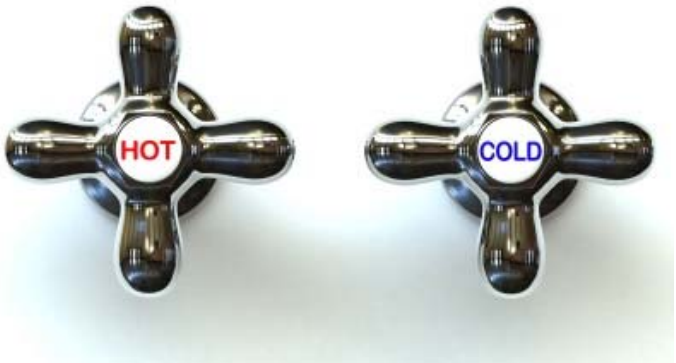
Basic Thermodynamics and Large Building Heating and Cooling

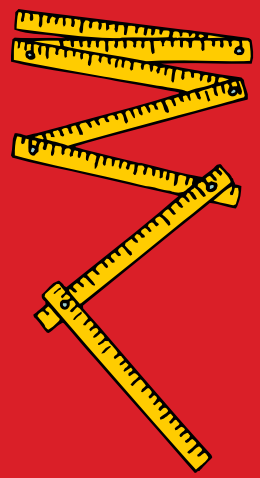
What is Thermodynamics?

- It's the study of energy conversion using heat and other forms of energy based on temperature, volume, and pressure.
- Its all around you, everyday things such as your car's engine, air conditioning, and heating. All work off of the basic ideas and laws of thermodynamics.



Measuring Heat, Pressure, & Work

Heating and Cooling things have their own units of measure.



- **BTU – British Thermal Unit,** unit of heat equal to the amount of heat required to raise one pound of water one degree Fahrenheit at one atmosphere pressure.
- **PSI – Pound per Square Inch,** a unit of pressure
- **Foot Pound –** a unit of work equal to the work done by a force of one pound acting through a distance of one foot in the direction of the force

Back to the Basics: Phase Changes

When Heating

- Distance between molecules expand
- Energy in the form of Heat is added
- Air can loose its moisture content
- Volume increases

When Cooling

- Distance between molecules contract
- Volume decreases
- Loss of kinetic energy on molecular level
- Gains density

Laws & Enthalpy

Don't worry, these are more like basic "rules"

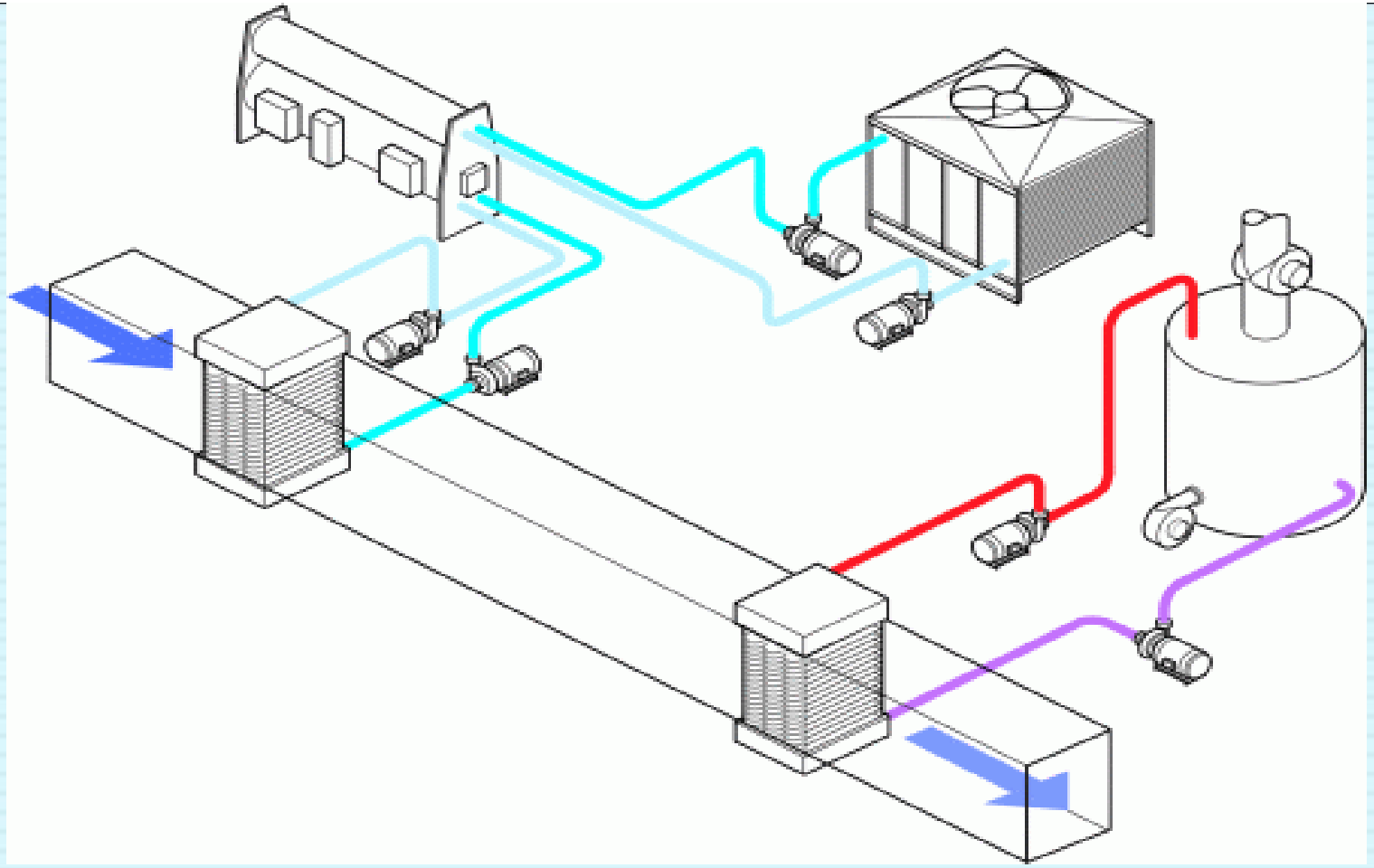
Enthalpy?

- **First Law-** Energy can be transformed from one form to another, but can not be created or destroyed.
- **Second Law-** While quantity of energy remains the same the quality of matter/energy deteriorates gradually over time.
- **Third Law-** As your thermo system approaches absolute zero, all energy processes stop.

- **Enthalpy-** Simply the measure of energy in your thermo system.

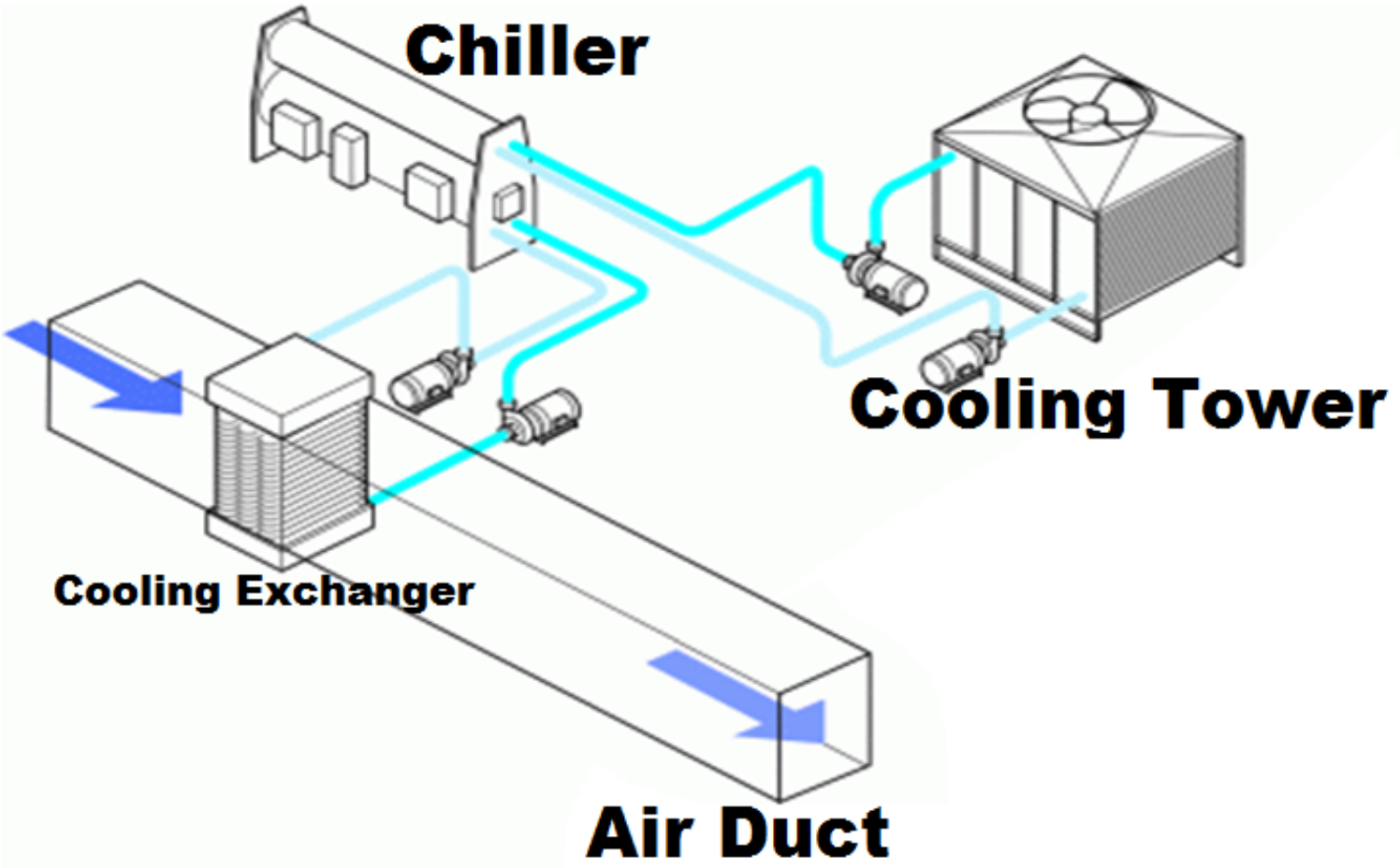
The Heating and Cooling of Major buildings

With the basics of Thermodynamics, we can now move to how these properties are applied in large building HVAC systems.



The BIG picture!

In the figure above, both the basic heating and cooling systems are laid out to describe their course through various components in a large building Heating and Cooling system (HVAC)

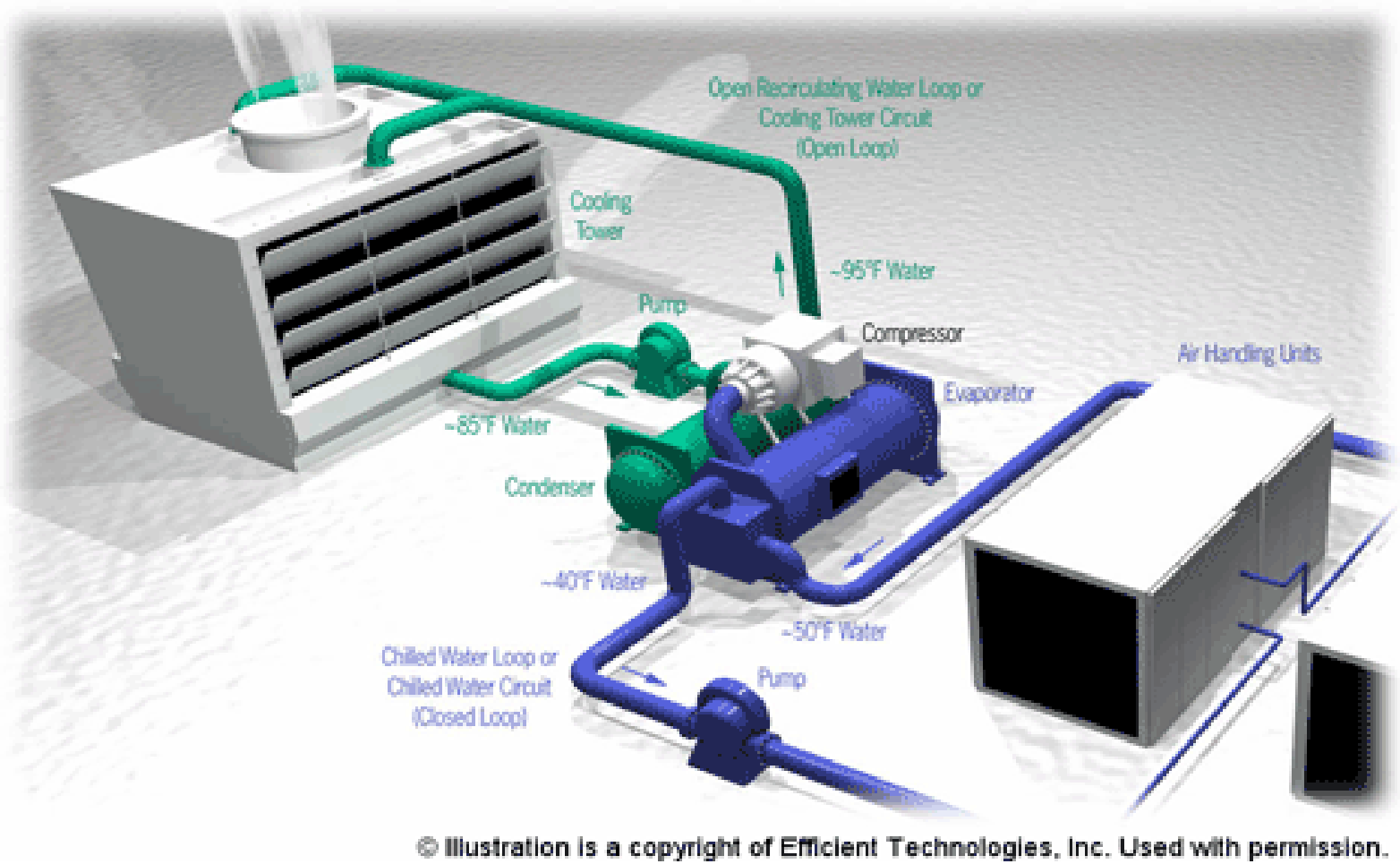


The Cool Side

This system uses water (from cooling tower) to cool a refrigerant that is vaporized in a special machine called a Chiller, which produces chilled water. The chilled water is then pumped to a cooling exchanger placed in the air duct where air can pass through and drop is temperature. The water and refrigerant never mix.

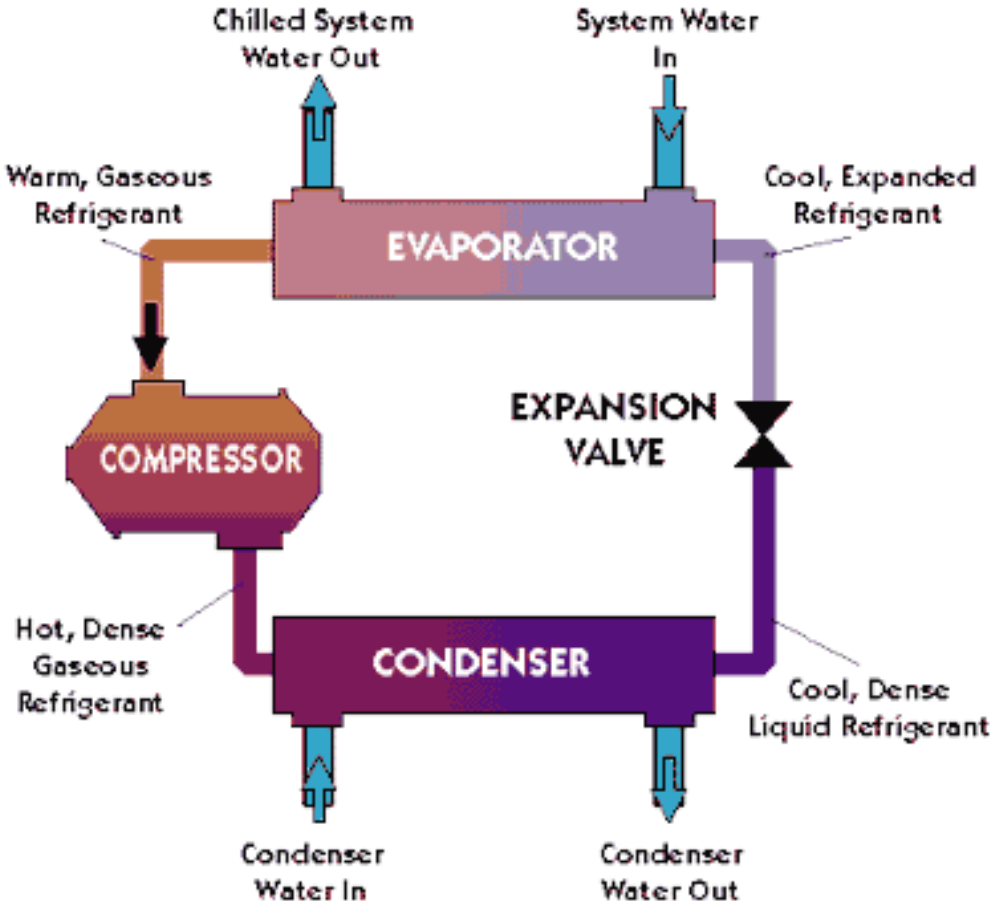
Component in Detail: Cooling Tower

The cooling tower is one of the larger pieces to the air conditioning puzzle. These large units are placed on the outside of buildings and use outside air to cool water trickling down special cooling fins on the inside of the machine. You are used to seeing these units on the tops of large buildings.



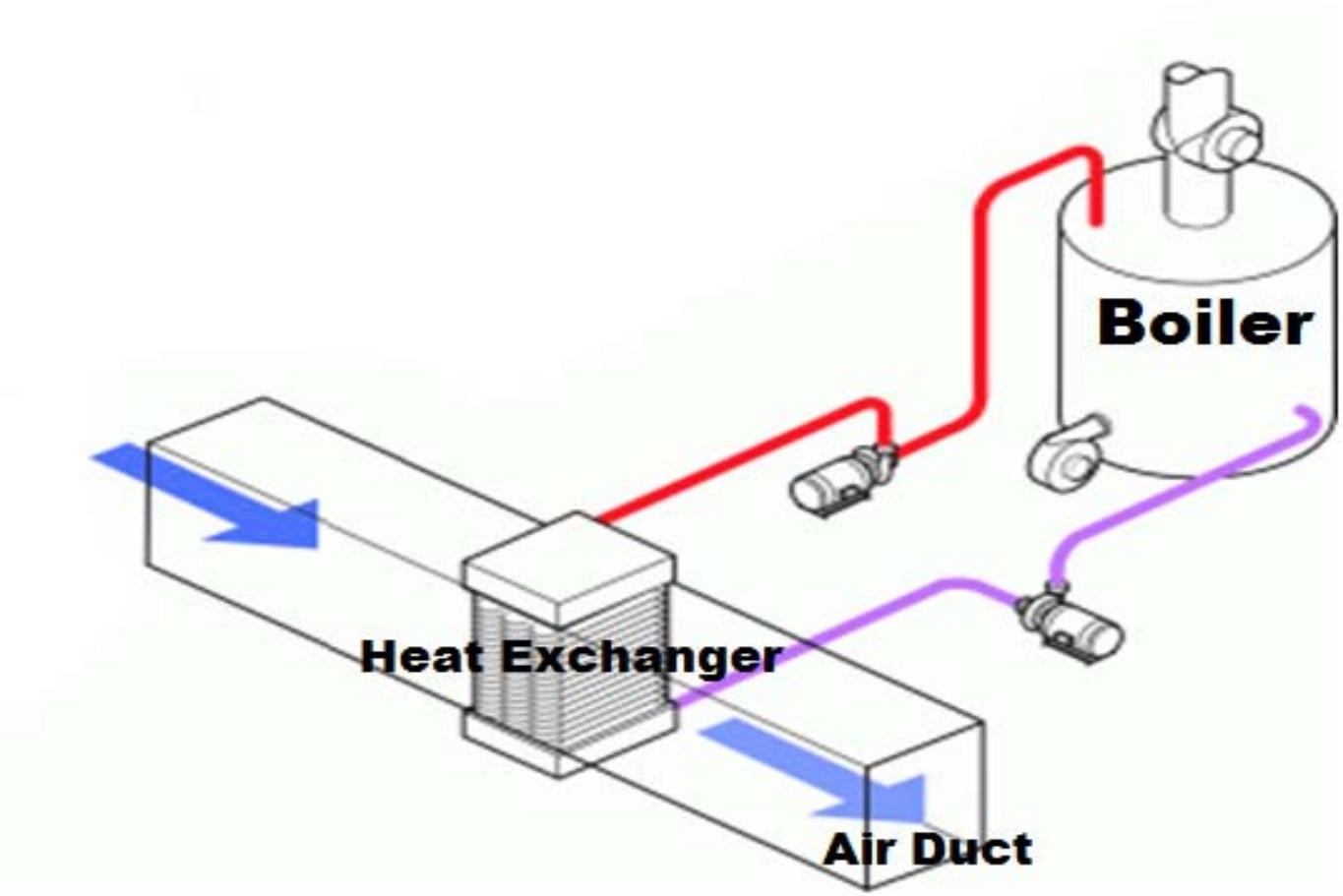
Component in Detail: Chiller

Located between the air duct and the cooling tower, the Chiller is where the real action happens. Refrigerant is vaporized and compressed via the refrigeration cycle to provide a cold source of water to the air duct.



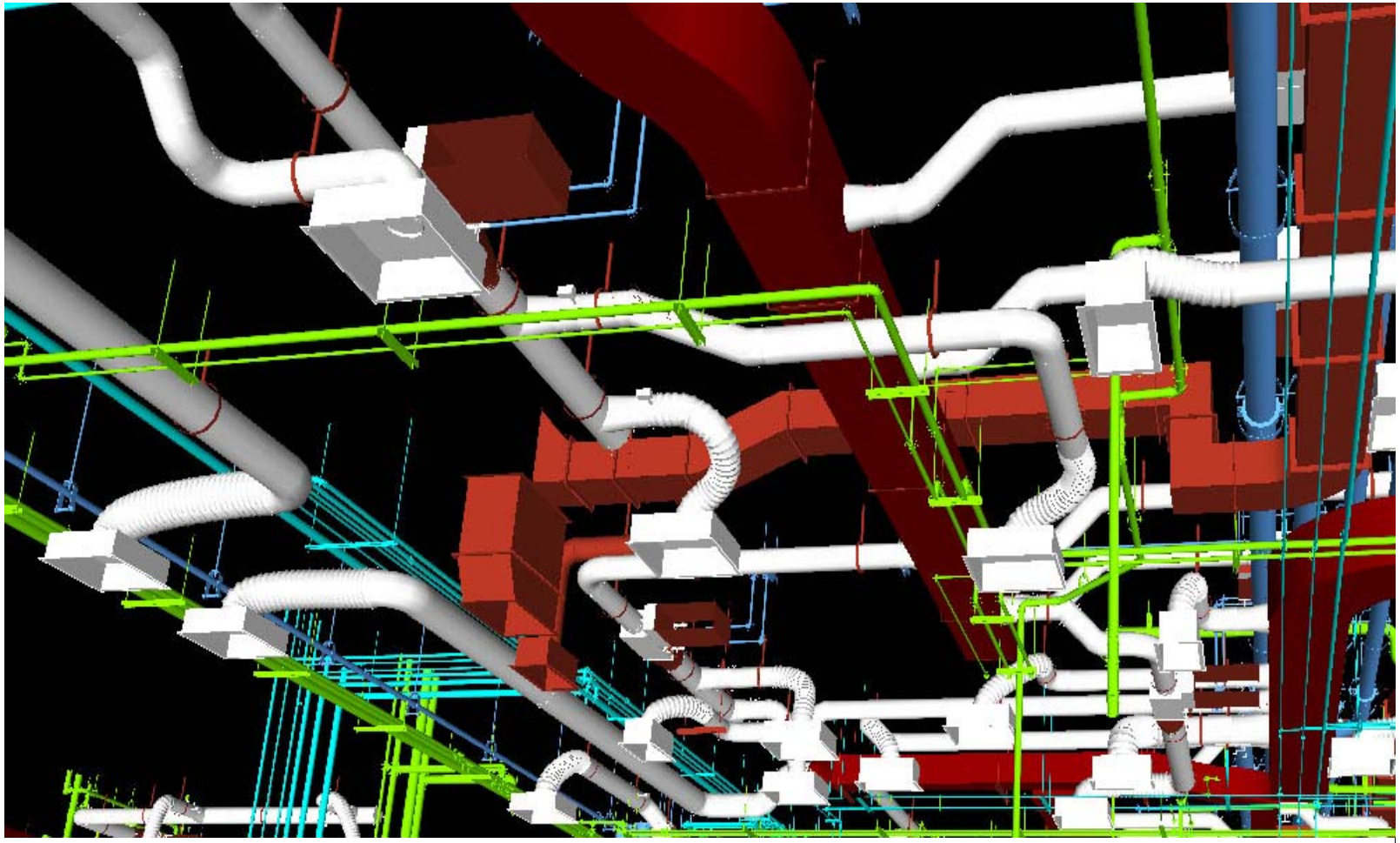
Further Detail: Refrigeration Cycle

This cycle works in a counterclockwise fashion, the chiller's refrigerant is in a closed loop getting expanded and compressed to raise and lower its temperature. As its compressed, the temperature increases and requires cool water from the cooling tower to contract its molecules for the expansion valve. The expansion valve then provides the state change to turn the refrigerant to a cool gaseous for heat exchange in the evaporator.



The Hot Side

- To heat a space, the system is considerably simpler. A heat source (in this case a water boiler) is used to create steam or heated water. This water is then pumped to the heat exchanger coil placed inside the duct where air can pass through and collect heat.



Right Above You

Air Conditioning and Heating Systems are right above you in every building working hard to make your indoor environment comfortable. The power required by these systems are a large portion of VCU's energy costs.

This Affects ...*YOU!*

ME?

- Buildings are kept at very specific temperatures depending on the season, these set points ensure that no excess energy is wasted on over heating or over cooling buildings
- These set temperatures are the best fit for the buildings occupants to ensure a comfortable working environment. These temperatures are also set to meet ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) and Commonwealth of Virginia Standards.