timer maintains at least 30 minutes between defrost cycles.
4. A fourth timer terminates the defrost cycle after a preset time period has passed.

[1] *An azeotropic mixture contains two or more liquids that behave with the properties of a single substance over a range of temperatures and pressures, but behaves differently than either mixture would alone. R-410a is made up of HFC-32 and HFC-125.*

The Acadia is controlled by an Emerson 1F95-1206 digital programmable touch screen thermostat. The thermostat is specially designed for the Acadia and includes provisions for system startup, shut down, and optimizing operation at various indoor and outside temperatures. It allows for three stages of heating and cooling, changeover logic used in heat pumps, temperature setbacks, morning warm-up and cool down.

Energy Savings Claims

The following information was provided primarily by the manufacturer and is not evaluated in this section. Acadia heat pumps are optimized for use in cold weather areas, but also work well in temperate climates. The Acadia is capable of operating efficiently at outside temperatures far lower than standard air source heat pumps and, with a SEER rating of 14, approaches efficiencies of ground source heat pumps (GSHP). In heating mode the nominal three-ton unit averages a COP of 2.8 across its operating range.

The Acadia heat pump maintains high efficiency when outside temperatures are down to 0°F and even somewhat lower. It approaches the efficiency of ground source heat pumps (GSHP) at the higher-range temperatures, but at a reduced cost. Heating costs, the manufacturer claims, can be reduced by as much as 40% when compared to fossil fuel heating. Cooling costs can be reduced by as much as 25% compared to standard cooling systems. Heating system efficiency at outdoor temperatures of 17°F is given by the manufacturer as 255%.[2] The Seasonal Energy Efficiency Ratio (SEER) is given as 14.

In Table 1 the manufacturer gives the heating coefficients of performance (COP) for each Acadia model. Comparison values were added

[2] *Technically, this is a misuse of the term "**efficiency**." According to the laws of thermodynamics, nothing can be more than 100% efficient. A heat pump does not generate heat or cold, but moves heat from one place to another. In this case, it is able to supply 2.55 times as much heat as the energy input (by extracting it from outside), achieving a COP of 2.55, which is effectively 255% efficiency.*

Table 1.
Comparison of Heating Coefficients of Performance (COP)

Temp (°F)	Acadia Model 36C/35H (COP)	Acadia Model 42C/46H (COP)	Rheem* RPNE-024J*Z (COP)	[GSHP]** FHP GT036 (COP)
62	4.12	4.59	3.2	4.0
47	3.47	3.86	3.1	3.8
30	2.80	3.06	2.4	3.2
17	2.45	2.55	2.0	–
10	2.35	2.50	2.0	–
0	2.21	2.24	1.9	–
-15	2.06	2.09	–	–
-30	1.93	1.95	–	–

* *The Rheem RPNE-024J*Z is an air source heat pump with a rated Heating Season Performance Factor (HSPF) of 9.1. Data is from actual in-field tests, which tend to yield lower ratings than lab tests.*

** *COPs listed are for entering water temperatures. With properly sized ground loops, entering water temperatures should always be above 30°F. Average ground temperatures 5 feet below the surface in the Northwest approach 50°F, yielding an average heating COP of about 3.5-3.7.*

for typical high-performance air source equipment (the Ducane and the Rheem) and ground source equipment.

Non-Energy Benefits

The Acadia heat pump offers several advantages over standard heat pumps. Due to the design and refrigerant, the temperature of the air from the heating duct is higher than from most heat pumps. The manufacturer indicates a range of delivery temperatures from 93°F to 120°F in the system's various operational modes – all without supplemental resistance heat. This would provide a more pleasant heat than normal air source systems, which typically deliver temperatures in the 85°F to 100°F range.

Since the compressor has a split-capacity it operates at a reduced load 80% of the time and for longer periods of time than a standard heat pump. This reduces the number of stops and starts, which should reduce wear and tear on the equipment. The unit also has a smaller footprint compared to many heat pumps and the manufacturer claims it is quieter than other heat pumps.

Independent Testing Results

1. Intertek ETL SEMKO

ETL SEMKO is a division of Intertek Group that specializes in electrical product safety testing, electromagnetic compatibility testing, and benchmark performance testing. Tests were performed in accordance with ARI Standards 210/240-2006 and Standard ANSI/ASHRAE 37-2005. Additional testing beyond this standard, including testing for ARI Region IV and Region V, was also completed. These tests, however, were not part of the ARI certification program. According to the distributor, discussions with ARI to standardize testing that includes this lower range of operating temperatures are ongoing and actual ARI certification testing will take place in the near future. The results of the Intertek testing are provided in Table 2.

Table 2.
Results of Tests of Model ACHP 36C35H (Fahrenheit) System,
October 3-4, 2006 @ Intertek /ETL SEMKO Cortland, NY

Outdoor Temperature (°F)	1st Stage Minimum Heating Capacity (BTU/hr)	Mode	2nd Stage Maximum Heating Capacity (BTU/hr)	Mode	Heating Efficiency (%)	Indoor Air Delivery Temp. (°F)
62	21,434	M1	N/A	M1	412%	99
47	17,188	M1	36,627	M2	347%	106
30	24,174	M2	52,020	M3	280%	119
17	17,784	M2	43,927	M3	245%	111
10	40,170	M3	56,855	M4	235%	108
0	34,680	M3	51,395	M4	221%	102
-15	29,580	M3	46,295	M4	206%	99

HSPF Region IV = 9.6 (Seasonal HCOP = 2.8)
HSPF Region V = 8.5 (Seasonal HCOP = 2.5)
Minimum Cooling Capacity @ 95° F = 18,349 BTU / HR (1st Stage Thermostat Call / M1)
Maximum Cooling Capacity @ 95° F = 36,000 BTU / HR (2nd Stage Thermostat Call / M2)
SEER 14.0
EER 12.30 @ 95°F / 15.48 @ 82°F

System Modes:

M1	Single cylinder primary compressor
M2	Two cylinders primary compressor
M3	Primary & booster compressors
M4	2 Cylinder Primary & booster compressors w/ 1st stage auxiliary heat
Recommended 1st Stage resistance heat 4.8 kW (16,387 BTU/hr)	

2. Chelan County PUD

Chelan County PUD (Wenatchee, WA) is working with Wenatchee Valley College testing the Acadia and the Nyle Cold Climate Heat Pump. Testing continues, but it is mostly for educational and demonstration purposes. The problem with this testing is that the heat pump serves a classroom. There are multiple heat pumps that are connected to the classroom for testing. Students have access to the thermostats and the thermostat positions are not logged, rendering the results not very informative.

Case Studies

1. The Bonneville Power Administration (BPA)

In 2006 BPA completed a two-year performance study of five Cold Climate Heat Pumps (CCHP) manufactured by Nyle. This earlier version of a similar technology by another manufacturer was shown to meet the heating requirements at three of the five sites without the use of any backup resistance heating. These sites ranged from 6300 to 8000 heating degree days. On-site monitoring found operational COPs similar to other typical air source systems ranging from 1.2 to 2.1 across all temperature ranges and averaging about 1.7. While less than the manufacturer's specifications based on lab testing, the onsite tested efficiency is of minimal concern compared to the benefit to utilities of the system's successful operation in cold climates without the use of backup resistance heat. On-site measured supply air temperatures (output) were consistently very close to 90°F in all operating modes, again significantly lower than the manufacturer's specification. Regardless, none of the occupants expressed comfort complaints, and none of them turned on the supplemental heat.

During the monitoring period one compressor unit had to be replaced and a second system failed to operate in its booster mode. These failures in such a small group suggest a still-maturing technology.

BPA is currently testing the Acadia heat pump in a similar study. Each Acadia will be monitored with data loggers for outside air temperature, indoor air temperature, supply air temperature, return air temperature, outdoor unit power, indoor blower power, indoor unit power, and reversing valve state. Monitoring will be done in one-minute intervals for an entire year. Preliminary results through the fall of 2007 indicate similar performance to the Cold Climate Heat Pump.

2. Johnson Research

Johnson Research is currently testing seven Acadia heat pumps. The Cooperative Research Network (CRN) of the National Rural Electric Cooperative Association sponsors the tests. Three test systems are located in Colorado, and one each in Florida, New Hampshire, Oregon, and Ohio. Monitoring has been in place from 6 to 12 months for the various locations. Preliminary results reported as of May 2007 indicate:

- All heat pumps performing well. None have failed or required service.
- Heat pumps are producing expected amount of heat based on manufacturer's specifications across a full range of winter temperatures.
- Very little supplemental heat has been used even down to -10°F.
- Heat pumps appear to be operating somewhat less efficiently than the manufacturer's laboratory tests would lead one to expect.

3. Cass County Electric Cooperative

Cass County Electric Cooperative (Kindred, ND) tested a Cold Climate Heat Pump by installing one at the new home of their marketing manager in North Dakota. The heat pump maintained the home at 72° F. without supplemental heat when the temperature was at -17°F. The electric company documented this simple case study in the April 2003 issue of their periodical *Highline Notes*. Note that this was the original version of the Cold Climate Heat Pump manufactured by Nyle while under the original patent contract.

Cost

The manufacturer and distributor are reluctant to publish prices because of all the variables involved, but say that a system with either model was in the range of $8,000-12,000 installed, including ducting. This is about $3,000 to $4,000 more than a standard heat pump.

Alternative Products and Strategies

Nyle, the initial manufacturer of this technology, is planning to manufacture the Cold Climate Heat Pump and have it on the market before 2009 (*http://www.nyletherm.com/space heating.htm*). Nyle is developing a heat pump that is very similar to the Acadia, but uses different technologies to address cold climate issues. It is not yet available. At least one other manufacturer has plans to produce a similar product soon.

Oversizing a conventional heat pump improves the low-temperature performance but can decrease the energy efficiency at more moderate temperatures due to excessive cycling. Cooling is also negatively affected by oversizing the system for winter heating. A dual-fuel system (using gas as backup rather than electric strip heat) can greatly decrease energy costs at low temperatures compared to electric-only systems. However, neither of these alternative strategies adequately addresses the issue of freezing coils at low temperatures.

Suggestions for Further Research and Testing

The critical testing for a heat pump is the ARI Standard 210/240. This testing establishes the performance rating of unitary air conditioning and air source heat pumps. The five tests are: ARI Standard Rating Cooling Capacity (Btu/h), the Seasonal Energy Efficiency Ratio (SEER, in Btu/W-h), High Temperature Heating Standard Rating Capacity (Btu/h), and the Region IV Heating Seasonal Performance Factor (HSPF), and Minimum Design Heating Requirement (Btu/W-h). The ARI certification testing that has been started should be completed. This will give the customer more confidence in the performance of this product since it will have been certified by a standards agency.

Additional Reviewer Comments and Analysis

In principle, the primary advantage of this design for colder climates is that it is the first of a class of heat pumps that was designed to optimize heating efficiency, whereas design of standard heat pumps has emphasized cooling. Research on this product seems to indicate that the Acadia heat ump has been well designed with attention to detail, quality, and sound engineering principles. Although the nature of this product review does not allow for actual testing of the product, and is limited to published data, interviews, and data searches, the product appears to advance the idea of energy efficiency in heat pumps for cold climates. As with all new technologies, we cannot be confident yet about long-term reliability.

The performance relative to field tests seems to be somewhat overstated. The average heating COP of 2.8 in the normal range of testing temperatures is only slightly higher than the 2.7 of typical high-performance air source heat pumps. In field tests, all heat pumps tend to not perform up to the laboratory rating, but the COP of 1.7 in the BPA test falls noticeably short of the claimed performance. Having said that, those tests were on the Nyle machines in earlier tests, and performance may be better now. Nyle admits that they had some reliability issues in their first model, which is one reason they are in redesign now. The biggest potential savings occur at lower temperatures because the Acadia is able to operate at much lower temperatures than the air source heat pumps without using inefficient supplemental heat. Ground source heat pumps (GSHP), sometimes referred to as geothermal heat pumps, can maintain even higher COPs, approaching 4.0, not because of any technical modifications, but because of the lower thermal lift required in a GSHP (because of the more constant input temperature of the ground water).

The manufacturer's claim that the Acadia can save 40% over a standard heating system may be true in special circumstances, but it will depend on the relative costs of electricity and natural gas and the efficiency of the other equipment. Likewise, their claim that the Acadia (SEER 14) can save 25% over typical cooling systems would require that the equipment you compare it to is a SEER of 10.5, but the minimum efficiency currently available for purchase is a SEER 13.

Conclusion

The Acadia heat pump shows promise to fill a market niche for a heat pump for colder climates. Initial field testing suggests that the heating COP of the Acadia is not as high as what is advertised, as high as laboratory testing indicates, or indeed may not be as high as other high performance heat pumps in the moderate temperature ranges. It does, however, seem to have superior performance at lower temperatures without having to resort to backup resistance heating required by other air source systems (except in extreme conditions).

The additional complexity of multiple hermetic compressors may reduce their service life and increase their frequency of replacement (since repairs of hermetic compressors are impractical). Given the improvement in low-temperature heating performance, however, the additional complexity is likely justifiable and cost-effective in an appropriate application.

Additional Information

Northwest businesses and electric utilities can contact the *Energy*Ideas Clearinghouse for additional information on this or other energy technologies or products. Contact:

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