## Residential $\mathbf{C O}_{\mathbf{2}}$ HPWH Results from Field Testing



## Sanden Profile

Founded in 1943 / Revenue: \$2.8 billion / Employees: > 10,000 Global network: 54 sites in 23 countries, 3 sites in the US

## Core technology

Cooling

## Automotive

 June 16 \& 17, 2016 - Chicago

## Project Overviews

## \#1 : Replacing Electric Storage \&

 HPWH's - 4M unit/year potential market- Homes across the NW from the Coast to Montana; Min family size 4, Maximum of 7
- Partners -Washington State University, NEEA, BPA, Avista, Energy Trust of Oregon, Ravalli Electric Coop \& Tacoma Power
\#2 : Demand Response Comparison
- What is the energy storage capacity in long-term field use when subject to high hot water use : 130+ Gallons per 24 hours
- Partners: Washington State University, NEEA, Bonneville Power Authority, PNNL \& DOE

Sanden HPWH


Standard HPWH


- R134a/R410a
- Indoor installation
- Noise >50dB
- Electric backup element required
- Cools home even in the winter


## Field Test Outcome

| Sample |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Site | | Sampled |
| :---: |
| Days |
| (n) |$\quad$ kWh/Day $\left.$| Total |
| :---: |
| Household |
| Hot Water |
| (Gal/day) |$\quad$| Mean OAT |
| :---: |
| ( ${ }^{\circ}$ F) |$\quad$| Minimum |
| :---: |
| OAT ( ${ }^{\circ}$ F) | \right\rvert\,

Units were monitored for Energy and Water use, along with multiple temperature sensors in the system
The energy needed to heat the cold water supply for each flow event was calculated as:
Supply Water BTU = Volume (Supply water) $8.34 \times$ (Avg. hot water temp. - Avg. cold water temp.) $\times 1$ $\mathrm{Btu} / \mathrm{l}$./oF, where $8.34 \mathrm{lb} . / \mathrm{gal}$ is the density of water

A Field Energy Factor (Energy Factor being the official DOE Water Heater Descriptor) was calculated: FEF = Energy Contained in Total Useful Hot Water/Total Energy In

Data from installation through 10/31/2014 June 16 \& 17, 2016 - Chicago

## Usage vs Energy

## Daily Flow and Energy



## Field Test Results

kWh per 100 gallons of Hot Water used


## Typical Hot Water Usage

Hot Water use is a case of two peaks and a two troughs - If a system can operate in the troughs but still supply Hot Water for the peaks then it has the potential for off peak power or renewable power usage


амегіса Sphere natural refrigerants June 16 \& 17, 2016 - Chicago

Demand Potential


Approx. 130 Gallons used per 24 Hour Period using varying Flow Rates and Length of Draw

System potential test : Outdoor unit is turned off for varying periods of time to determine if the system can meet Hot Water demand

Over Supply Schedule

|  | Off Time | On Time |
| :--- | :--- | :--- |
| Day 1 | None | None |
| Day 2 | 5PM | Midnight |
| Day 3 | 4PM | Midnight |
| Day 4 | 3PM | Midnight |
| Day 5 | 2PM | Midnight |
| Day 6 | 1PM | Midnight |
| Day 7 | Noon | Midnight |

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## System Power Usage

This graph shows the unit in standard operation responding just to the draw pattern \& tank temperature Energy use 5.05 kw , operating time 5 hours, 139 Gallons


## Demand Power Usage

This graph shows the unit was shut off for 12 hours
Total Energy use 5.63 kw, no reduction in HW performance


## Byproduct of Demand Operation

Because of the nature of $\mathrm{CO}_{2}$ Water Heating in a Transcritical System efficiency almost works backwards - The colder the water supplied to the Gas Cooler, the higher the efficiency
Conclusion turning off the unit for a period of time cools the tank and improves COP


Demand Response

- Yes
- •No

Tank Volume

- 40 Gallons
- 80 Gallons

Field Tested Validations
The Sanden SANCO $_{2}$ HPWH

- Provides Domestic Hot Water to any home in Ambient temperatures down below $-15^{\circ} \mathrm{F}$
- Energy Per Gallon of Hot Water from the field test shows
- $\mathrm{SANCO}_{2}$ system uses 0.0475 kwh/gallon
- Electric Resistance Water Heater uses 0.22 kwh/gallon
- Synthetic Refrigerant HPWH uses 0.1 kwh/gallon
- Can produce over 135 gallons of Hot Water per day, even with a 43 Gallon Tank size, and can
operate with a 12 Hour shutdown period

Water Heater

## LAUNCHING JULY 2016

- ETL certification obtained, Energy Star and AHRI certification ongoing, product in US inventory.....


## Next product

- Space Heating using Hot Water, standalone and in Combination with DHW
Barriers to the market for this product
- UL/ETL approval - Standard and testing required
- SNAP - Currently $\mathrm{CO}_{2}$ is not permitted as a refrigerant for Space cooling or Heating


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## Thank You


[^0]:    Delivering Excellence

