Final Report

Tankless Gas Water Heaters: Oregon Market Status

Developed for the Energy Trust of Oregon

by:

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Executive Summary

This study was conducted for the Energy Trust of Oregon to determine the current market status, identify key market barriers, review pricing, and assess market and program opportunities for tankless gas water heaters. The study included a review of published reports, background interviews with various parties active with tankless water heater research, an analysis of data from the Oregon Department of Energy related to their tax credits for tankless water heaters, and interviews with manufacturers, distributors, contractors and builders.

Tankless water heaters (TWHs) are at least 30% more efficient than standard storage water heaters, with typical energy factors of .82 to .85, compared to storage water heaters with energy factors of .58 to .65. In addition to their energy efficiency, TWHs are smaller, last longer, and provide "endless hot water" for larger users. Product changes over the last few years have allowed TWHs to serve both large water heating loads and small loads equally well. TWHs are dominant in the European and Japanese markets, and most TWHs are imported from those locations. Currently, TWHs are about 2% of the national gas water heating market, and about 1,000 to 2,000 units per year are sold in Oregon.

There are three primary residential applications for tankless water heaters, each with distinct opportunities and barriers.

- Domestic water heating in new construction
- Domestic water heating as a replacement in existing homes
- Combined space and water heating in new construction

Based on Oregon Department of Energy data for energy tax credits, the average installed price of TWHs is $1,471, which includes both new construction and replacement projects. More than 500 tax credit applications are anticipated for 2005. Savings from a California study conservatively estimates annual savings of 102 therms for single-family homes, and 83 therms in multifamily.

Based on the data obtained through the multiple aspects of this study, the following estimates of incremental costs and savings were developed for water heating applications.

Projected Incremental Costs and Savings for TWHs – Domestic Water Heating Applications Only

Application	Storage Water Heater Installed Costs	Short-term Incremental Costs	Long-term Incremental Costs	Annual Savings
New Construction Single Family	$500	$800	$600	102 therms
New Construction SF – High Use	$800	$500	$300	151 therms
New Construction Multifamily	$450	$600	$450	82 therms
Best Case Replacement (limited market)	$600	$1,000	$800	102 therms
Best Case Replacement – High Use	$1,000	$600	$400	151 therms
Average Case – Replacement	$600	$1,500	$1,300	102 therms

Estimated lifetime of TWHs is 20 years, compared to 13 years for storage gas water heaters. The total market for gas water heaters in the Energy Trust of Oregon service territory is about 50,000 units per year.

The study also found that the use of TWHs in combination space and water heating applications in new construction can reduce initial costs relative to separate water and space heating systems, as well as increase efficiency. The best opportunities for combination applications may be small to average size dwellings.

The study concluded that the technology of TWHs is relatively mature, with multiple manufacturers making competing products. However, the market for TWHs in the U.S. and Oregon is very immature. TWHs are not widely known to consumers and most contractors and builders have limited experience with them. The primary barriers to increased use of TWHs are first cost and lack of familiarity.

There are several market niches where TWHs have substantial performance advantages. These include residential new construction in general, and houses with higher amounts of hot water use in particular. TWHs can be difficult to use as a replacement technology in many existing homes, as the costs of physically accommodating their installation can add considerable expense.

In domestic water heater applications, TWHs provide both an energy resource in the short-term, and a classic case of an opportunity for market transformation. Among other recommendations, this study suggests that the Energy Trust of Oregon pursue the energy resource savings by:

- Conducting a further review on the cost-effectiveness of TWHs.
- Completing and publishing several detailed case studies, and
- Including TWHs as an aspect of the Energy Star Homes program.

However, while the Energy Trust can succeed in changing some aspects of the Oregon market, there will need to be substantial up-front investments in marketing, demonstration, and research. Success would be more robust, and some significant costs could be shared, by involving other national or regional partners in a market transformation strategy. It is very likely that substantial interest exists to support a broader effort, but the Energy Trust may need to provide some initial leadership.

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Introduction

The Energy Trust of Oregon retained David Hewitt to conduct a market study for residential tankless gas water heaters in both domestic water heating and combined space and water heating installations. The purpose of the study was to determine the current market status, identify key market barriers, review pricing, and assess market and program opportunities. Jeff Pratt assisted Mr. Hewitt with the technical applications and builder related aspects of the study, and Gary Smith conducted interviews with contractors and builders.

The study included the following components:

- A review of current published information including a recent report for Pacific Gas and Electric, information from the Consortium for Energy Efficiency and manufacturer information.

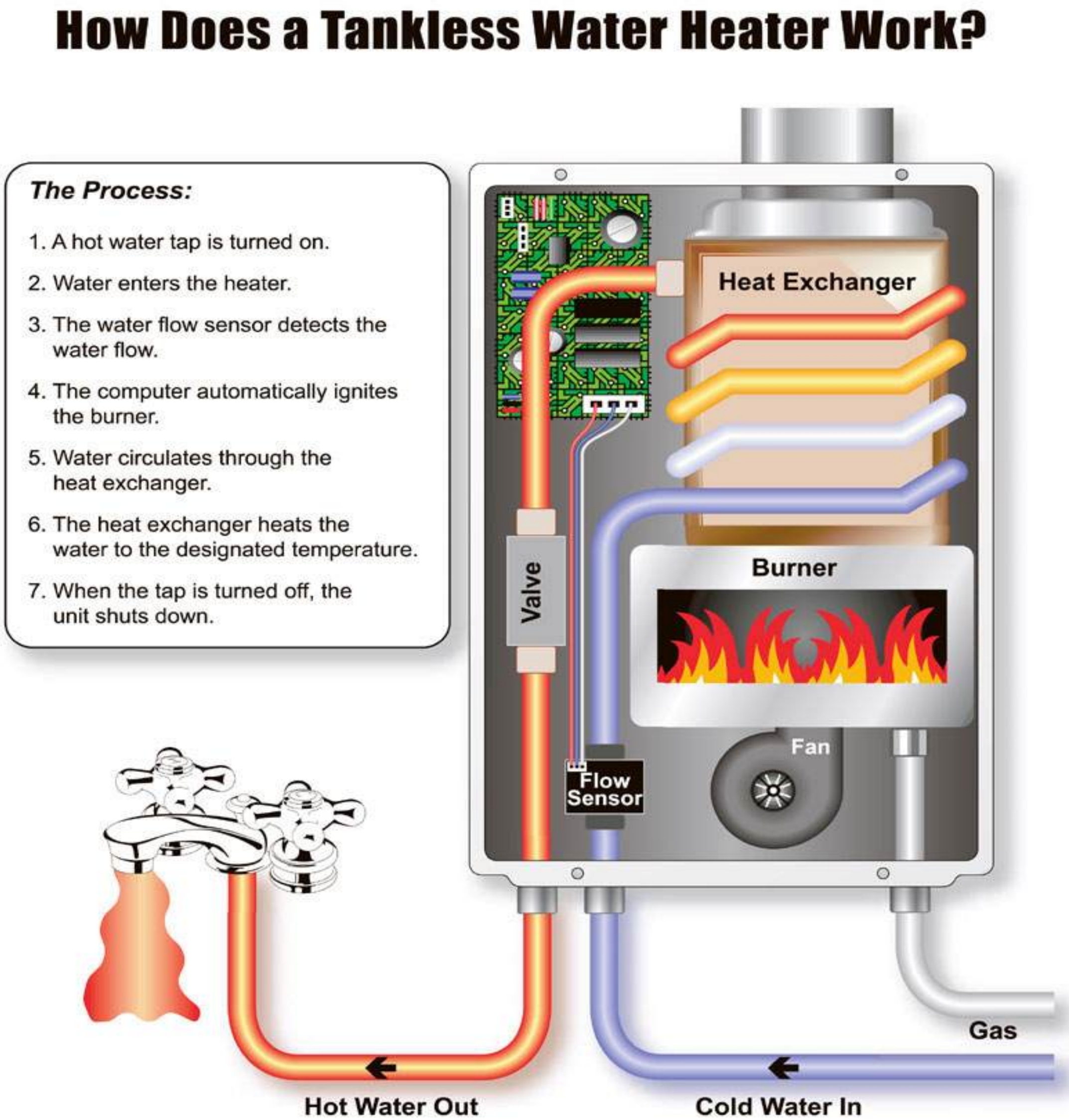
- Background interviews with:
  - National labs in the U.S. and Canada,
  - Utilities and program administrators, including Northwest Natural Gas, Southern California Gas, and Vermont Energy Investment Corporation, and,
  - The Oregon Department of Energy and California Energy Commission.

- Interviews with a 4 manufacturers or distributors, 6 contractors and 5 builders to determine current market status (both nationally and in Oregon), key market barriers, and pricing.

- A review of information collected by the Oregon Department of Energy for tax credits for tankless water heaters.

Technology Status and Performance

Tankless water heaters (TWHs) are common in Europe and Japan and are designed to meet residential loads without storing heated water.



Source: Takagi USA

While TWHs are the dominant water heater technology in some parts of the world, sales in the United States have been very modest. Nevertheless, the current generation of TWHs has incorporated a number of changes to better serve the U.S. market, including the following commonly available technology features:

- Gas consumption of up to 199,000 BTUs per hour, designed to meet the water heating needs of three hot water uses simultaneously.

- Fully modulating gas valves, which allow the TWHs to meet small loads (0.5 gallons per minute) as well as very large loads.

- Electronic ignition and efficiencies of at least 82%, substantially better that typical storage water heaters.

- Direct venting capabilities, permitting installation in a wide variety of locations without requiring a roof penetration.

The dominant manufacturers are all based in Europe or Japan, and import their products to the U.S. market. Overall, the market share of gas TWHs appears to be about 2% of the U.S. gas water heater market, with about 100,000 units sold per year.

Because of the business base in other parts of the world, manufacturers have the financial strengths and potential markets to allow innovation and improvements to product quality. Recent additions to the product lines include a Japanese unit with an operational efficiency of 95%, and a European unit that uses the water movement in the pipe to spark the ignition, thereby eliminating the need for electrical wiring to the TWH. One manufacturer is also introducing a model designed for condominiums, that has a lower energy input rating and a lower price point.

Current Market Position

Oregon Tax Credit Information

The State of Oregon provides a tax credit of up to $350 for the purchase of qualifying TWHs. The Oregon Department of Energy supplied several important elements of the data from the tax credit applications to assist this study.

The Oregon tax credit data indicate a relatively stable number of applications from 2002 through 2004 at slightly more than 350 per year. For 2005, applications through August are running substantially stronger, and could reach 500 applications by year end.

The installed price indicated on the tax credit applications shows a small but significant increase in the average price over a four year period of 11%. As the data in **Table 1** indicate, in 2002 the average installed price was $1,322, and increased each year, with the average price for 2005 data to date equal to $1,471. Most estimates in the literature reference $1,200 for an installed price, but these estimates may not fully account for costs of venting or the current limited market for TWHs.

Table 1: Sales and Average Installed Costs for Oregon

Year	Sales	Average Installed Cost
2002	356	$1,322
2003	380	$1,384
2004	362	$1,414
2005 estimated	485	$1,471

Because the size and features for TWHs have changed over time, changes in the installed prices for the more common TWHs models were also reviewed. In general, the prices by individual model increased somewhat, although not as much as the overall average. There is some evidence in the market that individual models have decreased in price over the last few years, and the Oregon tax credit data supports that change for Bosch/Aquastar models and perhaps for Takagi. The Oregon data reports installed costs, not just the cost of the equipment. There is some information that venting costs have increased generally, which may account for some of the increases. **Table 2** indicates some of the more common models over a multi-year period and their average installed price by year.

Table 2: Average Installed Cost by Model by Year

Year	Takagi TK2	Rennai 2532	Bosch/Aqua 125 HX	Bosch/Aqua 240 FX	Noritz N-063
2002	$1,296	$1,398	NA	$1,112	NA
2003	$1,351	$1,527	$759	$1,134	$1,238
2004	$1,159	$1,526	$702	$1,034	$1,429
2005	$1,297	$1,641	$704	$1,023	$1,647
Price Trend	Even	Increase	Decrease	Decrease	Increase

Oregon tax data also indicate that 10 to 12 brand names are active in the state, representing at least 8 different manufacturers. Most brands have multiple models, representing different BTU input/outputs, propane options, venting options, and updates to models over time. The most common natural gas models recorded in the Oregon tax credit information for 2004/2005 are listed in **Table 3** below, with key features from manufacturer information.

Table 3: Top Selling Models 2004/2005 Oregon Tax Credits

Model	Sales from Tax Credits	Rated Efficiency	Rated BTUs	Other Features
Bosch/Aqua 125 HX	51	82%	125,000	Recirculation and space heating not recommended.
Bosch/Aqua 240 FX	40	85%	175,000	Recirculation and space heating not recommended.
Noritz N-063	40	82%	194,000	
Rennai 2520	80	85%	180,000	Promotes recirculation and space heating applications.
Rennai 2532	181	85%	199,000	Promotes recirculation and space heating applications.
Takagi TK-2	51	82%	185,000	Promotes recirculation and space heating applications.

Finding from Interviews with Manufacturers and Distributors

Distributors and manufacturers representing the major suppliers of TWHs in Oregon were interviewed, as were distributors of some of the less common equipment. Key findings are below.

- Most TWHs move through plumbing wholesalers, although some distributors also sell directly to contractors. There were no sales directly to builders or developers. (Home Depot has several different models available directly to consumers or contractors through their website.)
- While not all manufactures and distributors would provide sales data, it appears that sales in Oregon are more than twice the ODOE tax credit applications. Thus, sales in Oregon in 2005 are at least 1,000 units, and may be as high as 2,000 units. This figure includes some commercial and agricultural sales.
- Manufacturer pricing for the most common units sold in Oregon range from $600 to nearly $900. Some smaller models are available for about $450.
- One manufacturer has a 93% efficient TWH with a price of $3,000. (While the price for this unit is expected to drop, it would offer only modest energy savings for water heating. Discussion in the rest of this report focuses on equipment with efficiencies of 82% to 85%.)
- Price reductions have varied by manufacturer. One major manufacturer noted a 10% decrease in the last two years, another noted a 5% decrease, while a third

major manufacturer has not reduced prices. Price reductions are not expected in the next two years, in part because of rising steel prices. The exception is newer, high-end models that may see some reductions. One manufacturer is purchasing their major U.S. distributor, with unknown impacts on price and distribution patterns.

- One manufacturer believed that doubling sales would reduce prices, while the others did not believe doubling sales would impact pricing. (However, there are volume discounts available to their customers that buy more units.)

- The primary advantage mentioned for TWHs was energy efficiency for all respondents. Space savings was also mentioned, as was the longer lifetime of the units compared to tank-type water heaters. The only disadvantage mentioned by manufacturers and distributors was the higher first price.

- All manufacturers and distributors were familiar with the ODOE tax credit. However, most did not think that the tax credit provided benefits to their business. In general, manufacturers and distributors believed that contractors were not very aware regarding the tax credits and did not do a good job of promoting them.

- Most manufacturers and distributors believed that an incentive program would increase sales substantially. They were not able to describe other incentive programs, except a rebate program in Japan that successfully promoted the higher efficiency TWHs over the less expensive standard efficiency TWHs.

- The larger manufacturers provide sales support and installation training, distributors do not.

- Two large manufacturers estimated that 20% to 25% of their TWHs are used in space heating applications, while the third major manufacturer believed that space heating uses were relatively uncommon with their equipment.

Findings from Interviews with Contractors

Six interviews were conducted with contractors. Names of contractors were referrals from manufacturers, distributors, or the Oregon Dept. of Energy.

The contractors interviewed installed between 3 and 40 TWHs per year, with a total of over 100 per year. One contractor, a radiant heating specialist, no longer installs TWHs, and their results are not included in the summary information. The other contractors included a plumbing contractor, a firm that does both plumbing and HVAC, two HVAC contractors, and a solar contractor.

For all but one contractor, TWHs are a very small part of their business, representing less than 5% of the number of installation of water heaters. The exception is the solar contractor, who installs TWHs about 20% of the time. All contractors purchased their TWHs from plumbing wholesalers/distributors.

About 60% of the installations covered by the interviews are for domestic water heating only, while the rest are water and space heating applications. The space heating applications included radiant floors, radiant baseboards, and coils in a warm air system. The primary benefits of TWHs were listed as efficiency by 4 of the 5 contractors, while endless hot water was listed by 3 of 5. One contractor listed space savings as a benefit.

Cost of TWHs was listed as a primary barrier by all contractors. Two contractors noted more complex installation issues, especially exhaust venting in existing homes.

Three contractors do not make any maintenance suggestions, while one suggests an annual service call, and one asked homeowners to check the water filter frequently. The estimated cost of a service call was about $100.

Installed costs listed by the contractors were substantially higher than the average costs noted in the ODOE data, ranging from $2,100 to $3,500. Average installed costs were over $2,700. Installations for 4 of the contractors were predominantly in existing homes, while the remaining contractor installed solar related heating system primarily in custom homes. The complexities of the installations may be the cause of the higher than average costs.

Contractors had not seen any consistent patterns to prices changes over the past two years, and either did not have an opinion or did not expect much change in the next two years. When asked if a doubling of their sales would result in a price drop, 3 responded no change, one responded a little change, and one noted they would get a better price from their distributor.

Four of the 5 contractors were familiar with the ODOE tax credit and had used it. They were less clear that the tax credit provided a benefit to their business, with 2 affirming the benefit, one not sure, and one saying probably not. Three of the five contractors said the incentives were important to expand the market, while one said no, and one said incentives would probably help.

In terms of suggestions for how to increase the market, the contractors were divergent, noting advertising, low-interest loans, the need for cost reductions and "leave it to the customer".

All but one of the contractors noted that their sales of TWHs were driven by customer request. They believe that the technology would work in any application, but do not appear to focus on education or providing options to the customer. The exception was the solar contractor, who noted that all of his business came from custom home owners who searched him out looking for an energy efficient and/or solar solution, and typically they took his recommendation. He noted that that no builders had ever ordered a TWH directly from him, even after the successful installation for one of their mutual clients.

The contractor excluded from the reporting of the survey results was a radiant heat specialty firm. This contractor no longer installed TWHs for space heating, due to concerns with voiding warranties, using line pressure in radiant applications and other detailed technical issues. This contractor preferred using small boilers with efficiencies approaching 98%, and a relatively high cost of about $4,000. This contractor noted that in the current housing market, they had plenty of customers for their higher-end applications. However, this contractor was adamant that TWHs were the best technology for domestic water use. (Additional review of the contractor's comments regarding warranty and some of the other technical issues indicated that their information was outdated, at least for some manufacturers.)

Findings from Interviews with Builders

Five interviews were conducted with builders. Builders were primarily referrals from Conservation Services Group, the Energy Star Homes contractor for the Energy Trust.

The builders were all in the single-family, custom homes market. Two builders were small, building 1 to 4 homes per year, while the other three build 25 to 30 homes per year each. Of the 86 homes constructed by the builders in 2005, TWHs were installed in 42 homes. One of the larger builders put TWHs in 100% of his homes, and two of the larger builders were the only builders to use TWHs for space heating as well as water heating. Only 5 combination space and water heating systems were installed. Space heating systems installed varied, including radiant floor and turbonic (fan assisted coil).

All five builders listed both efficiency and reduced space requirements as advantages of TWHs. Ease of installation, reliability, location flexibility, and endless hot water were each mentioned by one builder as advantages. One builder mentioned lower costs as an advantage to combo space and water heating systems.

Three builders estimated their installed costs of TWH, one at $1,200, one at $1,400 and the third a range of $1,200 to $1,500 based on size. Another builder, who installs TWHs in every home, simply had a "plumbing package" for the entire home of slightly over $5,000 that included the TWH.

Two builders expected prices of TWHs to drop, based on competition and volume, one builder expected prices to stay the same, and two builders had no opinion.

Only two of the builders were aware of the ODOE tax credit program. Two builders referenced the Energy Trust program (Energy Star Homes).

Unlike the other groups interviewed, not all builders believe that price is the primary barrier. Two builders mentioned negative consumer perception as an issue, three mentioned price, and one referenced industry practice. However, builders were unanimous in their recommendations that more promotion and advertising were needed to increase sales.

Applications: Opportunities and Barriers

There are three primary residential applications for tankless water heaters, each with distinct opportunities and barriers.

- Domestic water heating in new construction
- Domestic water heating as a replacement in existing homes
- Combined space and water heating in new construction

The primary advantage of TWHs is that they are more efficient that their tank-type competitors. Additional major benefits are the ability of TWHs to supply a hot water continuously, and their small size. There can be a number of advantages or disadvantages related to the practical elements of a TWH installation, which are covered by application below.

The primary disadvantage of TWHs is their increased first cost. Other substantial barriers are the lack of customer and trade familiarity with TWHs, and the different needs of TWHs from a maintenance and repair perspective. In particular, TWHs may need to have a mild acid (e.g. vinegar) run through the heat exchanger to insure efficient operation over a period of time. Depending on water conditions, this may be required as frequently as once every six months in areas with hard water. The heat exchanger may be reduced in efficiency or become plugged if no maintenance is performed for a multiple year period. Tank water heaters have similar issues and maintenance recommendations that may or may not be followed by the user, but they continue to operate even if at lower efficiencies.

Domestic Water Heating: New Construction

Because of their small size and direct venting, tankless water heaters can be mounted in a variety of locations, for example directly within a laundry room or closet. The small footprint means that 4 to 9 square feet of floor area does not need to be dedicated to a water tank. In residential construction where space is at a premium, such as condos or townhouses, this space savings may provide a significant benefit to the builder.

Generally, tankless water heaters need to be located on or near an exterior wall to accommodate venting requirements, but beyond that, the location is flexible. Noise does not appear to be an issue. This may allow for shorter plumbing runs, saving on piping costs and increasing efficiency.

TWHs can provide large amounts of hot water, which can meet the demands for homes installing large spa or soaking tubs, and this is a frequently cited benefit.

Conversely, because of the elimination of heat losses from storage tanks, households with smaller hot water use get a higher percentage savings, and still significant therm savings. Tank water heaters are rated by DOE with an average daily draw of 64 gallons. Lower draws mean that the tank standby loses increase relative to the water heating efficiency and the rated Energy Factor of a storage water heater would not be realized in practice. The Davis Energy Group (Davis, 2005) noted this impact in their field testing of comparison of tank-type and tankless water heaters.

However, barriers to the introduction of new, more expensive technologies in new construction are substantial. Because the majority of new housing is built as either spec construction or with a limited set of options for consumers, builders make most of the decisions regarding equipment choices. Builders are reluctant to do anything to increase costs that are not demanded or valued by the market, and they are reluctant to install new technologies (new to their market, at least) they may have the impact of increasing callbacks or customer dissatisfaction. Storage water heaters are well accepted by the marketplace, rarely cause customer dissatisfaction (unless undersized for the load), and are inexpensive to install.

There are several installation considerations for new construction applications. For example, the gas line must be large enough to supply the TWH, there must be a nearby electrical outlet for the ignition, and the TWH must be installed in a location with sufficient outside air for combustion or close to an exterior wall for direct venting. All of these considerations can usually be met, and it is the first cost and use of an unfamiliar technology that are the primary barriers.

Domestic Water Heating: Replacement in Existing Homes

Replacement applications offer one key advantage and several more technical difficulties relative to new construction water heaters applications. The key advantage is that the ultimate customer is involved, so the tradeoff between the initial price versus long term energy efficiency savings can be considered more fully. However, if a larger gas line is required to supply the TWH or if a new electrical outlet needs to be installed for the ignition system, initial costs may increase significantly. Generally, the main gas line to the home will be adequately sized, but the line to the water heater may need to be increased to ¾ inch. Also, venting may be an issue, and locating the unit for proper venting may require additional plumbing modifications. Class 3 venting is required in Oregon, which costs about $35 per linear foot, so keeping vent runs short is a priority to control costs.

In addition, most water heater replacements are done on an emergency basis, so little time is spent considering options. Given the increased expense and potential installation considerations, only a consumer very familiar and interested in energy efficiency is likely to request a tankless water heater, and few plumbers would even mention the option at the current state of the market.

Combined Space and Water Heating: New Construction

Because of their high capacity, TWHs have the potential to serve large loads, specifically to provide both water heating and space heating. These types of systems are common in Japan and elsewhere. However, it should be noted that TWH manufacturers vary in their recommendations and efforts to promote combined applications. Please refer to Table 3 for the dispositions of top selling manufacturers regarding using TWHs as the heating source for combination systems.

Basic Hydronic System Types

Hydronic systems distribute heat via circulating liquid rather than fan forced air. Several types of hydronic heating systems are possible using TWHs. Fundamentally, the heating system delivery portion or "loop" can be either "open" or "closed." Open loop systems circulate heated potable domestic water through the heating system components and the system materials must be designed accordingly. These systems are simple and inexpensive relative to other central heating system options and are allowed by Oregon code. One of the more interesting market angles with open systems is that they can be installed by plumbers. This raises the possibility of eliminating the need for the HVAC trade in a project.

Closed loop systems are typical boiler applications. Closed systems employ a heat exchanger to transfer heat from the domestic water to the "closed" heating loop working fluid and have additional installation and control requirements.

Heat Delivery Options

Beyond the type of distribution loop, various hydronic heat delivery mechanisms are available. Heat from the water/working fluid is typically delivered to the space by one of the following:

- Radiant floors
- Radiant heating panels and fan convectors
- Hydro-air coils in air handlers of ducted systems

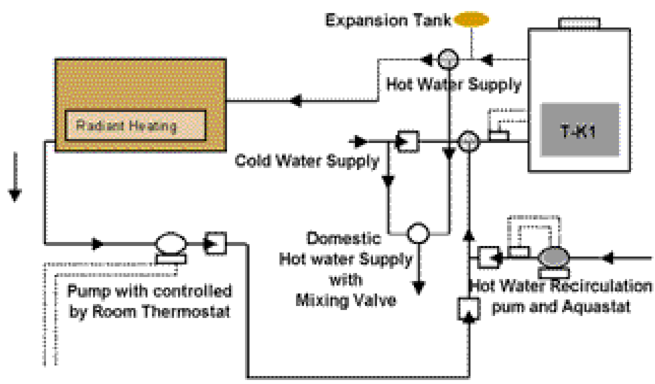
Radiant floors are growing in popularity due to their perceived comfort advantages and design flexibility. Modern radiant floors typically consist of cross-linked polyethylene piping (PEX) installed in concrete slab-on-grade, gypsum-based concrete sub-floor underlayment, or stapled-up under a framed floor.

Other radiant hydronic heat delivery approaches are common using liquid filled baseboards, fan convectors, or radiant panels. These types of systems have the key advantages of zone control and eliminating duct distribution systems. The key disadvantage with these systems is that providing air conditioning is challenging and/or expensive. Liquid-to-air coils installed in forced air plenums are also typical in boiler-based ducted applications where air conditioning is desired.

Typical Integrated Space and Water Heating System Designs

Figure 1 is a schematic of a simplistic, open loop combination water heating/space heating system. This system approach would be typical for open loop radiant floor and other hydronic heating applications.

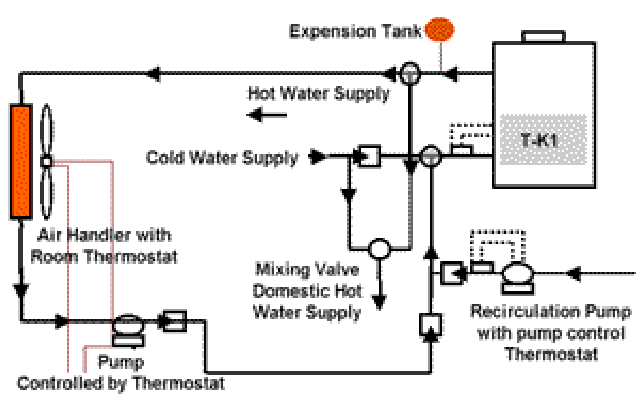
Figure 1: Open loop TWH-based integrated space and water heating system schematic.



Source: Creative Energy Technologies, Inc.

Figure 2 is a schematic of an open loop combination water heating/space heating system using a water-to-air coil in a ducted system. This system approach would apply to any air handler including those with DX air conditioning coils. This type of system may have particular promise as a low cost gas heating back up to heat pump systems.

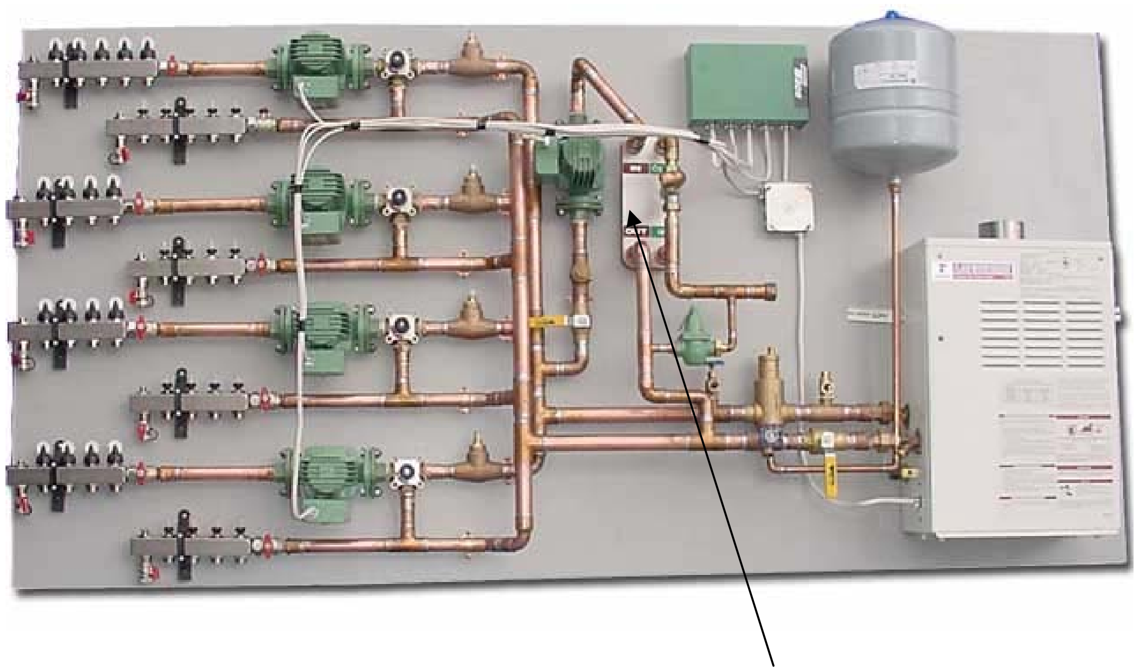
Figure 2: Open loop TWH-based integrated system schematic for ducted HVAC systems.



Source: Creative Energy Technologies, Inc.

Figure 3 shows a more complex, prepackaged multi-zone "closed loop" system that could be used for a variety of heating applications.   By employing a liquid-to-liquid heat exchanger and other boiler system controls, the TWH becomes a "wall hung boiler" and functions very much like a typical, more expensive boiler unit.

Figure 3: Multi-zone, closed loop TWH-based integrated space and water heating system core "boiler in a box."



Source: A.I.M. Radiant Heating (website)

The prepackaged system shown is set up for a multi-zone radiant floor application. However, there are a myriad of additional configurations that might be employed depending on the design criteria of the consumer.   For example, the "zones" could include any of the space heating delivery options discussed above. Domestic water heating with an indirect fired storage tank could be a zone, as could a hot tub/spa heat exchange. In Japan, it is also common for these units to provide reheat on fresh air make up for ventilation systems and/or to provide heating for Koi ponds.

Energy Savings

The most common TWHs have energy factors of .82 to .85, compared to about .58 for a standard storage water heater, .62 to .65 for an efficient storage water heater; more than 30% more efficient.

To date, estimates of savings and field data applicable to this study have been very limited. While most studies appear to use engineering estimates based on the energy factors, the research study by the Davis Energy Group for PG&E used a different methodology based on a field study and California Title 24 corrections to energy factors related to house size. The Davis Energy Group study indicated that storage water heaters do not reach their rated energy factors at smaller loads (testing is done using draws of 64 gallons of hot water per day). That study estimates 102 therms savings per year for single family and 82 therms for multi-family relative to a .62 energy factor storage water heater. The logic regarding their energy savings estimates is compelling, and we recommend using the Davis Energy Group estimates until more field data is collected.

In ACEEE's Consumer Guide to Energy Savings, TWHs saved 129 therms compared to standard storage water heaters, and 97 therms compared to efficient storage water heaters. ACEEE also estimates the lifetime of TWHs to be 20 years, compared to 13 years for storage water heaters. No savings estimates were available for houses that are large users of hot water.

Because THWs do not fire until the hot water draw is at least 0.5 gallons per minute, there may be small but noticeable savings by reducing the energy used to heat water that simply drips from faucets, or from low volume water flows when washing hands, for example. Based on the "endless hot water", there is also the possibility of some "takeback" of energy savings by taking longer showers, for example. These savings were not estimated.

No studies of combined space and water heating efficiency gains were located during this review. However, in new construction the vast majority of builders in Oregon install the minimum efficiency furnace allowed, 78% AFUE. So TWHs offer savings of more than 30% for water heating and 5% to 9% for space heating, as well as a lower energy cost to distribute the heat, using pumps rather than fans, and possibly considerably lower system losses in distribution using hydronics rather than ducts. Overall efficiency gains may be considerable, and are worthy of further investigation.

Cost Summary

The ODOE database is a very rich source of cost data. The database contains a mix of self-installed and contractor installed units in both new construction and existing housing. The overall installed average cost was $1,471, although some retrofit costs may be much more expensive based on problematic site characteristics. Also, the analysis of individual models indicates that some models are less expensive than other with similar performance characteristics, with the least expensive larger THWs (at least 175,000 BTUs) costing as little as $1,023 for a Bosch or $1,297 for a Takagi.

The price noted by contractors in the survey were all over $2,000, but also reflected either retrofit conditions or more complicated custom installations (solar or space heating) in new construction. The Davis Energy Group study documented over $1,300 in installation costs alone (not including the TWH) in the field study they conducted. Costs might include larger gas lines, extended lengths of expensive Class 3 venting, moving of water pipes to a different location and/or electrical wiring to accommodate the pilotless ignition. The contractor prices also reflect a market with limited competition for premium products.

Builders reported prices close to the ODOE tax credit results, with costs of $1,200 to $1,400. The consumer would see a slightly higher price, as builders would typically mark-up the plumber costs by 10% resulting in consumer costs of $1,300 to $1,550.

As a final check, this study also obtained contractor prices for equipment costs of just over $1,000 for several of the more common models, including vent kit and pressure relief valve. Labor and minor piping costs may add $200 in new construction and significantly more in retrofit, plus equipment markup. High volume purchasers could reduce the equipment costs substantially.

Based on these data points, this study proposes that $1,300 is a reasonable short-term (next two years) installed cost estimate for new construction, as several of the newer larger models are available at that price. An aggressive program could obtain further price discounts of perhaps 15% as competition reduces margins, volume pricing reduces equipment costs, and installation becomes more routine. Thus, a longer-term installed cost (five years) of $1,100 is estimated. Other variables could substantially change these costs estimates, including higher materials costs, aggressive U.S. manufacturer entry into the market, currency fluctuations, and moving production to lower cost countries.

Costs of retrofits are more difficult to predict, but even the best case situations are likely to be more expensive than new construction, due to the costs of sales, travel, scheduling issues, and installation complexities. A best case retrofit might occur when the existing water heater is next to an exterior wall for venting, the main gas feed is sufficiently sized, an electrical outlet is nearby, and sufficient combustion air is available. This may occur if the existing water heater is in a garage, for example. This study proposes a minimum of $300 in additional cost for these best case retrofits, resulting in minimum retrofit costs of $1,600 (short-term) and $1,400 (long-term). An average case retrofit may involve an additional $500 in costs to relocate gas pipes or provide more extensive venting, resulting in a shot-term cost of $2,100 (equal to the current lowest contractor pricing), and $1,900 long-term. The Davis Energy Group study estimated that only 20% of existing houses may be suitable for TWHs, although some contractors that they talked to estimated that up to 50% of houses may be suitable. The field study they completed had $1,300 in installation costs plus the cost of the TWH, which would increase their case study cost to over $2,000.

This study did a cursory survey of the installed costs of efficient storage water heaters by contacting 5 supply houses and plumbers for estimates. In SF new construction a standard storage water is estimated to cost $500 including venting, increasing to $600 in existing houses. High efficiency models may cost $100 or more additional.

The prospect of "endless hot water" means that TWHs are an excellent choice for high hot water use households, a significant element of new home construction that include showers with multiple spray heads and spa-sized tubs. Cost of the TWHs would be the same, but the comparison base case would be either two storage water heaters or a larger, more expensive and less efficient storage water tank. For high use households, larger storage water heaters are estimated to cost at least $800 in new construction and at least $1000 in retrofit. Using power vented or high efficiency models can increase this price considerably, with a top end estimate of over $3,000 in some new homes.

Water heating applications in new multifamily construction may vary substantially, but assuming a slightly smaller tank and efficiencies of multiple installations at one site, $450 was used as a base cost. Distributor costs for smaller TWHs are $200 to $300 less than larger TWHs with similar features, so installed costs were estimated at $250 less in the short-term, and $200 less in the long-term.

The table below summarizes short and long-term incremental costs and savings estimates for TWHs in domestic water heating applications. These are contractor installed costs. While costs are based on standard storage water heaters, energy savings were developed from a comparison with efficient storage water heaters, and therefore represent conservative estimates of performance versus costs. High use households are simply estimated to realize 50% more energy savings, an estimate that should be confirmed through field studies.

Projected Incremental Costs and Savings for TWHs – Domestic Water Heating Applications Only

Application	Storage Water Heater Installed Costs	Short-term Incremental Costs	Long-term Incremental Costs	Annual Savings
New Construction Single Family	$500	$800	$600	102 therms
New Construction SF – High Use	$800	$500	$300	151 therms
New Construction Multifamily	$450	$600	$450	82 therms
Best Case Replacement (limited market)	$600	$1,000	$800	102 therms
Best Case Replacement – High Use	$1,000	$600	$400	151 therms
Average case – Replacement	$600	$1,500	$1,300	102 therms

No cost data were obtained for combined space and water heating installations. The basic installed cost of the TWH would stay the same, but the controls and distribution system would add substantial costs.

A natural gas furnace market study for the Energy Trust completed by Habart and Hewitt estimated installed furnace costs in new construction (including venting, controls, and air handler/blower, but not including the distribution system) of $2,023. The addition of a storage water heater results in a standard cost in new construction of $2,523 for the furnace and water heater. Adding controls and pumps to a typical TWH installation would increase TWH costs for a combination space and water heating application to about $1,800. Given that the TWH is doing two jobs, installed costs may actually be less than the conventional warm air system installed in Oregon, depending on the costs of the distribution system and whether air conditioning is desired. Combo installations avoid the first cost related issues that builders are typically concerned with – however, the market needs proof. Builders will go for combos once they believe the technology works as advertised. While combination use of TWHs may be less efficient that the best warm air furnaces, the analysis that looks at benefits should include fan energy savings, reduced distribution losses, and hot water savings.

Conclusions and Recommendations

Conclusions

1. **The technology of TWHs is relatively mature.** There are multiple manufacturers with sufficient resources to make competing products. New product variations continue to enter the market in response to U.S. consumer needs. TWHs have a substantial product base in Japan and Europe.

2. **The market for TWHs in the U.S. and Oregon is very immature.** TWHs are only about 2% of the market, and are not widely known to consumers. Most contractors and builders have limited experience with them.

3. **While there is some opportunity for price decreases for TWHs, the opportunity is probably limited to 15%.** Decreases may be possible due to increased sales volume and, over time, increased competition between manufacturers. However, because TWHs are a relatively mature technology, large changes in price should not be expected. The product is more costly than standard tank-type water heaters, and the installation is slightly more complicated.

4. **There are market niches where TWHs have substantial performance advantages.** Generally, the new residential construction market should be cost-effective for TWHs in domestic water heating applications. In houses with large loads where larger (or two) storage water heaters are used, TWHs should be

extremely cost-effective. In either case, they offer a gain of more than 30% in energy efficiency.

5. **Use of TWHs in combination space and water heating applications can reduce initial costs relative to separate water and space heating systems, as well as increase efficiency.** Typically, reduction in first costs is a primary driver of market change. However, lack of product familiarity, performance concerns, limited infrastructure development, and changes to systems types (hot water rather than warm air, cooling system changes) will substantially slow market adoption of TWHs space heating applications.

Summary of Best Opportunity Applications

Market Opportunity	Rationale
Water heating in new construction with average loads.	Increased energy savings versus storage water heaters.
Water heating in new construction with large loads such as spa tubs.	Ability of TWHs to supply unlimited hot water efficiently. Increased cost of alternatives.
Water heating in new construction where space is at a premium, such as townhouses or condos.	Much smaller footprint of TWH. Flexibility in location. No storage losses in low use applications.
Combined space and water heating in new construction, especially in applications with low to average space heating loads	Reduced first cost relative to two heating systems. Increased efficiency relative to standard practice for both systems.
Replacement market for high use households, i.e. anyone considering a 75 gallon or larger tank.	Modest increase in first cost for significant increase in efficiency and savings. Probably only cost-effective where installation costs are not excessive.

Based on the prior Habart & Hewitt of gas furnaces in the Energy Trust of Oregon's territory, a rough market size for these opportunities is 16,500 for new construction and 30,000 to 35,000 in replacements.

Recommendations

In domestic water heater applications, TWHs provide a classic case of an opportunity for market transformation. Indeed, the parallels to the introduction of horizontal axis clothes washers into the U.S. market are remarkable. Specifically,

- A technology that is dominant in other countries is beginning to be introduced to the U.S. market.
- The technology is more efficient, and costs substantially more.

- There are significant non energy benefits (in this case, endless hot water and smaller size/location flexibility).
- Many key market actors believe that the technology is superior in performance.
- There are no substantial differences in the supply chain or installation practices (unrelated to manufacturer product support, which is a substantial change).
- The existing market is largely undifferentiated products, that compete on price rather than features.

There are a couple of key differences from the clothes washer market that are useful to keep in mind as well.

- There are no U.S. manufacturers currently making competitive products.
- Sales will likely be through builders or plumbers, not directly to consumers, which reduces the opportunity for customer education/sales.

What the strong parallels suggest is that for TWHs to grab a substantial market share, a significant market transformation strategy will likely be needed. While the ETO can succeed in changing the Oregon market, there will need to be substantial up-front investments in marketing, demonstration, and research. Success would be more robust, and some significant costs could be shared, by involving other national or regional partners such as additional gas utilities, the California Energy Commission (and potentially other utility commissions), the Consortium for Energy Efficiency, New Buildings Institute, DOE and/or EPA Energy Star. (Because the Northwest Energy Efficiency Alliance is not funded by gas utilities, their potential role is limited). Pacific Gas and Electric has funded a recent report (referenced below) and regulatory commissioners in the Midwest have begun a study of energy efficient gas technologies; the ETO is not the only energy efficiency entity looking at TWHs.

An Oregon Strategy

Key aspects of the Oregon market for TWHs include the lack of awareness on the part of consumers, plumbers and builders; higher first costs; some persistence of performance issues with an older generation of TWHs, and the presence of the state tax credit of up to $350.

Key recommendations are:

1. **Conduct a further review on the cost-effectiveness of TWHs**. In low-use applications, the TWHs may have an additional performance advantage over standard water heaters due to the elimination of standby losses. In higher use households, the TWHs may replace two standard water heaters or larger tank-type water heaters that are more expensive and/or lower performance than standard units. A more detailed review of cost effectiveness is warranted.

2. **Complete and publish one or more detailed case studies**. Related to the cost-effectiveness review, conducting and documenting case studies can bolster

savings estimates, and provide confidence to consumers and contractors regarding performance issues.

3. **Include TWHs as an aspect of the Energy Star Homes program**. The most likely market is new construction, and working through the existing program base will likely be the most successful route. Develop pathways within the program to show domestic water heating and the combination space and water heating applications.

4. **Promote TWHs at home shows, and other marketing venues that target new home purchasers**. Demonstrate the equipment and provide simple collateral piece to explain how the technology works and its benefits, along with case study results.

5. **Provide installation and sales training to plumbers, possibly in conjunction with manufacturers**. Trades people need to be more familiar and comfortable with the technology. Educating and training plumbers gives them an upsell technology that they currently do not have – one that represents potentially larger margins and higher sales volume. They can also be a major force in educating the market. A program that helped plumbers figure out which customers might be interested and which physical set-ups could be cost effectively addressed would lead to increased sales.

6. **Consider providing an incentive**. Depending on the cost-effectiveness analysis, an additional incentive may prove useful. Given that most of the market activity will be associated with new homes, a sales incentive to the builder or plumber may be most efficient.

A Regional or National Strategy

More benefits may be obtainable through a regional or national strategy to complement the ETO efforts in Oregon. It is likely that the ETO will have to provide some initial leadership in this area, but organizations exist to provide the regional or national coordination.

1. **Promote TWHs as an agenda item at CEE**. Promote this paper and the PG&E funded work as the beginning of a new analysis on TWHs.

2. **Research the interests of Puget Power, PG&E, Boston Gas, the CEC and the Midwest utility commissioners in TWHs.** Work with others, probably through CEE and/or NBI to assemble funding for additional research and development work.

3. **Work with others to conduct a more detailed assessment of the gas water heater market.** A current study being conducted on behalf of the NW Alliance may fill this need.

4. **Work with others to conduct a follow-up study of consumers, to determine satisfaction and general performance of TWHs in the field**.

5. **Conduct additional field tests and/or case studies to further investigate and determine field performance**.

6. **Work collaboratively with manufacturers to increase market push including sales and installation training and possibly manufacturer level incentives.** Manufacturers are extremely interested in increasing market penetration, and program features aimed at them may be the most direct path to the market.

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