VFDA Cold Climate Heat Pump Testimony — November 30, 2016

What are your concerns about the testimony presented by GMP in Docket 8794?
I have serious concerns about GMP's plan to lease cold climate heat pumps (CCHPs), specifically, the contention that a CCHP will save both energy and money.

What is the problem with GMP's claims?
The ability for CCHP to save energy and money is dependent on the consumer's level of knowledge about the device, the layout of the home, and the efficiency and cost of fuel for the existing central heating system. If used properly, a CCHP will reduce consumption of the fuel used by the central heating system, much like a wood stove. And similar to wood heating, the research and experience of heating fuel and service providers tells us that the impact on the displacement of fuel that is used by the central heating system is highly variable. Clearly, if a CCHP is used for heating, it will increase the amount of electricity consumed. Whether it will "reduce energy" is dependent on what fuel it is displacing and the efficiency of the central heating system. Whether this displacement saves money is entirely dependent on the efficiency of the central heating system and the price of the fuel that is used by the central heating system.

Will CCHPs work well in all Vermont homes?
No. CCHPs work best in open construction one-story homes. They do not heat the whole building, only the rooms where the appliance is located. Any energy savings will be due more to austerity than efficiency. Since the balance of the building is cooler, the central heating system will need to be kept on in order to avoid frozen pipes in the walls of the unheated rooms.

What happens if pipes freeze?
When pipes freeze up they can crack and cause significant damage. One freeze up with broken water and/or heat pipes can cost more than $10,000 to repair.

Wouldn't customers understand that installing a CCHP is not a fuel switch and that they still need a central heating system operating during the coldest part of the winter to ensure that pipes do not freeze?
One would hope. However, the language used by GMP in their testimony and marketing is that CCHP's "represent a fuel switch." In fact, only in very rare instances can a CCHP replace the entire heat load and allow for a fuel switch or equipment swap. If the home does freeze, the question of who is liable to repair the home is uncertain.

In your experience, what is the main selling point or the primary motivation of consumers to install a CCHP?
Air conditioning. While much more expensive than window units, they are far superior. A majority of homes in Vermont are radiant or steam heat, thus lacking the duct work necessary for a central air conditioning system. This has been the driving force behind the sale and installation of CCHPs by full service heating fuel dealers. While most installations of heat pumps are CCHP rather than cooling-only units, this is a function of Efficiency Vermont's upstream incentives. Based on my experience working with service

technicians and wholesale suppliers, the vast majority of installations of CCHPs are in response to consumer demand for air conditioning.

Even if they are installed for cooling, won't they be used for heating as well?
This is uncertain. GMP's assumption is that as customers become more familiar with the technology they will use it more in the winter, thus increasing electric usage. Even consumers that buy or lease a CCHP for heating eventually reconcile that it cannot provide the same warmth and comfort as a central heating system. Heat pumps circulate air that feels relatively cool. Unlike a gas furnace, which blasts hot air for a few minutes and then turns off, heat pumps run longer at cooler temperatures. If the air temperature being supplied from the CCHP is below skin temperature, there will be a perception of being cooled, especially when there is a velocity of air across the body. When supply air temperatures are at or below typical body temperature (slightly less than 100 degrees Fahrenheit) consumers report feeling cool and uncomfortable. This is reflected in research using the U.S. Department of Energy simulation tools (BeOpt and EnergyPlus) to quantify comfort level associated with various heating sources (Exh. VFDA-1). Supply air from CCHPs is colder than 100 degrees Fahrenheit 65% of the time. The resulting discomfort may cause consumers to rely more on the central heating system. While GMP indicates that only 1.4% of the customers who enrolled have left the pilot program, this occurred over a winter that had 10% fewer degrees days than normal. It is also assumed that these pilot program participants are early adopters whose primary motivation was to displace their fossil fuel heat load and were less concerned about the loss of comfort.

What is wrong with GMP's savings calculation?
GMP is using the wrong price per gallon for heating oil. GMP uses the average cost per gallon for the last five years. The first three years were an aberration. There is broad consensus that oil prices will be lower and less volatile than they have been for the last half-century, thanks to technology driven increases in domestic production. The United States is the dominant oil producer, which means future prices will be influenced more by supply and demand than global political issues. Most oil traders and analysts predict the price of crude oil to trade between $40 to $60 a barrel for the next ten years.

What price should be used?
According to the Energy Information Administration, the average price of heating oil in Vermont over the past two years has been $2.309 per gallon. The price per gallon for residential home heating oil in Vermont during the week of November 21, 2016 is $2.125 per gallon (Exh. VFDA-2). It is reasonable to assume the average price of heating oil will continue to fluctuate between $2.10 and $2.50 per gallon for the foreseeable future.

How do you reach the conclusion that the GMP CCHP Lease Program will end up increasing the cost of heating for Vermonters?
Emera, an electric utility that provides transmission and distribution services to 154,000 residential, commercial and industrial customers in Maine, conducted a comprehensive analysis of their CCHP Pilot Program (Exh. VFDA-3). The study on relative heating

costs between heating oil and CCHPs indicates that the average consumer in the pilot program displaced 239 gallons of heating oil. This represents about a third of the gallons consumed by the average Vermont or Maine home in a typical year. While not insignificant, consumers will spend more money for thermal energy under the GMP Heat Pump Lease Program that they would have if they continued to use their existing central heating system.

Using the data from the Emera Maine Heat Pump Pilot Program conducted by EMI Consulting, the installation of a CCHP is assumed to displace 239 gallons of heating oil a year. The displacement of 239 gallons at $2.30 per gallon results in $549.70 a year in savings, less the projected additional annual electric use for the heat pump in the heating cycle of 2,387 kwh @ $0.16 equals $381.92. This savings amounts to $167.78 per year in thermal energy costs. However, when you add the lease payment of $660 per year, the average customer would lose $492.22 per year, or $7,383.30 over the life of the lease.

Keep in mind that the data showing these losses come from a study sponsored by an electric utility. Furthermore, the Emera study assumes the CCHP is operating in optimal conditions. It is very hard to characterize how well CCHPs will perform because so much of their performance is dependent upon the design of the building; the way the homeowner operates the CCHP and the back-up system. According to GMP's assumptions, the amount of oil displaced varies by 60 percentage points from one type of building construction to another. How much oilheat is displaced depends on the temperature in the rest of the house, the efficiency of the central heating system, the cost of service for the CCHP, and its life expectancy. The Emera study noted that the range of savings varied significantly for participants in the program

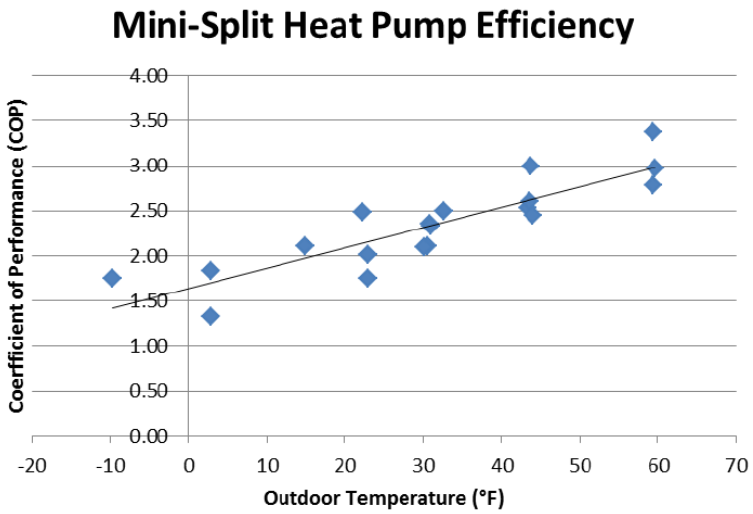
What would the price per gallon of oilheat would be required for there to be an economic payback under the GMP lease program?
The cost of heating oil would have to be in excess of $3 a gallon and electric prices to remain constant during the 15 year lease for there to be any savings under the GMP lease program.

What are the other factors beyond the price of competing fuels?
The United States Department of Energy Buildings Technology Program Laboratory Test Report for Fujitsu 12 RLS and Mitsubishi FE12pA Mini-Split Heat Pumps. In the report they determined the coefficient of performance for two popular models of CCHPs. The results are expressed in the following graph (Exh. VFDA-4).

Note that as the outdoor temperature drops so does the efficiency of the CCHP. This is just the opposite of the efficiency of petroleum fired central heating systems. As it gets colder the idle losses for these systems drops and their efficiency improves. The colder it gets, the more efficient they become.

Using this performance data, Brookhaven National Laboratory (BNL) developed an 8,760-hour model of a 2,500 sq. ft. Maine home (Exh. VFDA-5). It compared an oil fired

non-condensing boiler (that also heats domestic hot water) with a Two-Head Mini-Split 38,000 BTU Heat-Pump. The study looked at 3 modes of annual heating operation: Oil fired unit only, CCHP used in shoulder months, CCHP used all winter long. BNL found the CCHP output dropped from 100% at 60 degrees Fahrenheit to 45% at zero and 35% at -10 degrees Fahrenheit. The coefficient of performance (COP) was 1.7 at zero, 2.5 at 30 degrees Fahrenheit, and 3 at 48 degrees Fahrenheit. The study concluded that that while a CCHP is more efficient than oilheat at and above 48 degrees, oilheat is more efficient than a CCHP when temperatures dip below 48 degrees Fahrenheit.



More information about the the efficiency of CCHP comes from the Burlington Electric Department 2017 Energy Efficiency Utility Annual Plan (Exh. VFDA-5). The annual plan notes that CCHP's are becoming a popular technology but require "careful attention and on-going analysis." BED developed an analysis tool to help customers evaluate their specific economics when installing a CCHP. According to the report, this tool "clearly demonstrates that CCHP's are more expensive to operate than natural gas fired equipment at current rates." The same holds true for oilheat as the Vermont retail price of the two fossil fuels are nearly identical on a BTU basis.

A study released by the Consortium for Advanced Residential Buildings (CARB) further addressed the uncertainties about the capacity and efficiency of CCHPs in cold weather (Exh. VFDA-7). According to the report, "these uncertainties could lead to skepticism among homeowners; poor energy savings estimates; suboptimal system selection by heating, ventilating, and air-conditioning contractors; and inconsistent energy modeling." The report goes onto to state that "the results from this monitoring effort show a wide range of performance with many systems performing below expectations. More work is needed to better assess energy consumption and capacities of these systems in different climates and home configurations."

What are your concerns about emissions with heat pumps?

GMP's calculations on the success of the rental program depend to a degree on load control and strategic dispatch. This means customers will be switched to the backup heat during peak demand. This is not accounted for in the oil savings and environmental impact calculations. Furthermore, displacing renewable biodiesel blended oilheat with electric heat that is only 55% renewable is not reducing emissions.

What is renewable biodiesel blended oilheat?
One of the biggest transitions in oilheat over the last five years has been the blending of biodiesel into the oilheat supply. Biodiesel is a renewable energy resource made domestically from fatty acids found in soy and other vegetable oils, recycled restaurant frying oils, and other natural sources.

Are Vermonters currently using renewable biodiesel blended oilheat?
Most of Vermont's oilheat providers are already selling a fuel blended with biodiesel, thanks to a federal energy policy known as the Renewable Fuel Standard (RFS). The RFS requires 9 billion gallons of biofuel to be blended into the downstream supply every year. Biodiesel is blended at various levels into the oilheat distribution system and receives full credits from the EPA under RFS. In 2015, ASTM announced new performance specifications for fuel oils (D396) that will accommodate blends of 6% to 20% biodiesel in conventional fuels. This means that the upstream supply can be blended with 20% renewable biodiesel and still be sold as oilheat.

Why would biodiesel be blended into oilheat at such high levels?
Biodiesel blended with oilheat has been proven to work effectively in existing equipment without modification, thus allowing for a seamless and inexpensive way for consumers to transition to a renewable fuel. The National Oilheat Research Alliance (NORA) has made investing in renewable liquid fuels a top priority with a goal of making oilheat 100% renewable by 2050. NORA is also working to develop a pump and burner that can use up to 100% biodiesel as standard equipment (Exh. VFDA-8).

What are the environmental advantages of renewable biodiesel blended low sulfur heating oil?
The end result is that low sulfur oilheat with a 20% blend of renewable biodiesel is significantly cleaner than natural gas with regards to Greenhouse Gas Emissions (GHG). This was established by ICF International and was presented to the Public Service Board by Richard Sweetser in 2013 (Exh. VFDA-9).

Any final thoughts?
It is important to remember that CCHPs will primarily be used as redundant heating systems. In the vast majority of Vermont homes, they cannot replace the central heating system and will be used primarily in the spring and fall. Installing a CCHP in a Vermont home is similar to driving a convertible on Vermont roads. Sure, it may work out during the spring, summer and fall, but it is not practical in the winter.

EXHIBIT LIST

Exh. VFDA-1 Performance Comparison of Residential Heating Systems. July 2013. Newport Partners LLC

Exh. VFDA-2 Energy Information Administration. Weekly Vermont No. 2 Heating Oil Residential Price.

Exh. VFDA-3 Emera Maine Heat Pump Pilot Program. November 2014. EMI Consulting.

Exh. VFDA-4 Laboratory Test Report for Fujitsu 12RLS and Mitsubishi FE12NA Mini-Split Heat Pumps. September 2011. John Winkler, Ph.D. U.S. Dept. of Energy.

Exh. VFDA-5 Modeled Energy and Economic Performance Assessment of a Portland, ME Home with and Existing Oil-Fired Non-Condensing Boiler and a Two-Head Mini-Split 38,000 BTU Heat-Pump Operating in Three Modes. Dr. Tom Butcher. July 2015. Brookhaven National Laboratory.

Exh. VFDA-6 City of Burlington Electric Department 2017 Energy Efficiency Utility Annual Plan.

Exh. VFDA-7 Field Performance of Inverter-Driven Heat Pumps in Cold Climates. August 2015. U.S. Department of Energy Building. Consortium for Advanced Residential Buildings (CARB).

Exh. VFDA-8 Developing a Renewable Biofuel Option for the Home Heating Sector. May 2015. NORA Research Report to Congress.

Exh. VFDA-9 Prefiled Testimony of Richard Sweetser. Vermont Public Service Board Docket 7970. July 2013.

All documents can be downloaded at: vermontfuel.com/heatpump