Global Warming and the Carnot Cycle

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The Engine: Heat Flow -> Work

Technically speaking 'work' is a force applied over a distance. The engine in a car does work as it pushes a car against friction, gravity, and/or accelerates the car over some distance. An engine that turns the shaft of a generator does work as it moves the amateur shaft some distance through a magnetic field. Muscles do work as a person walks.

By far the most common way to initiate work is the conversion of heat flow. Heat flow to work converters include internal combustion engines used in cars, steam turbines used in power plants, and food to energy conversion in living beings.

For heat to flow there must be a temperature differences. It is not enough to create a high temperature source. One must also find a low temperature sink or heat will not flow. This is why nuclear power plants have cooling towers or dump hot water into rivers. Though the nuclear reaction is very efficient at creating hot steam, for the steam turbine to transform this heat energy into work, the other side of the turbine must be cold. A car engine will take more fuel to push a car up hill when it is 45°C outside than when it is zero outside, all other variables not being considered.

Carnot's equation gives the work produced by a lossless heat converter, where heat flows from a high temperature, Th, to a low temperature Tc:

$$W = \mathrm{Qh}\left(1 - \frac{\mathrm{Tc}}{\mathrm{Th}}\right)$$

Let us consider the incremental energy increase if we made the heat source one degree hotter. I take the first finite difference with Th increased by a single degree minus the original equation:

$$\frac{\mathrm{Qh\,Tc}}{\mathrm{Th}^2 + \mathrm{Th}}$$

Now consider the incremental gain by making Tc a single degree lower:

$$\frac{\mathrm{Qh}}{\mathrm{Th}}$$

This is a much larger value, to a first order multiplied by Th/Tc. If we consider going from a gasoline flame to the atmosphere, this can be over a factor 3 times more work done by lowering the temperature by one degree rather than having raised it by one degree. This has a profound implication for global

warming as Tc goes up for all engines on the planet. Not only will engines consume more fuel, but they will also have to move more heat to do the same work, and that heat ends up in the environment.

Heat Equilibrium and the Earth

Heat Sources

The earth generates heat from its core due to the natural radioactivity of the planet. In addition heat energy is absorbed from the sun. Accumulation of solar energy shows up on the planet again in modern times due to the burning of fuel. In addition we now artificially produce heat in nuclear power reactors.

Heat Sinks

The earth radiates heat into space largely through infrared radiation.

Equilibrium

When the heat radiated is the same as the heat gained from sources, the temperature on the planet remains constant. Of course if the heat radiated is less than that gained, the temperature goes up. Over the history of the earth this equilibrium has waxed and waned due to natural parameters. It is largely believed today that the temperature is rising due to artificial parameters.

There are two artificial parameters or primary concerned, not just one, 1) heat generated at the tail end of the flow in heat engines, 2) the reduction in heat radiated due to greenhouses gas blanketing. The reason greenhouse gases blanket the earth is that they permit the entry of visible light but reflect infrared. The radiation heat generated by the earth is directly affected by greenhouse gases. The infrared blocked from entering the earth from the sun due to the presence of greenhouse gases represents less heat than that which can not escape due to the conversion of visible light energy to infrared energy by life processes and burning fuel. I.e. visible light is converted to chemical energy by plants, and then processes of using that energy produce infrared, and a smaller portion of that infrared escapes the planet now that in times past due to the presence of more greenhouse gas.

Of further consideration is the distribution of heat with distance from the center of the earth. In consideration of this distribution, it is the surface temperature we usually place the most emphasis on.

What Is Global Warming Clean Energy?

It is largely said that nuclear power is a green energy source because it does not produce greenhouse gases. However, nuclear power does generate lots of heat. This heat is unique in that it has no solar origin, i.e. it is not representative of heat that was absorbed in the past. Nuclear energy is clean only to the extent that the heat energy produced does not significantly add to the heat radiating burden of the planet.

Hydrocarbon reactors produce a great deal of heat and greenhouse gases. Both cause global warming.

Passive, thermal, and photo voltaic solar energy does create work from heat flow, however, to the extent that the panel is equally reflective as the surface that would otherwise have been present, this heat flow would have already existed, i.e. it is counted among the natural parameters. In an aesthetic

sense, natural flow is more attractive than artificial flow and would appear to have more rightful claim to its existence; however from a scientific point of view, heat is heat. Putting up a solar panel in place of a heat mirror represents a lost opportunity to rid the planet of a heat input.

Geothermal heat flow engines displace heat from the planet's mantel to its surface. This heat energy now flows through less resistance to get to the surface than it had before, and this causes surface temperatures to rise. The process of moving heat to the surface is very direct, cold water is shot down, steam from the depths is brought to the surface along with heat and runs through a turbine, a portion becomes energy destined to later by released as heat, and the remainder goes through a cooling tower. As the used steam cools, the cooling tower and its surroundings warm. If the geothermal heat pump had not been there, the heat would have been insulated and radiated over a longer period of time. Hence the temperature distribution shifts to the surface. Geothermal engines are advantageous in that they do not generate greenhouse gases.

Contemplating Solutions

Controlling greenhouse gases can be done to a certain extent by shifting to nuclear power, solar, and geothermal. However, we still have to contend with natural sources of greenhouse gas associated with a large and possibly rising population of animals, the possibility of natural cyclic sources such as hydrates rising from the oceans, and the continued use of hydrocarbon fuels in many applications. The generated heat that would not have existed had man not run the engines must still be displaced.

It would appear that there are only three additional ways address global warming: 1) use less energy 2) find a way to absorb less heat from the sun 3) radiate more heat from the planet.

Technology has always given us more for less. For example soon LED light will reduce power consumption for lighting. LCD panels use less energy than CRTs, etc. However for each of these examples, there are counter examples. Television screens are now larger and more numerous. Power consuming devices are more accessible to more of the population than ever before. Population itself is rising. It would be very helpful from a greenhouse gas point of view if earth's population were to stop increasing as predicated, but it has yet to be observed. In my humble opinion, it is not clear of energy consumption will go up or down in the presence of a solution to global warming, but without one, baring a human catastrophe, it is almost certain to go up as heat engines become less efficient and more people use heat pumps (air conditioning) to stay comfortable.

For the second point, we could reduce the amount of energy that is absorbed by the earth either by shading the earth or changing its reflectivity. Putting shades in space or dust in the atmosphere seems like a bad idea as crops need sunlight. The reflectivity of the earth could be modified by making the surface lighter in color. Rooftops on cities and vehicles would be made reflective. A lighter colored grass could be planted in large fields. Perhaps a lighter colored algae could be genetically designed. Another method would be to create a substance that traps the heat, perhaps chemically, and then storing the substance in a manner the energy is not released, or removing the substance from earth. The solar or geothermal manufacture of rocket fuel would be a means of removing such a substance from the planet. Sequestering or increasing the size of the population of biological absorbers would be an example of storing a heart or greenhouse case absorbing material.

If hurricanes are heat pumps, perhaps it would be possible to place air foils on the earth in such a manner is to give the earth a spot, such as Jupiter. It would be a permanent hurricane with a low pressure center that radiates heat into space.