STORAGE OF FOSSIL FUELS (GASEOUS AND LIQUID)

Ender Okandan
Petroleum and Natural Gas Engineering Department, Middle East Technical University, Ankara - Turkey

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Contents

Summary

Storage of liquid fossil fuels is essential due to strategic stockpile for possible supply interruptions, for pipeline economics, peak shaving where market is weather dependent and to increase pipeline efficiency through better load factors. This chapter discusses the methodology of underground natural gas storage in geologic formations such as depleted oil or gas reservoirs, aquifers or in man made salt caverns. The storage of liquid fossil fuels namely crude oil or refinery products are realized in steel above ground or underground storage tanks.

1. Introduction

Oil and gas prices worldwide are strongly affected by the world production of oil and gas and their consumption. It is well known that oil and gas are consumed in areas/countries other than where they are produced. In 1999, 2.026 billion tons of oil was transported between countries. Figure 1 shows global major oil trade movements. Similarly natural gas trade movements indicate 360.51 billion cubic meters of natural gas by pipeline and 124.20 billion cubic meters as LNG was transported between countries and continents (Figure 2).

Storage of liquid fossil fuels is essential because of necessity of strategic stockpile for possible supply interruptions, for pipeline economics, peak shaving where market is weather dependent and to increase pipeline efficiency through better load factors.

Each country has a strategic stock of oil and gas reserves within their boundaries. The amount and type of storage facilities depend on the country's needs. The following focuses on storage methodology of gaseous fossil fuels; natural gas, LNG, and LPG and liquid fossil fuels, namely crude oil and refinery products such as gasoline, diesel oil, jet fuel etc.

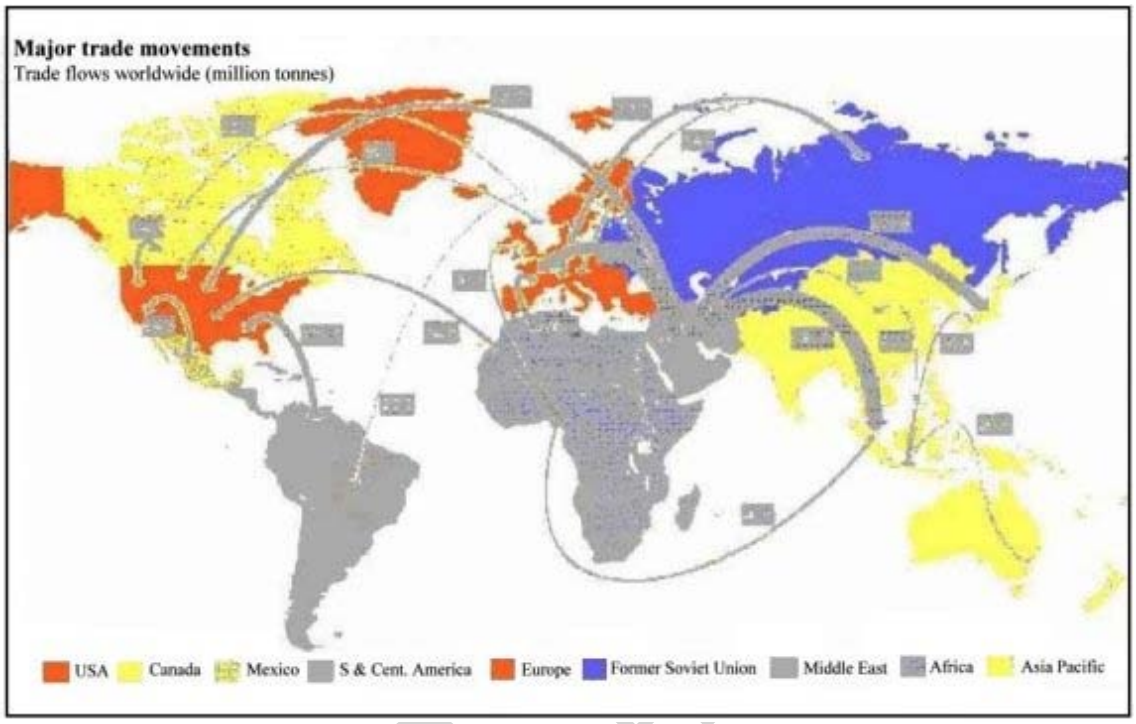

Figure 1: Major oil trade movements (www.bpamoco.com)

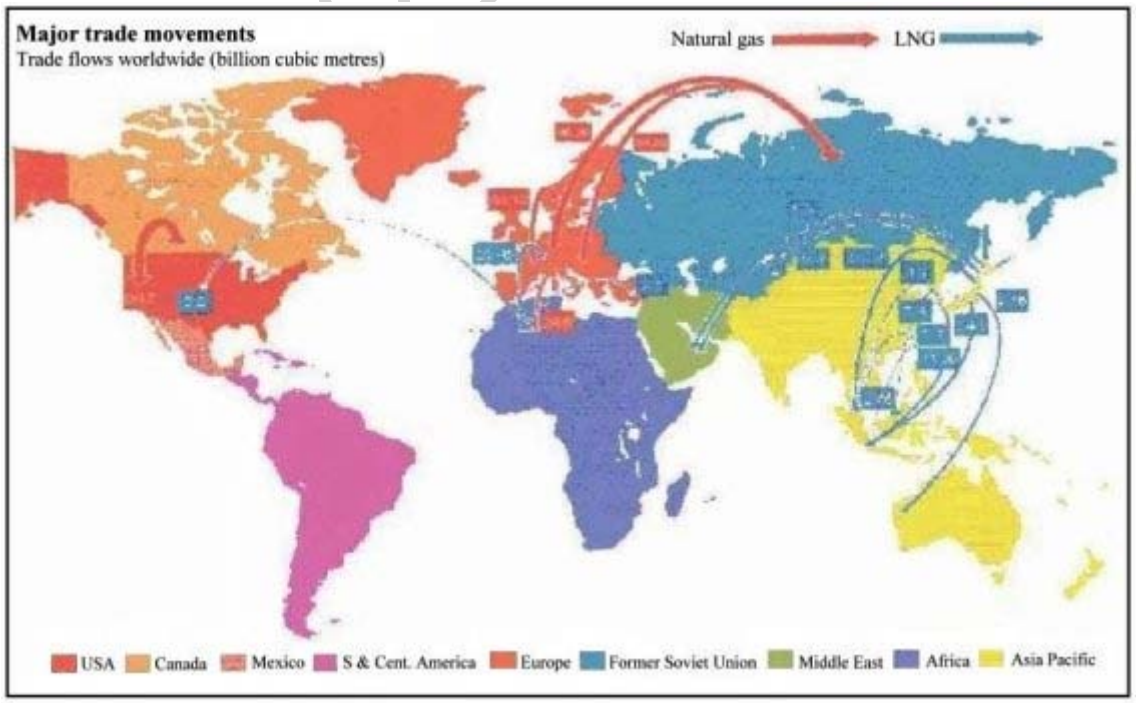

Figure 2: Major natural gas trade movements (www.bpamoco.com)

2. Storage of Gaseous Fossil Fuels

As most experts of the oil and gas industry claim the 20th century was an era of crude oil. However indications are such that natural gas market will grow much faster in the 21st century. Much of the growth is expected in the electric power generation through gas-fired processes. Therefore the need for natural gas storage with high peaking capabilities will become crucial.

The natural gas as it is produced from underground geologic formations is a mixture of light hydrocarbons from C_1-C_5 and small quantities of C_{5+}. Most of the produced natural gas at the wellhead has some impurities such as water vapor, H_2S, CO_2 or N_2. H_2S is very toxic and hazardous to health. In the presence of water vapor H_2S and CO_2 become highly corrosive and damage any steel container or equipment through which the gas flows. Produced gas is usually purified before it is fed to the pipeline.

The gas is transported under pressure in pipelines to plants where it will be used as process gas or as a source of energy. The pipelines are designed to supply a constant demand of gas or oil, which is called base load. However the demand of market fluctuates, low during summer months and high during winter. Similar daily fluctuations also exist. The storage facilities are designed to supply fuel necessary during peak periods and store fuel during low demand times (Figure 3), which will allow pipelines to operate near their design capacity despite the daily or seasonal fluctuations in demand.

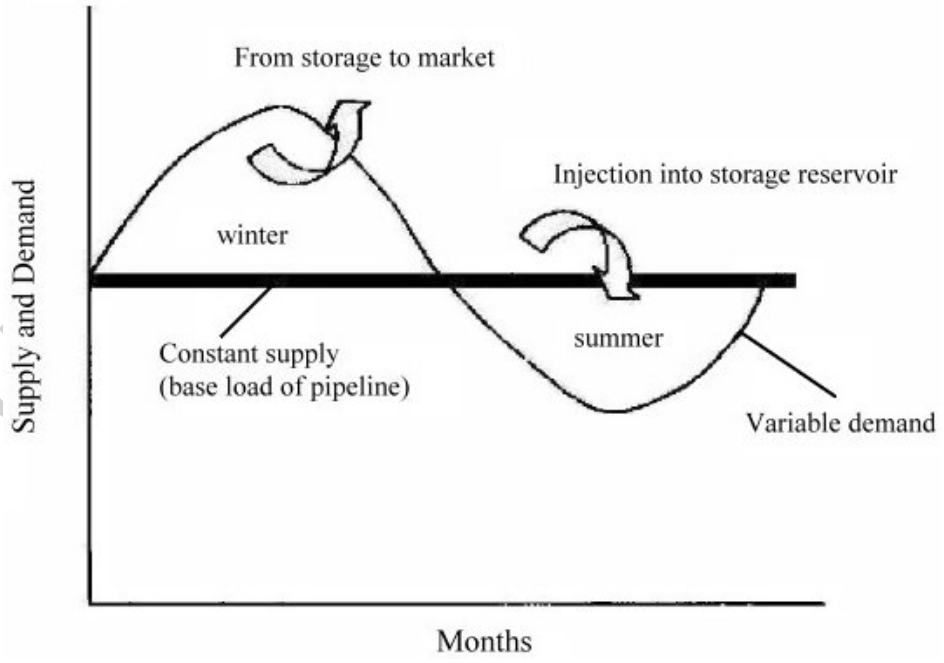

Figure 3: Supply and demand for natural gas

The gas transported by pipeline is either directly used in the market or stored in underground storage facilities. Sometimes natural gas is liquefied (Liquefied natural gas, LNG) under low temperature and ambient pressure conditions (cryogenic) and

transported to markets where it will be stored in specially built tanks under cryogenic conditions until it is used. At hubs along natural gas pipelines it is generally very convenient to have underground natural gas storage facilities. These hubs are located conveniently in locations where energy demand is variable, like near highly populated cities or industrial facilities. In underground environment gas is stored in depleted oil or gas reservoirs, in aquifers, in caverns leached in salt formations, in rock caverns, and in old mines.

Among these, storage in salt caverns and in depleted oil and gas fields had found wide application until today. There are about 550 underground gas storage facilities operating in the world 85 of which are aquifer storages, 422 are depleted gas field storages, 40 are cavern (salt and rock caverns) storages and 3 are mine storages. The stored gas makes about 25% of the worlds yearly consumption.

Underground gas storage facilities operate for planned periods of 25 to 30 years. During their operating life, inventory and deliverability of storage reservoirs become the key issues. Uncontrolled movement of gas from the storage volume decreases the amount of gas that can be produced, which directly affects the economics of the project. These three concepts namely **inventory**, **deliverability** and **containment against migration** are called performance attributes.

The inventory represents the gas present in the storage facility. It is made up two parts namely base gas also known as cushion gas and top gas known as working gas. The cushion gas, which is physically and economically unrecoverable, remains in the storage site to supply pressure necessary for production of working gas. Working gas is withdrawn and sold to market during peak demand and replenished through injection during summer or low demand period.

Deliverability is the measure of the rate at which the storage gas can be produced from and injected into the storage reservoir.The basics of gas storage in (a) for salt caverns (b) for storage reservoirs that are depleted oil or gas reservoirs or aquifers (porous media) will be discussed in this section.

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Biographical Sketch

Ender Okandan has BSc degree in petroleum engineering from Middle East Technical University and MSc and PhD degrees from Stanford University, USA with a minor in chemical engineering.

She is presently at the Middle East Technical University as the Director of Petroleum Research Center, PAL, and teaching reservoir engineering in Petroleum and Natural Gas Engineering Department. Her research interests are related to assessment of oil and gas fields and geothermal fields, enhanced recovery methods and fuel quality of diesel and gasoline products.