Frequently Asked Questions and Answers

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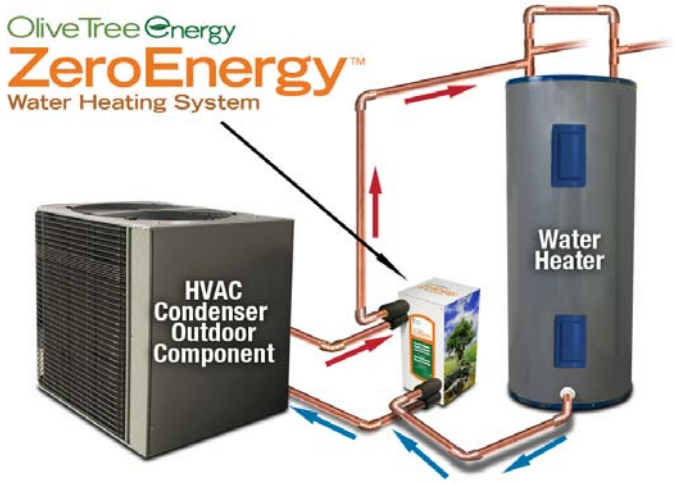
The questions and answers below are primarily for HVACR Contractors and Engineers seeking detailed information about the ZeroEnergy®Water Heating System. Consumers who are willing to "brave" the large amount of technical information are also invited to learn about the attributes, benefits and applications of the ZeroEnergy® system. There are many energy efficient products on the market today, but one must be careful to choose the ones with the best performance from an economic, green/sustainability and high performance point of view. The ZeroEnergy® Water Heating System is one of the best for many reasons, as explained below.

Index of Questions (see answers below):

How does ZeroEnergy® work? The principles of physics provide the pumping force required to move water through this "pumpless" heat recovery system. The main principle involved is the "thermosyphon" effect, which occurs when fluids are heated. As this happens, the fluids become less dense and move upward, while colder fluids are more dense and move downward. When the AC system is running, the hot gas refrigerant flows through **ZeroEnergy®** and exchanges its heat into the water that is also flowing through it. A surprisingly large amount of very hot water is moved without a pump through **ZeroEnergy®** (see question below: How hot will the water be coming out of ZeroEnergy®?). **ZeroEnergy®** typically installs right next to the water heater tank, thus making thermosyphon flow easy. HVAC system hot gas refrigerant lines run from the outdoor condensing unit to the **ZeroEnergy®** location near the water heater.



Is ZeroEnergy® a new, unproven technology? No, several thousand units are in the market with good success. The City of Austin, Texas (a leader in implementation of "green" building techniques) actually specifies thermosyphon "desuperheater" units like **ZeroEnergy®** as one of their "green" suggestions for water heating (www.austinenergy.com). Their guidelines were based on purchasing and implementing a large number of **ZeroEnergy®** systems in the past. The Tampa Housing Authority has installed 187 systems in two different low-income housing developments and is installing an additional 127 systems in two additional developments, including Moses White Estates, a new 69 unit LEED construction project. Numerous other successful commercial and residential applications attest to the performance of **ZeroEnergy®**.

Does ZeroEnergy® work on the high efficiency AC and heat pump systems? Yes, high efficiency systems still produce hot enough gas refrigerant to achieve great heat transfer and plenty of hot water. Some in the industry have an incorrect understanding that the heat is recovered from the phase change temperature of the

refrigerant in the condenser. Actually, the heat is recovered from the superheated gas temperature exiting the compressor (typically 60˚F+ above condensing temperature with a TXV in high efficiency units). Heat recovery rates from 13-14 SEER systems are actually higher in some cases than that from 10-12 SEER older systems with fixed orifice expansion devices.

Does ZeroEnergy® improve the AC or heat pump system's efficiency? Yes, for several reasons. **ZeroEnergy®** has very low refrigerant related friction loss by means of a properly engineered heat exchanger and refrigerant connection lines. The hot gas refrigerant that exits the compressor goes through the heat exchanger and is pre-cooled by **ZeroEnergy®** to a much lower temperature before it returns, thereby boosting the host AC system's efficiency (see more detailed explanation in the next question and answer below). Testing has shown an increase in EER and SEER of over 1 point in many cases. At ARI heat recovery test conditions, a 13 SEER system will function like a 14 SEER system after installation of **ZeroEnergy®** and likely experience a slightly longer useful life due to the corresponding lowering of the system head pressure. In addition to the hot water production cost savings provided by **ZeroEnergy®**, one will experience some energy and future equipment replacement cost savings, which are real benefits. These benefits have not been added or factored into dollar savings estimates (see question and answer below re: estimated cost savings); thus, **ZeroEnergy®** contributes more return on investment than just the savings on hot water heating costs.

From a technical point of view, how does ZeroEnergy® increase the efficiency of the host AC system? One must first understand the difference between friction related pressure loss and heat transfer related pressure drop. Friction related pressure loss is bad in that it decreases AC system efficiency, while heat transfer related pressure drop is good in that it increases system efficiency. When an HVACR system has a high friction related pressure loss (for example, because of an improperly designed heat exchanger or a too small refrigerant line), even though a pressure drop is seen at the liquid line port, the pressure seen by the compressor is actually higher, which increases the amp draw/power consumption and, thus, decreases efficiency. By contrast, **ZeroEnergy®** reduces pressure at the liquid line port by means of better heat transfer, which actually results in a lower high side (head) pressure at the outlet of the compressor, thereby causing lower amp draw/power consumption and, thus, increased efficiency.

What about the newer, 2 stage compressor, variable fan speed systems…does ZeroEnergy® work effectively with them as well? Yes, in most cases, it actually works better with these systems! In the single stage compressor mode and at very low fan speeds, these systems produce enough heat to create upwards of 140˚F hot water. When a 2 stage unit is operating in the single stage mode, it is operating at a lesser tonnage capacity. As the tonnage capacity drops lower, the percent of de-superheating accomplished by **ZeroEnergy®** actually increases, approaching or even exceeding 100%. When this effective de-superheating is combined with the typically longer run time at a slower fan speed, **ZeroEnergy®** will actually produce more BTUs and hot water than when installed on a conventional, lower efficiency AC or heat pump system. One other important aspect is that a 2 stage compressor, variable speed air handler system sacrifices efficiency when operating in the single stage compressor mode when the fan is running at low speed (for example, a 17 SEER system may only operate 13 SEER at those times). **ZeroEnergy®** helps overcome this problem by boosting the system efficiency at those times, with increased BTUs produced by the system as recovered heat into the hot water storage tank.

From a more technical standpoint, there are two unique aspects about **ZeroEnergy®** to consider:
First, **ZeroEnergy®** is a thermosyphon type heat recovery system which transfers heat from the hot gas refrigerant to a cool water supply ***only*** when there is a differential temperature between the refrigerant and the water. It draws the incoming cool water supply from the bottom of a storage vessel (or water heater tank) where the water temperature is the coldest because of temperature stratification. Therefore the incoming water would only flow as long as the water temperature entering was cooler than the refrigerant entering the **ZeroEnergy®** heat exchanger. The system is completely self regulating, without the need for any power or

controls. By contrast, pumped heat recovery systems do not have this feature and can create some problems if installed with 2 stage equipment.

Second, the **ZeroEnergy**® heat exchanger itself is constructed using a properly sized refrigerant line size which results in less than a 5 psi friction loss through the heat exchanger when attached to a five ton R-22 system and less than 2 psi friction loss when attached to a similar sized R-410a system. All of our line-set sizes specified for connection between **ZeroEnergy**® and host AC or heat pump system are sized for minimal friction loss (less than 7 psi total including the heat exchanger for R-410a systems and less than 10 psi for R-22). Importantly, installation instructions and specifications require sizing vertical lift piping to provide a minimum refrigerant velocity of over 1000 fpm (in fact, most are above 2,000 fpm). All horizontal runs and vertically downward flow runs are designed for a minimum 500 fpm refrigerant velocity, and typically average above 1000 fpm. Thus, **ZeroEnergy**® works very consistently with the refrigerant related requirements of 2 stage systems.

Overall, the actual increased heat transfer related pressure drop (especially at higher outdoor ambient temperatures) is much greater than the friction related pressure loss, resulting in a net gain in efficiency, even with 2 stage systems.

Will installing ZeroEnergy® on an AC or heat pump system void the original warranty? No. There were in the past and still are some poorly designed pumped type heat recovery units that negatively impact AC system performance, and therefore could void a manufacturer warranty. But **ZeroEnergy**® has none of these problems and was actually designed to eliminate them. The heat exchanger is rated and tested for use on up to 6 tons and actually increases host AC system efficiency (essentially, the addition of **ZeroEnergy**® is adding to the coil size/increasing coil surface area – see more detailed explanation in the next question and answer below).

Moreover, and very importantly, the Magnuson-Moss Warranty Act protects consumers from improper warranty voidances by manufacturers. This well established law puts the burden on manufacturers to actually "prove" any aftermarket product caused a problem. The law makes it illegal to even make a statement that a warranty will be voided, without having specific proof. While dealers of all aftermarket products in all industries (such as the auto industry) have sometimes heard this because of manufacturers' valid concerns, it is rare for it to arise in real situations. The truth is: The only thing that can be proven about a properly installed **ZeroEnergy**® is that it actually improves the performance and useful life of the host system!

What is the installed price for ZeroEnergy®? Typically, for residential applications and most commercial applications, the installed price is only about 1/3 the installed price of a solar water heater, about the same as a tankless water heater and less costly than a heat pump water heater. A typical installation should cost between $1,600 and $2,300, depending on the distance from the condensing unit to the water heater. See the separate **ZeroEnergy**® Dealer Reference Guide or have your local AC dealer or contractor call Olive Tree Energy for more details.

Why would one want to install ZeroEnergy® instead of a solar water heating system? Solar is a good concept and one that should continue to be developed. But where one has an AC or heat pump system, **ZeroEnergy**® is by far the best way to heat water. Here are 10 compelling reasons why:

> **First,** the installed cost of a solar system is about 3 or more times greater than the installed cost of **ZeroEnergy**®.
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> **Second**, solar systems provide the same or less hot water than **ZeroEnergy**® in many applications. In "sunbelt" regions, where cooling seasons are longer, **ZeroEnergy**® provides more BTU's per year toward water heating, on average. In areas where there is more heating than cooling, with a heat pump, **ZeroEnergy**® still performs very well (see more detailed discussion of heat mode performance in

another question and answer below). Thus, "dollar for dollar" (investment for savings), **ZeroEnergy®** pays back much faster than solar. Here is a sample BTU production comparison assuming a solar system with a 40 square foot panel that is ideally positioned in the Central Florida locale compared to **ZeroEnergy®** installed on a 3.5 ton heat pump system:

Solar: 5.5 hours average solar exposure per day, x 365 days per year, x 350 BTU per hour per sq ft x 4x10 panel (40 sq ft), x 55% efficiency, yields **15,457,750 BTUs per year, or 102 gallons per day** (on average) of 50˚F rise hot water (differential of entering vs. leaving the system), which is calculated as follows: 15,457,750 BTUs divided by 50 to get the pounds of hot water at a 50˚F rise, further divided by 8.3 pounds of water per gallon, further divided by 365 days).

ZeroEnergy®: Cooling mode contribution is 3,200 BTUs per hour per ton, x 3.5 tons, @ 75% de-superheating on average or x .75, yields 8,400 BTUs per hour, times 2,500 run hours per year, yields 21,000,000 BTUs per year; PLUS heating mode contribution: 1,900 BTUs per hour x 2.0 tons average (won't produce full 3.5 tons in the heat mode), @ 100% de-superheating (at that low of a capacity it will reach 100%) or x 1.0, yields 3,800 BTUs per hour times 500 hours of average run time per year, yields 1,900,000 BTU; the total of the cooling and heat modes production is **22,900,000 BTUs per year, or 151 gallons per day** (on average) of 50˚F rise hot water (differential of entering vs. leaving the system), which is calculated as follows: 22,900,000 BTUs divided by 50 to get the pounds of hot water at a 50˚F rise, further divided by 8.3 pounds of water per gallon, further divided by 365 days).

NOTE: The comparison is even more favorable for **ZeroEnergy®** because the above does not take into account the additional savings that result from the use of **ZeroEnergy®** due to increases in AC system efficiency (less energy usage/cost) and longevity of the host AC system (lasts longer and needs to be replaced less often).

Third, solar systems have many maintenance issues that come from 3 main sources: 1) potential failures and costly replacement of pumps, sensors, the large numbers of valves and controls that are required, 2) periodic cleaning of the panels (difficult to do on the roof) and 3) roof penetrations that can cause leaks over time and piping into the building envelope. By contrast, **ZeroEnergy®** has no maintenance requirements.

Fourth, solar systems often create aesthetic problems for a home or building, with unsightly panels often in view, whereas **ZeroEnergy®** is small and compact, and neatly installs next to the water heater.

Fifth, solar systems do not enhance the performance of AC systems like **ZeroEnergy®** does by creating energy (and cost) savings through increased efficiency from de-superheating the refrigerant, and longer equipment life (and cost savings) due to resulting lower system head pressures.

Sixth, some component parts and a majority of tube type panels for solar systems are now coming from overseas, which is not desirable for several reasons: 1) jobs are not being created as effectively here in the U.S.; 2) risk of currency weakness (particularly the dollar in light of US fiscal policy) could cause sudden price increases of materials from overseas; 3) risk of political change (terrorism, protectionism, bad relations, etc.) which could negatively affect trade and timing of product deliveries, and 4) larger carbon footprint/environmental cost due to long shipping routes using large amounts of fossil fuels (by contrast, the ZeroEnergy™ system and its component parts are produced in the U.S.).

Seventh, installation of solar systems is more risky and difficult compared to **ZeroEnergy®** for several reasons: 1) roof top labor work is more difficult, time consuming and likely to cause injury (Workers Comp insurance rates reflect this fact); 2) heavy panels are cumbersome to lift to the roof and

sometimes require cranes or other lifting equipment assistance; 3) more risk of collateral building and product damage; 4) 3 to 4 times the amount of labor required.

Eighth, Indirect costs associated with solar are higher because the materials and component parts take up much more space physically and are harder to handle than **ZeroEnergy®**. About 30 **ZeroEnergy®** units and installation kits can fit on one pallet, occupying about the same amount of space as the materials and component parts for just one solar system.

Ninth, tax credits currently subsidize solar heavily in order to make it more palatable to consumers. While this can be good on one level (lessening consumers' net cost to purchase solar if they have tax liability to use the credits), it creates 2 problems: 1) Government is financially subsidizing the solar industry and the funds come out of taxpayers' (our) collective pockets. There is no such thing as a "free lunch" and all taxpaying citizens of the U.S. are paying for the subsidy. 2) The current 30% tax credit may not be able to be sustained for as long as one might think, given the current US fiscal situation. While it is unlikely the credit would be totally eliminated, it could be scaled back to the 10% level that existed for many years, and this could leave some dealers facing problems from decreasing sales in what has become a very competitive market due to so many dealers entering the field.

Tenth, **ZeroEnergy®** has a 10 year warranty, which exceeds most solar system warranties on panels, component parts, etc.

Overall, **ZeroEnergy®** is the most sustainable and "green" water heating technology available. In very simple terms, while solar is good, **ZeroEnergy®** is a more sustainable product than solar. It has a much lower life cycle cost (the most important measurement) than solar and requires far fewer resources (short and long term). **ZeroEnergy®** has no negative impacts, whereas solar has several and produces the same amount or less hot water and overall energy savings (on average) than **ZeroEnergy®**.

Why would one want to install ZeroEnergy® instead of a tankless water heating system? A tankless system has about the same installed cost as **ZeroEnergy®**, but **ZeroEnergy®** greatly outperforms a tankless system. The only savings of a tankless system are related to it not having a tank and the corresponding tank heat losses. These savings are miniscule in comparison to the savings coming from use of **ZeroEnergy®**. In addition, the tankless system is still a complicated piece of mechanical equipment that can require maintenance.

Why would one want to install ZeroEnergy® instead of a pumped heat recovery system?

First, **ZeroEnergy®** does not have a pump with sensors and controls, which are subject to failure and costly replacement.

Second, **ZeroEnergy®** is mounted indoors next to the water heater, not outside in the weather elements (freezing, heat/sun, outdoor air elements).

Third, **ZeroEnergy®** has a superior heat exchanger design to minimize pressure loss and work well with ALL sizes of systems up to 6 tons (and even larger systems with larger ZeroEnergy® systems). The net effect is better/more efficient host AC system performance than with typical pumped heat recovery systems which often have built in design limitations as part of their components, installation line sets or heat exchanger design. One pumped heat recovery system manufacturer told us that their current refrigerant friction related pressure loss is approximately 12 psi on a 5 ton unit, which also agrees with the projected loss for a 20 ft. long ½" diameter copper line used for a 5 ton system, not including losses associated with coiling of the tube.

Fourth, **ZeroEnergy®** warranty is for 10 years on the unit (cabinet and heat exchanger) and the system could last for a lifetime as there is really nothing in it that would fail (no moving parts, etc.). By contrast, pumped heat recovery units might have, for example, only a 1 year warranty on the controls, 3 years on the pump, and 5 years on the heat exchanger. The overall life cycle cost of **ZeroEnergy®** is a fraction of the life cycle cost of a pumped system.

Fifth, **ZeroEnergy®** provides more hot water per ton (or horsepower) of refrigeration system capacity than a pumped heat recovery unit for one primary reason: The pumped heat recovery units have controls that limit the production of hot water. There are control sensors that prevent the pump from coming on until the hot gas temperature gets above 130˚F. More importantly these controls turn off the pump when the return water temperature (or tank temperature) exceeds 140˚F. **ZeroEnergy®** has no such limiting controls and can safely provide higher temperature water into the storage tank, because it has a separate anti-scald valve which prevents scalding water from reaching the building.

Sixth, with regard to AC efficiency impact, **ZeroEnergy®** is always providing an increase in efficiency to the AC system, unless the water tank is totally full and hot, in which case there is virtually no impact on the host AC system. With pumped heat recovery units, there can be some increase in AC efficiency but it only occurs when the pump is circulating water. However, efficiency in the host AC system is actually decreased when the pump is not operating. This is because the better heat transfer that occurs when the pump is operating provides a heat transfer improvement related pressure drop that is greater than the heat exchanger related pressure loss due to friction. The much smaller friction related pressure loss of **ZeroEnergy®** is lower than the heat transfer improvement related pressure drop provided by **ZeroEnergy®**, since the "pumping" action of the thermosyphon effect rarely stops or "turns off."

Seventh, a related issue for pumped heat recovery units is their limited workability with newer, high efficient AC units which operate at low speeds. In these systems, hot gas temperatures are lower and sometimes will be less than the turn on set point for the pump in a pumped heat recovery system for a significant period of time. Thus, the pump does not turn on and the system doesn't work. In high efficiency systems, **ZeroEnergy®** actually becomes more effective because at lower system capacity the heat transfer rate of **ZeroEnergy®** is actually improved. And **ZeroEnergy®** self regulates…it is always working as needed, and it never "turns off."

Eighth, to counter the above problem with pumped heat recovery systems, some pumped heat recovery system installers have installed switches on fan motors to keep them from turning on for a period of time, thus allowing the hot gas temperatures to get hot quicker. The big problem with this is that the host system performance has been altered for the worse: resulting higher operating head pressure and compressor temperatures yield diminished efficiency and lower equipment life. This would also most certainly be grounds for manufacturers to void their AC warranties.

Why would one want to install ZeroEnergy® instead of a heat pump water heater?

First, a heat pump water heater is a complex piece of equipment consisting of a compressor, evaporator fan motor, evaporator coil, an immersion condenser as well as multiple electronic components and controls, all of which have potential failures associated with each component. Over a typical 13 year life cycle (typically used for comparison of water heaters), a heat pump water heater will likely experience some component failures, resulting in ongoing maintenance costs. In fact, the compressor alone is going to see much higher temperature operating conditions than the typical AC system, which is the leading factor in compressor failures. **ZeroEnergy®** has no moving parts, no electrical components, no maintenance and a 10 year warranty.

Second, the initial cost of a heat pump water heater is much more than **ZeroEnergy®**, so the life cycle cost of **ZeroEnergy®** is a fraction of that of a heat pump water heater.

Third, if the water in the heat pump water heater tank is not hot enough (typical tank temperature settings of 120°F to 130°F) to handle the draw down caused by high use, then the heating elements will turn on, resulting in less than the advertised heat pump water heater efficiency and less energy savings. Where the claimed efficiency of a heat pump water heater is based on the efficiency of the heat pump itself, the primary problem is that the size of the compressor in the heat pump water heater is so small that at a typical heat pump water heater's power input of less than 1,000 watts, the output in BTUs/hr. at a COP of 2.2 is only 2.2 x 1,000 x 3.413 = 7,508.6 BTUH. The typical water heater element is a 5,000 watt input heating element, and at the typical COP of .93 for an electric water heater, this results in a BTU/hr. heat production of 5,000 x .93 x 3.413 = 15,870.5, or over twice the recovery rate of the heat pump water heater.

How does ZeroEnergy® compare to other water heating systems? **ZeroEnergy®** has the lowest life cycle cost of any water heating system (the most important measurement when evaluating systems as it takes into account the cost over a long period of time - see separate document which can be provided on request: "Water Heating Systems Life Cycle Cost Comparison"). Solar and tankless systems are compared above. Heat pump water heaters are good but are more costly to install, and like solar, tankless and others, they are not the "best" in light of their life cycle comparison: cost vs. payback, and long term performance and maintenance considerations. Standard pumped heat recovery units often have design and other problems like negatively impacting AC system performance and freezing because they are located outside. All of the above systems have pumps and/or other mechanical parts that are more likely to fail and require maintenance over time, whereas **ZeroEnergy®** has no maintenance required.

If I already have a new heat pump water heater, will ZeroEnergy® work with it? Yes, a heat pump water heater will work very well with **ZeroEnergy®**. The reason is that the heat pump water heaters being produced today all have insertion type heat exchangers that produce very little movement of the water in the storage tanks, and water temperature stratification occurs just like in a conventional electric hot water heater, where the coolest water in the tank is at the bottom and the hotter water is at the top. This provides for optimum thermosyphon flow conditions for **ZeroEnergy®**.

What types of water heating and AC systems work best with ZeroEnergy®? **ZeroEnergy®** attached to a heat pump system and an electric water heater is ideal. It is better (easier) to install the system where the AC outdoor condensing unit is close to the water heater and **ZeroEnergy®**, but the total one way distance can be up to 125 feet of line set length. Many different configurations are possible, including using the system in combination with a tankless system (for backup) or solar systems where one uses a lot of hot water. When coupled with a gas water heater tank, a separate storage tank is used to receive the hot water from **ZeroEnergy®** and it feeds the regular gas water heater, which functions only as a backup (a separate storage tank is required since gas water heaters heat from the bottom, prohibiting thermosyphon flow, which depends upon colder water being at the bottom of the tank and warmer water at the top of the tank). There are some additional energy efficiency considerations with a gas water heater that would suggest that just capping the gas and changing to electric with **ZeroEnergy®** is the best approach in some situations. The reason is that a gas water heater, by design, has an uninsulated gas vent pipe going up the entire interior height of the tank, which leads to it having over 3 times as much heat loss as an electric water heater.

Will ZeroEnergy® work with commercial systems? Yes, **ZeroEnergy®** works great with commercial package systems and can produce outstanding savings, especially where a lot of hot water is needed and used. The most efficient installation would be to use a single **ZeroEnergy®** on a 10 ton commercial package unit. Most of these are dual circuit, so there are two five ton units in one package. A single **ZeroEnergy®**, which is rated for up to 6

tons, can be installed on the lead 5 ton compressor or primary circuit that runs the most. For even more savings, an additional **ZeroEnergy®** can be used and together with the first system there would be two line sets (the second **ZeroEnergy®** would be installed on the second, less utilized circuit). On 20 ton systems, which are dual circuit (two 10 ton compressors), two **ZeroEnergy®** systems can be manifolded together to use with each one of the 10 ton circuits and applied in the same manner as with the 10 ton systems, depending on how much free hot water is needed (use one dual manifolded system, or two dual manifolded systems for even more savings). Refrigerant flow restriction is avoided in these cases by "splitting" the refrigerant lines and running them through the **ZeroEnergy®** system(s) and then bringing them back together. The same principle (manifolding units) is applied with up to 30 ton systems, and custom applications are available for larger systems. **ZeroEnergy®** can also be installed in conjunction with walk in freezers where proximity to the water heating storage tank location is better (water heater closer to the freezer or more accessible to it than the nearest AC condensing unit).

Does ZeroEnergy® produce hot water during the heating season in the heat mode? Yes, with heat pump systems. While the benefits are greater in the cooling season, **ZeroEnergy®** also provides significant amounts of hot water during the heating season with heat pump systems. At outside temperatures of over 37˚F, some of the heat produced by the heat pump system is recovered into the water heating system. Below 37˚F, a smaller amount of heat is also recovered. It is still more efficient to create hot water with the heat pump system in the winter than using the heat strip in the water heater, since the average coefficient of performance (COP) of the heat pump system under all operational temperatures (between 47˚F and 17˚F outdoor temperatures) is approximately 3.1, and the COP of the typical electric water heater is only .92, which corresponds to a 70.3% savings. See related question below.

How does ZeroEnergy® affect a heat pump's efficiency and ability to heat a home? In the heat mode of a heat pump, **ZeroEnergy®** helps efficiency the same way it does in the cooling mode (essentially providing a bigger condenser surface area). Approximately 8.7% of the heat is "robbed" from the heat pump in the heat mode (on average) when outdoor temperatures are above 37 degrees. Thus, the heat pump would have to operate only 8.7% longer (5.8% at lower outdoor temperatures) in order to supply the same amount of heat. But, this is significantly lessened or offset by the efficiency gain to the host heat pump accomplished by **ZeroEnergy®**; and the fact remains that it is still more efficient to produce hot water with the heat pump than it is with the heat strips in the water heater.

From a very technical standpoint, it should be understood that a de-superheater only removes the superheat available in the refrigerant that is to be cooled in a condenser (the indoor component of the heat pump in the heating mode), and the bulk of the heat rejection occurs in the phase change (and sub-cooling) of the refrigerant in the condenser (providing the majority of the heat produced in the heating mode by the heat pump to the conditioned space). This means that, at most, if a heat pump system is operating to absorb one ton of heat (12,000 BTUH) there is a maximum superheat available of 3,200 BTUH± (approximately 3,200/(12,000 + 3,200) = 21% of total heat of rejection), and even less in the heating mode as outdoor temperatures fall (superheat values can be as low as 1900 BTUH per ton of mechanical capacity (= 13.7% of total heat of rejection)) and the total heat of rejection after absorbing 12,000 BTUH of heat is 15,200 BTUH (as low as 13,900 BTUH). Where the de-superheating rate is less than 100% as it is with **ZeroEnergy®** on larger systems and especially in the heating mode where temperatures from the compressor are lower, the de-superheating rate can be as low as 40% (or even lower at lower outdoor temperatures) which would mean that at lower outdoor temperatures (less than 37˚F) the total heat of rejection into production of hot water, in the heating mode for the average of all conditions between 17˚F and 47˚F outdoor ambient conditions, would be less than .4 X 21% (or .4 X 13.7%) of the total mechanical heat of rejection (realizing that there is a fixed amount of heat supplied by the blower motor of 280 to 365 watts [X 3.423 BTU/watt per 1000 CFM of blower capacity) = less than 8.0% (less than 5.5% at low outdoor temperatures) of the total heat of rejection. This would leave 92.0% (94.5% at low outdoor temperatures) of the total heat of rejection to heat a home or conditioned space, and would only mean, as already noted above, that the heat pump would have to operate just 8.7% (5.8% at low outdoor temperatures)

longer in order to supply the same amount of heat to the residence or other occupied space as it would without **ZeroEnergy®**. But, as mentioned above, this extra operation time is offset greatly by the efficiency gain that comes from **ZeroEnergy®** in the heat mode. Of course, if supplemental or emergency heat is required, the savings due to **ZeroEnergy®** would be a wash during times when that electrical heat was utilized.

How much money can one expect to save with ZeroEnergy®? There are many variables that factor into actual energy and dollars saved including the cost of electricity, the number of people in a household, hot water usage, the geographic location of the household (impacts cooling and heating run times), the way the AC or heat pump is operated (set points low or high?), the size of the system to which **ZeroEnergy®** is attached, and others. According to the U.S. Government and independent sources, approximately 20% to 30% of the average U.S. family electric bill is spent on hot water production, second only to comfort cooling and heating. **ZeroEnergy®** will typically save between 50% and 80% of these costs, but can save even more in the right conditions. In typical U.S. conditions, this could average between $200 and $600 per year, depending on all of the influencing factors (see more detailed analysis below). A significant factor that is not included in this average savings estimate and which should not be overlooked is the additional savings accomplished by **ZeroEnergy®** from better AC system efficiency and lesser future equipment replacement costs.

To understand how the savings are achieved in a more detailed way, standard water heater labeling assumes an average of 4,850 kilowatts (±) of electricity per month is used by the typical family of 4 to create hot water. This equates to an average of about 28 gallons per person per day of 50 degree rise hot water used for all uses (dishes, showers, hand washing, laundry, tank and line losses, etc.). The cost savings provided by **ZeroEnergy®** will vary, as mentioned above, upon many factors including the geographic area (affects heat pump system cooling and heating run time) and electric rates. The range of AC system cooling load run hours per year in the U.S. is between 400 hours per year in the far north to 2,800 hours in the deep south, and the range of heating load run hours is between 3,000 and 500 hours, respectively. Assuming one has a heat pump system and an electric rate of $.12 per KW hour (represents an average of many different U.S. regions), **ZeroEnergy™** can save a family of 4 about $400 per year, on average. The savings could be higher or lower, primarily depending on the cost of electrical energy (higher or lower than $.12 per KW hour), geographic location (more or less AC cooling load run time since there is more savings in the cooling mode), and other factors as mentioned above.

Do heat recovery units save enough to warrant their purchase? As can be seen from the above, the answer is yes as long as it's **ZeroEnergy®**! Some people, particularly those in the HVACR industry in the state of Florida, may remember a report from the Florida Governor's Energy Office in late 1991 that outlined the problems associated with certain poorly designed, pumped type heat recovery units that were being sold at that time. While these units produced a lot of hot water and performed well in that respect, the high cost of replacing failed pumps, freeze damage to the water lines and high refrigerant pressure loss resulting in efficiency losses in the AC system were all mentioned in the report. **ZeroEnergy®** solves all of these problems in that it has no pump, is not located outside where it can freeze and was designed specifically for very insignificant refrigerant friction related pressure loss. It actually results in an efficiency increase that comes from pre-cooling the refrigerant coming back to the AC system.

Does ZeroEnergy® qualify for any tax credits or rebates? There are rebates available in certain areas from certain power companies, and we are working to acquire approval through legislative efforts for the federal tax credit initiated by the Energy Policy act of 2005 (extended recently). But the value equation of **ZeroEnergy®** is already so strong that tax credits are not needed to make it attractive.

Is it difficult to maintain ZeroEnergy®? No, **ZeroEnergy®** is "maintenance free" as there are no moving parts and no mechanical or electrical components. The only maintenance that should be observed is the normal maintenance that would be best for your water heater: an annual purging of scale from your water heater tank.

Will ZeroEnergy® affect my water heating tank in any way? Yes, a side benefit of **ZeroEnergy®** is that one will notice a marked decrease in scale deposits in the water heater as water is being heated by the system the majority of the time, which means the normal water heater heating element/strip does not turn on as often and create scale deposits (a particularly big concern in hard water areas). The net result is that the water heater element and the overall heater itself will last longer, which saves/defers replacement cost later.

What kind of warranty is offered with ZeroEnergy®? **ZeroEnergy®** has a 10 year warranty, which is better than most warranties on comparable products (solar, heat pump water heater, tankless water heater, or other).

How is ZeroEnergy® a "green" or "sustainable" product? In general, "green" or "sustainable" products allow for long term function in harmony with and not detrimental to our world's environmental systems. A major measure of this capability is our creation or elimination of greenhouse gasses, or carbon dioxide (CO_2) emissions, which also relates to our dependence on fossil fuels. Just one **ZeroEnergy®** reduces CO_2 production by an average of approximately 3 tons per year for a typical family of 4. It does this at the lowest life cycle cost of any water heating system currently available, including solar, tankless and heat pump systems. The 3 tons of CO_2 saved is approximately equal to the CO_2 emissions for a car that drives 6,700 miles per year at a gas mileage rate of 25 MPG. A study recently completed showed that if just 100,000 of the approximate 4,000,000 homes in the state of Florida (as an example) were to have **ZeroEnergy®** installed, the peak demand for electricity could be reduced by as much as 500 megawatts during times of AC cooling operation (as well as some reduction during heating operation), which is about the same amount as the peak production rate of a typical power plant! This would also be equal to removing the amount of CO_2 produced by about 55,000 cars during that same period of time. **ZeroEnergy®** also has no pump or moving parts to fail, and requires no electrical power input. Plus, the unit itself requires no maintenance and will likely last much longer than its 10 year warranty. Finally, it is manufactured right here in the United States, thus saving environmentally costly transportation from overseas. Overall, **ZeroEnergy®** is the "greenest" and most sustainable hot water heating device in the world!

What sizes of AC equipment will ZeroEnergy®? One **ZeroEnergy®** is rated for all AC and heat pump systems up to 6 tons in size and is used primarily on residential and smaller commercial AC or heat pump systems. However, as mentioned above, it can be customized for commercial systems by using two or more units manifolded together, and custom applications for virtually any AC system size can also be produced.

Are there any types of ACs or heat pumps that should not be used with ZeroEnergy®? No, **ZeroEnergy®** works well with any and all HVACR air conditioners, heat pumps, refrigeration or ice machine equipment including high efficiency systems. The primary application is with heat pump AC systems and the largest benefit comes during the cooling season.

What size water heater or storage tank is required for ZeroEnergy®? Typically for maximum utilization of available heat, assuming the AC system operates an average of 8 hours per day, a minimum of 40 to 60 gallons of storage capacity per 5 tons of AC capacity would be ideal. However, **ZeroEnergy®** can be used with water heaters as small as 20 gallons in size (there would be no maximum size).

Is ZeroEnergy® approved for use with the new refrigerants? Yes, it has been pressure tested at values far exceeding the requirements for any and all refrigerants including R-410a.

Does ZeroEnergy® require a circulation pump? No, due to thermosyphon flow, it does not need a pump. However, where a re-circulation pump already exists or in some unique conditions, a properly specified pump can be utilized in conjunction with **ZeroEnergy™**.

How hot will the water be coming out of ZeroEnergy®? The water temperature coming out of **ZeroEnergy®** can get as high as 180˚F or more at times. This also increases the thermal storage capacity of the

water heater tank and thus gives the effect of increased capacity. Many customers are able to turn off the power to their water heaters during the cooling season, and even if left turned on, the heating element will only come on to heat water when it is not being produced by **ZeroEnergy®**.

Can the high temperature of the water produced by the temperature cause scalding? Hot water can scald, but every **ZeroEnergy®** is installed with a separate anti-scald valve that mixes cold water with the very hot water stored in the hot water heater. This ensures water entering a building will be less than scalding temperature, and it will allow users to adjust the temperature to the desired level at their point of use.

Can the high temperature of water that is produced by ZeroEnergy® be too hot for the water heater and cause problems? Applied Research Laboratories did a certified performance and safety test of **ZeroEnergy®** based on ARI conditions and criteria using a 210.8˚F hot gas discharge from the condensing unit. Very few residential systems operate at higher temperatures than that unless there are desert like conditions outside or if there is a problem with the AC system to begin with, such as system leaks, a bad coil, etc. The water produced by **ZeroEnergy®** in this test was only 186˚F (the water produced will never be as hot as the hot gas refrigerant no matter what conditions exist). In addition, as the water temperature in the water heater tank gets hotter, several things happen: the heat transfer rate decreases, the heat loss in the tank increases, and the thermosyphon flow rate slows down (due to lesser temperature differential in the tank). So, the system is self regulating. Another factor that can mitigate risk is hot water usage, which will be the norm, especially in commercial systems where there is usually significant usage taking place all the time (helps to pull hot water out of the water heater tank). Finally, most water heater pressure relief valves are designed to release around 205˚F. In the worst case, if a pressure relief valve was faulty or in some rare condition the water in the tank reached 205˚F, it would relieve out of the pressure relief valve first. Many systems have this drained to the outside (required by code in most areas), but if not, standard **ZeroEnergy®** installation procedures include extending the drain to the outside.

What is the highest peak thermal output of ZeroEnergy®? Thermal recovery efficiency is affected by heat exchanger design, HVACR system size, efficiency and refrigerant type, as well as other variables such as outdoor conditions. **ZeroEnergy®** technology exceeds most other heat exchanger designs for hot water production while still maintaining a very low friction related refrigerant pressure loss. Based on an ARI performance test at standard conditions with an R-22 system, the heat recovery rate for **ZeroEnergy®** varied between 53% and 100% of available superheat on a 5 ton system. With a 60,000 BTU cooling capacity, this yields between 1,785 and 3,369 BTU per hour per ton of system capacity (calculated: between 53% and 100% of (132.7 – 113.0) Δh superheat X 171 pounds per hour per ton).

Is there financing available for ZeroEnergy® installation? Many dealers have financing programs available and there are some “green energy” financing programs that are emerging. Check with your local dealer and with your bank. Typically, the payments on any loan will be less than the average savings experienced from **ZeroEnergy®**.

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