Building America Case Study

Zero Energy Ready Home and the Challenge of Hot Water on Demand

Denver, Colorado

SAMPLE HOME STATISTICS

Construction: New production-built home

Type: Single-family, detached

Location: Stapleton Community, Denver, CO

Stories: 2

Bedrooms: 5

Bathrooms: 3

Size: 2,330 ft^2

Year Completed: 2014

Building America Partner: IBACOS Inc., *ibacos.com*

SAMPLE HOT WATER DELIVERY SYSTEM

Piping material: Cross-linked polyethylene

Hot water fixtures: 13

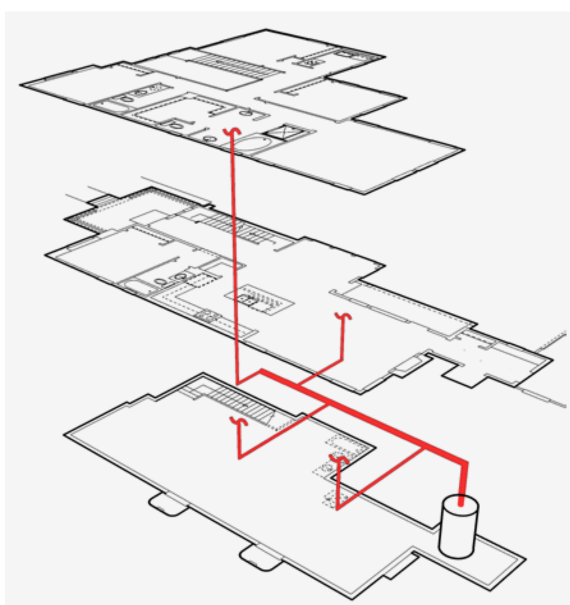
Farthest fixture first draw facts:

- Pipe length: 90 ft
- Fixture flow: 2.2 gal/min
- Wasted water: 1.8 gal
- Wasted time: 49 s
- Wasted energy: 1,359 Btu

Building America U.S. Department of Energy

Production builders in the Stapleton community of Denver, Colorado, now build 2,300-ft^2 or larger homes that earn the U.S. Environmental Protection Agency (EPA) ENERGY STAR® through the Certified Homes Program, Version 3. These builders are repositioning to build comparably sized homes to the standards of the U.S. Department of Energy's (DOE's) Zero Energy Ready Home (ZERH) program. Most ZERH criteria align closely with ENERGY STAR and are familiar to these builders.

However, the ZERH mandate to provide efficient hot water delivery systems as defined in the EPA WaterSense New Home Specification is beyond the scope of ENERGY STAR and is new to these builders. WaterSense requires that no more than ½ gallon of water be stored in the pipes between the system heat source and any fixture. This means hot water must arrive quickly to the user upon demand. The Stapleton builders' first reaction was concern about perceived



The standard domestic water heating packages offered at Stapleton include a conventional trunk-and-branch piping arrangement. In the sample home, the builder placed the water heater at one end of the basement, and hot water fixtures are spread out over the two floors above. The system has considerable piping length and excessive stored water volume between the domestic water heater (DWH) and the fixtures. An isometric diagram of the pipe to the most remote fixtures is shown at left.

Ways to Conserve Water, Energy, and Time

Responsive strategies are available to reduce the water, energy, and time lost in the first draw from an idle residential DWH system.

A simple approach is to add a circulation pump that senses a request for hot water. The main hot water must form a loop.

Plumbing manifold systems can assist a home-run (see comment in table) distribution design or can be distributed among a home's water use zones.

Instantaneous water heaters, even tank-type heaters, can be distributed among water-use zones to minimize water and energy waste.

For more Information see the Building America measure guideline report *Community-Wide Zero Energy Ready Home Standard* at *buildingamerica.gov*.

Image credit: All images were created by the IBACOS team.

costs and implementation strategies. DOE's Building America research team IBACOS chose a sample Stapleton home in which to explore the ZERH hot water challenges.

Trunk-and-branch piping arrangements cause lengthy initial wait times for hot water to reach the fixtures. Tepid water stored in the piping system is wasted directly to the drain. Energy used to initially heat the stored water is also wasted. IBACOS evaluated several redesign options to address these issues. Results are shown in the table below.

Farthest Fixture First-Draw Comparisons for a Large Home

Delivery System Description	Stored Water Pipe Length[d] (ft)	Water[e] Wasted (gal)	Energy[f] Wasted (Btu)	Time[g] Wasted (s)
Original Trunk-and-Branch Design[a]	90	1.81	1,359	49
Modified Trunk-and-Branch Design[b]	65	1.15	864	31
Relocated DWH with Home-Run Branch Piping[b]	65	0.66	496	18
WaterSense-Compliant Recirculation Loop[c]	35	0.36[h]	270	14

[a] Builder's standard system arrangement with DWH at the end of the basement
[b] DWH is relocated to a central basement location with either trunk-and-branch or individual dedicated ("home run") branch pipes to each water fixture
[c] In this approach, the recirculating loop piping becomes is considered to be the heat source, not the DWH
[d] Length of pipe between the heat source (DWH or loop) and the farthest water fixture
[e] Water stored in pipes, lost to the drain, waiting for hot water to arrive
[f] Energy to initially heat the wasted water by 90°F is lost as the stored water cools
[g] Time elapsed for hot water arrival to a fixture; based on a 2.2-GPM fixture as standard and a 1.5-GPM fixture for a WaterSense-compliant system
[h] This system is ZERH compliant because wasted water is les s than 0.50 gal

Lessons Learned

- Efficient hot water delivery systems improve convenience for the homeowner while conserving water and energy resources.
- Current large-home designs (>2,000 ft^2) present size-related and cost-related barriers to builders wanting to implement simple strategies for efficient hot water delivery.
- Traditional trunk-and-branch designs typically are not compatible with ZERH hot water standards for homes of average size and larger.
- ZERH compliance for hot water delivery for existing large-home designs is readily achievable with a recirculation loop at a cost.
- Smaller homes are candidates for optimizing the DWH placement and using home-run piping to meet ZERH, whereas larger homes are likely to require other strategies.
- The next generation of large-home designs intended for production-scale ZERH could better cluster water-use zones and better integrate responsive hot water system strategies to help reduce the cost impact.

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