**Heat engines**

Fuel consuming work-producing devices are devices that use the chemical energy obtained through combustion oxidation reaction directly. This way of harvesting energy is more useful than its equivalent in the form of heat energy.



*The conversion of heat energy into useful work is limited by the constraints of the 2nd Law of Thermodynamics.*

Other forms of non-heat energy such as *electrical, chemical, high pressure* are more accessible to conversion into useful work – *Energy to heat conversion is not required.*

*2nd Law of Thermodynamics* states that heat flows naturally from regions of higher temperature to regions of lower temperature, but that it will not flow naturally the other way.

Heat can be made to flow from a colder region to a hotter region, which is exactly what happens in an air conditioner, but heat only does this when it is forced. On the other hand, heat flows from hot to cold spontaneously.

Fuel cell process





Pneumatic work process





Pneumatic work process

* Fuel cells – chemical energy converted into electrical energy
* Batteries – Stored electrical energy into electrical work
* High pressure energy of the compressed air converted into pneumatic work

http://frpc.net.technion.ac.il/files/2012/11/Picture21.png

http://www.mpoweruk.com/images/fuel\_cell.gif

http://energyeducation.ca/encyclopedia/Pneumatic\_Hydraulic\_energy

**Work production from heat energy through a heat engine is typically only a fraction of the energy input.**

To convert the potential chemical energy of the fuel into heat does represent in principle a loss of opportunity to optimize fuel usage for the production of work. For example, to burn the fuel and use the heat liberated by combustion to produce the steam employed in a heat engine by operation on the Rankine cycle, it is possible to convert only a fraction of the fuel energy into useful work.



**Work production through an internal combustion engine can convert the energy input more usefully into work.**