



## Did You Know Crude Oil Can Be Sweet or Sour?

Crude oil is called "sweet" when it contains only a small amount of sulfur and "sour" if it contains a lot of sulfur. Crude oil is also classified by the weight of its molecules. "Light" crude oil flows freely like water, while "heavy" crude oil is thick like tar.

## Did You Know?

A barrel's capacity often depends on who uses the term, or what it contains, for example:

- 1 barrel (bbl) of petroleum or related products = 42 gallons
- 1 barrel of Portland cement = 376 pounds
- 1 barrel of flour = 196 pounds
- 1 barrel of pork or fish = 200 pounds
- 1 barrel of (US) dry measure = 3.29122 bushels or 4.2104 cubic feet
- A barrel may be called a "drum," but a drum usually holds 55 gallons!

## Nonrenewable

## Oil (petroleum)

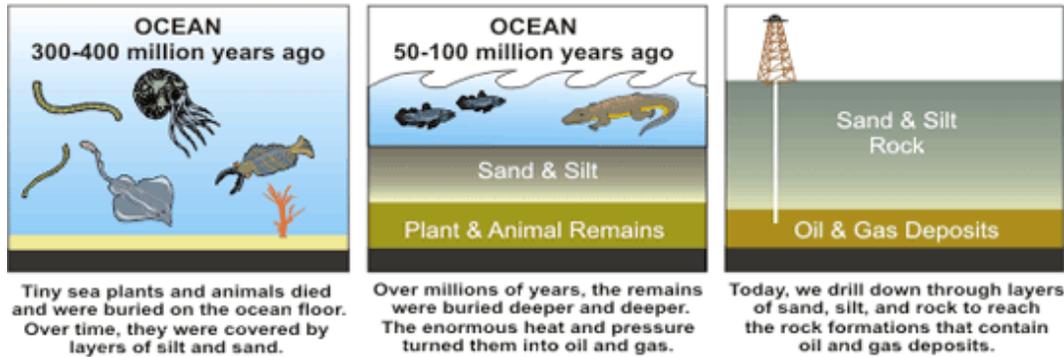
## Oil (petroleum) Basics

### How Was Oil Formed?

Oil was formed from the remains of animals and plants (diatoms) that lived millions of years ago in a marine (water) environment before the dinosaurs. Over millions of years, the remains of these animals and plants were covered by layers of sand and silt. Heat and pressure from these layers helped the remains turn into what we

today call crude oil. The word "petroleum" means "rock oil" or "oil from the earth."

## PETROLEUM & NATURAL GAS FORMATION



Crude oil is a smelly, yellow-to-black liquid and is usually found in underground areas called reservoirs. Scientists and engineers explore a chosen area by studying rock samples from the earth. Measurements are taken, and, if the site seems promising, drilling begins. Above the hole, a structure called a 'derrick' is built to house the tools and pipes going into the well. When finished, the drilled well will bring a steady flow of oil to the surface.

## Getting (Producing) Oil

### Where Is Oil Produced?

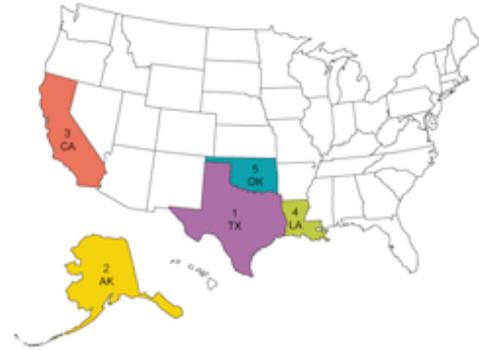
The world's top five crude oil-producing countries are:

- Saudi Arabia
- Russia
- United States
- Iran
- China

Over one-fourth of the crude oil produced in the United States is produced offshore in the Gulf of Mexico. The top crude oil-producing States are:

- Texas
- Alaska
- California
- Louisiana
- Oklahoma

### Top Petroleum Producing States

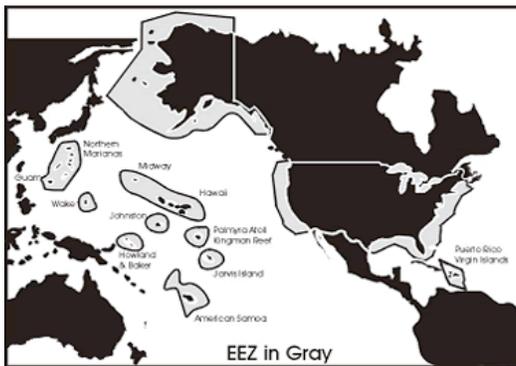


The amount of crude oil produced in the United States has been getting smaller each year. However, the use of petroleum products made from crude oil has been growing, making it necessary to import more oil from other countries. About 58% of the crude oil and petroleum products used in the United States in 2007 came from other countries.

## Offshore Drilling

### What Is Offshore?

Map Showing Exclusive Economic Zone Around the United States and Territories



Source: National Energy Education Development Project

Image of a Coastline



When you are at your favorite beach in Florida or California, you are not at the very edge of the country.

Diagram of Land and Ocean Overlayed With 3 Miles of Territorial Sea, 200 Miles of Exclusive Economic Zone, the Continental Shelf, and Continental Slope



Although it might seem like the ocean is the border of the United States, the border is actually 200 miles out from the land. This 200 mile wide band around the country is called the Exclusive Economic Zone (EEZ).

In 1983, President Reagan claimed the area of the EEZ in the name of the United States. In 1994, all countries were granted an EEZ of 200 miles from their coastline according to the International Law of the Sea.

There is a lot of activity just beyond the beach. The beach extends from the shore into the ocean on a continental shelf that gradually descends to a sharp drop, called the continental slope. This continental shelf can be as narrow as 20 kilometers or as wide as 400 kilometers. The water on the continental shelf is shallow, rarely more than 150 to 200 meters deep. The EEZ is part of the United States. The federal government manages the land under the sea on behalf of the American people.

The United States Minerals Management Service (MMS) leases the land under the ocean to producers. These companies pay MMS rental fees and royalties on all the minerals they extract from the ocean floor. Individual states control the waters off their coasts out to 3 miles for most states and between 9 and 12 for Florida, Texas, and some other States.

The continental shelf drops off at the continental slope, ending in abyssal plains that are three to five kilometers below sea level. Many of the plains are flat, while others have jagged mountain ridge, deep canyons, and valleys. The top of some of these mountain ridges form islands where they extend above the water.

Most of the energy we get from the ocean is extracted from the ground. Oil, natural gas, and minerals all come from the ocean floor. People are working on new ways to use the ocean too.

[Solar](#) and [wind](#) energy have been used on land, and now they are also being used at sea. Other energy sources that are being explored in the ocean are [visit to an offshore rig](#) or learn about [jobs in the offshore](#).

# Fuels Made From Crude Oil

## What Fuels Are Made from Crude Oil?

After crude oil is removed from the ground, it is sent to a refinery by pipeline, ship, or barge. At a refinery, different parts of the crude oil are separated into useable petroleum products. Crude oil is measured in barrels (abbreviated "bbls").

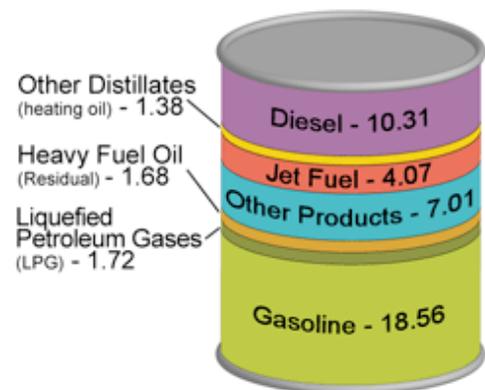
A 42-U.S. gallon barrel of crude oil provides slightly more than 44 gallons of petroleum products. This gain from processing the crude oil is similar to what happens to popcorn, which gets bigger after it's popped. The gain from processing is more than 5%.

One barrel of crude oil, when refined, produces about 19 gallons of finished [motor gasoline](#), and 10 gallons of [diesel](#), as well as other petroleum products. Most petroleum products are used to produce energy. For instance, many people across the United States use [propane](#) to heat their homes.

Other products made from petroleum include:

- Ink
- Crayons
- Bubble gum
- Dishwashing liquids
- Deodorant
- Eyeglasses
- CDs and DVDs
- Tires
- Ammonia
- Heart valves

**Products Made from a Barrel of Crude Oil (Gallons)**



## What Is a Refinery?

A refinery is a factory. Just as a paper mill turns lumber into paper, a refinery takes crude oil and turns it into gasoline and many other useful petroleum products.

A Night Photo of the Pascagoula Refinery in Mississippi



### Refineries Operate 24/7

A typical refinery costs billions of dollars to build and millions more to maintain. A refinery runs 24 hours a day, 365 days a year and requires a large number of employees to run it. A refinery can occupy as much land as several hundred football fields. Workers often ride bicycles to move from place to place inside the complex.

## Refining Process

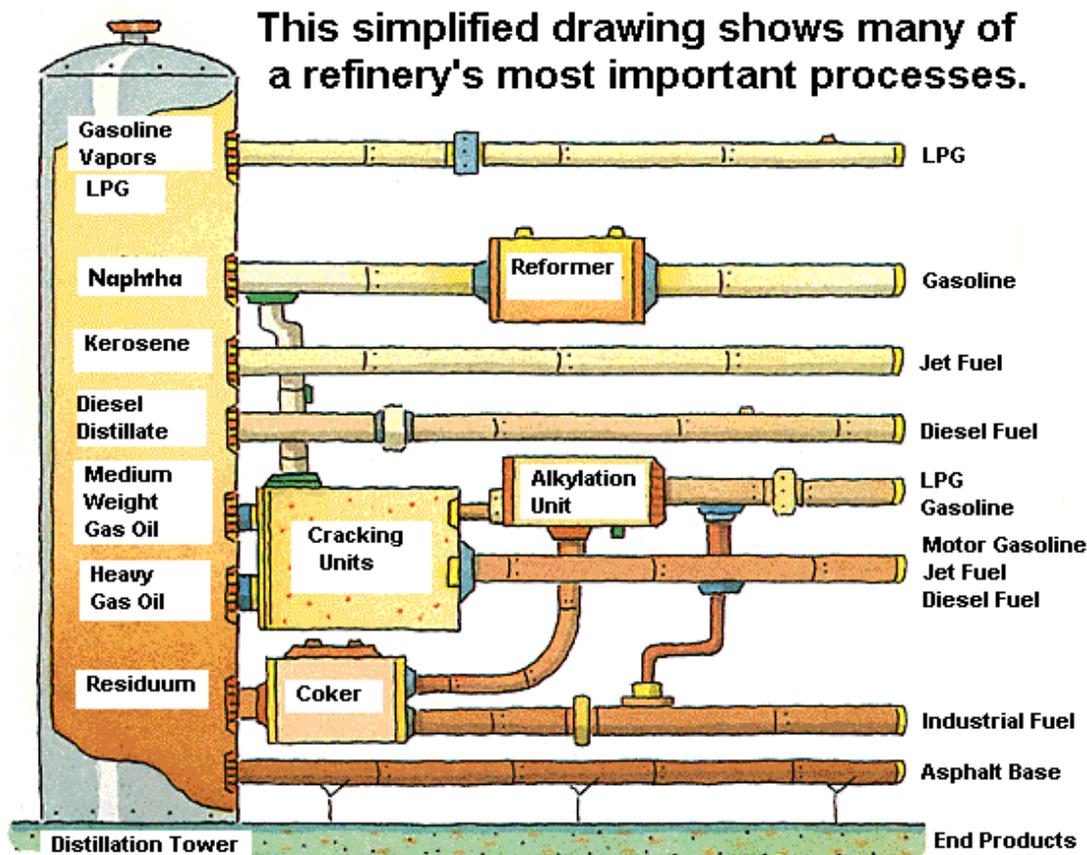
### How Crude Oil Is Refined into Petroleum Products

The world uses gasoline and petroleum products to move merchandise and people, help make plastics, and do many other things. At a refinery, different parts of the crude oil are separated into useable petroleum products. Today, some refineries turn more than half of every 42-gallon barrel of crude oil into gasoline.

How does this transformation take place? Essentially, refining breaks crude oil down into its various components, which then are selectively reconfigured into new products.

All refineries perform three basic steps:

1. [Separation](#)
2. [Conversion](#)
3. [Treatment](#)



## Separation

Heavy petroleum components or "fractions" are on the bottom; light fractions are on the top. This allows the separation of the various petrochemicals. Modern separation involves piping oil through hot furnaces. The resulting liquids and vapors are discharged into distillation towers.

Inside the towers, the liquids and vapors separate into fractions according to weight and boiling point.

The lightest fractions, including gasoline and liquid petroleum gas (LPG), vaporize and rise to the top of the tower, where they condense back to liquids.

Medium weight liquids, including kerosene and diesel oil distillates, stay in the middle.

Heavier liquids, called gas oils, separate lower down, while the heaviest fractions

with the highest boiling points settle at the bottom.

## Conversion

To make gasoline, Cracking and rearranging molecules adds value to the products. This is where refining's fanciest footwork takes place — where fractions from the distillation towers are transformed into streams (intermediate components) that eventually become finished products.

Refining Workers Overlooking a Refinery



Fluid Catalytic Cracking Distillation Column



Photo courtesy of Chevron.

The most widely used conversion method is called cracking because it uses heat and pressure to "crack" heavy hydrocarbon molecules into lighter ones. A cracking unit consists of one or more tall, thick-walled, bullet-shaped reactors and a network of furnaces, heat exchangers, and other vessels.

Cracking and coking are not the only forms of conversion. Other refinery processes, instead of splitting molecules, rearrange them to add value.

Alkylation, for example, makes gasoline components by combining some of the gaseous byproducts of cracking. The process, which essentially is cracking in reverse, takes place in a series of large, horizontal vessels and tall, skinny towers that loom above other refinery structures.

Reforming uses heat, moderate pressure, and catalysts to turn naphtha, a light, relatively low-value fraction, into high-octane gasoline components.

## Treatment

The finishing touches occur during the final treatment. To make gasoline, refinery technicians carefully combine a variety of streams from the processing units. Among the variables that determine the blend are octane level, vapor pressure ratings and special considerations, such as whether the gasoline will be used at high altitudes.

## Storage

Both the incoming crude oil and the outgoing final products need to be stored. These liquids are stored in large tanks on a tank farm near the refinery. Pipelines then carry the final products from the tank farm to other tanks all across the country.

All of these activities are required to make the gasoline that powers our cars, the diesel fuel that brings our food to market, and the jet fuel that flies our planes. These provide us with the energy we need to get from place to place quickly and comfortably.

Tank Farm Near a Refinery



## Oil & the Environment

### How Does Oil Impact the Environment?

Products from oil (petroleum products) help us do many things. We use them to fuel our airplanes, cars, and trucks, to heat our homes, and to make products like medicines and plastics. Even though petroleum products make life easier — finding, producing, moving, and using them can harm the environment through air and water pollution.

## **Emissions and Byproducts Are Produced from Burning Petroleum Products**

Petroleum products give off the following emissions when they are burned as fuel:

- Carbon dioxide (CO<sub>2</sub>)
- Carbon monoxide (CO)
- Sulfur dioxide (SO<sub>2</sub>)
- Nitrogen oxides (NO<sub>x</sub>) and Volatile Organic Compounds (VOC)
- Particulate matter (PM)
- Lead and various air toxics such as benzene, formaldehyde, acetaldehyde, and 1,3-butadiene may be emitted when some types of petroleum are burned

Nearly all of these byproducts have negative impacts on the environment and human health:

- Carbon dioxide is a greenhouse gas and a source of global warming.<sup>1</sup>
- SO<sub>2</sub> causes acid rain, which is harmful to plants and to animals that live in water, and it worsens or causes respiratory illnesses and heart diseases, particularly in children and the elderly.
- NO<sub>x</sub> and VOCs contribute to ground-level ozone, which irritates and damages the lungs.
- PM results in hazy conditions in cities and scenic areas, and, along with ozone, contributes to asthma and chronic bronchitis, especially in children and the elderly. Very small, or “fine PM” is also thought to cause emphysema and lung cancer.
- Lead can have severe health impacts, especially for children, and air toxics

are known or probable carcinogens.

## Laws Help Reduce Pollution from Oil

Over  
the

Fish Swimming Through "Rigs-to-Reefs"  
Project



No Dumping/Drains to River Sign



years, new technologies and laws have helped to reduce problems related to petroleum products. As with any industry, the Government monitors how oil is produced, refined, stored, and sent to market to reduce the impact on the environment. Since 1990, fuels like gasoline and diesel fuel have also been improved so that they produce less pollution when we use them.

### Reformulated Fuels

Because a lot of air pollution comes from cars and trucks, many environmental laws have been aimed at changing the make-up of gasoline and diesel fuel so that they produce fewer emissions. These "reformulated fuels" are much cleaner-burning than gasoline and diesel fuel were in 1990.

### Technology Helps Reduce Drilling's "Footprint"

Exploring and drilling for oil may disturb land and ocean habitats. New technologies have greatly reduced the number and size of areas disturbed by drilling, sometimes called "footprints."<sup>2</sup> Satellites, global positioning systems, remote sensing devices, and 3-D and 4-D seismic technologies make it possible to discover oil reserves while drilling fewer wells.

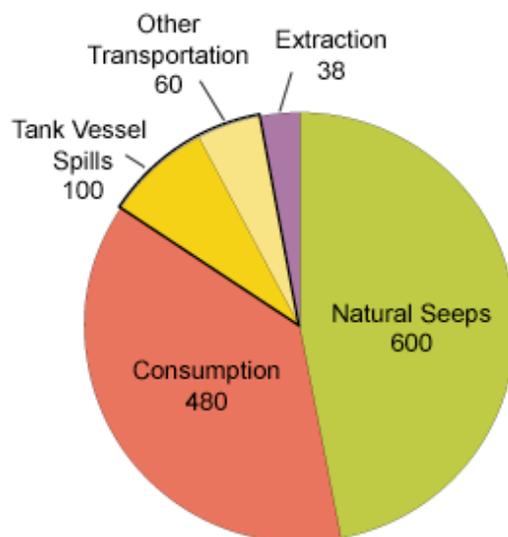
The use of horizontal and directional drilling makes it possible for a single well to produce oil from a much bigger area. Today's production footprints are also smaller those 30 years ago because of the development of movable drilling rigs and smaller "slimhole" drilling rigs.

When the oil in a well is gone, the well must be plugged below ground, making it hard to tell that it was ever there. As part of the "rigs-to-reefs" program, some old offshore rigs are toppled and left on the sea floor to become artificial reefs that attract fish and other marine life. Within six months to a year after a rig is toppled, it becomes covered with barnacles, coral, sponges, clams, and other sea creatures.

### **Eight Percent of the Oil in the Sea Comes from Tank Vessel Spills**

If oil is spilled into rivers or oceans, it can harm wildlife. When we talk about "oil spills" people usually think about oil that leaks from a ship that is involved in an accident. Although this type of spill can cause the biggest shock to wildlife because so much oil is released at one time, a study by the National Research Council says only 8% of all oil in the sea comes from ship or barge spills.<sup>3</sup> The amount of oil spilled from ships dropped significantly during the 1990s partly because new ships were required to have a "double-hull" lining to protect against spills.

**Average Annual Contribution from Major Sources of Petroleum in Worldwide Marine Waters, 1990-1999 (thousands of metric tons)**



Source: Based on data from *Oil in the Sea III* from the National Research Council (2002).

[Data for this figure](#)

### **The Greatest Share of Oil in the Sea Comes from Natural Seeps**

While oil spills from ships are the most well-known source of oil in ocean water, more oil actually gets into water from natural oil seeps coming from the ocean floor.

Leaks also happen when we use petroleum products on land. For example,

gasoline sometimes drips onto the ground when people are filling their gas tanks, when motor oil gets thrown away after an oil change, or when fuel escapes from a leaky storage tank. When it rains, the spilled products get washed into the gutter and eventually flow to rivers and into the ocean. Another way that oil sometimes gets into water is when fuel is leaked from motorboats and jet skis.

When a leak in a storage tank or pipeline occurs, petroleum products can also get into the ground, and the ground must be cleaned up. To prevent leaks from underground storage tanks, all buried tanks are supposed to be replaced by tanks with a double lining.

1. U.S. Environmental Protection Agency, [Climate Change State of Knowledge](#).
2. U.S. Department of Energy, *Environmental Benefits of Advanced Oil and Gas Exploration and Production Technology*, October 1999.
3. National Academies Press, *Oil in the Sea III*, Chapter 3, 2002.