

# HWSIM: A Detailed Model for Evaluating Distribution System Performance

ACEEE Water Heating Forum

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# HWSIM History

- Originally developed in 1990 as part of California Title 24 detailed water heating methodology development
- Event-based distribution model with user input plumbing configuration & draw schedules (ignored pipe losses during draw; only thermal decay effects)
- Used to develop performance estimates of alternative distribution systems in Title 24
- An enhanced HWSIM has now been developed with support from Building America and the CEC

# Program Capabilities

- “Delta Volume” based simulation
- First principles heat transfer modeling
- Detailed distribution piping layout to each use point
- Recirculation loop piping and control
- Weekly draw schedules by use point
- Monthly environment and cold water temperatures
- Simplified water heater performance
- Annual and Monthly reports by end use

# Program Inputs

- Distribution System
  - Pipe material, diameter, length
  - Insulation thickness
  - Location
- Recirculation Loop
  - Type: Timed, Demand
  - Sensor location, set point, flow rate
- Draw Schedules
  - Draw type: Appliance, MinTemp, Mixed
  - Use point, flow rate, desired temperature
  - Hot water ratio

# Outputs

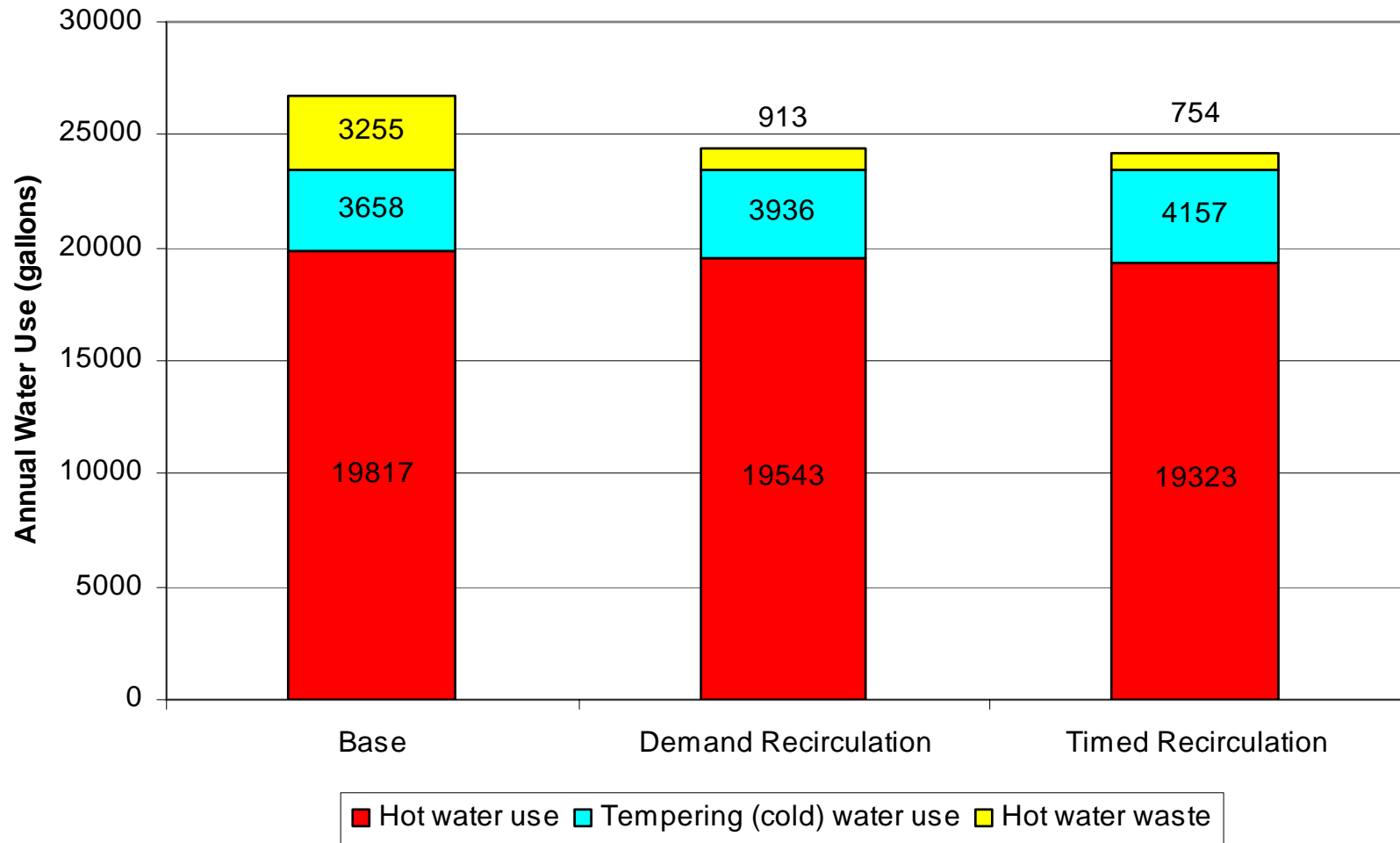
- Annual Summary
  - Hot and Cold water, used and wasted
  - Energy losses and loads
  - Efficiencies: water use, distribution, water heater, overall
- Water use by use point
- Energy use by use point
- Heat loss by environment
- Water heater detail



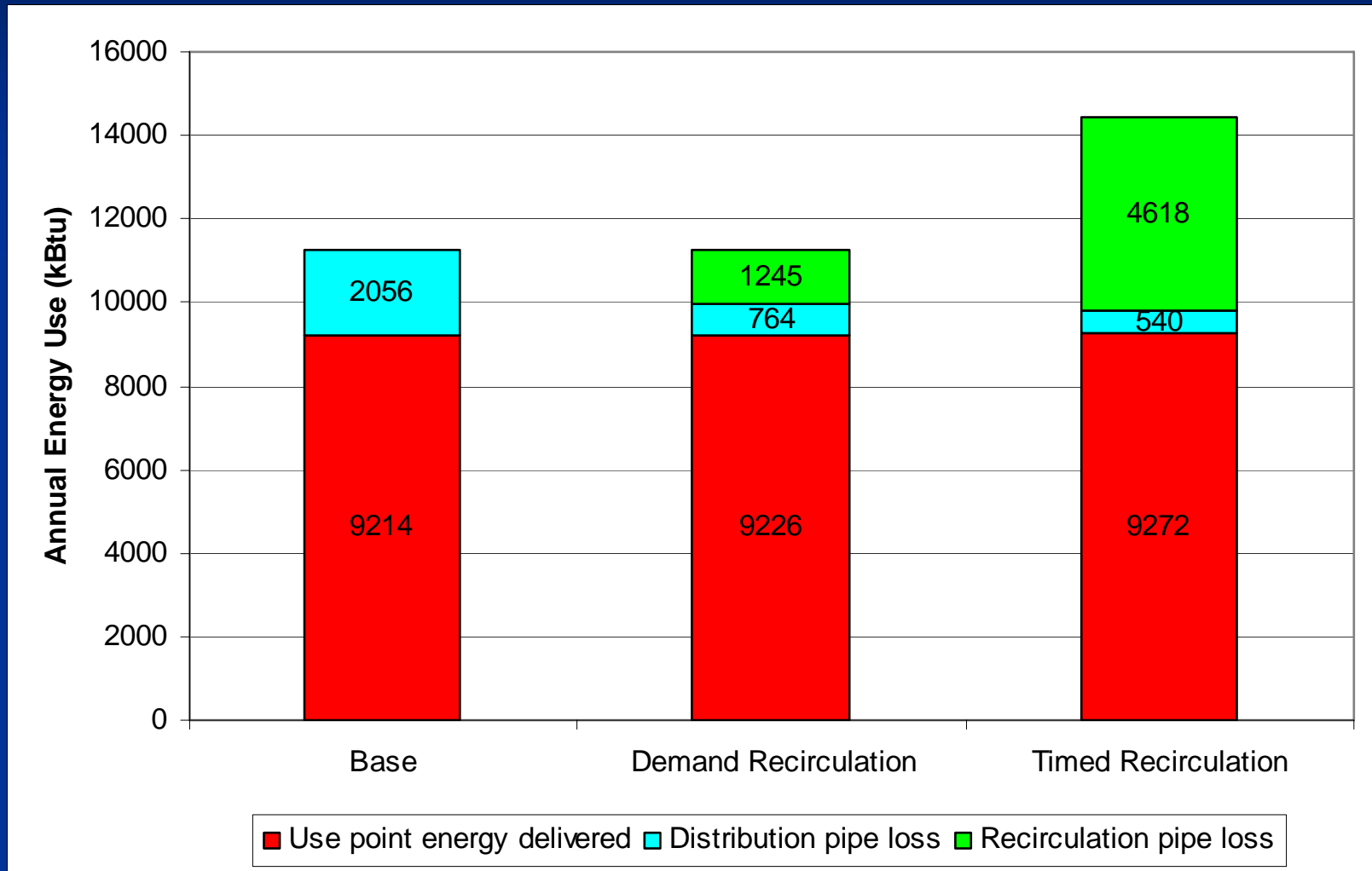
# Example Comparison

- Base Case
  - 2010 sqft, 3 bedroom, 2½ bath, basement, St Louis
  - Uninsulated 1/2” and 3/4” Cu pipe
- Timed Recirculation
  - 6:00am - 10:00pm, 1 gpm
  - Insulated loop
- Demand Recirculation
  - 3 gpm, 105°F set point, sensor at use point
  - Buttons at all use points except CW and DW

# Water Use



# Energy Use



# More Results

	<i>Base</i>	<i>Demand Recirculation</i>	<i>Timed Recirculation</i>
<b>Water heater fuel energy (therms)</b>	222	222	261
<b>Recirculation pump time (hours)</b>	0	16	5840
<b>Water use efficiency (%)</b>	88%	96%	97%
<b>Distribution efficiency (%)</b>	82%	82%	64%
<b>Water heater efficiency (%)</b>	51%	51%	55%
<b>Overall efficiency (%)</b>	42%	42%	35%

# Potential Future Enhancements

- Improved water heater models
- Time/Temp recirculation
- Pump and water heater electric use
- Validation of PEX and in-ground pipe heat loss
- Field data validation
- Flow and temperature visualization
- Parametric run generator

# Discussion Question....

How do we develop representative draw schedules to accurately model occupant behavior?

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