Zero Energy Buildings and the role of Gas Absorption Heat Pumps

Stone Mountain Technologies Inc., October 2015

Zero Energy Buildings need to minimize the amount of source energy used by systems and appliances to minimize the amount of renewable energy production needed to offset onsite use. Gas Absorption Heat Pumps (GAHP), with heating COPs of 1.4 or higher, can offer significant contributions towards achieving the goals of Zero Energy Buildings, especially in heating dominated climate zones or buildings with high domestic hot water needs, by significantly reducing the amount of on-site renewable energy generation required, as well as the total capital cost. Thirty-four percent of the useful heat delivered by a GAHP is energy harvested from ambient air (renewable). Based on an installed GAHP cost of $0.30 per watt, the renewable portion of the delivered energy is provided at $0.85 per watt, three times less than the installed cost of incentivized solar PV, while requiring 52 times less installed surface area per watt.

Introduction:

Zero Energy Buildings combine energy efficiency (in construction, systems and appliances, operation and maintenance, and change in user behavior) with renewable energy production to use less than or an equal amount of source energy that is produced onsite annually [1]. Increased energy efficiency in each of the four areas will decrease the renewable energy production requirements needed to offset use and to be a Zero Energy Building. Within those four, a main area of focus is systems and appliances because they are primary users of energy in buildings.

In northern climate zones (Fig. 1), the energy intensity required for heating is high, while solar intensity is low, making it difficult and expensive to offset source energy used for heating with onsite renewable production. Water heating is also very energy intensive in certain commercial applications such as lodging and food service.

Gas absorption heat pumps can significantly reduce energy requirements for space and water heating. They are able to do this by achieving higher source energy coefficients of performance (COP) than other heating systems. The gas absorption heat pump is a thermally driven heat pump that combines high temperature heat from the combustion of natural gas with low temperature heat from the ambient to provide medium temperature heat that can be used for space and water heating.

Implementation of GAHPs for space and water heating will result in a 32% decrease in energy use when compared to high efficiency furnaces, boilers and water heaters. GAHPs will reduce the source energy used for all buildings, and contribute significantly to achieving zero energy buildings.

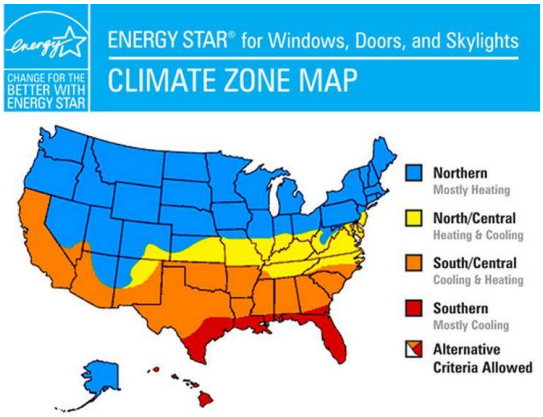

Figure 1: Climate Zone Map

Discussion of Technology:

Stone Mountain Technologies has developed a suite of Gas Absorption Heat Pump (GAHP) products for space and water heating. These systems will greatly reduce energy use and required renewable energy production for space and water heating in Zero Energy Buildings. From a source energy use standpoint the residential and commercial building sectors would benefit significantly from the use of GAHPs for space and water heating.

For example, a home or small business with a 40,000 BTU/hr design load in a cold climate will require approximately 85,000 kBTU annually for space heating. Figure 2 shows that a GAHP will use 30% less primary energy than a condensing furnace or boiler and 35% less than an electric heat pump. The electric heat pump (EHP) uses more primary energy than the other options because its Coefficient of Performance (COP) is significantly reduced at cold ambient temperatures. The GAHP is able to maintain performance at cold ambient temperatures because the ambient is not the only source of heat used by the system.

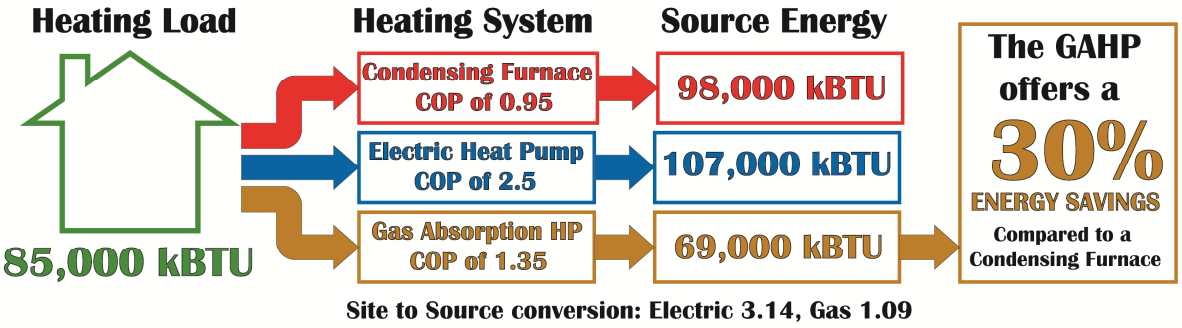

Figure 2: Annual primary energy use comparison for space heating in cold climate

For a second example, water heating for a restaurant is considered. Annual water heating requirements are 729,000 kBTU assuming 3,000 gallons of daily hot water use and a 80°F temperature rise. Figure 3 shows that a GAHP will use 34% less primary energy than a condensing water heater and 28% less than an EHP. GAHP and EHP systems benefit from year round operation and higher ambient temperatures in the spring and summer, which results in higher annual average COPs.

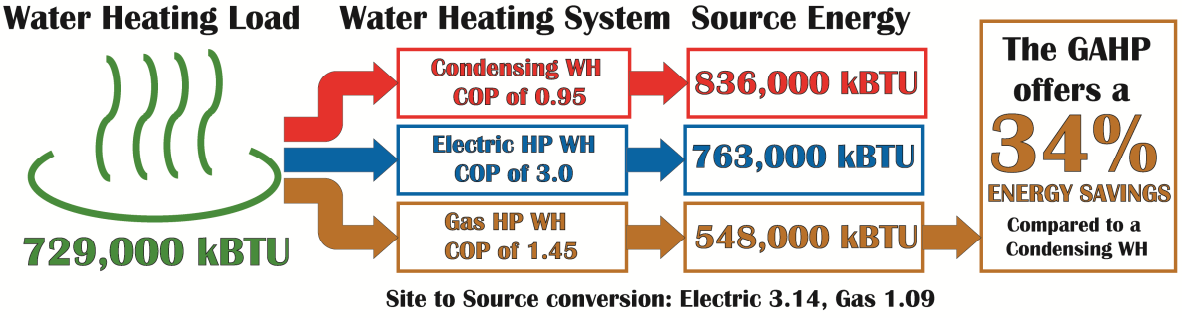

Figure 3: Annual primary energy use comparison for water heating in a restaurant

Cost Comparison:

Total cost of the systems installed to be a Net Zero Building will be considered when evaluating the different options and technologies. Implementation of a GAHP would require less onsite renewable energy production systems when compared to installation of a condensing furnace or boiler. In addition, the renewable energy (heat from the ambient) provided by the GAHP can be done so at a price that is competitive with current renewable energy technologies. Current pricing for PV system installation is roughly $3.89 per watt [2] before government incentives. With incentives it is expected to be around $2.50 per watt. The incentivized cost per square foot of these systems is roughly $32 where the energy density is 12.13 watts per ft^2. It should be noted that costs vary based on system size and solar panels selected and government incentives. Installing a GAHP heating system could be done at a total cost of $0.30 per watt. As 34% of the heat delivered by a GAHP is renewable energy harvested from the ambient, the cost of the renewable energy provided is $0.85 per watt which is roughly three times less than the cost of incentivized solar (Fig. 4). The cost per ft^2 of a GAHP is $518 where the energy density is 1,860 watts per ft^2 and the renewable energy density is 633 watts per ft^2. Based on these numbers the GAHP offers 52 times more watts per ft^2 renewable energy when compared to PV.

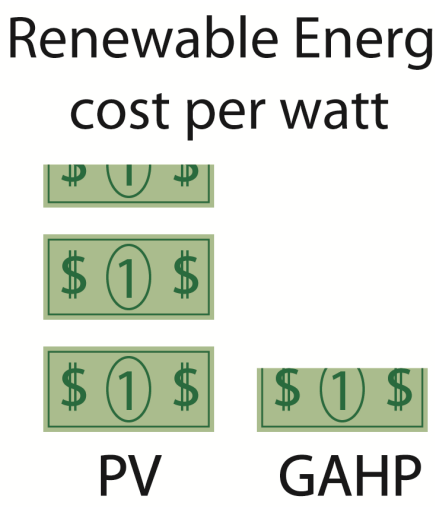

Figure 4: Cost comparison

Conclusions:

Zero Energy Buildings require high efficiency systems and appliances to minimize source energy use and the required offsetting renewable energy production. Space heating and water heating are major users of commercial energy (combined total of 34% of total energy use) [3] and residential energy (>50% of total energy use) [4]. The gas absorption heat pumps being developed by Stone Mountain Technologies are a major advancement for gas fired space and water heaters. They allow for at a 32% reduction in energy use compared to high efficiency condensing gas systems. For Zero Energy Buildings, implementation of these systems in residential and commercial buildings will reduce that amount of onsite renewable energy production required, and greatly improve the building owners and fabricators ability to achieve Zero Energy Building requirements. Finally, the cost per watt of the GAHP systems were shown to be advantageous when compared to current renewable energy systems.

References:

[1] http://energy.gov/eere/buildings/zero-energy-buildings
[2] NREL, Photovoltaic System Pricing Trends: Historic, Recent and Near Term Projections, 2014
[3] http://www.eia.gov/consumption/commercial/
[4] http://www.eia.gov/consumption/residential/