# Efficiency the solution to our energy woes

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Water is the most abundant compound on Earth's surface. It is fascinating and amazing stuff. Few people realize how astounding it really is. Its abundance exists because of Earth's serendipitous location at just the right distance from the sun to accommodate H2O in its liquid state: a little bit closer to the sun, like Venus, and most water is in the vapor state while a little bit farther away, like Mars, and it's all frozen. Such placement allows our numerous and diverse life forms to exist.

Water has other fascinating properties. Its molecular chemistry is a bit odd.

Because like charges repel while unlike charges attract, we would expect that the two positive hydrogen atoms to be on the exact opposite sides of the negative oxygen atom, separated by a 180º angle.

But that's not the way water works. The hydrogen atoms are separated by a 104.5º angle making water a polarized molecule: slightly positive on one side and slightly negative on the other.

This, in turn, allows the positive side of one water molecule to snuggle up with the negative side of another to form a hydrogen bond. One familiar result of this polarization is that things get wet!

Water is attracted to any static electrical charge, positive or negative. Charged surfaces get wet. Uncharged materials, like Teflon, can be dried simply by shaking any water droplets out.

Another, weaker, type of molecular bond, the van der Waals bond, helps to hold the molecule tighter against its neighbors.

Water also has a high heat capacity. It absorbs lots of heat energy before it warms. Would you rather hold 10 grams of water that had been held over a candle for five seconds or 10 grams of steel? It takes one calorie of heat to raise the temperature of one gram of water one degree Celsius. Steel has a lower heat capacity and warms much faster.

Ice differs from water in that it only takes half of a calorie to raise its temperature one degree. With each degree of rising temperature, the ice molecules vibrate a little faster until, at melting temperature they are vibrating fast enough to begin breaking the van der Waals bonds and start to change solid ice into liquid water.

This doesn't happen all at once. In fact, ice will stay at the freezing temperature until it absorbs enough energy to break nearly all of the van der Waals bonds.

It takes an extra 80 calories per gram to break these bonds and melt ice completely. That's why snowballs don't melt immediately when brought indoors and why an ice cube doesn't melt immediately when plunked into a martini. Subsequent heat input elevates the liquid temperature but if the temperature remains constant, Earth's atmospheric pressure is low enough so that liquid water evaporates.

Water continues absorbing energy to the point where it vibrates so fast that the hydrogen bonds and any remaining van der Waals bonds are broken, liberating individual water molecules to be absorbed into the air as water vapor. Incredibly, each gram of water must absorb an additional 580 calories before it evaporates at room temperature (20º C).

At boiling temperature (100º C), only an additional 540 calories/gram are needed. These transitions of state, from solid to liquid and from liquid to vapor, are referred to as the latent heat of melting and the latent heat of vaporization, respectively.

During cooling, energy is released at these state transitions, which are referred to as the latent heat of condensation and latent heat of fusion or freezing.

Because water is so abundant in nature, these energy transfers through state transitions go on all of the time. We give it a special name: weather. Basically, weather is the transfer of heat through the medium of water vapor carried on the winds. General weather patterns are referred to as climate. The Industrial Revolution was based on the realization that tremendous amounts of energy could be stored in steam if water were heated in boilers fed by coal.

Some of that energy could be expended by using pressurized steam to drive pistons or spin turbines to make electricity.

Under pressure, steam and its abundant energy can be forced through pipes and delivered to radiators for space heating. What is done with that steam on this campus is the real topic of this essay.

Myers Dining Hall, Coltrane, McLarty-Goodson, Beam Administration, and Moore Science are heated with hot water that is heated by steam from the central steam plant.

Steam is pumped through underground pipes at high temperature and low pressure (83 kiloNewtons/square meter (12 lbs/in2), with about 40% heat loss to the environment through leaks and inadequate insulation. The steam then enters a heat exchanger where it warms water to about 65º C. The heated water is then pumped to the radiators where it heats the air to a temperature set by the thermostat (20º C).

The steam condensate is then recycled back to the boiler systems and heated again for another round.

In its endeavor to do away with the central steam plant and decentralize steam heating, the College is not only abandoning a crumbling infrastructure but it is creating a huge savings in energy costs and reducing our carbon footprint by becoming more efficient in the way it uses energy for space heating.

The new "boilers" in the buildings will not really boil water because they don't need to create steam. This will save the large amounts of energy required to overcome the latent heat of vaporization.

Instead, water can just be heated to 65º C and pumped through the buildings to the radiators. There will be no further need for steam! We will have entered the latter third of the 20th Century!

To move us into the 21st Century, the next step will be to heat water used in our buildings directly from the sun and use the new water heaters for back-up when temperatures are cold or the sun isn't shining.

Through grants from the Katherine Preyer Foundation and the Student Government Association, the College has $10,000 in starter money. Institutional Advancement is currently pursuing grants to raise the rest of the money needed for our first foray into the Solar Era. Our little college is getting smarter and moving into a greener future.