City of
Portland, Oregon
Bureau of Development Services
FROM CONCEPT TO CONSTRUCTION

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To: **Tad Everhart**

From: **Alternative Technology Advisory Committee:**
Edward Vranizan (chair) Joshua Klyber
Howard Thurston Kathy Bash David Todd

RE: **Application #09-008 (Everhart) – Final Recommendation**

Date: **February 11, 2014**

Summary of Proposal: The applicant requests that the committee review a Sanden USA Model GAU-A45HPA heat pump water heater for domestic hot water. The unit is composed of a heat pump, a tank that uses carbon dioxide refrigerant to heat water from an outdoor heating unit and pumps the water to an indoor storage tank for use as needed. The unit that the applicant wishes to install is manufactured in Japan and currently sold in Australia and was tested at Washington State University. It is not yet UL-listed

Applicable Building Code Section(s): 2010 Oregon Mechanical Specialty Code section 1002.1 requires that all potable water heaters and hot water storage tanks be listed and labeled. Section 105.2 of the Mechanical Specialty Code allows the building official to approve an alternative material or method of construction if the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of the Mechanical Specialty Code.

Committee Findings:

1. The Sanden heat pump water heater Model GAU-A45HPA uses carbon dioxide refrigerant to heat water within an outdoor condenser unit. That water is then pumped to an indoor hot water storage tank, where it is available for use within the home.
2. The outdoor compressor operates at 2,030 psi. Field service of the unit is limited to the fan, boards and water pump. If the compressor and heat exchanger fail, these components are returned to the factory, and a new unit is installed. These units are not repaired in the field.
3. The units are rated to minus four degrees Fahrenheit, with freeze protection provided by reversing the motor and flowing warm water back through the system. The units are powered by 220V, so no electrical modifications are required to run them.
4. The heat pump hot water system complies with the current version of the Oregon Energy Code.

5. The heat exchanger is UL listed, as is the carbon dioxide refrigerant. However, the Panasonic compressor the unit utilizes is not UL listed.
6. Carbon dioxide refrigerant has far lower global warming potential than conventional refrigerants used in conventional heat pumps, and the system has substantially higher coefficient of performance and energy factor than conventional consumer heat pump domestic hot water systems. The system is powered by electricity, which is renewable. Because the unit does not require large penetrations for ducts, the unit is more compatible with a passive house design. The hot water storage tank maximizes off-peak electrical power use.
7. Four of these hot water heating units are installed in residential applications as part of the Washington State University study in conjunction with BPA. In addition, these units are manufactured in Japan and sold in Australia. Sanden is currently pursuing UL approval of this unit in the United States.

Final Committee Recommendation:

Based on these findings, the Alternative Technology Advisory Committee recommends approval of the use of this technology for residential purposes.

Please note: The Bureau of Development Services and the Administrative Appeal Board are not bound by the recommendations of the Committee. A favorable recommendation of a technology by the Committee does not guarantee approval of a building code appeal.

Further instructions for the applicant:

You may submit your building code appeal to use this technology in a site-specific project at any time by following the instructions found on the BDS website. A building code appeal must be approved by BDS to be able to use this technology in a project. Please submit a copy of this committee recommendation with your appeal application. Please contact the Appeal Board Secretary at (503) 823-7335 if you have any additional questions about the appeal process.

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Alternative Technology Advisory Committee Application Form

For information about the Alternative Technology Advisory Committee, instructions for filling out this application form and a list of submittal requirements please see our web site at www.portlandonline.com/bds/atac

Applicant Information:
Name: Tad Everhart **Company Name: None**
Email Address: tad.everhart@comcast.net; teverhart@earthadvantage.org
Address: 539 SE 59th Court
City: Portland **State: OR** **Zip Code: 97215-1969**
Phone No.: (503) 239-8961 **FAX No.: (none)**

Project Information:
This application involves (check one):
☐ **A technology not associated with a specific project**
☐ **A specific project currently under review**
Project Address:
Tax Account number:
Building Permit No.:
LU Case No (if applicable):
X **Other (specify): A specific project not yet under review but for which all required building and/or plumbing/mechanical/electrical permits will be requested if technology is recommended by ATAC.**

I. Overview of Technology

A. Proposed Technology: Please describe the material/product/construction method you would like to have reviewed by the committee

Domestic hot water heat pump water heating system (HPDHW or heat pump) using carbon dioxide refrigerant and manufactured by Sanden USA (Sanden). The Sanden heat pump I wish to install heats water which flows from the (outdoor) unit to a storage tank. All refrigerant is contained within the outdoor condenser unit. Heat from the refrigerant is transferred to water in the outdoor unit. That unit is connected to the tank with control wiring and both cold and hot water lines. The water lines are connected to a hot water storage tank. The unit is also connected to 220volt power supply. The Sanden heat pump is not yet UL-listed.

B. Application of Technology: Please describe the specific application of the technology. How, when and where will this technology be used?

I hope to install (immediately upon ATAC's recommendation and successful code appeal) the Sanden HPDHW outside my house to supply our DHW. Eventually, I hope this system can help supply heated water for a hydronic coil to heat air in our ventilation system to provide space heating.

C. Code Conflicts: Please describe any known building code issues related to this technology.

This is a mechanical system which is not yet UL-listed.

II. Sustainability

A. Sustainable Elements: Describe how this alternative substantially reduces the environmental impact on the planet over similar technologies currently allowed by the code*? **Please attach any documentation that supports your answer.***

1. CO2 refrigerant has far lower global warming potential (GWP=1) than conventional refrigerants used in heat pumps. It does not damage ozone.
2. CO2 HPDHW systems have substantially higher coefficient of performance (COP) and energy factor (EF) than conventional HPDHW systems available to consumers for DHW. This makes better use of energy.
3. HPDWH systems are powered by electricity allowing renewable energy sources instead of fossil fuels. We currently have a high-efficiency gas DHW (tank) system, but we wish to avoid fossil fuels in order to minimize climate change. Unfortunately, HPDHW systems available in the US market for residential use have relatively low COP operating in the Portland area climate. Given the 40% coal primary energy for electricity in Portland combined with the low COP, our high-efficiency (condensing) gas DHW tank system appears to may cause less global warming than available HPDHW systems. However, with the higher COP of the Sanden system and our choice to purchase 100% wind electricity, we hope to reduce our impact on the environment and reduce our contribution to climate change. All without the risk of inadvertently causing global warming if/when refrigerants from millions of our HPDHW systems eventually escape into the atmosphere.
4. In addition, since we have a house that is close to meeting the Passive House Standard, we try to maintain it airtight integrity. We cannot have a gas DHW system inside the house without relatively large penetrations for ducts to carry in combustion air supply and to exhaust combustion products. Yet we would like to locate the DHW tank inside our home in order to enjoy the vagrant heat that escapes even the well-insulated Sanden DHW tank. This electric heating system allows only the relatively minor penetrations of our air barrier needed for water lines and wiring, and those penetrations are already in place and well-sealed. Thus, we can locate the storage tank indoors without large penetration in our air barrier.
5. The HPDHW system potentially simplifies mechanical systems for low-load houses like ours (and hopefully many others in Portland) by conceivably allowing us to combine water heating and space heating as a single system. A single system reduces resource use in manufacturing (including embodied energy in manufacturing and transportation energy) and minimizes maintenance, repair, replacement, and total lifetime costs. At this time, we will not attempt to use the Sanden DHW for space heating, but it is a possibility for the future.
6. The HPDHW has a hot water storage tank which allows us to make use of off-peak electrical power generation by heating water and storing the heat in the DHW tank at that time for later use during the hours of peak electrical load (when our compressor and heat exchanger will not need to be running). This "thermal battery" becomes a means to store electricity that may be produced by renewable energy systems in excess of the grid load (e.g., late at night and early in the morning). Clearly, achieving this optimal timing will take some careful thought and planning. Ideally, we can also optimize the time of day in which the system operates (in compression heat collection cycle) while storing heat in the tank for space heating needs during periods when the compressor is not operating. This allows us to take advantage of diurnal high ambient temperatures where the system COP is higher. Unfortunately, peak daily temperatures often coincide with peak loads on the grid. However, the CO2 refrigerant technology promises relatively high COP even at colder ambient supply air temperatures.

B. Reason for Alternative: Describe why this alternative is desired?

As stated above, this alternative makes better use of resources, uses less energy, and avoids environmental damage associated with conventional refrigerants (having high GWP).

C. Comparison to Other Technologies: How does this technology provide equivalent life safety and/or fire protection than the current technologies allowed by the code?

The significant differences of this heat pump and conventional alternatives is that CO2 is used as higher temperatures and pressures which are as safe given equipment designed and manufactured for those temperatures and pressures. The Sanden outdoor unit is sealed at the factory and is not to be repaired on site. In the event it does not function correctly, it is disconnected and returned to the manufacturer for analysis and disposition. This is not a system in which the refrigerant is installed (and pressurized) onsite.

III. Supporting Documentation

A. Testing Data: Describe any testing that has been performed on this technology to show how it may be able to meet code requirements. ***Please attach all available testing data.***

The government of Japan supported development and testing of CO2 refrigerant HPDHW systems from 1995. "Eco-cute" units substantially similar to the Sanden unit we wish to install have been sold in Japan to consumers since 2001. Sanden has been testing its HPDHW system since 2011. The company has mass-produced CO2 heat pump water heaters in Akagi, Japan in since 2006 and in Tinteniac, France since 2011. Sanden has established markets in Japan, France and Australia. The unit tested by NEEA is an indoor unit that is manufactured and currently sold in France (which we do not hope to install). The unit tested by Washington State University is a split unit that is manufactured in Japan and currently sold in Australia. We hope to install this system.

In addition to Sanden's initial testing and continuous testing, over the last year Ken Eklund of the Washington State University Extension Energy Program has been bench testing the exact unit we wish to install. He reports no failures or unsafe operating conditions in his testing. In fact, his initial testing has yielded such favorable results that Bonneville Power Administration is funding WSU's pilot project involving installation of this same Sanden unit in 4 homes through the Pacific Northwest. Mr. Eklund's presentation is cited below.

One printed copy of all supporting documentation is attached with links to documents on internet below:

WSU presentation on early test results of Advanced Heat Pump Water Heater Research project for BPA @ http://aceee.org/files/pdf/conferences/hwf/2013/1A-eklund.pdf

REHVA Journal – October 2012 "Inside view into the Japanese heat pump market" @ http://www.rehva.eu/index.php?id=210

Wilkenfeld presentation to ACEEE 5 November 2013 "Heat Pump Water Heaters: Growing the Global Market" @ http://aceee.org/files/pdf/conferences/hwf/2013/5A-wilkenfeld.pdf

Owner's Manual for Sanden Heat Pump Water Heater with Natural Refrigerant (CO2) for model GAUS-315EQTA (Heat Pump Unit GAU-A45HPA and Tank Unit GAU-315EQTA) @ http://www.sanden.com.au/iS_admin/files/Eco%20cute%20owner's%20manual%20version%206.pdf

Brochure (including international certifications on last page) @ http://www.sanden-hot-water.com.au/sites/all/themes/sanden/Sanden_Brochure_070213.pdf

For certification information, see
For IAPMO Oceana @ http://www.iapmooceana.org/Pages/default.aspx
For Japan Accreditation Board @ http://www.jab.or.jp/en/system/service/product/accreditation/
For Union of Japanese Scientists and Engineers (JUSE Registered Firm) @ http://www.juse.or.jp/e/qc/01_qc.html

Information for comparing Sanden's product with other heat pump water heaters available in our market

BPA "Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates" 9 November 2011 (only first 2 of 90 pages is attached, but entire report on HPDHW systems available in Portland @ http://www.bpa.gov/energy/n/emerging_technology/pdf/HPWH_Lab_Evaluation_Final_Report_20111109.pdf

ENERGY STAR database printed for HPDHW systems available in US with energy factor (EF) highlighted (4 pages printed only)

General Information about Sanden and its product development in Europe (different Sanden HPDWH model) : Dr.-Ing. Georges Khoury "Development of high efficiency CO2 Heat Pump for domestic hot water" @ http://www.atmo.org/media.presentation.php?id=103

Also see information about Sanden at Everything R44 @ http://www.r744.com/companies/view/sanden

B. History of Use: Describe all known instances where this technology has been applied to a constructed building, including approximate date, location and building type. ***Please attach any documentation that supports your answer.***

Please see articles and documents cited above showing installations in Japan (over 3.5 million), Australia, and Europe. The REHVA Journal states fast-growing sales in Japan had reached 550,000 units in 2012.

Responsibility Statement:

As the applicant submitting this application I am responsible for the accuracy of the information submitted. I have submitted all the relevant information available about the technology I am requesting the Alternative Technology Advisory Committee to review. I believe the information submitted to be a compete and accurate representation of the proposed technology and I am aware that any omission (either voluntary of accidental) could cause the application to be denied. I understand that more information may be requested before the committee can make a recommendation on my application.

I understand that the recommendation from the committee is not binding. In addition a favorable recommendation from the committee is not a guarantee that the Administrative Appeals Board will approve a subsequent building code appeal. The City of Portland and the committee members have no implied or expressed liability associated with the conclusions of the Alternative Technology Advisory Committee. By my signature, I indicate my understanding and agreement to the Responsibility Statement.

Applicant's signature: **Date: 11/20/13**

Property owner's signature (if applicable): Tad Everhart

Date: 11/20/13

For Office Use Only:

Received By: Date Received: Receipt No.: