Water Heating Technology Selection

Technology Assessment and Acquisition
EMGT 531/631

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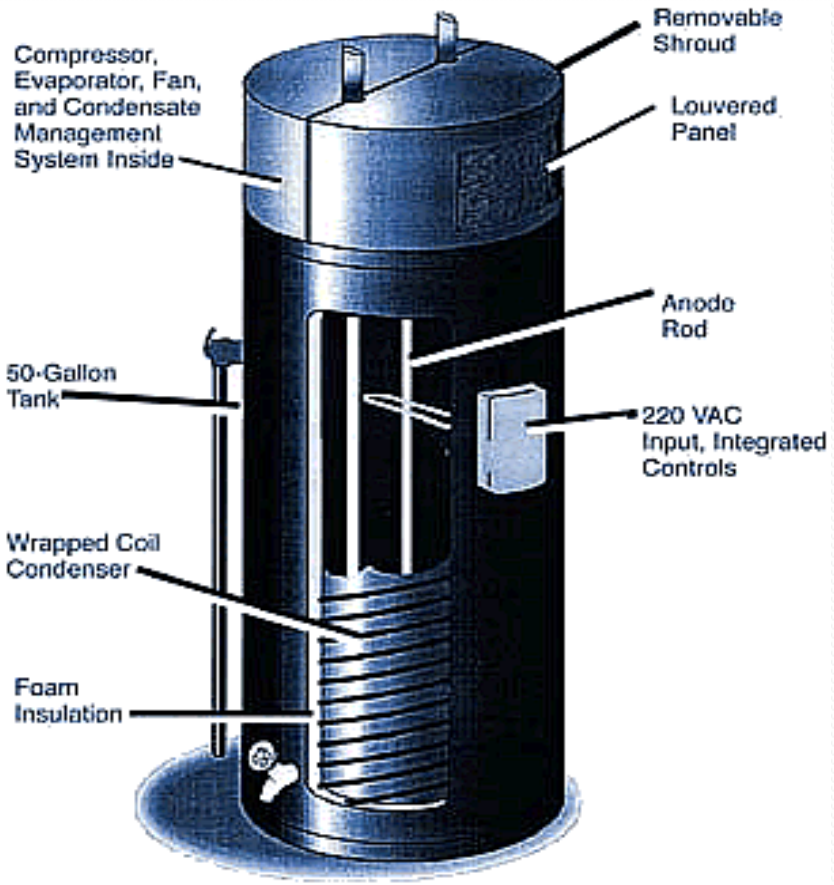
Introduction

About half of all domestic water heating is done with electric resistance storage water heaters. The most efficient resistance water heater has an energy factor (EF) of 0.95, only 5% below the maximum efficiency possible for that type of water heater. Yet by using electricity to "pump heat" from the surrounding space, the residential heat pump water heater (HPWH) can attain much higher efficiencies, reducing the electricity needed for water heating by at least half.



GAP Analysis

Method of Gap Analysis

Technical factors	1- .. 2- ..	Gap	1- .. 2- ..
Non-Technical Internal factors			
Non-Technical External factors			
	Current Status		Desired Status

Gap and how to fill the Gap Heat Pump Water Heating

- **Technical factors**
- **Non-Technical Internal Factors**
- **Non-Technical External Factors**

Current Problem -Utility View

- Despite such high efficiencies, today's U.S. market for residential HPWHs is small and stagnant (less than 2,000 units/year) and is served by only two or three manufacturers. (DOE)

Current Status - HPWH

- **Technical factors**
  - Performance: The efficiency factor is about 2.0 (EF=2.0)
  - Size : 50-gallon tank to be used
  - Flexibility: Can be installed in locations where there is no floor drain (e.g., a closet); where a drain is available, the HPWH will provide dehumidification, space cooling, and improved performance
  - Installation requirements: Design minimizes or eliminates need for water heater piping changes
  - Maintenance requirements: Minimal; evaporator air filter needs periodic cleaning
  - Noise: HPWH uses a small, ducted evaporator fan; noise not expected to be an issue
  - Hot water run-outs minimization: At least one resistance element will be retained in the final design to meet unusually heavy draws
- **Exogenous/External non-technical Factors**
- **Indigenous/Internal non-technical Factors**

Current Status - HPWH

- **Technical factors**
- **+ Non-Technical Internal factors**
  - Cost: $375–400 above installed cost of conventional 50-gallon electric water heater / Utility Direct Load Control.
  - Economics: Potential for 1-year simple payback.
  - Warranty: HWPH is based largely on refrigerator components.
- **Non-Technical External factors**

Current Status - HPWH

- **Technical factors**
- **Non-Technical Internal factors**
- **+ Non-Technical External factors**
  - No external incentives for more R&D
  - No public regulation
  - No public awareness or bad image of some early failure experiences

Desired Status

+ **Technical factors**
  - Performance: current status
  - Size : 80 gallon heating to Flash heating (Tank less)
  - Flexibility: Current Status
  - Installation requirements: Compatible with Ave. Plumbers skills
  - Maintenance requirements: current Status
  - Noise: current Status
  - Hot water run-outs minimization: At least one resistance element will be retained in the final design to meet unusually heavy draws

- **Exogenous/External non-technical Factors**
- **Indigenous/Internal non-technical Factors**

Desired Status

- **Technical factors**
- + **Non-Technical Internal** Factors
  - Cost: Cost shed off about $375-$400 / System Reliability Incentive (GFA*) / Appliance Learns usage pattern (EE savings) / Automated response to TOU, CPP rates
  - Economics: Appliance pays for itself (DR income - Appliance "sells" Energy)
  - Warranty: life time
- **Non-Technical External Factors**

Desired Status

- **Technical factors**
- **Non-Technical Internal factors**
- **Non-Technical External factors**
  - Incentives for more energy saving.
  - Incentives for use of this technology in the buildings.
  - People are aware of the benefit of the technology.

Gap and how to fill the Gap -HPWH

- **Technical** factors
  - Achieve to a Tank less HPWH
  - Climate Condition: Operating range needs to be increased
  - US Standards: It's not compatible with US 120V standard
  - Value chain for HPWH needs to be analyzed for Production cycle & cost effectiveness
  - More R&D needs for alternative to high cost refrigerant(CO_2)
  - More R&D needs for low cost of compressor Technology
  - More R&D needs for high Pressure needs for refrigerant(CO_2)

- **Non-Technical Internal** Factors
  - Builders, contractors, engineers need to promote
  - Marketing needs –Independent sales rep., Wholesale distributors, Utility co-op, plumbing supply houses, retailers
  - Easily available with retailers
  - Manufacturers and energy companies should increase the public awareness of the technology

- **Non-Technical External** Factors
  - More big companies need to enter the market to change in the market structure.
  - Builders, contractors, engineers need to promote
  - Rebates from Govt. like Tax rebates
  - Most of the component suppliers in North & East America.
  - Governmental Promotion for R&D
  - Government should increase the public awareness of the technology

Candidate Technologies

Candidate Technologies

1. Conventional Electric Heating.
2. Conventional Gas Storage.
3. Heat Pump Water Heating.
4. Tank less Water Heater – Electric
5. Tank less Water Heater – Gas
6. Solar Water Heater

Conventional How Water Heating

- Heat hot water heating via electric, gas or propane.
- Storage tank, continuous heating as needed to tank
- Wide size range
- Standby losses from tank, venting losses (gas)
- Temperature setpoint controls

Technology Requirements

- **Energy factor** - min. of 2.0 as recommended by Energy Star rating.
- **Capacity** - min. of 50 gal as recommended by Energy Star rating.
- **Recovery Rate** faster rates to avoid shortages
- **Smart Controls -** Appliance Learns usage pattern (EE savings) / Automated response to time-of-use (TOU), critical peak pricing (CPP) rates.
- **Size** – Integrated, split units, easily fits into garage, basements, utility rooms, even closets.
- **Cost** -low & comparable with other sources <= 500$
- **payback periods** – Shorter (2 years)
- **Installation Requirements** easily replaceable with existing heaters, retrofit, less workmanship, integrated units.
- **Maintenance Requirements** min. Maintenance or Maintenance free. Condensate-free model
- **Noise** Quiet operation, Robust compressor and common refrigerant, small and widely available
- **Operating Conditions** wide range of operating temperatures (climate –Summer, Winter) i.e. <40 Deg F

HPWH-Heat Pump Water Heating

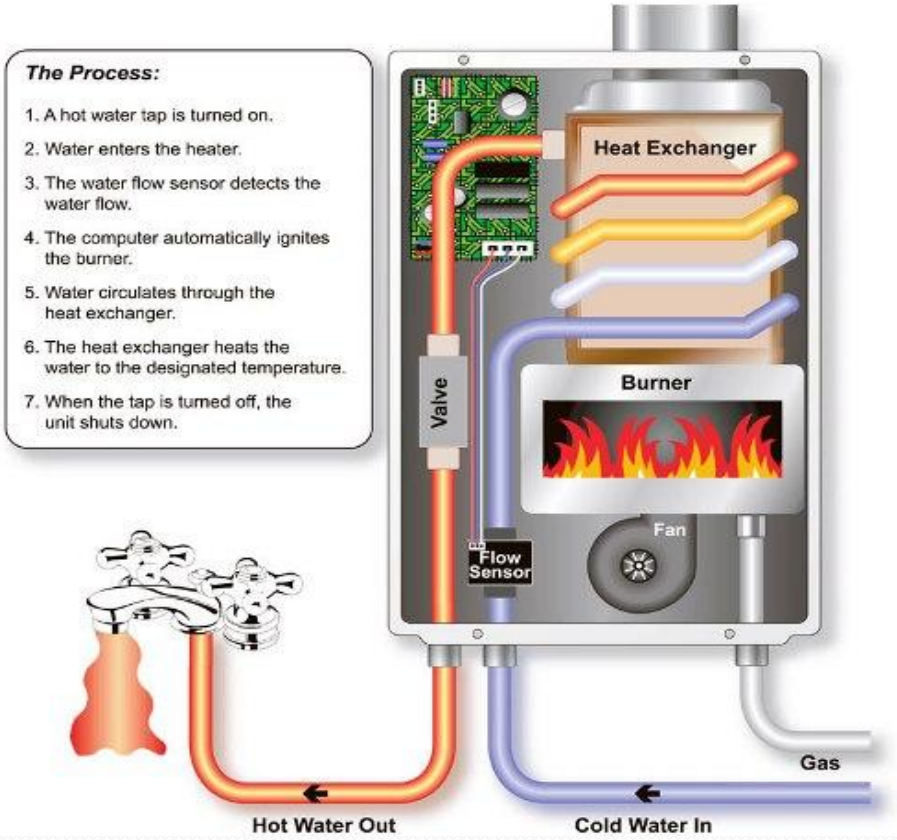
- **Energy Efficiency** – min 2.0, max 2.5, future R&D may produce up to 4.0
- **Capacity** – 50 to 80 Gal
- **Cost of Equipment** – $1200 to $1600
- **Manufacturers** – six companies manufacturing, In future, demand may attract more manufacturing companies to enter the market.
- **Design** – Both Integrated & Split models are available. Retrofit units for existing heaters and as stand-alone units that completely replace an existing hot-water heater.
- **Installation** – Single workmanship, plumber can install the equipment easily.
- **Energy Saving** – 50 to 75% electricity saved compared to electric resistance heaters.
  – Alternative where other fuels like Gas are not available to expensive.
- **By Product** – Some HPWH models can also provide air conditioning as by product of water heating.
- **Noise Level** – Measured up to 67 dba as compared to window air conditioner with 57 dba noise.
- **Maintenance Needs** – Simple, No major maintenance costs, low as $30/year.
- **Refrigerants Used** – R-22 used in US, no major environmental impacts.

Tank less Water Heater

- Tank less Water Heater heat water directly without the use of a storage tank.
- Called Instantaneous or Demand Water Heaters, provide hot water only as it is needed.
- Saving from 10% to 50% on water heating costs.
- Long life-span (20 years versus 13 for a tank heater)
- Compact size

Tankless Water Heater

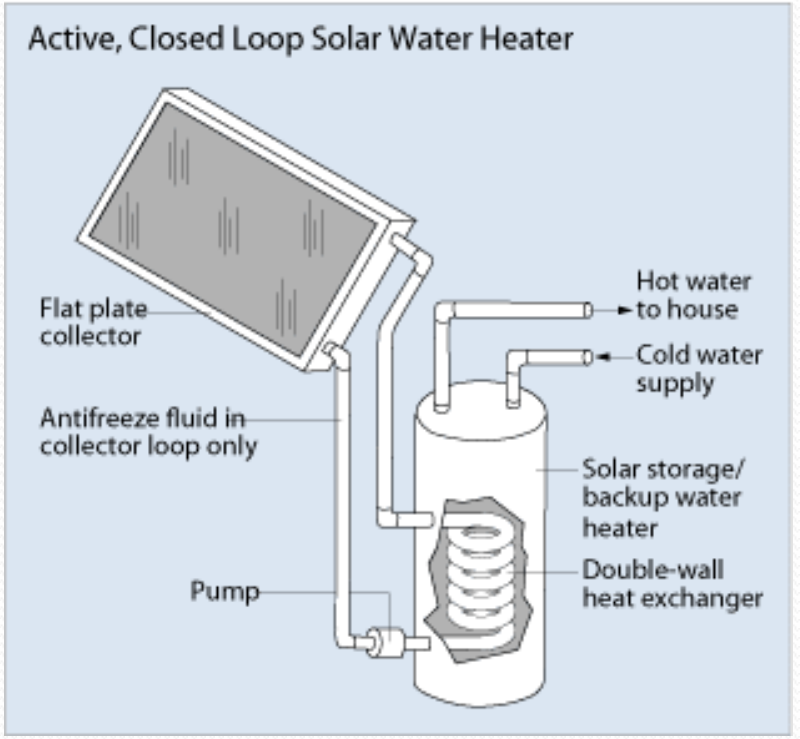
Gas



Electric

Solar Water Heater

- Flat-plate collector
- Integral collector-storage systems
- Evacuated-tube solar collectors
- Direct circulation systems
- Indirect circulation systems
- Integral collector-storage passive systems
- Thermosyphon systems



Technology Selection

Requirement Matrix

Factor / Technology	Energy Factor	Capacity	Controls	Size	Cost	Lifetime Cost (13yr)	Other
Conventional Storage - Electric	0.90-0.95	20-80 gallons	Standard temperature control	Varies with size of storage.	$750	$6,769	Standby losses due to storage.
Conventional Storage - Gas	0.60	20-80 gallons	Standard temperature control	Varies with size of storage.	$850	$5,394	Life expectancy: 13 years
HPWH	2.0 to 2.5	50-80 gallons	(Lacking) Smart Controls for Off Peak operation	ht. 60” -80" Dia. 21”-26"	$1,660	$4,125	Warranty 6-10yrs Models -Split & integrated Manufacturers - up to Six in USA
Tank less HW - Electric	0.99	1-3 GPM	digital temperature control	14.2” x 21.75” x 4.6” Weight: 21 lbs	$800	$6,000	Warranty 10 yrs, 80A 19.2k W, Small Home
Tank less HW – Gas	0.85	1-5 GPM	digital temperature control	22” x 14” Weight: 56 lbs	$800	$5,008	Limited 5-year entire appliance Limited 10-year heat exchanger
Solar Water Heater	1.20	80-120 Gallons	digital temperature control	Varies with size of storage.	$4,800	$5,800	Life expectancy: 15-30 years

Perspective

Utility

- Energy conservation(30% to 50% of the energy used to heat water in US homes).
- Lowering peak demands.
- Water Heating Efficiency more than double.
- Air Conditioning Efficiency improved when combined with HPWH systems.

End User

- Benefit from lower utility bills.
- Added benefits of dehumidification and space cooling.
- Alternative to other fossil fuels (Gas, Oil) whose prices & availability fluctuate.
- Cheaper than other alternative technologies like solar water heater system.
- Low Operating & Maintenance costs compared to solar water heater system.
- Tax benefits.
- Very useful for larger families.
- Easy to replace old water heaters.
- Hazardless compared to other heating technologies (Coal, Gas, Electric).

Other Perspectives

- Opportunity exists to expand jobs within the value chain as the market for heat pump water heaters increases.
- Significant environmental savings through reductions in CO_2, NOx & SO_2 emissions.
- Reduction in energy used to heat water (Btu/yr).

Technology Drivers

Pacific NW Utility Drivers:

- Utility's driving variable is a requirement, target, set by regulatory bodies to achieve energy savings.
- 6th power plan identifies 85% of future electricity load growth to be met with conservation.
- HPWH offer a large opportunity for energy savings.

Customer Driver:

- Reliable maintenance free hot water. Minimum first cost, lower lifetime cost.
- To acquire energy savings in this sector today the utilities need to close gaps in the technology and with the user to account for varying perspectives.

Criteria Weights

	Utility	End user
Energy Factor	0.40	0.05
Capacity	0.15	0.15
Controls	0.17	0.05
Size	0.01	0.03
Cost	0.05	0.25
Lifetime Cost (13yr)	0.05	0.07
Installation	0.03	0.07
Maintenance	0.10	0.07
Customer Perception	0.02	0.10
Ease of Use	0.02	0.16
Total	1.00	1.00

Scoring -Utility

	Energy Factor (0.40)	Capacity (0.15)	Controls (0.17)	Size (0.03)	Cost (0.01)	Lifetime Cost (13yr) (0.05)	Installation (0.03)	Maintenance (0.1)	Customer Perception (0.02)	Ease of Use (0.02)	**Total**
Conventional Storage - Electric	5	8	5	8	10	3	9	9	9	9	**6.31**
Conventional Storage - Gas	4	8	5	8	10	5	9	9	8	9	**5.99**
HPWH	9	8	7	8	3	9	4	5	3	7	**7.49**
Tankless HW - Electric	6	4	5	9	6	6	5	7	6	6	**5.63**
Tankless HW – Gas	5	5	5	9	6	7	5	7	6	6	**5.43**
Solar Water Heater	8	8	5	8	1	6	3	6	5	7	**6.61**

Scoring -End User

	Energy Factor (0.05)	Capacity (0.15)	Controls (0.05)	Size (0.03)	Cost (0.25)	Lifetime Cost (13yr) (0.07)	Installation (0.07)	Maintenance (0.07)	Customer Perception (0.01)	Ease of Use (0.16)	**Total**
Conventional Electric Storage	5	8	5	8	10	3	9	9	9	9	**8.25**
Conventional Gas Storage	4	8	5	8	10	5	9	9	8	9	**8.24**
HPWH	9	8	7	8	3	9	4	5	3	7	**5.67**
Tankless HW - Electric	6	4	5	9	6	6	5	7	6	6	**5.74**
Tankless HW – Gas	5	5	5	9	6	7	5	7	6	6	**5.91**
Solar Water Heater	8	8	5	8	1	6	3	6	5	7	**5.01**

Gaps

- **Utility needs to lower first cost barrier for user.**

  Suggestion: offer an incentive to purchase the unit
- **Utility needs to validate energy performance and persistence of energy savings:**

  Suggestion: review lab testing, perform field testing
- **Utility needs to ensure customer adoption and acceptance**

  Suggestion: perform field testing and market research

End User –Gap Perception

	Energy Factor (0.05)	Capacity (0.15)	Controls (0.05)	Size (0.03)	Cost (0.25)	Lifetime Cost (13yr) (0.07)	Installation (0.07)	Maintenance (0.07)	Customer Perception (0.01)	Ease of Use (0.16)	**Total**
Conventional Electric Storage	5	8	5	8	10	3	9	9	9	9	**8.25**
Conventional Gas Storage	4	8	5	8	10	5	9	9	8	9	**8.24**
HPWH	9	8	7	8	10	9	4	5	3	7	**7.42**

Recommendations Conclusion

- **Next steps for HPWH:**
  - **Electronic Power Research Institute (EPRI) lab tests**

    Completion soon. Need to analyze data
  - **Pacific Northwest and Northern climate lab tests**

    Answer needs of these regions and data points not addressed in EPRI tests
  - **Conduct field demonstration tests**

    At minimum 40 sites in the Pacific Northwest
- **Goals:**
  - Verify energy performance and benchmark manufactures
  - Validate reliability and operation of units
  - Monitor consumer acceptance and market introduction

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