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# The Petroleum Industry and Climate Issues

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## Abstract

*In recent years, the world picture stands at a crossroads with regard to the recovery and use of energy in the context of sustainable development and environmental protection.*
*The imbalance between demand and supply and the growing realization of the impact of fossil fuel consumption on global climate have raised significant movements in the development of real and sustainable actions to reduce pollution from the energy sector.*
*The successful development and deployment of technologies for reducing pollutants from petroleum industry and the use of alternative energy could play a major role in satisfying society's growing energy demands while stabilizing GHG concentrations in the atmosphere.*

**Key words:** *energy crisis, oil industry, GHG, climate change*

## Introduction

The modern petroleum industry began in 1859 in Pennsylvania, when a man named Edwin L. Drake constructed the first oil well, a facility for extracting petroleum from natural deposits. Since then, petroleum - black gold, has become the most valuable resource in industrialized parts of the world.

In recent years, the world energy picture has changed dramatically. The imbalance between demand and supply and the prices that are expanding rapidly to higher levels raised a current energy crisis.

Current changes in the energy market, increasing energy prices, and emphasis on global climate change offer significant opportunities for expansion of renewable energy use. The need and desire to implement available technologies already have driven the market to respond with new products and resources.

## Composition

Petroleum is naturally occurring liquid oil normally found in deposits beneath the surface of the earth. Through refinement processes, a variety of consumer products can be made from petroleum. Most of these are fuels: gasoline, jet fuel, diesel fuel, kerosene, and propane are common examples. It is also used to make asphalt and lubricant grease, and it is a raw material for synthetic chemicals. Chemicals and materials derived from petroleum products include plastics, pesticides, fertilizers, paints, solvents, refrigerants, cleaning fluids, detergents, antifreeze, and synthetic fibers. [8]

Petroleum includes only crude oil and natural gas. Both crude oil and natural gas are predominantly a mixture of hydrocarbons.

Under surface pressure and temperature conditions, the lighter hydrocarbons methane, ethane, propane and butane occur as gases, while the heavier ones from pentane and up are in the form of liquids or solids. However, in the underground oil reservoir the proportion which is gas or liquid varies depending on the subsurface conditions, and on the phase diagram of the petroleum mixture.

The proportion of light hydrocarbons in the petroleum mixture is highly variable between different oil fields and ranges from as much as 97% by weight in the lighter oils to as little as 50% in the heavier oils and bitumen's.

The hydrocarbons in crude oil are mostly alkenes, cycloalkanes and various aromatic hydrocarbons while the other organic compounds contain nitrogen, oxygen and sulfur, and trace amounts of metals such as iron, nickel, copper and vanadium. The exact molecular composition varies widely from formation to formation but the proportion of chemical elements varies over fairly narrow limits as follows.

**Table 1.** The proportion of molecular composition of crude oil (Composition by weight) [9]

| Element | Percent range |
|---|---|
| Carbon | 83 to 87% |
| Hydrogen | 10 to 14% |
| Nitrogen | 0.1 to 2% |
| Oxygen | 0.1 to 1.5% |
| Sulfur | 0.5 to 6% |

Four different types of hydrocarbon molecules appear in crude oil. The relative percentage of each varies from oil to oil, determining the properties of oil.

**Table 2.** Types of hydrocarbon molecules in crude oil (Composition by weight) [9]

| Hydrocarbon | Average | Range |
|---|---|---|
| Paraffin | 30% | 15 to 60% |
| Naphthene | 49% | 30 to 60% |
| Aromatics | 15% | 3 to 30% |
| Asphaltics | 6% | - |

## Environmental issues with petroleum

Petroleum-derived contaminants constitute one of the most prevalent sources of environmental degradation in the industrialized world. In large concentrations, the hydrocarbon molecules that make up crude oil and petroleum products are highly toxic to many organisms, including humans. Petroleum also contains trace amounts of sulfur and nitrogen compounds, which are dangerous by themselves and can react with the environment to produce secondary poisonous chemicals.

There are a number of environmental issues with petroleum as a result of it being toxic to almost all forms of life. The possibility of climate change exists. Petroleum, commonly referred to as oil, is closely linked to virtually all aspects of present society, especially for transportation and heating for both homes and for commercial activities.

For a right approach of an analysis study of petrol contribution to environmental crisis and its effects it is necessary to diagnosis the pollution by highlighting its sources and their impact on environmental factors.

## Air pollution - Petroleum industry greenhouse gas emission sources

In the last years, scientific researches have shown that the chemical structure of the atmosphere is changing, so the attention is focused on the impact of human activities on the atmosphere.

Air pollution has profound effects in various fields, being the main reason for the manifestation of global warming; its climatic implications are already expressed by extreme weather phenomena such as: rapid alternation between rainfall and severe heat waves, severe drought, altered meanings of traditional seasons, acid rain, photochemical smog, etc.

The increase in global consumption of oil and coal since the early '40s led to a substantial growth in carbon dioxide which increases the greenhouse effect, influences the trend of atmosphere warming and affect global climate

Greenhouse gas emissions from the petroleum industry arise from a variety of different types of sources.

These sources fall within three main categories:

- Combustion Emissions- including stationary and mobile combustion sources
- Process emissions
- Fugitive emissions

Fugitive emissions of greenhouse gases are unavoidable events during activities in the petroleum industry. This category includes all emissions from the production, processing, transport, refining and distribution of oil and gas and oil products, and emissions from non-productive combustion of natural gas. Significant are fugitive emissions of methane from oil and gas production, and from all aspects of natural gas activities, but certain quantities of $NO_x$, CO, NMVOC and $SO_2$ from crude petroleum refining and distribution of petroleum products are also emitted. Their impact on the air can be viewed primarily from their contribution to global warming. For the most part methane contributes directly to the greenhouse effect and its greenhouse potential equals 21. [7]

$NO_x$, CO, NMVOC are gases with no direct greenhouse effect, but they influence generation of tropospheric ozone which has the properties of a greenhouse gas, thus contributing indirectly to the increase of total greenhouse gases in the atmosphere

Stationary combustion emissions include the emissions resulting from the combustion of fuels in boilers, furnaces, burners, heaters, and stationary turbines and engines, as well as the combustion of wastes in incinerators and flares. These sources exist widely within the petroleum industry, and account for most of its GHG emissions.

Mobile combustion sources include combustion of fuels in ships, barges, train, trucks, automobiles and aircraft. While these sources are also commonly used within the petroleum industry, their emissions are generally much smaller than from stationary combustion sources.

Process emissions of GHGs result from the physical or chemical processing of materials- within the petroleum industry, typically gaseous or liquid hydrocarbon streams. Venting $CO_2$ removed from gas streams, and the production of $CO_2$ in the manufacture of hydrogen are examples of process emission from the industry. The magnitude of process emissions varies widely, and may represent significant emissions from some petroleum industry facilities.

Fugitive emissions occur from equipment leaks such as from seals, gaskets and valves. Within the industry, fugitive emissions historically have been of primary concern due to releases of volatile organic compounds (hydrocarbons heavier than methane), due to the high concentration of methane in many gaseous streams, as well as the presence of CO2 in some streams.

A simple classification divides the pollutants from petroleum industry in two categories:

- Primary pollutants

These are emitted on a consequence of a process and they exist in air in the same form as they were discharged (ex. The exhaust of nitrogen oxides from a car, sulfur oxides, carbon monoxide and hydrogen sulfide volatile organic compounds ($VOC_s$), benzene ($C_6H_6$), toluene ($C_6H_8$) , xylems ($C_8H_{10}$)

- Secondary pollutants

They are formed as products of some reactions; generally the existing pollutants react with other substances in the atmosphere (ex. Smog, formed when oxides of nitrogen combine with $HC_s$, oxidation of NO to $NO_2$, oxidation of hydrocarbons, formation of ozone).

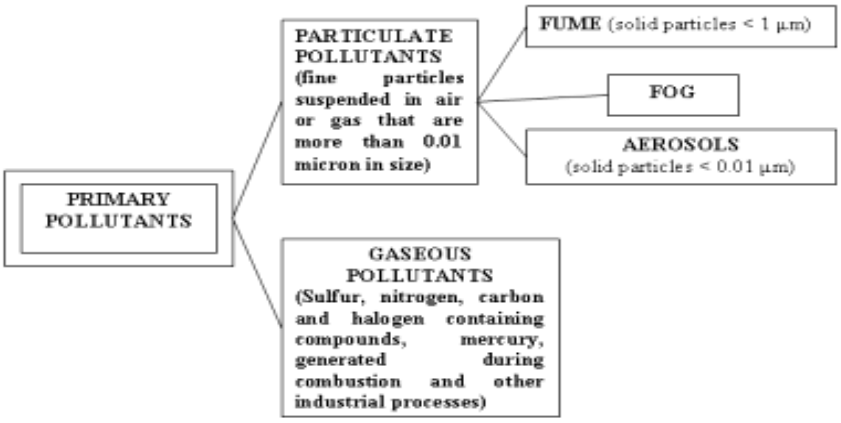


**Fig.1.** Classification of primary pollutants

Quantification of GHG emissions from the petrol industry is complicated by the wide variety of emission sources and the nature of the fuels consumed by the industry.

GHG emissions come from the major sub-sectors of the petroleum industry:

- Upstream operations
- Downstream operations
- Chemicals

**Other sources of air pollution in oil field**

- The exhaust of derrick engines and generators pump engines, compressors, etc
- Pungent fumes and odors;
- Evaporation of crude oil in the form of vapors;
- Burning of oil from the effluent pit;
- Flaring of natural gas to the atmosphere;
- Burning of gas and effluent water from the flare pit in the air directly from various oil terminals;
- Oxidation;
- The weather and orography of the oil fields;
- Increase in surrounding temperature due to flare.

## Acid rain

High temperatures created by the combustion of petroleum because nitrogen gas in the surrounding air to oxidize, creating nitrous oxides. Nitrous oxides, along with sulfur dioxide from the sulfur in the oil, combine with water in the atmosphere to create acid rain. Acid rain

causes many problems such as dead trees and acidified lakes with dead fish. Coral reefs in the world's oceans are killed by acidic water caused by acid rain.

Acid rain leads to increased corrosion of machinery and structures (large amounts of capital), and to the slow destruction of important archaeological structures such as the marble ruins in Rome and Greece.

## Photochemical smog

Photochemical smog is a toxic fog produced by the chemical interaction between pollutant emissions and solar radiation. Ozone from lower atmosphere is very poisonous and has a devastating action on ecosystems and human.

Smog is formed in urban highly industrialized areas when nitrogen dioxide is decomposed by sunlight, releasing ozone, aldehydes and ketones.

Their combined effect results in an extreme harm of various toxic gases (especially $SO_2$ and $NO_2$) even below the maximum permissible concentrations.

During high hours in major urban areas atmospheric concentration of nitrogen oxides and hydrocarbons increases rapidly as these substances are emitted by cars, industrial activity and the energy domain.

## Toxicity

Crude oil is a mixture of many different kinds of organic compounds, many of which are highly toxic and cancer causing (carcinogenic). Oil is lethal to fish at a concentration of 4000 parts per million (ppm) (0.4%). It only takes one quart of motor oil to make 250,000 gallons of ocean water toxic to wildlife. This would be a concentration of only 1 ppm. Crude oil and petroleum distillates cause birth defects.

Benzene is present in both crude oil and gasoline and is known to cause leukemia in humans.

The compound is also known to lower the white blood cell count in humans, which would leave people exposed to it more susceptible to infections. Studies have linked benzene exposure in the mere parts per billion (ppb) ranges to terminal leukemia, Hodgkin’s lymphoma, and other blood and immune system diseases within 5-15 years of exposure.

Volatile organic compounds (VOCs) from petroleum are toxic and foul the air, and some like benzene are extremely toxic, carcinogenic and cause DNA damage.

## Oil Spills

The most visible source of petroleum pollution is the catastrophic oil-tanker spills, like the 1989 Exxon Valdez spill in Prince William Sound, Alaska.

Oil spills occur during the transportation of crude oil from exporting to importing nations. Crude oil travels for long distances by either ocean tanker or land pipeline, and both methods are prone to accidents.

Oil may also spill at the site where it is extracted, as in the case of a blowout like the Ixtoc I exploratory well in 1979 (see Table 3). A blowout is one of the major risks of drilling for oil. It occurs when gas trapped inside the deposit is at such a high pressure that oil suddenly erupts out of the drill shaft in a geyser.

Accidents with tankers, pipelines, and oil wells release massive quantities of petroleum into land and marine ecosystems in a concentrated form.

The ecological impacts of large spills like these have only been studied for vary few cases, and it is not possible to say which have been the most environmentally damaging accidents in history.

**Table.3.** Five largest oil spills in history (by volume) [5]

| Location | Date | Amount Spilled |
|---|---|---|
| Sea Island Installations, Persian Gulf, Kuwait | January 26, 1991 | 240,000,000 gallons (816,327 tons) |
| Ixtoc I exploratory well, Bahia del Campeche, Mexico | June 3, 1979 | 140,000,000 gallons (476,190 tons) |
| Production well, Fergana Valley, Uzbekistan | March 2, 1992 | 88,000,000 gallons (299,320 tons) |
| Nowruz No. 3 well, Persian Gulf, Nowruz Field, Iran | February 4, 1983 | 80,000,000 gallons (272,109 tons) |
| Tanker Castillo de Bellver , Table Bay, South Africa | August 6, 1983 | 78,500,000 gallons (267,007 tons) |

### Petroleum-Contaminated Soil

Not all oil released from land sources is quickly washed away to sea, however. Pipeline and oil-well accidents, unregulated industrial waste, and leaking underground storage tanks can all permanently contaminate large areas of soil, making them economically useless as well as dangerous to the health of organisms living in and around them.

Removing or treating soil contaminated by petroleum is especially urgent because the hydrocarbons can leach into the underlying groundwater and move into human residential areas.

The engineering field of bioremediation has emerged in recent decades as a response to this threat. In bioremediation, bacteria that feed on hydrocarbons and transform them into carbon dioxide can be applied to an affected area. Bioremediation has in many cases made cleaning up petroleum-contaminated sites a profitable real-estate investment for land developers. [3]

## The Future of Petroleum

The world's reliance on petroleum is expected to grow, despite widespread environmental, economic, and political consequences.

There are many compelling reasons to decrease society's dependence on petroleum for energy, and the most obvious place to begin is in the transportation sector. Energy-efficient engines and hybrid gas/electric cars can help to reduce some of the need for oil, providing higher gas mileage and less demand.

A variety of alternative fuels have also been developed, such as ethanol, biodiesel (made from vegetable oil), and hydrogen. Each of these would produce little or no exhaust pollutants or greenhouse gases, and each derives from plentiful renewable resources.

Petroleum is a useful chemical substance for many important purposes. But it is also a nonrenewable resource with a highly toxic composition, and it poses significant problems when used in huge volumes throughout the industrialized world.

Another problem raised are the depletion rates of global fossil fuel taking into account current consumption as it is shown in the table below.

**Table 4.** Advantages and disadvantages of using biofuels instead of petrol [4]

| Advantages | Disadvantages |
|---|---|
| - E85 (85% ethanol and 15% gasoline) can reduce the net emissions of greenhouse gases by as much as 37.1%.<br>- E10 (10% ethanol and 90% gasoline) reduces greenhouse gases by up to 3.9%.<br>- The effect of biofuels use results in an overall decrease in ozone formation.<br>- Ethanol is considered renewable because it is primarily the result of conversion of the sun's energy into usable energy.<br>- Biofuels benefits energy security as it shifts the need for some foreign-produced oil to domestically-produced energy sources.<br>- Burns more cleanly (more complete combustion)<br>- Reduces amount of high-octane additives<br>- Spills are more easily biodegraded or diluted to non-toxic concentrations<br>- Any large-scale or ongoing leaks of gasoline pose a threat to the public's health and the environment | - Production of biofuels requires significant energy and large amounts of land<br>- Fuels with more than 10% ethanol are not compatible with non E85-ready fuel system components and may cause corrosion of ferrous components.<br>- Can negatively affect electric fuel pumps by increasing internal wear and undesirable spark generation.<br>- Biofuels not compatible with capacitance fuel level gauging indicators and may cause erroneous fuel quantity indications in vehicles that employ that system.<br>- Not always compatible with marine craft, especially those that use fiberglass tanks.<br>- Decreases fuel-economy by 15-30%. |

**Table 5.** Estimated period until exhaustion (years)

| Fuel | Depletion rate (years) |
|---|---|
| Coal | 206 |
| Natural Gas | 66 |
| Oil | 45 |

Analyzing these estimates, it is noted that the extremely short time remained until the depletion of existing resources, at least for oil and natural gas, requires immediate solutions and efficient energy replacement. These solutions are the more necessary as energy consumption for the world economy is growing and minimizing the consumption isn't expected in the near future.

The world's fossil fuel supplies are expected to be exhausted within the next century. The consumption of oil by industrialized and industrializing countries is increasing at a rate almost twice as fast as the rate oil is being discovered.

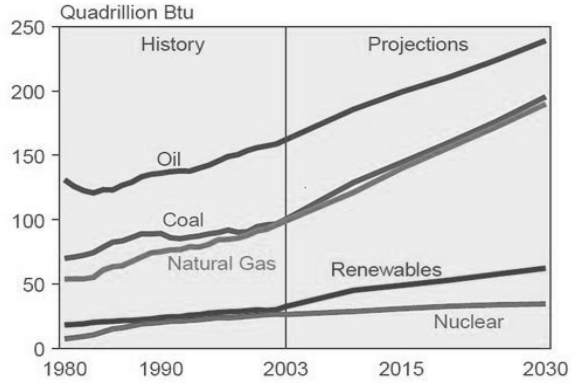


**Fig.2.** Scenarios of oil consumption until 2030 [1]

In this context many nations, organizations and companies are beginning to search for alternative energies, rather than continue dependence on fossil fuels.

Alternative energies include the renewable: wind, solar, hydrogen – inexhaustible and less toxic "green" sources of energy; and other forms of alternative energies: natural gas, coal, nuclear – which are, by nature, alternative products to oil, but provide for some concerns of exhaustibility and toxicity to the environment. [6]

Renewable energy is becoming competitive with conventional energy production, and applications in remediation are growing, as is support for their implementation.

## Conclusion

At present global energy demand far surpasses the existing traditional sources, which's burning cause, because GHG emissions harm the environment, generating amplification of the natural greenhouse effect, the main reason for global warming event.

In the current energy and environmental crises it is necessary to have an ecologist behavior in all actions, to be aware of the environmental risks raised by petrol and the depletion rate of this fossil fuel and not at least to accept some alternative solution for changing the world picture for a sustainable development.

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# Industria petrolieră şi problemele climatice

## Rezumat

*În ultimii ani, imaginea lumii se află la o răscruce de drumuri în ceea ce priveşte recuperarea şi utilizarea energiei în contextul dezvoltării durabile şi protecţiei mediului.*
*Dezechilibru între cerere şi ofertă şi realizarea impactului consumului de combustibili fosili asupra climatului la nivel global au creat premise pentru dezvoltarea de acţiuni concrete şi durabile pentru a reduce poluarea, principala cauză a manifestării fenomenului de Încălzire globală.*
*Dezvoltarea şi implementare tehnologiilor pentru reducere poluanţilor din industria petrolieră prin folosirea energiilor alternative are un rol deosebit de important în satisfacerea cererilor din domeniul energetic in timp ce ajuta la stabilizarea concentratiilor gazelor cu efect de sera din atmosfera.*