Fundamentals of Natural Gas

Contents

Chapter 1

The Basics

Introduction

Natural gas, called “the prince of hydrocarbons,” is the fastest growing energy source in the world. As the most flexible of all primary fossil fuels, it can be burned directly to generate power and heat, converted to diesel for transportation fuel, and chemically altered to create a plethora of useful products including liquid vehicle fuels, fertilizer, chemicals, and plastics. Best of all, it can do all of this at competitive costs and from a plentiful supply and emits considerably fewer harmful pollutants than other fuels.

Gas was not always viewed in such high regard. It was something to avoid and safely dispose of during the search for more valuable crude oil. Numerous gas reserves around the world remained unexploited because local markets were undeveloped, and limited technology made transportation to more distant markets difficult. Unlike oil and coal, natural gas cannot simply be loaded on a ship or train for transportation from its source to the consumer. Transportation of gas requires the use of expensive pipelines, which are uneconomical over large distances, or of complicated conversion systems that cool the gas into liquid form, compress the gas to higher pressures, or modify its chemical composition to allow conversion into other products. Technology advances and declining costs have finally allowed gas to economically overcome these challenges to become the fuel of the future.

Worldwide consumption of natural gas is forecast to almost double over the next 15 years.[1] The developing economies of Asia, Latin America, and Africa, which have only recently discovered the magic of natural gas, will show the highest growth rates. The greatest potential not strict enough with this definition and use the terms resource and reserve interchangeably.

The Society of Petroleum Engineers (SPE) approved a system that is a commonly accepted standard for classifying reserves as *proved*, *probable*, and *possible* (fig. 1–13).

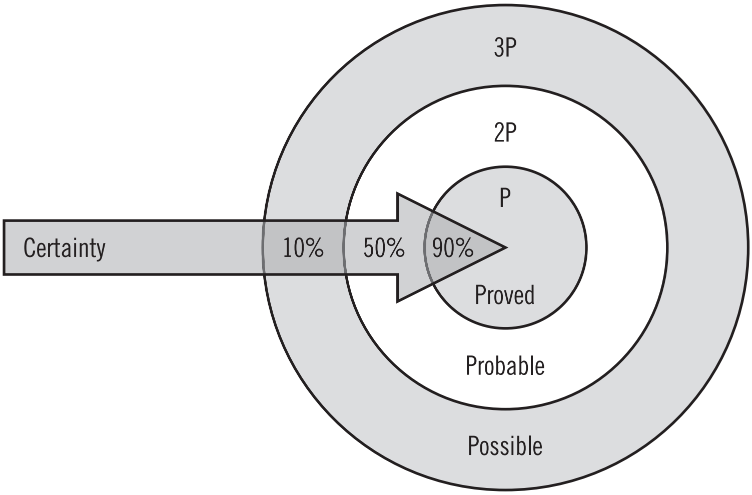

Fig. 1–13. Categories of reserves

Proved reserves are quantities of petroleum that can be estimated with reasonable certainty to be commercially recoverable from known reservoirs under current economic conditions, operating methods, and government regulations. There should be a 90% probability that the quantities actually recovered from the reservoir will equal or exceed this estimate. Generally, proved reserves have known reservoir characteristics supported by actual or specific production tests and are commercial in the current economic climate. In some instances, proved reserves are assigned on the basis of specific data, such as well logs and core analysis, and are analogous to reservoirs in the same area that are producing.

Proved reserves, also called *1P* or *P reserves*, can be further classified as developed and undeveloped. *Proved developed reserves* are expected to be produced from existing wells and infrastructure. *Proved undeveloped reserves* (PUDs) are located near an existing infrastructure, and it is reasonably certain that they will be developed in the future, requiring additional investments to ensure their production.

Australia is home to the only LNG projects based on CBM reserves. In other countries, CBM gas is typically injected into the natural gas network or is used to generate power close to fields. Supplying the three Eastern Australian CBM-to-LNG projects with current total capacity of 24 million metric tonnes annually (MTA) requires hundreds of CBM wells to be drilled every year for the life of the LNG project. Even though the wells are generally less deep and simpler to produce than conventional wells, the scale of this effort raises significant project risks. Because CBM reservoirs are not homogeneous, well designs have to be tailored to each location, and future well costs are not easy to estimate. For example, the 8-MTA GLNG project in Australia requires gas from more than 500 wells, plus a further 800 wells, drilled over 20 years to produce 5 tcf of feed gas. By contrast, a conventional LNG project of similar size, such as Pluto LNG in Western Australia, is expected to receive all its feed gas from only five or six wells, with one or two additional wells every 5–10 years.

Because of the ongoing well drilling and completion expense, CBM-to-LNG projects are more exposed to volatile LNG prices than conventional gas-based LNG projects, whose major expenses occur only in the early years of plant operation. In addition, CBM drilling results and volumes of waste water produced are not as consistent and predictable as project sponsors claim. Thus, the level and expense of the ongoing well drilling requirement is a “wildcard” that has to be absorbed in the project economics. Importantly, a large portion of the profits of most LNG projects comes from NGL (LPG and condensates) production. CBM-to-LNG projects do not get this benefit because CBM feed gas is dry.

Shale gas

Shale gas refers to natural gas reservoir contained within layers of fine grain clay and siltstone rocks commonly referred to as *shale*. Shale is the earth’s most common sedimentary rock, rich in organic carbon but characterized by relatively high porosity but ultralow permeability. Permeability refers to the ability of the rock to allow gas to flow, so gas trapped in these reservoirs is difficult, if not impossible, to produce without artificially increasing its permeability. Gas can flow via natural fractures within the rock, or else fractures must be artificially created.

As shown in figure 1–31, shale reservoirs often have permeabilities similar to those of granite rocks—the same materials used, because of

Contact with seawater in warmer climates or heated water in colder climates keeps the heat exchangers warm. Large volumes of seawater are kept flowing through the system to avoid ice buildup on the panels. If water must be heated, costs increase as 1.5%–3% of throughput energy goes to fuel the water heater system. Much as boil-off from LNG ships provides fuel for the propulsion of the ship, boil-off from the regas terminal storage tanks can be used as fuel for the vaporizers and pumps. Warm water may also be sourced from neighboring power plants, utilizing its discharged by-product, if available.

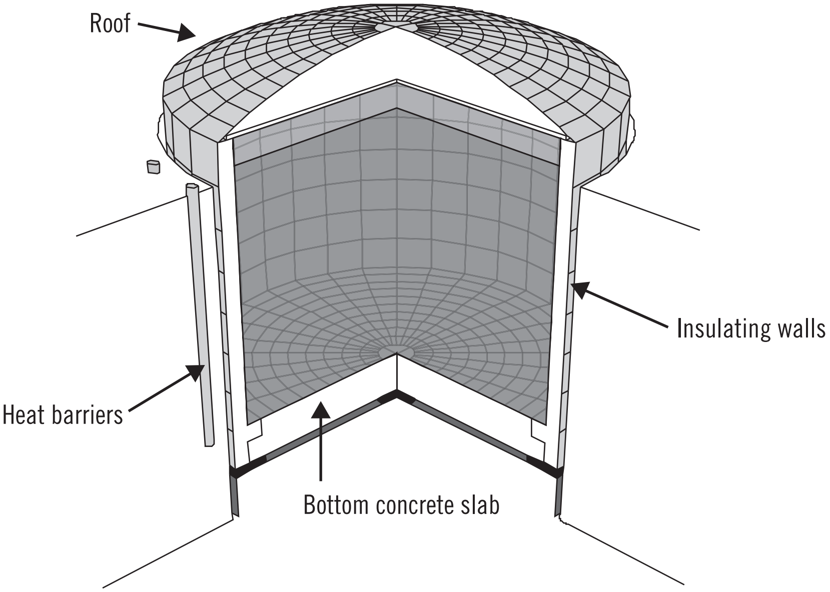

Fig. 2–14. Typical LNG storage tank

Locating regas facilities can be difficult, especially in high-density areas such as Japan and Europe. LNG regas ports require deepwater access, sufficient land to build tanks and other facilities, and connections to local gas grids. The perception, not based on facts, is that LNG facilities are polluting, will destroy real-estate values, or are safety hazards. In reality, if a leak occurred, LNG would rapidly convert to methane and rise above the immediate area. Methane derived from LNG is extremely pure, with no harmful impurities such as lead or sulfur. Additionally, if the gas did combust, it would probably not explode, because neither LNG nor the resulting methane is stored or transported under high pressure and the cold temperatures make combustion difficult.

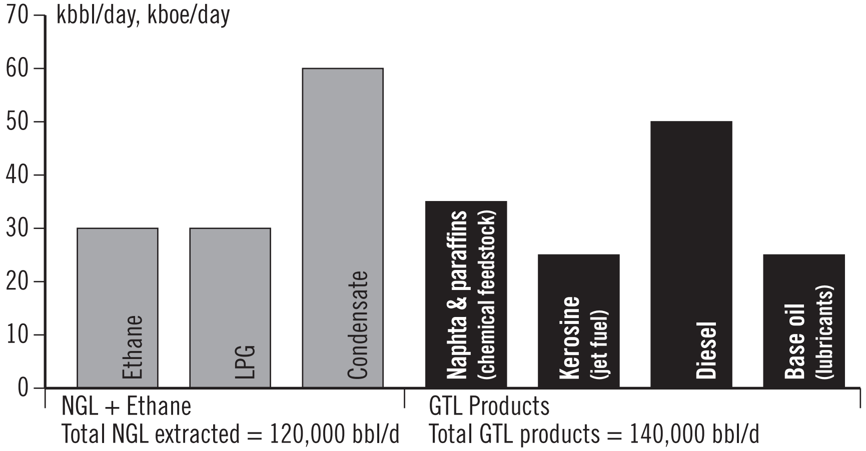

Fig. 3–7. GTL product state and end products (*Source:* Author estimates; data adapted from Pearl GTL presentation at 15th Annual Condensate and Naphtha Forum, March 2011; and comparison from S&P Global Platts, "Pearl's gas-to-liquids project rolls out, taking its cues from many world markets," July 17, 2011)

The key factor in the economics is not the size of the gas resource, but the capital and operating cost of the GTL plant and the relative price of the feed gas versus the end liquid products. Operational costs are largely a function of the input gas price, catalyst costs, and plant efficiency. GTL processes require inexpensive and plentiful gas feedstock. Ideally, gas feed costs should be low, and liquid product retail prices should be relatively high.

GTL project economics are more attractive if the project includes the entire chain, from upstream gas production through liquid sales. For a project considered as a stand-alone investment purchasing lean methane gas from an independent gas producer without gaining any benefit of NGL sales, the project economics could be marginal, and investment would be difficult to justify against the technical risks.

The future for GTL remains questionable. Long-term performance of the Qatari plants (Oryx and Pearl) will be critical for any future proposal. Technology and the prize are promising, but technical and capital overrun risks are high, with limited improvements likely in near term. Global liquid fuel markets are not willing to pay a premium for produced fuels; also, the process remains relatively energy destructive when compared to alternatives such as LNG and may have applicability only in cases where gas feedstock is very cheap or even negative (e.g.,