

E11: Autonomous Vehicles

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Harris & Lape with Keeter & Ong

Lecture 1: Energy

You will need energy to operate your vehicle.

1. FORMS OF ENERGY

Forms of energy include:

- Heat
- Electrical / Magnetic
- Mechanical (kinetic or potential)
- Chemical
- Nuclear

Some of these forms are useful for powering your robot.

1.1. ENERGY SOURCES

Energy sources include:

- Batteries
- Solar
- Fossil fuels
- Bio fuels
- Living organisms
- Wind
- Hydro (and other gravitational potential energy)
- Mechanical storage
- Geothermal
- Fission, fusion
- Capacitors
- Ocean: tidal and thermal

- Fuel cells

For example, one might burn coal, involving chemical energy converted to heat energy in a boiler converted to electrical energy with a generator.

1.2. ENERGY CONVERSION

To power a device, we need to get energy from a source and convert it into the necessary form. Figure 1 shows examples of these sources and conversions.

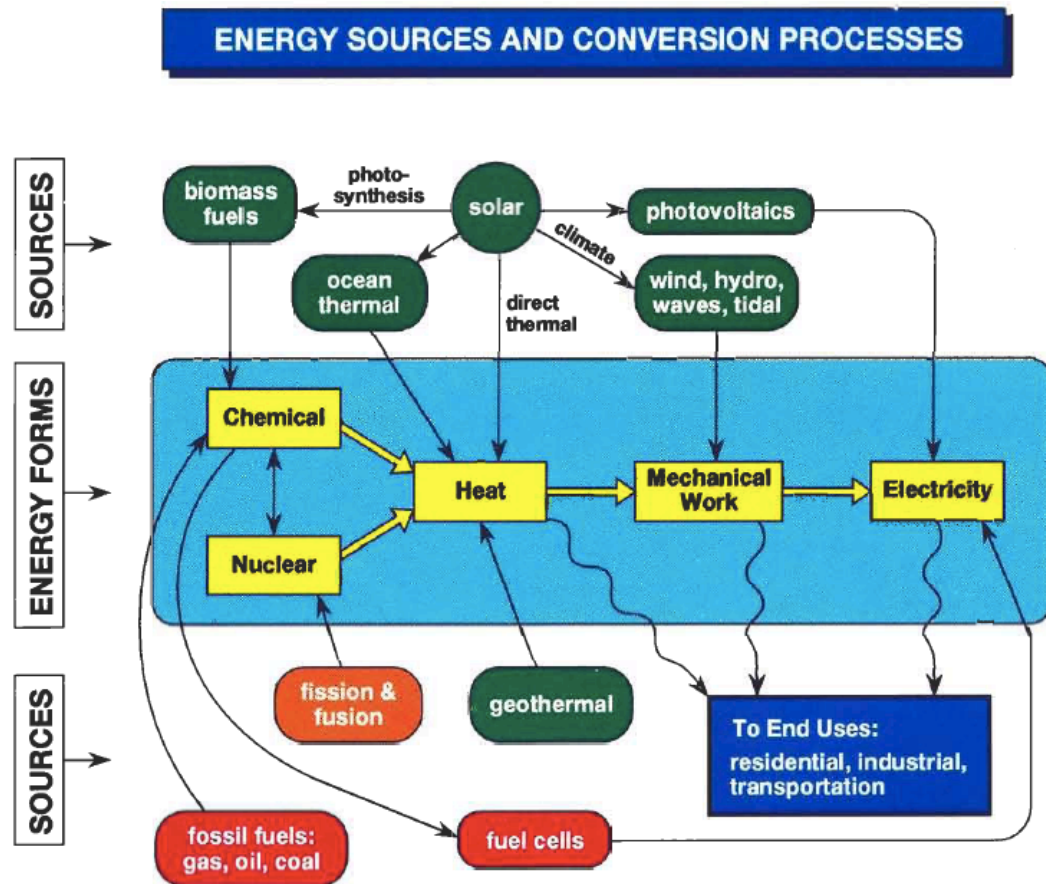


Figure 1 Energy sources and conversion

from MIT OpenCourseWare "Sustainable Energy" 2005 course notes

For example, fossil fuels usually are burned, converting from chemical to heat to mechanical to electrical. There are losses at each stage, reducing the efficiency. Fuel cells are interesting in that they convert chemical energy directly to electrical energy.

1.3. CHOICE OF SOURCES

Characteristics of good energy sources include

- high efficiency of conversion to the desired form of energy
- abundant

- easy to store
- constant power
- safe and easy to store, use, transport
- controllable
- high energy density
- high power density ($P = dE/dt$)
- low cost
- renewable / sustainable

Different sources are appropriate for different applications. For example, the appropriate sources for mobile applications are different than for power plants. For mobile applications, the energy density is a critical factor. Good sources for mobile applications include:

- Batteries
- Solar
- Mechanical (spring)
- Fossil fuels

At the right scales, mobile devices could be operated by living organisms (e.g riding a bicycle), wind (sailboats) or nuclear power (nuclear submarines).

Figure 2 is a Ragone plot showing the energy and power density of various energy sources. The upper right corner is the most desirable location, but is not practical. Gasoline is fairly good at both, explaining why it is used so widely. Supercapacitors and flywheels have excellent peak power, but not such good energy density. Different battery chemistries have different tradeoffs; lithium-ion batteries are presently some of the most attractive.

Ragone Plot for comparing storage technologies

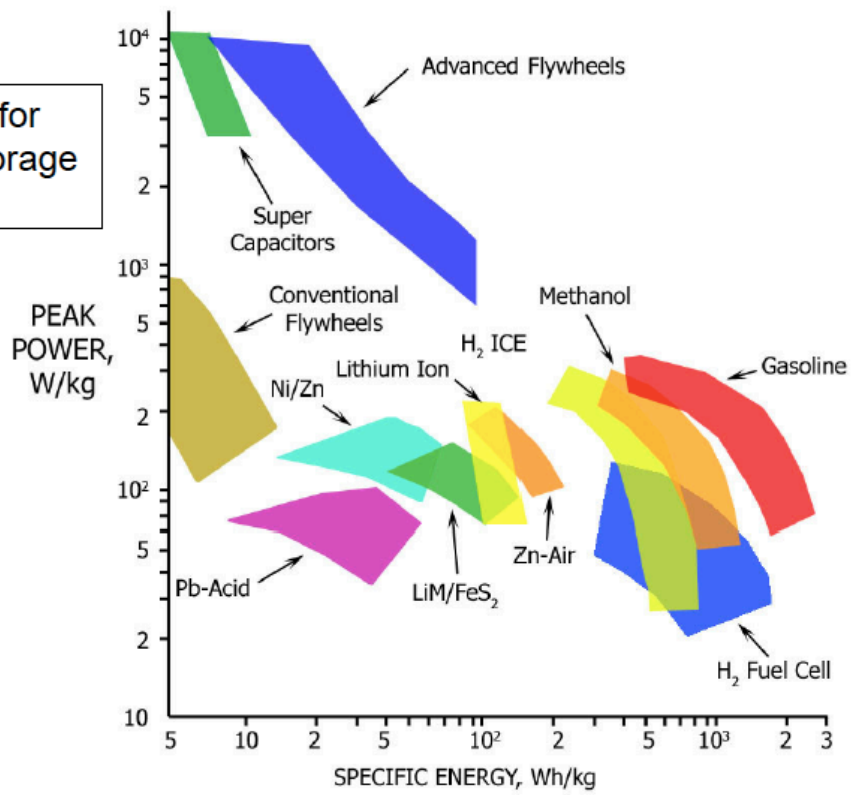


Figure 2 Energy sources and conversion

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