#3976

DEMAND WATER HEATERS

FACTSHEET

WASHINGTON ENERGY EXTENSION SERVICE

April 1988

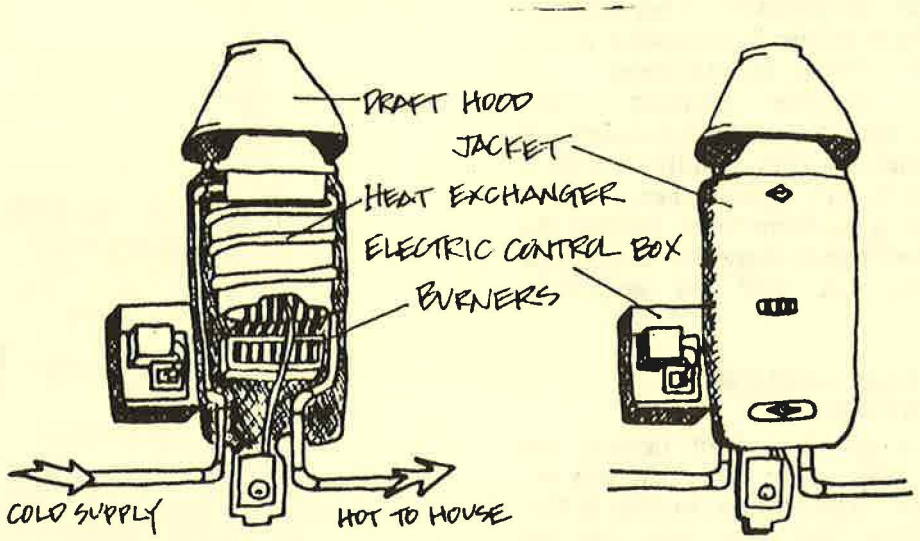
INTRODUCTION

Your water heater uses more energy than any other appliance in the home except your heating system. It costs a typical family of four up to $300 per year or more for water heating. For many families, this represents a significant portion of their energy costs. Fortunately, there are many ways to lower this cost by reducing hot water consumption and increasing heating system efficiency. Techniques for this are described in a WEES factsheet "Hot Water Conservation."

If further reductions of your hot water bill are desired, other water heating alternatives may be considered. These include superinsulated tanks, tempering tanks, solar water heaters, and wood-fired heaters. In general, these systems are most cost-effective for someone deciding on a system for a new home or for families using greater than average quantities of hot water.

This factsheet will discuss the design and installation options of demand water heaters. For information on other water heating options, refer to other WEES publications listed at the end of this factsheet.

Figure 1
Components of a Demand Water Heater



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Demand water heaters, sometimes called tankless or instantaneous heaters, are cabinet size units that heat water instantly. They can be mounted next to the tap they serve, or in the case of larger units, be centrally located and plumbed to all the fixtures in the home. This offers continuous hot water to the consumer, making them particularly well suited for large families or households that run out of hot water frequently. Since they have no storage tank, their small size makes them adaptable to apartments or vacation homes where space is limited. Smaller units are frequently called *point-of-use* heaters, while larger units are called *centralized* heaters. Both gas and electric models are available. They are also easy to drain if freeze protection is a concern (as in a summer house). In new home construction, demand water heaters offer the additional advantage of simplified plumbing details.

Demand water heaters are simple in design, which makes them less susceptible to breakdown and easy to repair. Temperature control allows the user to adjust for specific use requirements. They have a long life of 20 years, twice that of a conventional water heater. As shown in Figure 1, they consist of a heat exchanger, a burner or coil, and a control system that can designate heat input to the water, temperature rise, output temperature, and flow rates.

Energy savings from replacing a conventional water heater with a demand water heater typically range from approximately 10 - 25 percent of a household's total hot water bill, or $20 - $60 per year.

Despite all their advantages, demand water heaters do have drawbacks, the major one being the cost of purchase and installation. To furnish an entire home with hot water from a demand heater might cost $550 - $1500, as compared to $250 - $400 for a conventional water heater. Most households will need to use the heater for many years (12 or more) to see a payback.

Since they draw large amounts of power in a short period of time, people who live in areas where peak rates are in effect may find demand water heaters more expensive to operate than conventional water heaters. Households using them may also need to install more capacity in their electrical service.

In areas where water quality is a consideration, demand water heaters may become clogged or restricted (alkali-calcium buildup between 120° and 140°F is a major cause of system breakdown). This problem is overcome by periodic maintenance or installing a water softener in the system.

Lastly, because demand water heaters are not widely used in this country, it may be difficult to find qualified professionals to install and service them. Also, they may pose a problem when selling the house as homebuyers may be unfamiliar with their operation and the associated benefits.

HOW DEMAND WATER HEATERS WORK

Not all demand water heaters are able to deliver water to the tap in the way we are accustomed. The reason for this is that their temperature and flow rate controls differ significantly from conventional water heaters. Control choices are 1) a modulating mode, or 2) a fixed-output mode.

The *modulating* mode units offer a constant temperature regardless of selected flow rate. These units are best suited for serving the whole house or for shower taps where minimum flow rate and steady output temperature are required.

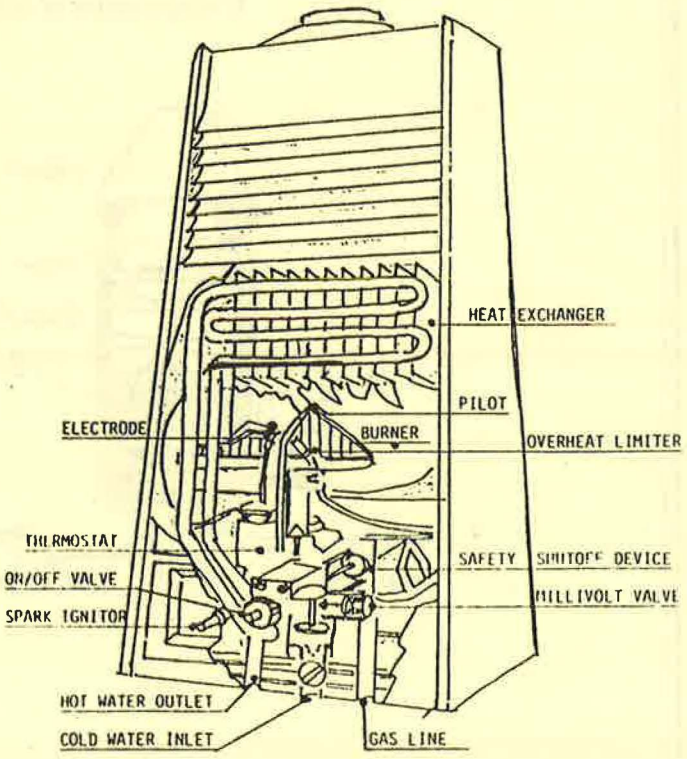


Figure 2
Centralized Unit

Table 1
Characteristics of a Sample of Demand Water Heaters

Manufacturer/ Distributor	Model	Temp.Rise(F) @Flow Rate(GPM)	Max heat Input(kW)	Start Up/Shut Off FlowRate(GPM)	Price $	Comments
FIXED OUTPUT HEATERS						
ELECTRIC						
Chronomite Laboratories 21011 S. Figueroa Carson CA 90745	Instant flow S-60C " " " S-90I " " " S-30L	30 @ 1.50 61 @ 1.00 40 @ 0.50	6.0kW 9.0kW 3.0kW	1.0/0.65 1.0/0.65 0.40/0.30	185 185 185	Booster units work w/ storage tank set at 110 deg;S-60 is a dishwasher booster;S-90I hooks cold-water line;flow control limits rate to 1 gpm
Pecbras Co. 1300 Stirling Rd #4 Dania FL 33004	Corona CTH-40 Corona CHS-40	58 @ 1.00 38 @ 1.50	8.4kW 8.4kW	0.55/0.50 0.50/0.50	189 120	Lower-powered shower head also available for RV use.
GAS						
Inter. Technology Sales Corp 6450-E E. Jewell Ave Denver CO 80231	Fastomatic Maxtisk V300 Fastmat. Multitask V450	90 @ 1.48 52 @ 2.50 90 @ 2.26 58 @ 3.50	85,000 Btu/hr 132,000 Btu/hr	0.25/0.25 0.50/0.50	435 565	Available for liquid propane gas, equipped w/ piezoelectric ignitor; can be used with single lever & temperature controlled faucet
Saunier Duval 7 Odell Plaza Yonkers NY 10701	Aquavac S042	90 @ 2.10 80 @ 2.35 60 @ 3.15	117,000 Btu/hr	0.66/0.66	599	Porcelain finished; liquid propane models available
MODULATING HEATERS						
ELECTRIC						
Acutemp Corp Box 8115 Ann Arbor MI 48107	144 180	95 @1.00 51 @ 2.00 23 @ 4.00 120 @1.00 63 @ 2.00 30 @ 4.00	240V/14.4 kW 240V/18.0 kW	0.50/0.35 0.50/0.35	500 530	Temperature-rise settings between 40 and 120 degrees on heater or remote thermostat; small booster units available.
Thermar Corp Thermar Center Trombull CT 06611-0398	Super Power Pack 7kW Super Power Pack 9kW	90 @ 0.75 30 @ 0.20	240V/5.0 kW 240V/7.0 kW	0.50/0.50 0.50/0.50	248 248	Set between 100 & 145 degrees; automatic cutoff above 150 degrees, hooked in series, heaters yield 90 degrees rise at higher flow rate
GAS						
Paloma Industries 241 James St. Bensenville Il. 60106	PH-12MD PH-16MD	100 @ 0.48-1.43 90 @ 1.59 100 @ 0.48-1.90	89,300 Btu/h (max) 30,000 Btu/h (min) 121,000Btu/h (max) 30,000 Btu/h (min)	0.4/0.48 0.4/0.48	550 695	Adjustable setting for temp. rise between 60 and 100 degrees
Thermar Corp. (see above)	Homemaster Delux	90 @ 0.8-1.60 30 @ 0.8-1.90	100,000Btu/h (max) 30,000 Btu/h (min)	0.50/0.50	499	Also comes directly vented; temperature-rise settings between 40 and 100 degrees on heater or remote thermostat.
Controlled Energy Corp P.O. Box 19 Fiddlers Green Waitsfield Vt. 05673	AquaStar AS80 AquaStar AS125	90 @ 130 45 @ 2.60 90 @ 2.11 45 @ 4.22	77,500 Btu/h (max) 25,300 Btu/h (min) 125,000Btu/h (max) 44,000 Btu/h (min)	0.75/0.60 0.75/0.60	450	Set dial at 110 to 150 degrees automatic shut-off at 185 degrees push button piezelectric ignitor

The *fixed-output* mode units operate in only one mode with full capacity used to heat the water at all times. Depending on the unit, it may control its own flow rate so that adjusting the hot water faucet has no effect, or it may allow the user to adjust the flow rate within certain parameters. The problem with fixed-output heaters is that they can overheat water if they direct all of their heating capacity at a small stream. For this reason, they are best used at taps that operate independently of temperature and flow rate, such as dishwashers, clothes washers, tubs, and basins.

STARTUP FLOW RATE

The startup flow rate is the minimum flow of water needed to pass through the unit before the coil or burner will turn on. Startup flow rates will vary from unit to unit with the overall range from 0.25 to 1.0 gallons per minute (gpm). See Table 1 for examples. A low startup rate of 0.50 gpm (equivalent to a stream the size of lead in a pencil) is best suited for a centralized unit. This eliminates the inconvenience of not having hot water at low flow rates. Temperature adjustment at low flow rates may be difficult with centralized units, so be sure to check on startup flow rate with the manufacturer.

HOW A CONVENTIONAL WATER HEATER USES ENERGY

A conventional water heater uses energy in two ways, *demand* and *standby* (see Figure 3).

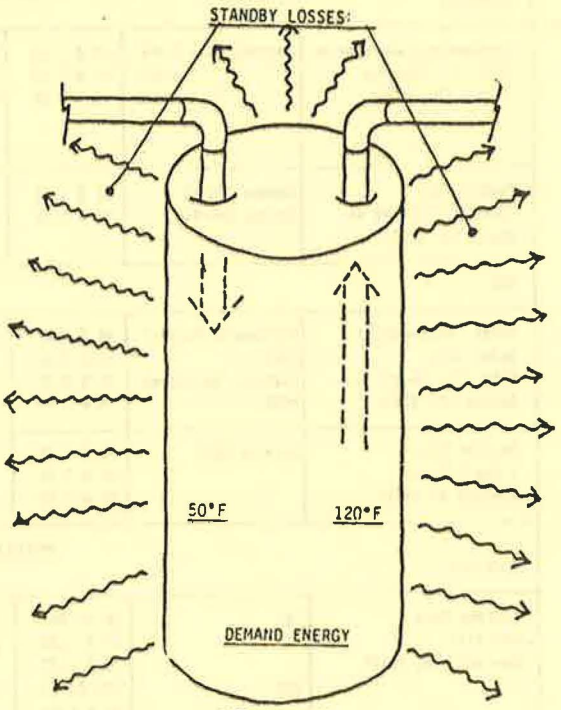


Figure 3
Demand and Standby Energy for a Conventional Water Heater

Demand is the energy used to heat cold water from its incoming temperature (averaging 50°F) to the temperature desired in the tank (typically 120°F). *Standby* is the energy lost due to conduction of heat through the walls of the tank and associated plumbing. Standby energy is typically much less than demand and is lowest in well-insulated tanks. As shown in Table 2, standby is 10 - 25 percent of the total energy consumed per year by an electric water heater with 30 feet of pipe. If the water heater is installed inside the insulated shell of the building, these standby losses help heat the building most of the year.

To calculate your own water heating costs, refer to the WEES factsheets listed in "Suggested Reading."

Table 2
Typical Water Heater Energy Consumption and Cost(1)

	kWh(2)	Cost(2)	Appx. % of Total
Demand	3996-4995	$200-250	75-90
Standby	443-1171	$ 22-59	10-25
Total	4439-6166	$222-309	100

(1) For a 52 gallon electric water heater set at 120°F with 30 feet of uninsulated pipe used by a family of four at $.05/kWh.

(2) Ranges in kWh consumption and dollar costs account for variations in water usage (64 - 80 gallons per day), tank insulation levels (R5 - R16) and ambient air temperature (50°F - 65°F).

ENERGY SAVINGS

It is important to note that demand water heaters use the same amount of energy to heat the cold water supply as a conventional water heater (some gas models use slightly less energy than their conventional counterparts because heat transfer efficiency is a few percentage points higher). This energy is referred to as demand in Table 2, and may cost from $194 - $235 per year. Demand water heaters save energy because they don't store hot water, thereby eliminating the energy costs associated with standby losses from the tank (and sometimes the pipes as well). As shown in the same table under standby, this can amount to a yearly savings of $22 - $59.

If the demand water heater is replacing an uninsulated water heater, savings in the high range of $50 or more per year can be expected. But for most people, standby losses are fairly low because their water heaters are wrapped with insulation. For these people, savings with a demand heater would be relatively low, in the range of $22 - $30 per year. For comparison to other investments, you may want to calculate a simple payback.

Table 3
Calculating Simple Payback

$$\text{Simple Payback (in Years)} = \frac{\text{Extra Cost of Demand Water Heater}}{\text{Energy Cost Savings/Year}}$$

The cost of a centralized demand water heater above that of a conventional water heater will vary considerably depending on the household size. Let's use $600 an example. Comparing this to a typical energy cost savings of $40 per year yields a payback of 15 years (Table 4). For most people, payback on a demand water heater will be from 12 - 20 years.

Table 4
Example of Payback for a Demand Water Heater

$$\text{Simple Payback: } - \frac{\$600}{\$40\dagger} = 15 \text{ years}$$

† Savings is based on current electric rates. If these rates go up, potential savings will be greater and payback considerably faster. However, for most people, energy savings will not be the sole basis for using a demand water heater.

SELECTING THE DEMAND WATER HEATER

To ensure good performance, it is important to match the capacity of the demand water heater to your hot water needs. Demand water heaters are sized according to their heat output capacity(Btu/hr). Ratings range form 25,000 - 132,000 Btu/hr. Lower heating capacity models (50,000 Btu/hr or less) are best suited for single tap installations such as a kitchen sink, bathroom basin or dishwasher. Medium capacity models (50,000 - 100,000 Btu/hr) would best serve a large single appliance such as a clothes washer or a bathtub. High capacity models (100,000 Btu/hr or more) are designed for centralized installations where they serve showers and other taps, or all the taps in the home. See Table 1 for examples.

To pick the appropriate size unit for your needs, it is best to calculate the maximum heating capacity you'll need to provide sufficient hot water for your home. Keep in mind that use of low flow shower heads and faucet flow controls will reduce the flow rate requirements for the home, enabling a smaller, less expensive demand water heater to meet your needs. Adding a flow restrictor or low flow shower head can reduce shower rates from 4 gpm to 2 gpm and thereby reduce heating capacity requirements for a demand water heater.

A recent demand water heater innovation is the specific point-of-use application for showerheads, where the demand water heater is built into the showerhead, as shown in Figure 4. This small unit supplies 110°F - 120°F water at 1.5 gallons per minute. Since they are fixed output units, as gallons per minute increases, the available temperature decreases.

To calculate heating capacity, you must first figure out the amount of hot water you will need at any one time, or your "peak maximum demand." Assume that faucets draw 1/2 to 1 gpm, low-flow showers need 2 gpm, and average showers need 3 to 4 gpm. If the most hot water you'd ever need would be for simultaneous use of a low-flow shower (2 gpm) and one faucet (1 gpm), your peak demand would be 3 gpm (2 + 1). If you want your hot water heated to 104°F (a typical temperature for showering), and your cold water supply averages 50°F, then you will need the demand water heater to provide a temperature rise of 54°F. These two numbers, plus the heater efficiency, allow you to calculate heating capacity requirements, as shown below.

Insert those numbers in the equation in Table 5 and you will come up with a heating capacity requirement of 101,000 Btu/hr. (for a gas model).

Figure 4
Showerhead with Built-in Demand Water Heater

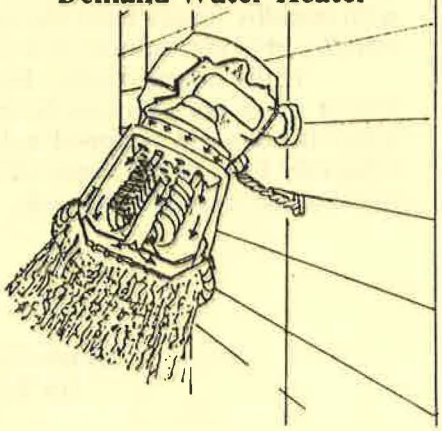


Table 5
Calculating Your Heating Capacity Requirements

$$\text{Heating Capacity (Btu/hr)} = \frac{\text{Peak Gallons Per Minute(gpm)} \times \text{Temperature Rise (°F)} \times 500\dagger}{\text{Heater Efficiency (1.00 for electric unit, 0.80 for gas units)}}$$

† This number is a constant, the product of 1 Btu/pound of water x 60 minutes/hr x 8.33 pounds/gal.

$$\text{Heating Capacity} = \frac{3 \text{ gpm} \times 54°\text{F} \times 500}{0.80 \text{ (gas model)}} = 101{,}000 \text{ Btu/hr}$$

(Source: *New Shelter*, March 1985, p. 92.)

Larger demand water heaters are capable of meeting a maximum heating capacity of 101,000 Btu/hr. To get by with a smaller heater, you could reduce the desired tap temperature or reduce the volume of your demand (use fewer taps simultaneously).

INSTALLATION OPTIONS

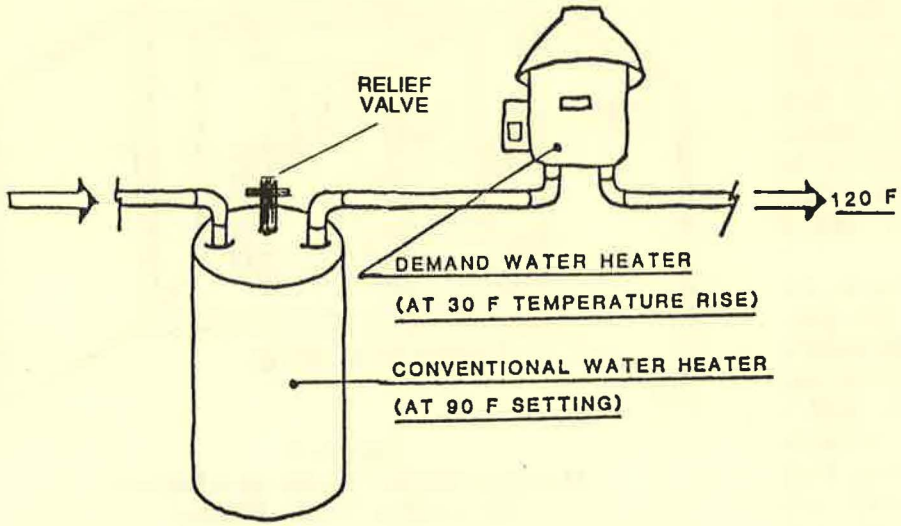
There are a variety of installation options for demand water heaters. These are outlined below with a discussion of their advantages and disadvantages.

Demand Water Heater in Combination with Conventional Water Heater

A small demand heater can be plumbed on the hot output side of the conventional water heater to act as a temperature booster. The conventional heater can be set at a lower temperature of 90°F- 100°F. The advantages are reduced standby losses, increased life of the conventional water heater, and minimal replumbing costs.

Also, a small, inexpensive unit can be purchased. Though minimal, one disadvantage is some presence of standby losses on the tank and pipes. Also, the conventional water heater may need to be fitted with new thermostats to accommodate the lower temperature setting.

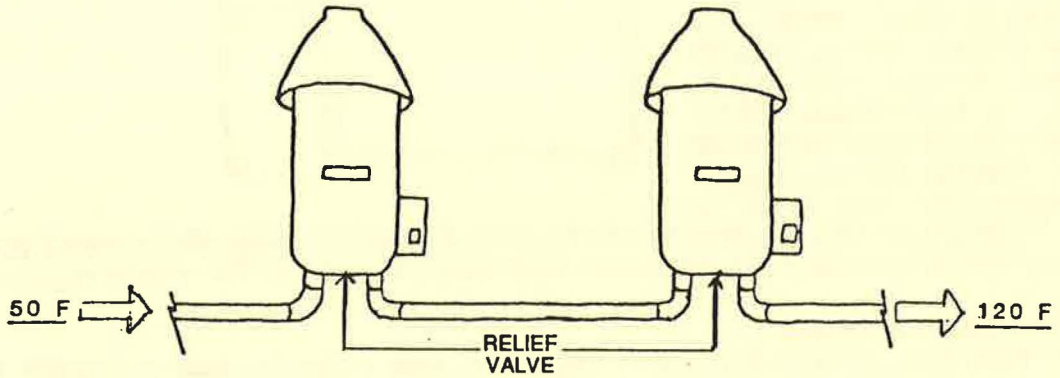
Figure 5
Demand Water Heater in Combination with a Conventional Water Heater



Two Demand Heaters in Series

The conventional water heater can be replaced with one large centrally located demand water heater or two small units installed in series (Figure 6). This eliminates tank standby losses entirely, although heat loss from pipes is still present. The initial cost of this option is high, in the range of $550 - $1,000 for purchase and installation, but savings on standby losses would be higher than the first option.

Figure 6
Two Demand Water Heaters Installed in Series and Centrally Located



Point-of-Use

The conventional water heater can be replaced with several small demand water heaters at every tap, or point of use (Figure 7). Tank and pipe heat loss is eliminated and hot water is provided almost instantly at the tap. This installation option is best suited to new home construction where plumbing can be customized. Initial cost can be high, in the range of $700 - $1500, but savings on standby losses are greatest with this option due to the elimination of long piping runs.

Figure 7
Point-of-Use Installation

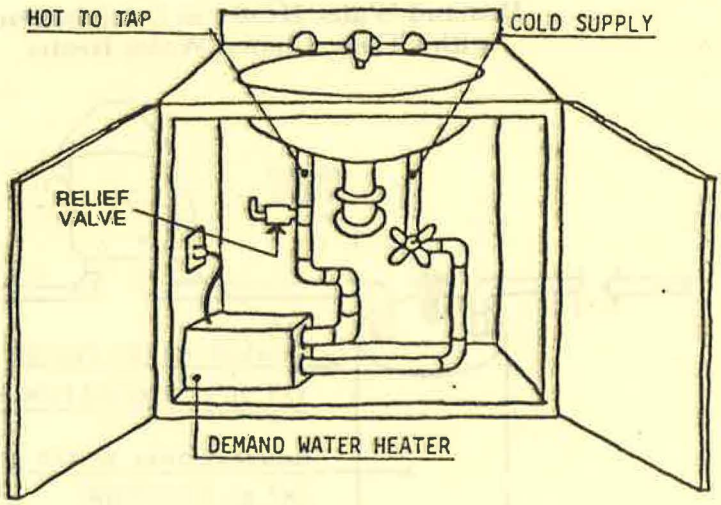
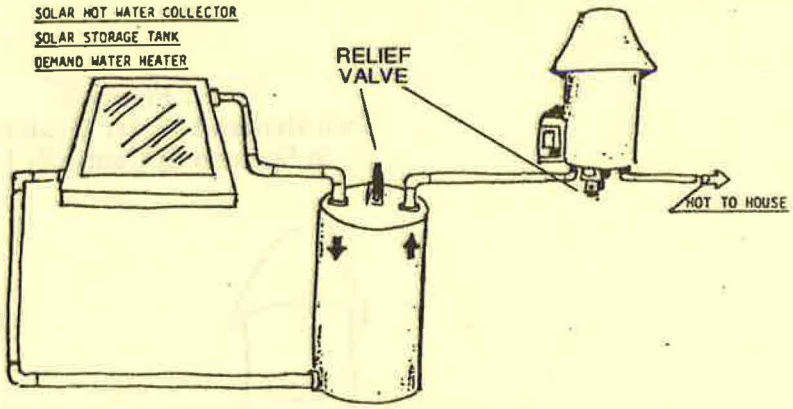


Figure 8
Demand Water Heater as a Booster for a Solar Water Heater



Solar and Wood Water Heating

Demand water heaters can be used as a booster for a solar or wood water heating system. To work effectively, the unit must be plumbed in line with the solar of wood storage tank and have a minimum capacity of 80,000 Btu/hr. A start up flow rate 0.50 gpm or less and a modulating mode unit are necessary as well. Savings on standby losses would be comparable to the central installation option.

Installation specifications for all demand water heaters are provided with the manufacturer's literature. Costs for professional installation can range from $50 - $250 per location. The location should be planned to minimize long plumbing runs, and side-wall and floor clearances should be observed. The gas heater must be located near a chimney for venting. Both gas and electric units should be located in a freeze-protected area, and one where a water leak will not cause any damage. Having a floor drain or sink nearby is handy for draining the unit.

With an electric model, it is important to know heating capacity requirements, so ample wiring can be provided. A conventional electric water heater draws about 5kW when it is on, whereas electric demand water heaters draw from 1.5kW to 18.5kW. If the present electric service to the house cannot accommodate the increased power demand, new service may be necessary. Manufacturers offer units with 110 and 220 voltage requirements.

Wood-Fired Demand Heater

A wood-fired demand heater is a single unit with a firebox, heat exchanger, storage tank, circulation and control system. It has the appearance of a tall, thin storage tank with a small firebox at the base. An exhaust stack runs up through the center and must be vented to a solid fuel chimney. The storage tank is made of welded steel, and can store 6.2 gallons of water. The firebox is made of cast iron, and designed to handle small pieces of fuel such as kindling, wood scraps, brush or paper.

When hot water is needed, a fire should be started in the firebox. As it burns, heat travels up through the exhaust pipe and is transferred to the water in the tank. Demand heater manufacturers claim that it takes 8 - 10 minutes to heat the water in the tank to desirable temperatures. Though they are relatively inexpensive to purchase and install, about $200, wood-fired demand water heaters are not designed to handle a large hot water demand. They are most practical for a weekend or seasonal home where conventional fuel hook-ups might be costly.

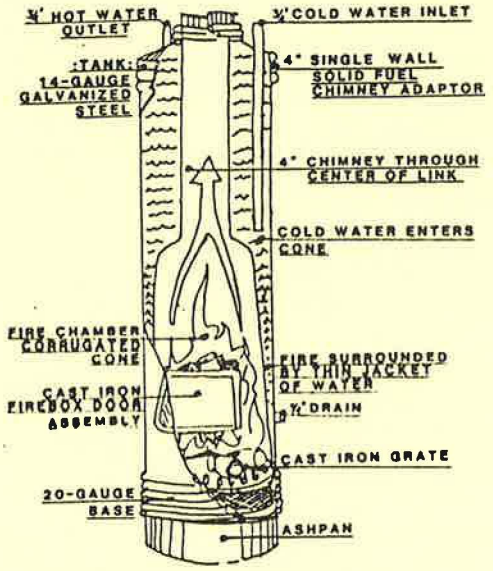
CONCLUSION

Demand water heaters offer a viable alternative to conventional gas and electric water heaters, especially in homes with high water usage. Their simple design and small size make them ideal where there is limited space. There is a consistent yearly energy savings with their use, but payback to the initial investment is long (12 - 20 years).

Several installation options are available, including the larger whole-house units, and the smaller point-of-use models. There has also been successful application as a booster in a solar or wood heat system.

As in all hot water applications, careful consideration should be given to proper installation of demand water heaters. A correctly designed and safe system will benefit the user for many years.

Figure 9
Wood-Fired Demand Water Heater



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SUGGESTED READING

1. "Hot Water on Demand," *New Shelter Magazine*, Rodale Press, March 1985, pg.88-93.
2. "Never-Ending Hot Water--and Energy Savings Too," *Popular Science*, April 1986, pg.106-108, 150-151.
3. "Endless Hot Water?", *Energy Auditor & Retrofitter*, Jan/Feb 1986, pg. 32.
4. "Water Heater Innovations," *Solar Age*, Solar Vision, Inc., September 1985, pg. 24.
5. "Saving Energy," *Progressive Builder*, Solar Vision, Inc., March 1987, pg. 39.

WEES Publications:

- *Solar Domestic Hot Water Heating*, FS 1607
- *Water Heating With A Woodstove*, FS 1705
- *Hot Water Conservation*, FS 1301

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