Fossil fuel

Gas station in Hiroshima, Japan. (Fg2, via Wikimedia Commons)

Introduction

Fossil fuel is any naturally occurring carbon compound found in the Earth's crust that has been produced by anaerobic conditions and high pressures acting on deadorganisms. These fossil fuel deposits are typically found at depths beneath the Earth surface or ocean floor of tens of meters to kilometers, and often occur in large agglomerations of gas, liquid or solid matter. Presently, combustion of fossil fuels account for over 86 percent of the world's artificial energy delivered to the human society. These fuels are considered non-renweable in that their natural creation time requires millions of years.

The extraction, processing and combustion of fossil fuels causes significant adverse environmental consequences to biodiversity, air quality and water quality, as well as substantial impacts to human health and mortality. These processes also generate large quantities of greenhouse gases delivered to the atmosphere.

Fossil fuels are utilized as feedstock for synthesis of a wide variety of petrochemicals and medicinal products. These fuels may occur as gases ranging from low molecular weight compounds such as methane, to liquid petroleum products, and also include solids, chiefly coals.

Formation

Fossil fuels began as living plants and animals, which died and subsequently decayed under anaerobic conditions; thereafter, they were subjected to immense pressure from overlying crustal features, sometimes including surface water bodies such as oceans and lakes.
The largest natural stores of fossil fuel are coal deposits, ehich are mainly formed by decay of terrestrialplants.In contrast much of the oil is produced by planktonic decay and ensuing ocean pressure at the seabed level. The resulting high levels of temperature and pressure caused the organic matter to chemically alter, first into a waxy material called kerogen, that occurs in oil shale and then with more heat into liquid and gaseous hydrocarbons in a process known as catagenesis. This process explains why many of the oil strata are found below the contnental ocean shelves, even as deep as the bathypelagic zone. Crude oil strata also frequently occur in low lying coastal areas, which may have early been seabeds uplifted by tectonic forces.

Most of the coal fields derive from decayed vegetation dating to the Carboniferous Period. Some coal deposits lie at relatively shallow depths below the land surface, so that strip mining can be conducted, whereas other seams occur deeper into the Earth and are accessed

by systems of vertical shafts and horizontal tunneling. The Carboniferous forests of about 300 million years ago often grew in iron rich clayey substrate soils, which typically form the underbed of the lowest carbon seam; it is quite common for dozens of striated coal layers to be formed in vertical layers, probably correlated with the Milankovich cycles with the present and previous ice ages.[1]
The vast coal deposits stretch from a latitude of North America around the globe to the Urals of Russia, tracing the earlier belt of extensive swamp forests, where trees fell decaying first to peat and therafter being compressed to form coal. Thus, by the end of the Carboniferous, atmospheric carbon dioxide levels had fallen to the same low levels as today, since vast stores of carbon had become trapped in the decaying swamp forests.

Petroleum deposits occur where specialized geological traps have been formed. Quite often a natural gas layer lies above the liquid petroleum level in these subsurface structures.[2] An example of a prolific zone of such trap occurrences is the Zagros Mountains region of Iran. Most trap areas are considered structural, i.e. formed by tectonic, gravitational, diapiric or compactional forces.
Tar sands are another naturally occurring form of fossil fuel; these deposits are bitumen (high molecularweight hydrocarbons) found admixed with sand and clay; moreover, oil shale is sedimentary rock infused with kerogen, which is a mixture of waxy high molecular weight hydrocarbons.

Ecology

In some cases naturally occurring deposits of fossil fuels interact with biota of the natural environment. The chief example of this phenomenon is the prevalence of natural seeps of petroleum and natural gas (especially methane) from the ocean floor. These seeps are particularly common in the Gulf of Mexico, Barbados Prism, Japan Trench and Oregon Margin. Cold seeps occur in these basins at depths ranging from 400 to 6000 meters below the sea surface. Remarkably there are certain bivalves, vestimentiferans andbacteria that are dependent on methane consumption for their survival;[3] in the case of certain bivalves and vestimentiferans, this metabloic behavior is often intermediated by methanotrophic symbiont bacteria. These unusual ecological systems are usually predicated upon relatively slow seepage rates. In addition there are a variety of microorganisms that can metabolize petroleum hydrocarbons, although this process is usually dependent upon the particular seep creating a thin film or very small droplets of petroleum in effective suspension.

Reserves

The chief fossil fuel presently used is oil, with estimated total worldwide proven oil reserves, as of January 1, 2008, estimated at 1.332 trillion barrels, an increase of 14 billion barrels from 2007. Fifty six percent of the world's proved oil reserves are located in the Middle East. Among the top 20 reserve holders in 2008, eleven are Organization of Petroleum Exporting Countries (OPEC) that, collectively, account for 69 percent of the world's total oil reserves.

The current rate of global oil consumption, approximately 85 million barrels per day, represents 43 years of proven reserves. The actual amount of recoverable oil reserves could vary as technology changes or new discoveries are made. The rate of consumption is also projected to increase with expanding world populationand increasing per capita energy demand.

Environmental issues

Extraction, processing and combustion of fossil fuels produces a number of significant adverse environmental impacts, including effects on air quality, water quality and biodiversity. Extraction of coal damages natural habitat, especially when the technique of strip mining is used. Drilling for crude oil is less damaging to the natural environment; however, the risk of major upset in off shore oil drilling, such as theDeepwater Horizon oil spill, poses a catrostrophic risk to the marine environment; a large oil spill of this type kills many marine organisms, and may create a benthic "dead zone" for decades; moreover, there is considerable harm to sensitive coastal marshes and estuaries.

Principal air pollutants produced by the burning of fossil fuels include carbon monoxide, sulfur dioxide, oxides of nitrogen, particulate matter and heavy metals such as mercury. Some of these chemicals such as sulfur dioxide also contribute to acid rain formation. Collectively these air pollutants cause annual human deaths exceeding one million people in addition to large numbers of respiratory and other illnesses. Ecological damage from these air pollutants and associated acid rain can be appreciable.

Water pollution impacts arise from strip mining of coal and ensuing sedimentation of area watercourses; in the marine environment, a more serious threat is the risk of upset from drilling platform failure or oil tanker rupture. In the case of a large marine release of petroleum, not only are there the reaily observable impacts to seabirds and other large aquatic life, but there are the more long term and systemic adverse impacts of mortality to large numbers of planktonic and benthic species, many of which are quite small and not easily observable. In some cases such as the Gulf of Compeche release from 1979, the benthic "dead zone" may persist for decades and in fact widen over such time.

Fossil fuels also contain radioactive materials, chiefly uranium and thorium, which are released into the atmosphere upon combustion. In 2000, about 12,000 tons of thorium and 5000 tons of uranium were released worldwide from burning coal.[4] U.S. coal combustion has released 155 times as much radioactivity into the atmosphere as the Three Mile Island incident.[5]

Geopolitical factors

Since reserves of fossil fuels are distributed unevenly across the globe, there are intrinsic issues with access to these important sources of energy. Considerable amounts of financial and even military maneuvering occur among the world's nations to insure that each region has its perceived objectives of energy security met. Issues of access to adequate fossil fuels include: (a) national ownership of fossil fuel reserves; (b) political stability of the regions where reserves exist; and (c) transport or shipping capability in moving fossil fuels in crude or refined forms to the end user country.

The critical international commodity among fossil fuels is crude oil, whose transport is the limiting factor in satisfying end user demands for this fuel type. Since most transport is via ocean tanker, the movement of crude oil is inherently slow and also subject to shipping bottlenecks in such areas as the Suez Canel, Straits of Hormuz and Panama Canal. A fundamental issue is that the crude oil reserves are typically in countries of relatively small final demand for fossil fuels (e.g, Kuwait, Iraq, Venezuela), whereas the bulk of the demand is from countries with more most reserves (e.g. Western Europe, India). The imbalance of reserve ownership and end user demand places an intrinsic instability on fossil fuel distribution and refining for end use.[6]

In addition to crude oil issues, the pipeline transport of natural gas can also be problematic. For example, large reserves of natural gas are held in countries such as Russia and Canada, much of which requires transport south to other user countries. There have been instances in the Russian supply, where political forces have influenced the viability of the flow for these natural gas supplies.[7]

Historical context and outlook

Early man relied chiefly on burning of wood and peat for energy, with some contributions from animal oils for lighting; semi-solid hydrocarbons from seeps were also burned in ancient times, but these materials were mostly used for waterproofing and embalming. The use of coal as a fuel predates recorded history. Coal was used to run furnaces for the melting of metal ore.These patterns persisted up to the Late Middle Ages when harnessing of wind and river power began in earnest. Prior to the Industrial Revolution windmills or watermills provided most of the power needed for processes such as milling, timber sawing; burning wood or peat still provided most domestic heat. The wide-scale use of fossil fuels, coal at first and petroleum later, to fire steam engines, enabled the mass production of goods that commenced in the western world in the 18th century. At the same time, gas lights using natural gas or coal gas were arriving into broad use. The invention of the internal combustion engine and its use in motor vehichles considerably increased the demand for gasoline and diesel oil, both made from fossil fuels. Other forms of transportation, such as railways and aircraft, also required fossil fuels. The other major use for fossil fuels is in generating electricity and the petrochemical industry. Tar, a leftover of petroleum extraction, is used in road construction.

Fossil fuels are of great importance because they can be burned to produce carbon dioxide and water, releasing significant amounts of energy. Commercial exploitation of petroleum, largely as a replacement for oils from animal sources (notably whale oil) for use in oil lamps began in the nineteenth century. Natural gas, once flared-off as an unneeded byproduct of petroleum production, is now considered a valuable resource. Heavy crude oil, which is much more viscous than conventional crude oil, and tar sands, where bitumen occurs mixed with sand and clay, are becoming more important as fossil fuel sources. Oil shale and similar materials are sedimentary rocks containing kerogen, a complex mixture of high-molecular weight organic compounds, which yield synthetic crude oil when pyrolyzed. These materials have yet to be fully exploited.[8]

References

1. ^ Jennifer A. Clack. 2002. *Gaining ground: the origin and evolution of tetrapods*. Indiana University Press. 369 pages
2. ^ P.A. Allen and John R. Allen. 1990. *Basin analysis: principles and applications*. Wiley Publishing. 451 pages

3. ^ Paul A. Tyler. 2003. *Ecosystems of the deep oceans*. Elsevier. 569 pages
4. ^ Alex Gabbard. 2008. Coal Combustion: Nuclear Resource or Danger Oak Ridge National Laboratory, USA
5. ^ Gordon J. Aubrecht. II. 2003. Nuclear proliferation through coal burning. 3rd ed. Ohio State University. Prentice Hall
6. ^ Ron Nielsen. 2006. *The little green handbook*. Picador. 365 pages ISBN 0312425813
7. ^ Keith Crane. 2009. *Imported oil and U.S. national security*. Rand Environment, Energy, and Economic Development (Program), International Security and Defense Policy Center
8. ^ US Department of Energy plans for oil shale development

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http://www.eoearth.org/view/article/51cbedcf7896bb431f694153/?topic=51cbfc8ff702fc2ba812d783