



Master Yoda – the E⁵ Jedi

“Take only the fuel we need” and “use all that we take” are important principles, but matching up source temperatures with load temperatures is the ultimate goal. BY ROBERT BEAN

Bear with me while I take you on a journey to a Galaxy far, far away...where there are five words that every Jedi involved in intergalactic HVAC calls must know, at least on some rudimentary level. We will call them E factor 5 - or E⁵; those being efficiency, entropy, efficacy, energy and exergy...yes E-X-E-R-G-Y. It is not a spelling mistake and you need to appreciate its significance if you want to be a true Jedi HVAC technician.

Yoda, a Jedi master, was a master of E⁵. He saw a force in everything - either in action (kinetic energy) or waiting to be activated (potential energy). He sensed kinetic energy in sound, light, motion, electrical currents and heat and when advising Luke on his lame efforts to try, he says: “No. Try not. Do or do not.”

He is telling Luke to release the force into action – to use kinetic energy. The energy in the force is stored in such things as chemicals, gravity, nuclear and mechanical systems, which have within them all the potential to “do.” Yoda saw this kinetic and potential energy in people. He saw it for what it was, a fixed resource, which was neither created nor destroyed – always conserved and always accessible.

Like many processes in the universe, when energy converts from one form to another unrecoverable energy is released, this is measured or described by the word entropy. Entropy expresses the quantity of heat served in beverages from the Chalmun's Cantina on the planet Tatooine, cool-

ing and evaporating into thin air. Indeed, if entropy were an emotion it would follow along the lines of Led Zeppelin, dazed, confused and wasted. Like all master Jedi, Yoda didn't like to see things wasted. He very much believed in take what you need but use what you take – this is the basis for his philosophy on energy efficiency. For him what goes in also comes out but nothing is wasted or destroyed in the process.

In this, the Jedi were also taught to see energy in highly concentrated forms, such as in the light sabers or as an invisible force field to protect their jets during dogfights. The ability for energy to evenly surround the jet was known as its efficacy. Thus the first four words - energy, efficacy, entropy and efficiency are well known to the Jedi and understood by most others but “e-x-e-r-g-y” is the force of energy that is more important than all others. Exergy is wasted by bullies like Darth Vader who had immense power and rather than use an appropriate dose he would unleash tremendous kinetic energy on the least of his enemies in a manner akin to hitting a finishing nail with a 25-lb. sledgehammer – he had a bad attitude and bad exergy efficiency.

Here on earth we take the potential energy in gas, oil, coal or wood; chemical forms of energy and release its fullest thermal potential through the combustion process to create heat energy. In the case of space heating, the heat energy is divided up, some is released into the home to

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condition the occupants and then subsequently flows outside as heat loss. In the case of a condensing boiler or furnace, some is captured but unused in the condensate and some is released out through the venting. When this heat is distributed evenly throughout the house for comfort (like the invisible force field around the Jedi jets) we say it has good efficacy. Low intensity radiant floor cooling and heating like the force field has good efficacy, a high intensity fireplace like the light saber has bad efficacy.

In all cases the heat dissipates back into the environment as entropy but the energy first released as heat from the fuel is never destroyed. It just went from a potential form to a kinetic form – this is the First Law of Thermodynamics. When most, if not all of the heat from a unit of energy, travels through the home for comfort conditioning rather than out the venting, or down the drain, we say it is energy efficient. We are taking only the fuel we need and using all that we take (or as much as technology allows).

There is one thing however, that is not conserved - rather it is destroyed and unrecoverable - this loss is a loss of exergy. Exergy asks: Why are we taking the potential energy in a nonrenewable energy source and converting it into a high quality temperature of say 1,500C (2,800F) for heating, or using coal fired plants to generate electricity to run a compressor for around -5C (23F) for cooling when all we need in high performance homes conditioned with radiant is low quality fluid temperatures in the range of 15.5C (60F) for cooling and 32C (90F) for heating?

Using high quality temperatures for space conditioning is bad exergy efficiency in the same way that Darth Vader has bad exergy efficiency. When we can heat and cool our buildings without using combustion or compression by tapping into renewable energy sources in the earth, sun, wind and water, we have good exergy efficiency because the exergy in these earth elements is significantly closer to what we need to keep us comfortable.

Fortunately, exergy efficiency does exist at higher quality temperatures when used in cogeneration coupled to district heating systems, for example. Combustion temperatures of 1,500C (2,800F) can turn water into steam to drive a turbine for electrical power generation resulting in high quality condensate that could be cascaded down in temperature using other heat exchangers for other processes.

It does this until the temperature is low enough to be used for space heating – this as well, would be good exergy efficiency. Exergy efficiency is all about matching up source temperatures with load temperatures and the closer the two are the better the exergy efficiency.

So why is this important to the universe? When we convert energy from one form to another we release entropy and in the process destroy exergy. The energy is always conserved but the exergy is lost. For this reason we should only use the fixed supply of nonrenewable energy for high quality applications so the exergy is not destroyed and use low quality energy for low temperature applications so the exergy is always optimized.

The magnitude of this challenge is demonstrated by observing plumes of heat coming out of hundreds of thousands of homes during Canadian winters. Society ignorantly sees this as entropy and efficiency (or lack thereof) but the real waste is the loss of exergy. Can you image how beneficial it would be to capture all that exergy which is currently destroyed in every home?

If you can see this, then you realize why consolidating thousands upon thousands of exergy inefficient systems into single community-based combined power, heating and cooling plants is essential for sustainability. This is especially true when these plants incorporate renewable energy with nonrenewable energy. Not only do these poly-generation plants extend the availability of nonrenewables for future generations, they provide energy and exergy efficiencies beyond what we currently obtain from traditional systems. Exergy is not a word from: “A long time ago in a galaxy far, far away...” it is a here and now word and must be integrated into today’s energy analysis.

May you and yours have good exergy efficiency in 2011. <>



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