The Hidden Battery

Opportunities in Electric Water Heating

PRESENTED TO

PLMA Grid Interactive Behind the Meter Storage Interest Group Meeting

PRESENTED BY

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PREPARED FOR

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Introduction

This study analyzed the economics of controllable hot water heaters

- Controllable water heaters can serve as distributed energy resources (DERs) that can serve as grid resources and provide flexibility to help integrate renewable generation
- We evaluated a range of load control strategies that utilities and demand response aggregators might implement
- New Federal efficiency standards and legislation have created a new opportunity for controllable water heaters

The study evaluated different water heater types, sizes, and control strategies:

- Two water heater types (electric resistance and heat pump)
- Two different water tank sizes (50 and 80 gallon)
- Three distinctly different market scenarios (MISO, PJM, and MISO 2024)
- Five water heating strategies

Five Strategies Were Evaluated

All strategies evaluated against a baseline 50-gallon uncontrolled electric WH

Electric WH Strategy #1: Peak Shave

- The WH is curtailed only on a limited number peak load hours during the year
- This strategy is used largely to capture **capacity value**

Electric WH Strategy #2: Thermal Storage

- WH daily heats at night and curtails during highest price hours of the day
- This strategy is used to capture **energy value** through price arbitrage, as well as **capacity value**

Electric WH Strategy #3: Fast Response

- The water heater offers frequency regulation into the wholesale ancillary services
- Captures **ancillary service value, energy value, and capacity value**

Heat Pump WH Strategy #1: Uncontrolled

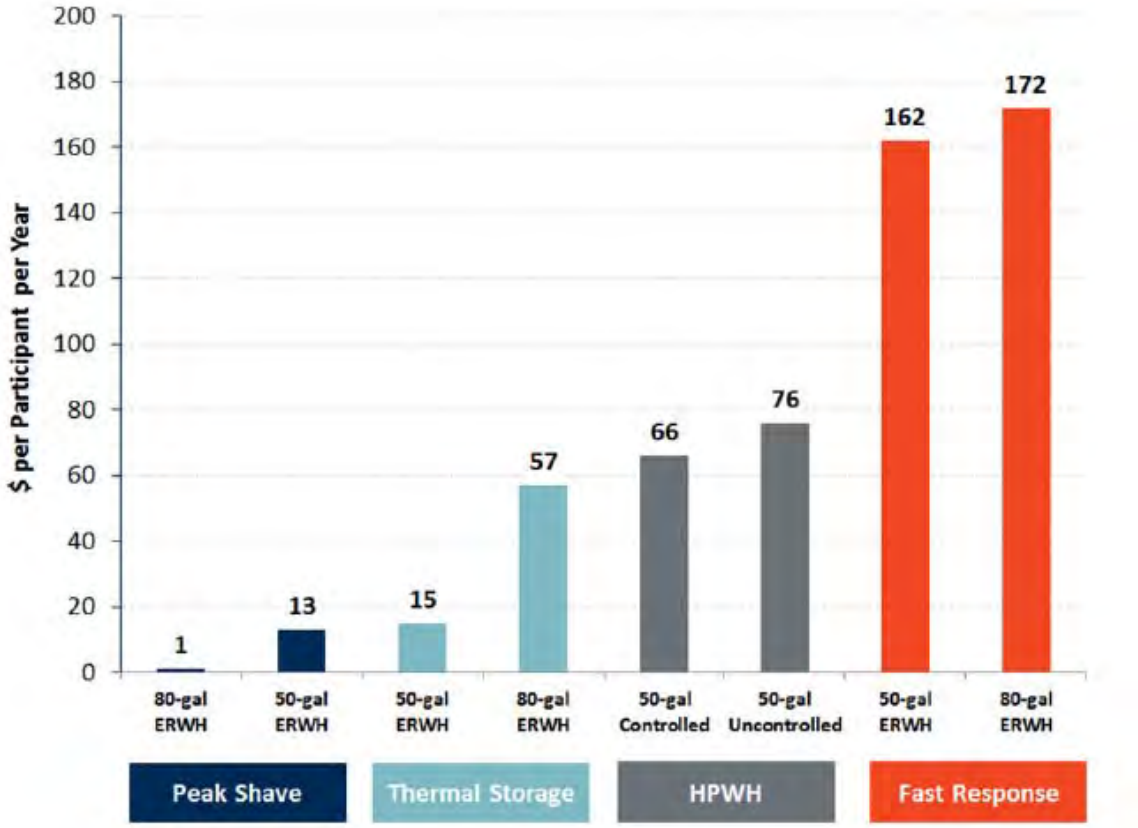
- Customer switches to an uncontrolled Heat Pump WH, reducing energy consumption and emissions
- Provides **energy value** and **capacity value**

Heat Pump WH Strategy #2: Controlled HPWH

- HPWH load is curtailed consistent with the Peak Shave strategy for Electric WHs
- Provides **energy value** and additional **capacity value**

Controllable and Heat Pump WHs can provide significant value

Annualized Net Benefits Summary (PJM 2014)



Comments

Both controllable electric WHs and heat pump WHs can have very strong positive economics

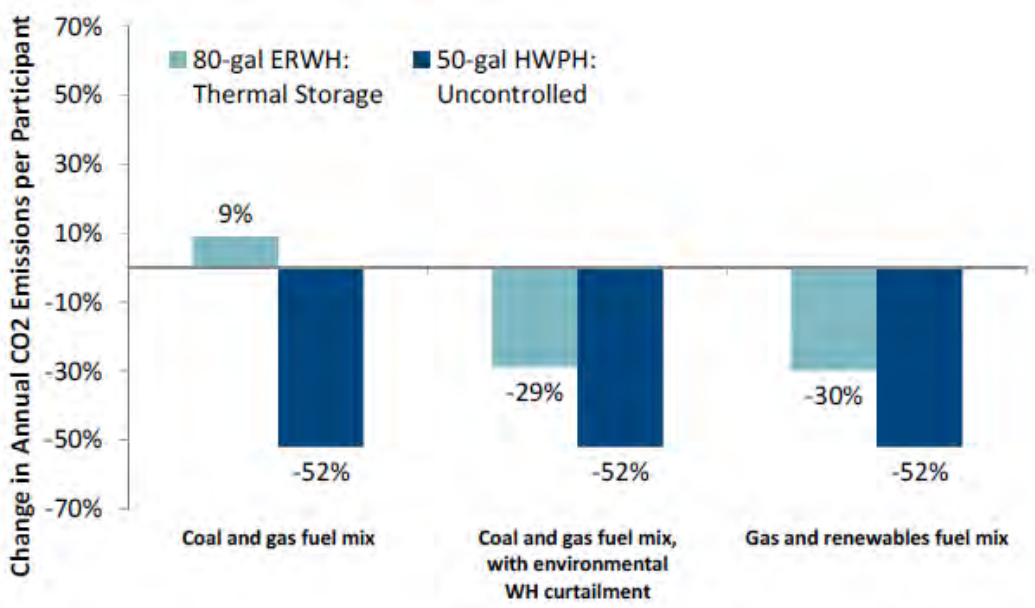
Payback could be as little as 5 years

Fast response WHs can have particularly high net benefits, depending on market conditions

Net benefits are incremental relative to maintaining an uncontrolled 50-gal electric WH

Emission Benefits depend on control strategy and generation mix

Change in Water Heater CO2 Emissions
(Relative to Baseline Uncontrolled 50-gallon Electric WH)



Notes:
Figure shows only two of many possible different marginal fuel mix scenarios; results can vary significantly based on the assumed fuel mix and water heater load curtailment or efficiency strategy. Coal/gas scenario based on 2014 PJM market conditions. Gas/renewables scenario based on illustrative assumptions. Environmental water heater curtailment based on reasonable but illustrative assumptions about water heater operations. Emissions of 50-gal tanks are lower than those of 80-gal tanks due to different efficiency levels. Efficiency benefit of HPWHs depends heavily on ambient air temperature. Total annual marginal CO2 emissions of baseline uncontrolled 50-gallon ERWH are 1.9 tons in the coal/gas scenario and 0.5 tons in the gas/renewables scenario.

Comments

Generally, Heat Pump WHs provide the greatest environmental benefit

The environmental case for electric WHs is more nuanced but has significant potential

- Depends on the mix of generation in the fleet
- Also depends on how the WH is controlled

Summary of Key Findings

The Peak Shave strategy is well suited when there is a peak demand-driven need for generation and/or transmission capacity, a relatively flat energy price profile, and/or a limited ability to promote adoption of larger ERWH tank sizes.

The Thermal Storage strategy can significantly increase benefits if offered to customers with larger (80+ gallon) water tanks in market conditions with a significant price differential between peak and off-peak periods.

The Fast Response strategy can significantly increase benefits in markets with a need for fast-ramping resources. Benefits are very dependent on market conditions and market rules.

Uncontrolled heat pump WHs provide significant economic and environmental benefits when technical factors can be effectively addressed.

Potential Further Analysis

Assess techniques for optimal management and dispatch of a portfolio of water heaters

- Optimal dispatch across various value streams (energy, capacity, ancillary services, and environmental impacts).
- Optimal coordination of a fleet of water heaters

Analyze participant benefits

- Analysis of the bill savings to participants and non-participants to inform customer-facing policies and incentive structures

Analyze how widespread adoption of controllable water heaters may affect wholesale electricity market prices

- Large amounts of water heaters may provide diminishing returns, particularly for ancillary services

Extend the analysis to other market settings

- Expand to ERCOT, CAISO, or international markets with various market rules and fundamentals

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