
# $CO_2$ Heat Pump Water Heater Tests

## What We Know and What We Wish We Knew

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# What We Know

# The $CO_2$ Split System HPWH Performs Well

- As an efficient water heater
- In cold climates
- Meeting an average or larger hot water load
- As a Demand Response provider
- As a Capacity Reducer

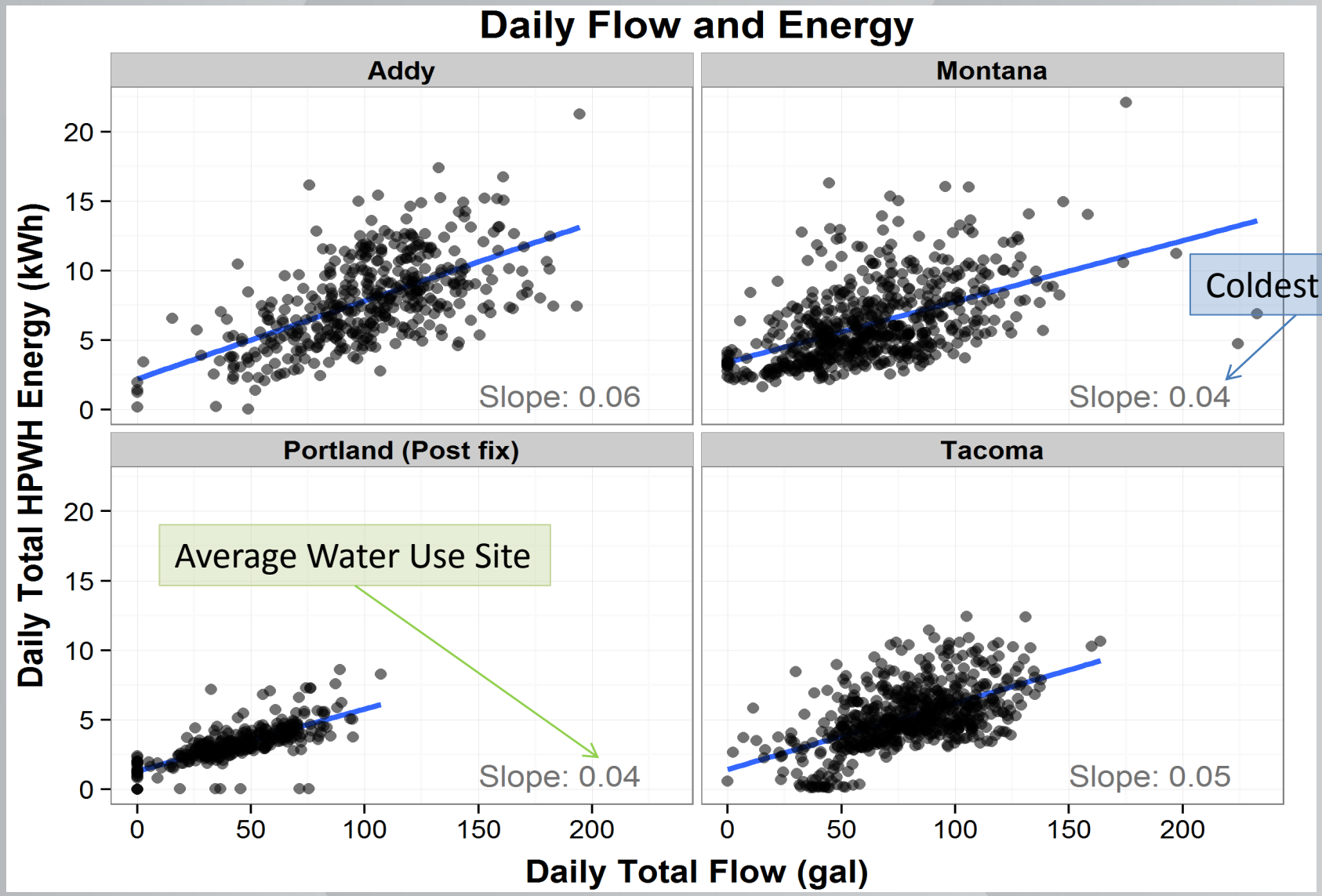
# HPWH Performance

- Energy per gallon is a great metric to compare water heater performance
- The average energy per gallon over the full field test period was .0475 kWh per gallon
- Electric resistance water heater performance is .22 kWh per gallon or 4 times more energy
- A major field study of US made unitary HPWH averaged .1 kWh per gallon

# Field Sites

- 4 homes from the coast to Montana
- Minimum family size of 4—up to 7
- Billing history of at least 3 years with electric resistance water heat
- Avista, ETO, Ravalli Electric, and Tacoma Power found sites

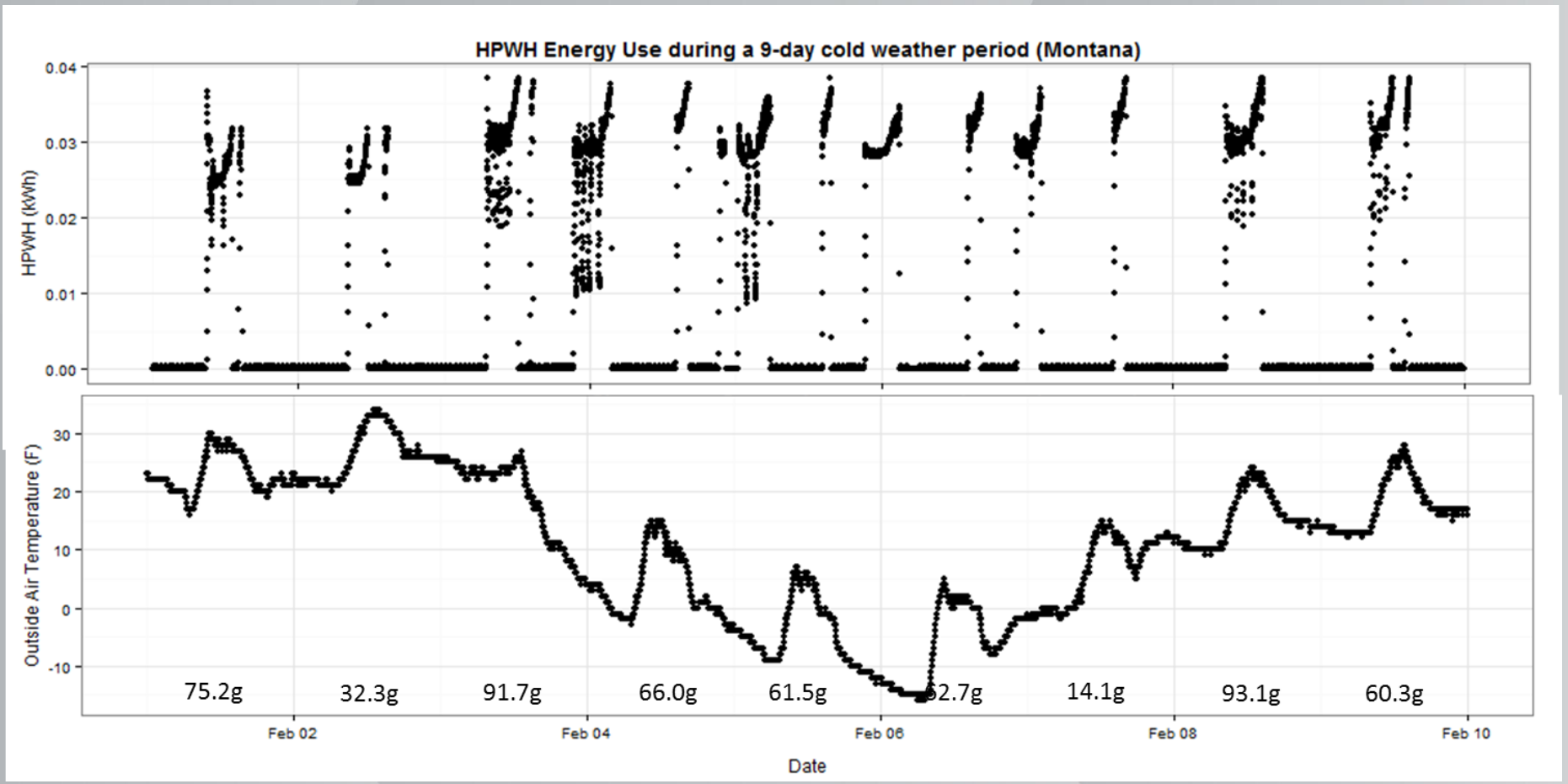
# kWh/g for Each Site



# Savings Potential

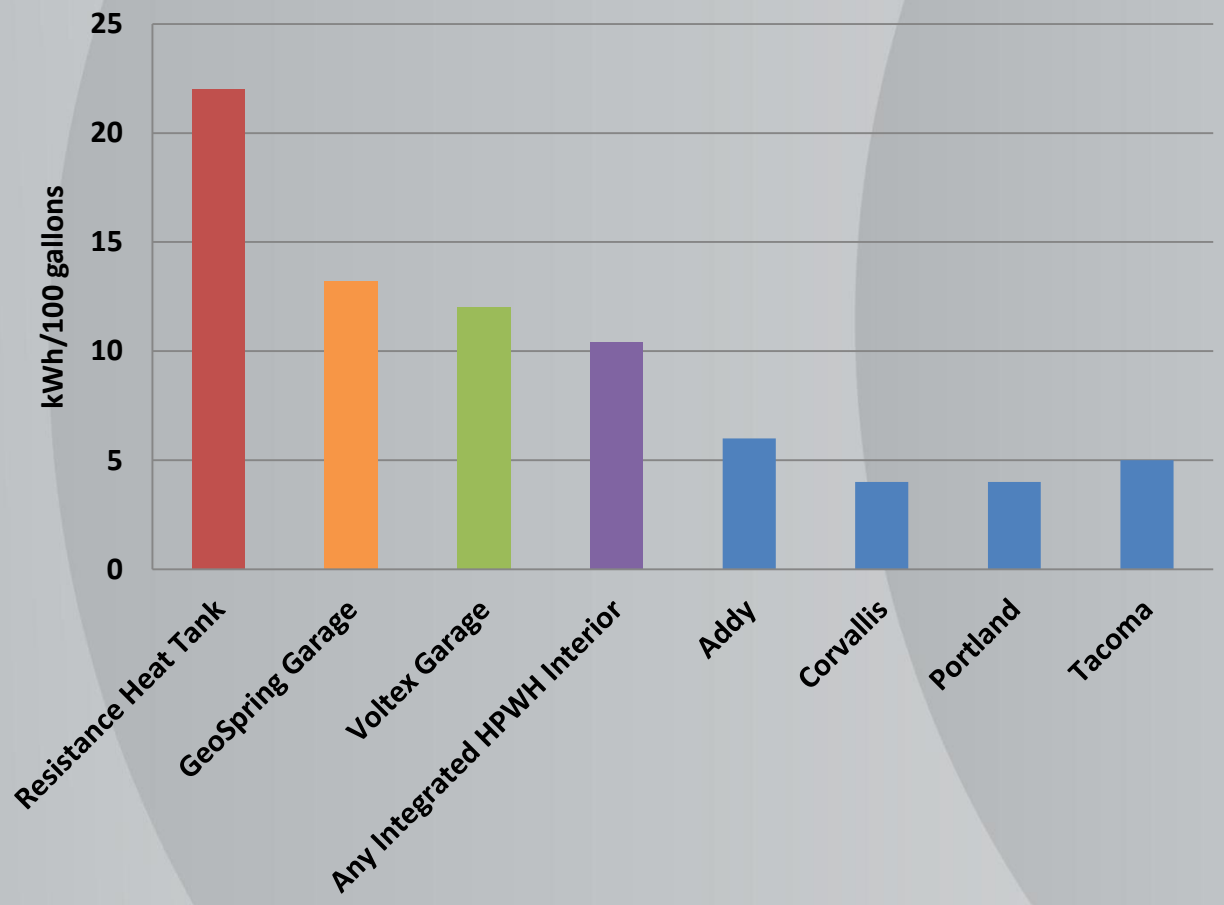
- 2.7 people per household (PNW average)
  - Use ≈ 45 gal/day
- Split System $CO_2$ HPWH saves ≈ 0.175 kWh/gal
  - 2,436 kWh/year savings

# Cold Weather Performance



# HPWH Performance

- kWh per 100 gallons water delivered (inverse Logsdons)



# DEMAND RESPONSE

PNNL Lab Home

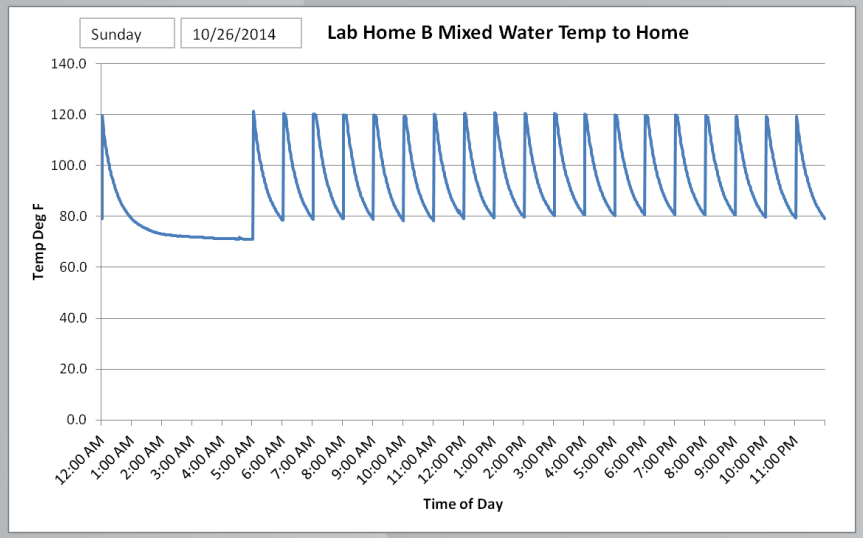
# SPLIT SYSTEM

# Extreme Oversupply Mitigation Test

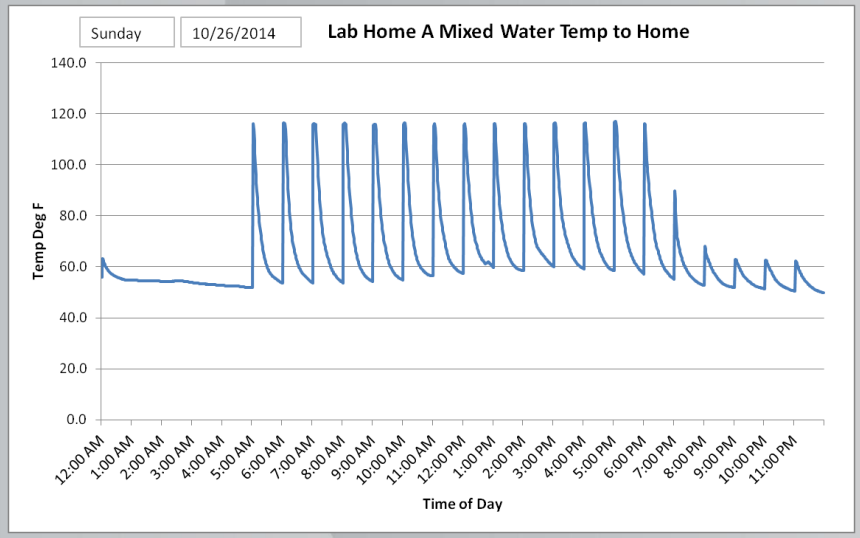
## Water Heater Off at 1 pm

## To Make Room to Absorb Off-Peak Wind Energy

### Split System (80 Gallons)




### Unitary System (40 Gallons)




Note: the top point on the chart is water temperature – the bottom point is the cooled pipe temperature between draws and not relevant to delivery

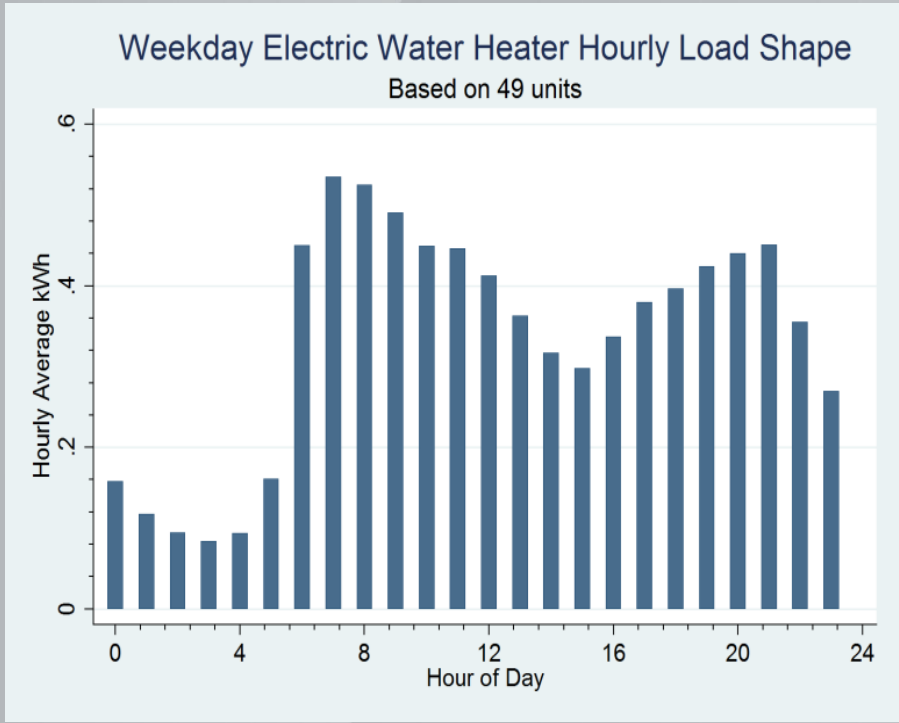
# DR Value

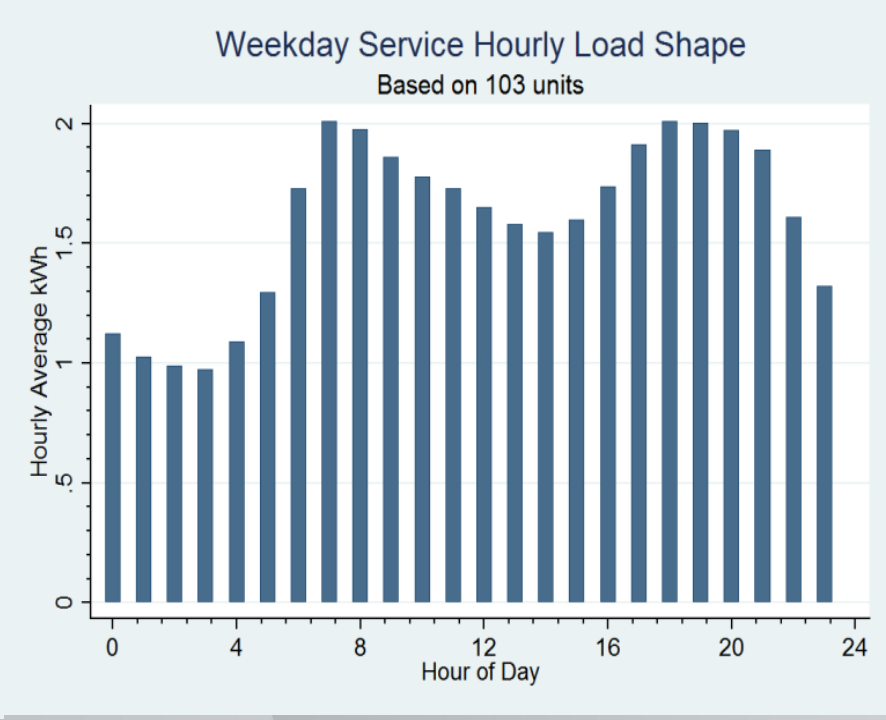
"A significant amount of [Demand Response] potential, nearly 1,500 megawatts, is available at relatively low cost; less than $25 per kilowatt of peak capacity per year" 7th Power Plan

The controllable power draw of the split system is 1.2 kW. It can also provide 2.6 kW of storage for oversupply mitigation.

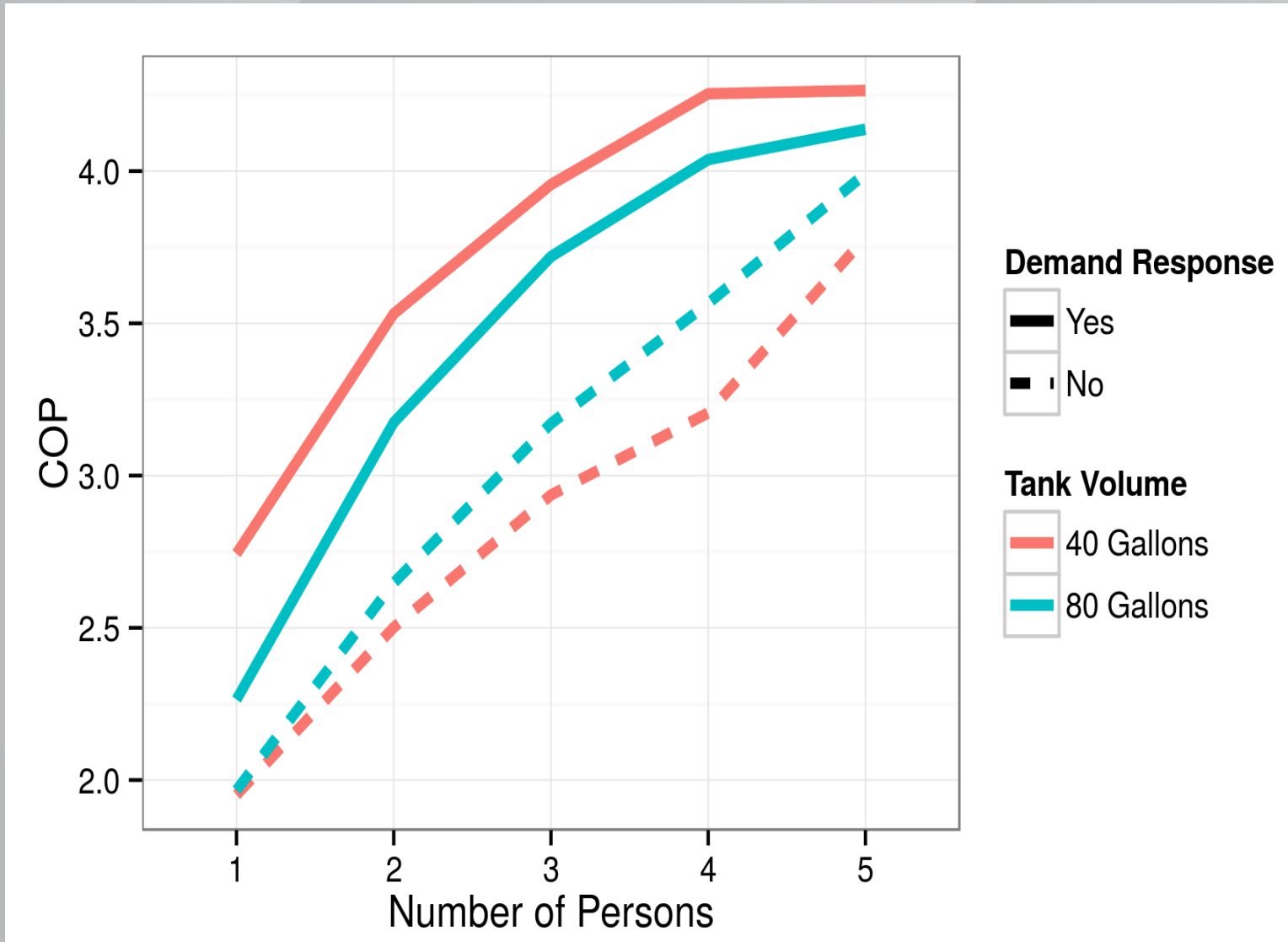
# Peak Impact

## Most Hot Water Demand is at Peak Times



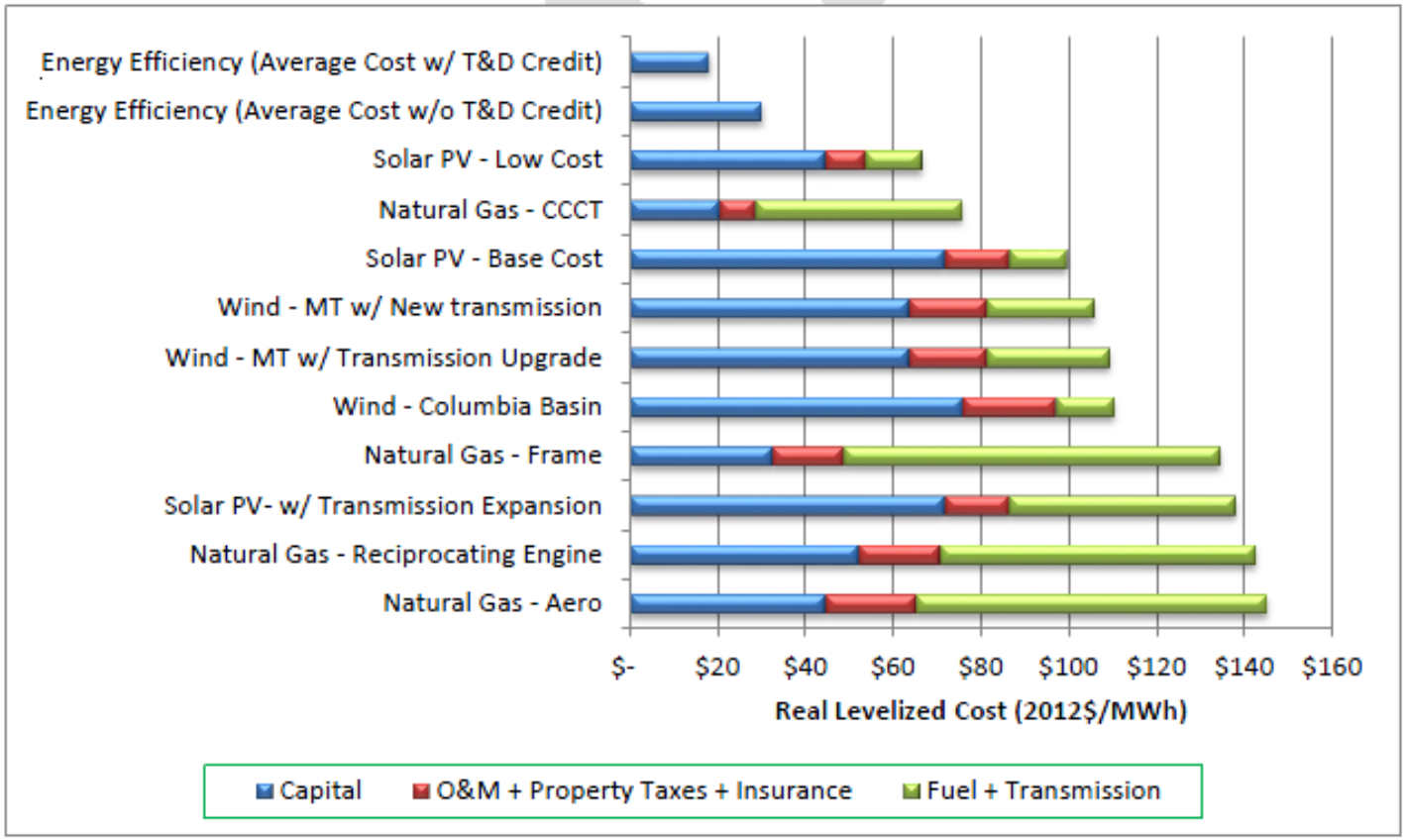



# Efficiency Impact of Load Shift



# Capacity Reduction

The 7th Pacific NW Regional Power Plan gives a Transmission & Distribution credit of $12 per MWh



# Capacity Value

- Average Annual Load ERWH = 3.2 MWh
- Average Annual Load CO2 HPWH = .8 MWh
- Delta is 2.4 MWh
- @ $12/MWh = $28.8 per year in value
- PV at 5% Rate and 20 year life - $360

# What We Wish We Knew

# Will Utilities Support This Technology?

- Does it get the T&D credit?
- Will it be compared to an electric resistance water heater for cost effectiveness analysis?
  - No electric element
  - No impact on conditioned space
  - Arguably cost-effective if it is compared to ERWH

# Benefit to Cost

## Cost

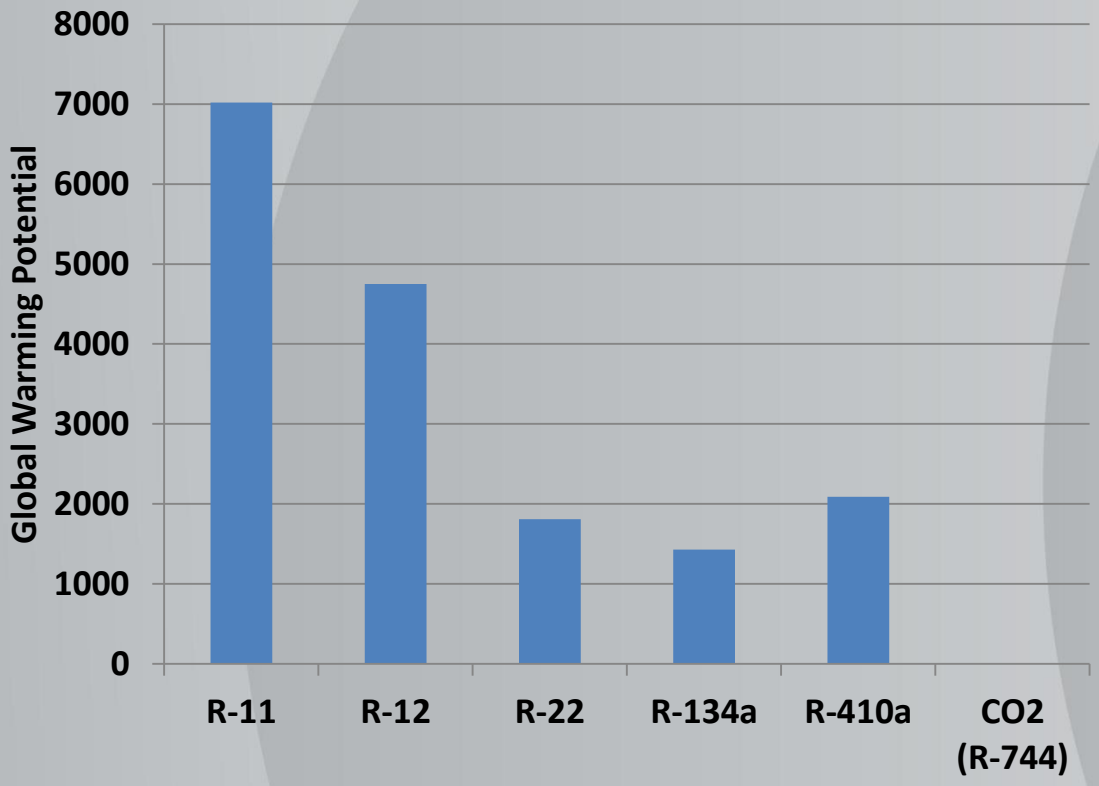
| | | |
|---|---|---|
| $CO_2$ HPWH with 43 gallon stainless tank | = | $2,200 |
| Installation by efficient experts | = | 800 |
| Parts (wholesale) | = | 200 |
| Markup | = | 600 |
| Total Gross Cost | = | 3,800 |
| Credit for no ERWH (as per NWPCC) | = | 800 |
| Net Cost | = | $3,000 |

# Benefit to Cost

## Benefit & Ratio

| | |
|---|---|
| Annual Savings = 2,436 @ $.10/kWh | = $244 |
| T & D Value = 2.4 MWh x $12 | = 29 |
| Total Benefit | = $272 |
| Discount Rate | = 5% |
| Life | = 20 yrs |
| Simple Payback | = 12 yrs |
| PV Savings | = $3,395 |
| Benefit to Cost Ratio | = 1.13 |

# NEBs




| | GWP | ODP |
|---|---|---|
| R-11 | 7020 | 1 |
| R-12 | 4750 | 1 |
| R-22 | 1810 | 0.055 |
| R-134a | 1430 | 0 |
| R-410a | 2088 | 0 |
| CO2 (R-744) | 1 | 0 |

- Source: http://www.epa.gov/ozone/snap/subsgwps.html

# CONCLUSION

- The split system can handle water heating to minus 20 degrees F
- Is 4x as efficient as electric resistance water heating and uses about half current HPWH energy
- Has strong DR capability and high capacity value
- 40 gallon unit can produce 135 gallon per day
- Impact of refrigerant on the climate is minimal

# Thanks

To Adria Banks, WSU lead analyst

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**DISCUSSION**