Chapter 22 - Lecture Notes

Alternative Fuels

Usually in the context of alternative for use of oil, especially in the transportation sector.

In the USA, in the utility sector, oil is little used to produce electricity.

Also in the USA, oil is not favored for residential space heating.

Rationale for seeking alternatives to oil:

- Security of oil resource
- Balance of trade
- Long-term availability
- Local pollution
- Global climate change

Alternative fuels: also in the context of alternatives for coal and nuclear-fuel for production of electricity

When we examined primary energy consumption for several countries, we saw oil as the most-used (or maybe second most-used) resource for all of the countries.

Approaches for reducing oil consumption

- Energy efficiency
- Energy conservation
- Alternative fuels -- which might be another fossil fuel

- Electnicification of vehicles
- Expanded mass transportation
- Government incentives -- fuel taxes, carbon tax, % of ULEVs and ZEVs.

ULEVs: ultra low emission vehicles

ZEVs: zero emission vehicles

Alternative fuels:

- Natural gas is regarded as alternative fuel for vehicles -- because it is not very widely used.

  Natural gas is being used more and more for electnicity generation, via the CCCT.

  CCCT: combined cycle combustion turbine

  Of all the fossil fuels, generally natural gas has the lowest emission of CO_2 ($\frac{kg}{s}$) per kW of work (power) or electnicity produced.

An additional advantage: natural gas can be burned in more thermodynamically efficient heat engines than coal, e.g. CCCT vs conventional steam cycle.

Natural gas as a vehicle fuel:

- It is a very good engine fuel. Can improve engine efficiency
- It is used significantly as a fleet vehicle fuel. Though there are concerns:
  - some claim it is more costly to run a fleet of vehicles on natural gas than on gasoline or diesel
  - some claim a power reduction, and a range reduction

- there have been problems with fueling stations

- Pollutant output from the engine is reduced:

Relative to Gasoline Engine:

CO ↓
Photochemically reactive HCs ↓
NOx ↓

However, ultimate emission depends on pollutant conversion in the catalyst
-- some catalysts may work better on gasoline exhaust than natural gas exhaust

Relative to Diesel Engine:

Soot (black smoke) ↓↓↓
NOx ↓
Noise ↓
Odor ↓

- Compressed natural gas (CNG) versus Liquified natural gas (LNG)

Propane (LPG)

- Issues similar to natural gas

Alcohol Fuels:

- <u>Methanol</u>: wood alcohol: CH_3OH
  - Toxic, breathing of vapors should be avoided.
  - Very good engine fuel -- fuel of choice for race engines because of its high latent heat of vaporization & high octane number.
  - Reduced emissions, compared to gasoline

- Can be produced from biomass: potentially <u>renewable</u>.
  Gasification to CO & H_2.
  Methanol formation over catalyst.

  Can be produced from coal.

  Most methanol available today is produced from natural gas -- thus, effectively methanol is a "fossil fuel."

- Blends:

  M100 - pure CH_3OH
  M85 - 85% CH_3OH, 15% gasoline

  Oxygenated gasoline:
  MTBE made from methanol, which is made from natural gas

<u>Ethanol</u>: grain alcohol: C_2H_5OH. Potentially <u>renewable</u>

- Non-toxic
- Very good engine fuel
- Blends: 100%, 85% with gasoline, oxygenated fuel.
- Produced from fermentation of biomass. However:
  - Energy cost of producing ethanol can be high, i.e.

<u>Energy Content of Ethanol</u>

Generally Fossil Energy { Energy Required to Raise and Harvest the Crop, and Convert it to Ethanol

ratio is low.

- Biomass converted to Ethanol by Fermentation. Cellulosic, fiberous biomass is difficult to convert to Ethanol. Research is conducted on this.

- Brazil decided in the 1970's to convert a significant fraction of its transportation system to C_2H_5OH. By 1985, 25% of automobiles in Brazil were running on ethanol. But now, with oil being relatively cheap, ethanol cannot compete cost-wise -- even in Brazil with abundant sugar cane feedstock and cheap labor.