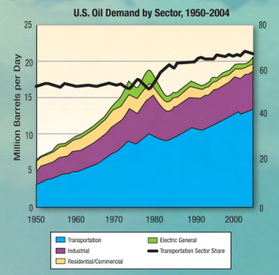
Argonne NATIONAL LABORATORY

Petroleum-free Roads

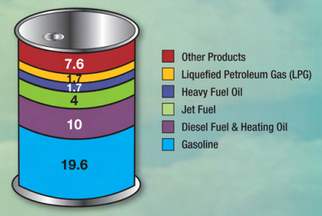
Reducing our dependency on petroleum by making gasoline, diesel, and ethanol from coal or biomass

Our Dependency on Petroleum

- **The U.S. is the world's largest consumer of petroleum**, 20.7 million barrels per day (MBPD).
  - 24% of worldwide consumption
  - 40% of our total energy usage
  - 67% is used as transportation fuel (we consume 383 million gallons of gasoline daily)
- **About 60% of our petroleum is imported**
  - Canada is our largest supplier (2 MBPD)
  - 50% comes from the Western Hemisphere
  - 19% comes from the Persian Gulf



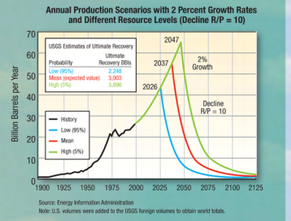
Petroleum Products



A barrel contains 42 gallons of oil that, when processed, yields about 44 gallons of petroleum products due to changes in density.

Oil Is Not a Limitless Resource

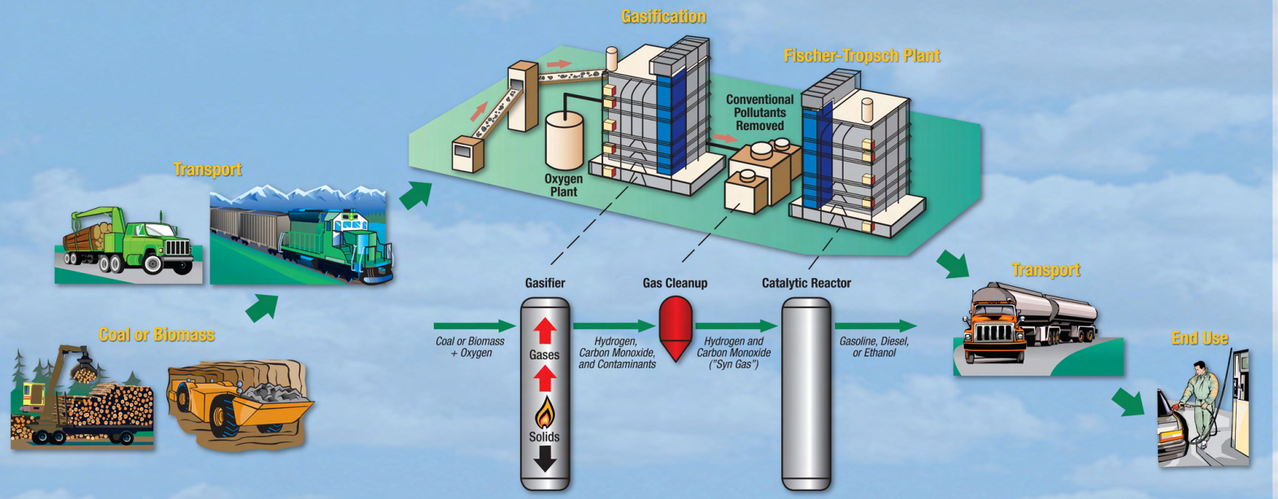
- Worldwide, proven oil reserves contain 1.3 trillion barrels of oil. U.S. reserves are 21 billion barrels.
- World demand for petroleum is 29 billion barrels a year (2.2% of proven reserves).
- Demand is projected to increase by 50% to 43 billion barrels a year by 2030.
- Since the mid-1980s, the demand for oil has exceeded the amount discovered.
- We are rapidly depleting reserves that can be easily recovered and processed ("cheap oil").



Argonne's Catalysis R&D

Argonne scientists are developing new catalysts for converting syn gas (a mixture of hydrogen and carbon monoxide) to liquid fuels such as gasoline, diesel or ethanol more efficiently. A catalyst is a chemical compound that modifies and increases the rate of a reaction without being consumed in the process. In a coal- or biomass-to-liquids process, the cost of producing syngas is a significant portion of the overall fuel production cost. Since the Fischer Tropsch catalyst is responsible for converting syn gas to the desired product, the better the catalyst is at producing the desired fuel, the less syn gas is required, and the less the fuel costs to produce.

How Does the Synthetic Gas Process Work?

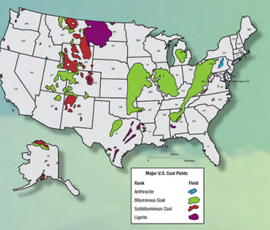


Coal or biomass is gasified by reacting it with Oxygen (O_2) at ~1000°C, producing a gas consisting mostly of carbon monoxide (CO) and hydrogen (H_2) with small amounts of contaminants such as nitrogen oxides (NO_x), Hydrogen sulfide (H_2S), hydrogen chloride (HCl) and other compounds.

CO and H_2 are reacted using a catalyst to produce liquid fuels such as gasoline and diesel. The reaction is referred to as the Fischer-Tropsch (F-T) reaction and the liquid fuels produced are referred to as "F-T liquids" or "syn fuels". By modifying the reaction conditions, ethanol can be produced.

Coal Is a More Abundant Resource

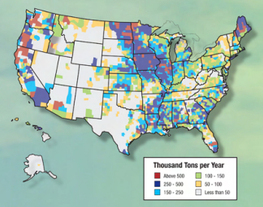
- There are 1 trillion tons of recoverable coal reserves worldwide.
- The U.S. has 270 billion tons of recoverable coal reserves, the most of any country in the world.
- U.S. coal reserves are equivalent to 540 billion barrels of oil (1 ton of coal equals about 2 barrels of oil).
- If we were to replace all of our petroleum-derived fuels with coal-derived fuels, U.S. coal consumption would increase from 1.1 to 4.8 billion tons of coal per year.



Biomass Is a Potential Renewable Resource for Producing Syn Gas

- Biomass can be derived from a variety of sources.
  - Crop and forest residues
  - Dedicated energy crops like switchgrass and willow and poplar trees
  - Pulp and paper mill residues
  - Methane from landfills, manure, and wastewater
  - Urban wood wastes
- An estimated 423 million tons of biomass is available annually in the U.S.
- Unlike coal, biomass does not contribute to greenhouse gas emissions; any released carbon dioxide is "recycled" into growing trees, plants, and grasses.

Biomass Resources Available in the United States



Illinois Is Well-suited for the Syn Gas Fuels Industry

- **Third largest** coal reserves in the U.S., 38 billions tons of recoverable coal.

  The energy content of Illinois coal reserves is greater than that of ***Saudi Arabia and Kuwait oil reserves combined!***
- **Second largest** biomass resource in the U.S., 28 million tons of biomass annually.
- **Abundant supply of water.** Western states with large coal reserves do not have the water resources to support a coal-to-liquid syn gas fuels industry.

Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

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