Best Practice – Water Heaters

Subject: Water Heater – Repair or Replacement?

Date: 7 September 2011

Problem or Question:

Question #1: "When may an existing water heater be replaced?"

- "Water heaters may be replaced when energy savings justify the replacement cost. As with all energy efficiency measures installed with DOE funds, water heater replacement must result in a savings-to-investment ratio (SIR) of 1.0 or greater.
  - The lifetime used in the SIR calculation should not exceed the manufacturer's guarantee. Water heater replacements are generally not cost effective unless savings accrue for at least 10 years. Therefore, agencies should purchase new replacement water heaters with at least a 10-year guarantee.
- Water heaters may be replaced for related health and safety reasons. When replacing water heaters for health and safety reasons, they must be brought up to code." (From *"Water Heater Replacement into the Weatherization Assistance Program Information Tool Kit"* by Jordan Kelso at *D and R International,* 2003). Important note: In general, the use of the word 'code' in this best practice refers to the 2009 IRC for the State of Texas; however, municipal and local codes may be more stringent than the 2009 IRC, in which case those codes would take precedence.

Question #2: "Can I replace water heaters based solely on their age?"

- "No. The age of the water heater does not provide an accurate indication of whether it should be replaced." (Kelso, 2003). Water heaters must have an SIR of 1 or greater. Install energy star water heaters with an Energy Factor of .67 or above; these will sometimes rank when dealing with existing older units.
- **Discussion**: Older gas water heaters typically use 250 or more therms per year. New gas water heaters use as little as 175 therms per year. A savings of around 75 therms can repay the initial investment in 4-to-9 years at today's gas costs. Weatherization providers should be well aware of traditional, low-cost measures such as low-flow showerheads and faucet aerators that reduce the demand for hot water. Methods to reduce the energy use of existing water heaters can be found on pages 67-71 of the *Texas Mechanical Systems Field Guide*. http://www.tdhca.state.tx.us/ea/docs/TXMFG.pdf

Question #3: "We see a variety of concerns with already-installed water heaters. Some are natural gas fueled and inside conditioned space. Others do not have valves or existing valves are pointed toward people. Some water heaters are functional but seriously rusted or starting to leak. I understand that I must bring the water heating system up to code if I replace a water heater, but what type of situations require me to take action for health and safety reasons? What kind of appliance problems should not be rectified because the concerns are pre-existing and we are not replacing the unit? Furthermore, if the situation might be dangerous to the occupants, should I ask them to sign a document acknowledging the possible danger and recommending that they take action to address the potential issue?"

- Response: You ask a difficult question with no quick, easy answer. The following guidance and examples can serve to remove some of the "gray area" when reconciling problem appliances with the codes. Although the following guidance is useful, it cannot remove the need for balanced good judgment in the decision making process regarding problem appliances. Judgment must also be used to determine the appropriate category for a problem appliance. Seek program officer guidance when making difficult or costly determinations regarding problem appliances. Do not blindly apply the current (or local) code on all existing appliances or you will be replacing many water heaters that do not need to be replaced.
  - There are three categories for water heaters that have problems or issues. They are:

Category 1- Problems that pose an immediate threat to the occupants. These are Health and Safety measures.

Examples: High-CO readings (per TAC), exposed electrical wires, flame roll-out or back-drafting (add combustion air), no pressure relief valve, no safety discharge pipe (in a living area, laundry area, or any conditioned space), or improper flue venting (Combustion Appliance Zone worst case test failure).

Category 2- Problems that potentially pose a future threat to the occupants.

Examples: Improperly installed relief valves (that may vent toward residents), water leaks that will likely cause mold or deterioration to structure, water heaters that are not at the required height off the ground. Improperly installed discharge piping. No safety discharge pipe (in a mechanical closet or outside vestibule). Improper vent type. If repair a water heater then you must bring it up to code.

Category 3- Problems or issues that do not appear to pose a future threat to the occupants.

Examples: Water heaters that have been installed with piping that is too large or is not run (installed) properly. Rusty exteriors. Missing drain pan.

- There are 3 types of weatherization efforts that involve water heaters.

A) Replacement. If a unit is replaced then the entire unit must be brought up to the IRC code (or more stringent local code. Note, this does not include piping, electrical wiring, gas lines beyond the immediate connection to the water heater unit unless there is a category 1 or category 2 issue with the piping, gas lines, or electrical wiring, etc.).

B) Modification of existing water heater.

- If an existing water heater is modified and is in category 3 then only the modifications themselves need to be up to code.
  - For example, if an existing water heater is "wrapped" with a insulating blanket and/or pipe insulation is performed, and issues with the unit do not appear to pose a future threat (category 3) to the occupants (e.g. drain line is metal instead of PVC plastic piping), then the existing unit does not need to be brought up to code.
- If an existing water heater is modified and is in category 1 or category 2 then the entire water heater must be brought up to code. Make sure to include photos and good documentation explaining why the water heater is a current or future threat to the occupants; document your thought process in the file.
  - Example- if there is a small leak from the water heater, and this poses a long-range moisture/mold potential future threat to the residents (category 2), then in this case the issue should be addressed and the unit brought up to code.

C) Inspection of water heater only as a part of the whole house assessment. If the pre-existing water heater is only inspected and is in category 1, then the issue must be corrected (through repair, or if necessary replacement) and the entire unit brought up to code.

- If the pre-existing water heater is only inspected and is in category 2 or 3, then the unit does not need to be brought up to code because the unit was not modified and there is no immediate danger to the occupants. If, however, the water heater is in category 2 then the client must sign and be given a copy of a document that notifies them of the concern because it is a possible future concern to the occupants.

Use your best judgment, applying building science to each decision; however, remember that in the end, the local code enforcement official is the authority having jurisdiction. In most cases, where there is no municipal code jurisdiction, the 2009 IRC applies to weatherization efforts in Texas as outlined in this best practice.

<u>Question #4:</u> "What are the Health and Safety considerations for water heaters?

- Response: "An adequate supply of combustion air is necessary for all fuel-burning water heaters. Most water heaters vent by gravity—their flue gases are lighter than the air in the environment in which the combustion occurs—so they naturally rise up in a vent that is open to atmosphere at the top. The open draft hood on the top of the water heater allows additional air to dilute the flue gases. Insufficient combustion air is hazardous. If there is not sufficient oxygen to fully burn the fuel at the correct temperature, deadly carbon monoxide will also be a product of combustion. If the air pressure in the water heater space is lower than that in the vent, production of combustion might 'spill' out of the draft hood and enter the interior environment." (*Code Check Complete*)

There are three problems with water heaters located in the thermal boundary:

- **Negative pressure increases infiltration.**
  When the furnace or water heater or both are running, they're pulling in room air and sending it to the outside. Remember a basic rule of building science is 1CFM in = 1CFM out. The appliances are using conditioned air for combustion. Atmospheric combustion appliances, located inside the conditioned space, will increase the air infiltration the house experiences. The client may report that the house is a bit drafty while the furnace/water heater is running.
- **Negative pressure can back-draft the appliance.**
  If the air pressure in the water heater area is low, relative to the air pressure where the flue terminates outside, air will come down the flue. If air enters the flue while the water heater is firing, combustion gases will not exit the flue. They will enter the room. Back-drafting changes the combustion process. The flame may get starved for oxygen, causing incomplete combustion, which results in significantly more carbon monoxide. High winds may also cause back-drafting.
- **Common venting of water heaters and furnaces can override built in safety features on furnaces.**
  At the base of the flue in an atmospheric combustion furnace is a draft inducer. This fan pulls air up through the heat exchanger. Right next to that fan is a pressure sensor that will cut off the furnace if it detects high pressure in the flue. If a bird builds a nest at the top of the flue, for example, and the combustion gases can't escape, this will trigger the sensor to turn off the furnace.

  When the water heater flue is connected to the furnace flue a bird's nest at the top of the flue will keep the combustion gases from exiting. However, the sensor may not detect a high enough pressure to shut off the furnace, because the combustion gases now have another escape path--the water heater.

Another viable WAP solution to water heaters located within the thermal boundary is to create a sealed combustion closet out of the room or area where the water heater and/or furnace is located. This is achieved by isolating the combustion appliance zone; separating the unit from inside the house to outside the thermal boundary. A closet may be built around the zone. This closet is then air-sealed and insulated from the rest of the house and combustion air is brought into the closet from either the attic or outside the house. However, it is important to note that the fact that a water-heater is inside the thermal boundary is not a singular reason to relocate, wall-off, or replace the water heater. If there are other problems with the water-heater and/or other work accomplished now mandates that the water heater must come up to code (as outlined in this best practice), then relocation or closet building may be necessary. (See "Isolating the CAZ" Best Practice.)

High CO levels DO NOT necessarily mean automatic appliance replacement. If the water heater is inside the thermal boundary and has high CO levels, evaluate why. Here are some helpful questions to guide your inspection and analysis:

- Are combustion by-products not venting properly to the outside?

    - Add adequate venting, unblock the existing flu, or check for proper flu design.
    - Supply combustion air from outside the thermal boundary.
        - Remember to block the flue in the attic to keep insulation from falling onto the water heater.
- Is the draft hood present, aligned, or restricted?
    - Assure the draft hood is present and functioning properly.
- Are chimneys blocked or are vents terminating inside the living space?
    - Have the chimney cleaned out.
    - Vent to outside the thermal boundary or outside the house.
- Is the appliance back-drafting? What is the cause?
    - A dryer, situated close to the water heater. Example--when the water heater is located in the laundry room/closet.
    - An exhaust fan, or leaky return air duct or plenum located near the water heater. Example--when the water heater is located in the kitchen and there is an oven exhaust fan.
        - Consider isolating the appliance zone.
    - Do the occupants keep their bedroom doors closed, causing positive pressure in the bedrooms and negative pressure in the combustion appliance zones? Educate the client on keeping doors open for a balanced system. If they won't leave the doors open, then install jump ducts or install offset bypass grills. Simply cut a hole between two studs at the top of the bedroom and hallway wall; seal the top plate with caulk and install a grill; then repeat at the bottom of the other side of that wall.
    - Are the supply or return ducts leaky? This can cause negative pressure—SEAL the ducts/plenums.
- Is the flame being impinged?
    - The baffle, thermocouple or other parts may have been knocked out of position. These can be adjusted so that the flame is longer impinged.
- Are combustion air and gas pressure settings out of adjustment?
    - Air and pressure can be adjusted to reduce carbon monoxide to acceptable levels, by a certified person. Yellow flames indicate the need for adjustment.

Other Health and Safety issues to consider:

- Missing a temperature and pressure relief valve or discharge pipe?
    - Follow the instructions in the *Mechanical Field Guide* and local codes.
        - Codes and Standards: The removal and installation of water heaters should comply with all local building codes and permit requirements. Work may need to be performed by a licensed contractor.
        - When a TPRV (Temperature Pressure and Relief Valve) on a gas water heater is non-existent or not functioning there is an option to install a "Watts 210" gas shut off valve. This is especially useful if the installation of a TPRV drain line to the exterior of the house is cost prohibitive.
- Excessive tank corrosion? Are irreparable water leaks causing damage to the structure of the home?
    - Take photos and document for replacement.

These last two points would also apply to electric water heaters. If wiring is an issue, then address (electrical issues)—not the appliance.

Factors Affecting Water Heater Energy Use and Savings (Kelso, 2003)
The major factors that determine energy savings for replacing water heaters are:

Hot water consumption

- The number of people per household is a major driver of hot water consumption. In addition to showers and baths, washing machines and dishwashers are large users of hot water. The remaining household hot water use is primarily attributed to kitchen and bathroom faucets. *EDUCATE YOUR CLIENTS!*

Table 2 – Sample Hot Water Consumption Calculation

End Use	Driver	Example	Average Daily Household Hot Water Use per Driver (gallons/day-driver)	Total Daily Household Hot Water Use (gallons/day)
Bathing & Showering	Occupant	3	10.5	31.5
Clothes Washing	Clothes Washer Present	Present	7.5	7.5
Dishwashing	Automatic Dishwasher Present	Present	6.4	6.4
Faucets	with Dishwasher or without Dishwasher	with Dishwasher	2.6 or 6.3	2.6
Total				48

- **Housing location**
  - The geographic location of the home dictates the climate and fuel prices. Depending on the geographic location of the water heater, climate can significantly affect the energy use of the water heater. The decision to replace a water heater should be based on local fuel prices. Using default fuel prices can produce inaccurate estimates of energy cost savings and can lead to inappropriate replacement decisions. Enter local pricings into NEAT fuel library.
- **Water heater location**
  - Energy lost from the storage tank can be significant when a water heater is located in either an unheated space or outside the building. The higher these standby losses, the more energy can be saved by replacing the water heater with one that has better tank insulation or installing a water heater insulation blanket (consult manufacturing instructions and document that a blanket installation is permissible for the unit per the manufacturer).
  - When a water heater is located in a conditioned space, the heating and cooling thermostat set points for estimating energy savings are assumed to be 68° F and 78° F, respectively.
  - When a water heater is located outside the home, the statewide average seasonal air temperatures for winter, spring, summer, and fall are used to estimate standby losses.
- **Water heater performance**
  - The energy efficiency of water heaters was difficult to gauge until recently. The National Appliance Energy Consumption Act (NAECA), enacted in 1987, required minimum energy efficiencies for water

heaters manufactured after 1990. NAECA established an energy efficiency parameter called an Energy Factor (EF) that includes steady-state efficiency, standby losses, and thermal efficiency losses. In 2004, NAECA revised the minimum standards, as seen below:

NAECA 2004 Standards

Mandatory Minimum Efficiency Levels for Gas & Electric Storage Water Heaters

- Gas-fired Storage-type – EF 0.67 – (0.0019 x Rated Storage Volume in Gallons)
- Oil-fired Storage-type – EF 0.59 – (0.0019 x Rated Storage Volume in Gallons)
- Electric-fired Storage-type – EF 0.97 – (0.00132 x Rated Storage Volume in Gallons)
- Tabletop – EF 0.93 – (0.00132 x Rated Storage Volume in Gallons)
- Instantaneous Gas-fired – EF 0.62 – (0.0019 x Rated Storage Volume in Gallons)
- Instantaneous Electric – EF 0.93 – (0.0013 x Rated Storage Volume in Gallons)

Table 4: Minimum Energy Factors Required by NAECA* for Post-1990 Water Heaters

Fuel Type	30 gal tank	40 gal tank	50 gal tank	75 gal tank
Natural Gas or Propane	0.56	0.54	0.53	0.48
Electric	0.89	0.88	0.86	0.83
Oil	0.53	0.51	0.50	0.45
* National Appliance Energy Consumption Act of 1987				

o TDHCA requires the use of **Energy Star** rated appliances. Please verify that water heaters installed comply to current Energy Star ratings (Energy Star ratings change with technology; go to www.energystar.gov for current ratings. The below example ratings are only current as of July 2011):

A missing or illegible nameplate sometimes makes it impossible to obtain the EF of a particular water heater or determine when it was manufactured. In this case, the minimum NAECA EF from Table 5, should be used in the spreadsheet to evaluate a potential water heater replacement. Newer combustion analyzers give efficiency readings; these should be used for the appliances.

Table 5: Water Heater Energy Factors

Type	<1982	1982-1984	1985	1986-1987	1988-1989	1990-2004	2004-2010	2010-present
Electric	0.8	0.81	0.82	0.82	0.83	0.88	0.97	0.98
Natural Gas	0.48	0.48	0.48	0.49	0.49	0.54	0.62	0.67

Source: http://energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters

Data on the Recovery Efficiency (RE) of existing water heaters is also elusive. The REs, in Table 6, were obtained from the same Lawrence Berkeley National Laboratory report used to develop Table 5. As Table 6 indicates, REs have not improved over the years as EFs have.

Table 6 – Typical Water Heater Recovery Efficiencies

Fuel Source	Recovery Efficiency (RE)
Electric	98%
Natural Gas or Propane	76%
Oil	76%

Source: Wenzel, Tom P., Jonathan G. Koomey, Gregory J. Rosenquist, Marla Sanchez, and James W. Hanford. 1997. *Energy Data Sourcebook for the U.S. Residential Sector*. Lawrence Berkeley National Laboratory (LBL-40297).

To estimate the energy savings that may result from a potential water heater replacement, the EF and RE of the existing and replacement water heater must be known. If you are replacing an old water heater with a current higher efficiency Energy Star one; such as one with an EF of .67 or above, you may find that it will actually have an SIR of 1 or greater. The EF and RE of new replacement water heaters should be readily available from the nameplate or GAMA. This information must be entered into your NEAT Supply Library under the "Hot Water Equipment" tab; including the "energy details" for NEAT to evaluate the cost effectiveness of the new unit to the old one.

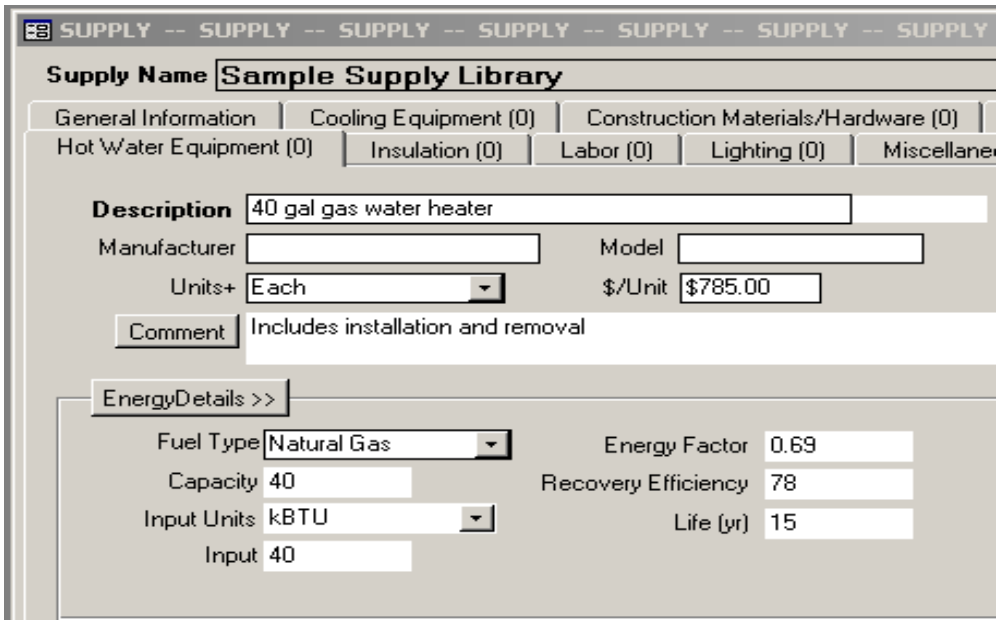

Figure 1 – Determining the EF and RE of an Existing Water Heater