EXTRACTION AND DISTRIBUTION

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EXTRACTION AND DISTRIBUTION

Introduction

Natural gas is the last fossil source of energy to be used on a global scale. For over a century, when the gas was discovered in areas that were far from the places where it could be utilized, it was preferably burnt at the gas well or freed into the atmosphere, because harnessing it in a pipeline and making it travel for many kilometres was too expensive. The situation has changed over the past forty years and today natural gas ranks third in world consumption of energy and is the fossil source with the best growth prospects.

Extraction and distribution

Often, albeit not always, natural gas is extracted from the same fields as oil. Just like oil, natural gas is the result of the transformation of organic substances deposited at the bottom of ancient seas and lakes (sedimentary basins). Therefore, there is no search for natural gas distinct from that of oil, but a single research activity for hydrocarbons: only after exploration wells are drilled is it possible to ascertain the nature of the deposit. The term “associated gas” is used when natural gas is dissolved into oil or makes up the top layer of the oil field; the expression “non-associated gas” is used when the field contains almost exclusively natural gas (for example, the large field of the North Sea or the Netherlands).

Extracting natural gas from underground is quite easy. Usually, it is trapped together with oil under a rock layer. Due to the big pressure, as soon as drilling is finished, the gas comes out and it is necessary to “direct” it into a pipe and guide it towards its final destinations or storage centres. The latter are not tanks like the ones containing oil, but they are exhausted natural reserves that once contained natural gas, oil or water and that are used today as real “warehouses” for the gas.

The treatment

If the natural gas from the field is wet, it undergoes a preliminary conditioning to separate methane from the other gaseous hydrocarbons such as propane, butane and ethane. The separation is simplified by the fact that methane is marked by a much lower critical temperature (above which gas cannot be liquefied). The amount of wet gases available on the market is very large since gas extracted along with oil is always wet. After being liquefied, humid gases are bottled for household uses in 10/15 kg containers or bigger bottles for industrial purposes. Methane is distributed through the pipeline networks. Albeit rarely, the methane from some fields needs to be purified. The most damaging impurity undoubtedly is sulphur because it produces sulphur dioxide during combustion and when the weather is humid it causes acid rain, responsible for lung diseases, the deterioration of plants and anything being exposed to it. Sometimes the gas extracted contains precious substances too, such as helium, used to make airships fly and mixed with oxygen in scuba-diving bottles. Although extraction is simple and the quality of natural gas as a fossil fuel is high (also from

the environmental viewpoint), up to the second world war the use of methane was very limited.

The transport

The long-distance transport of natural gas started in 1958 when natural gas was imported from Canada into the U.S. At present natural gas is transported in the gaseous state through gas pipelines, else by means of natural gas carriers in the liquid state (Liquefied Natural Gas). Gas pipelines allow the transport of a large quantity of natural gas directly from the place of production to the place of consumption without any loading or storing operation. After the safest and more effective route is identified, a trench is dug to lay previously welded together steel pipes. To prevent any leak, each welding is x-rayed to check it is perfect. To prevent corrosion, the pipe is covered by a layer of bitumen, tar and synthetic resins and protected by means of dedicated electronic devices. Finally, the gas pipeline is buried and the landscape is restored. The presence of the gas pipeline is signaled by special signs. Every 100/200 km compression stations are installed to restore a sufficient pressure to make the natural gas move at a speed of 20-30 km/h. Gas pipeline networks also comprise storage stations where the natural gas is kept available in case of emergency. Depleted fields near the place of consumption are preferably used as deposits. Their geological features ensure maximum safety against possible leaks.

The whole of Europe is crossed by long gas pipelines that run underground. In this way the landscape is not spoilt. When resorting to gas pipelines is impossible – because the distance to be bridged is excessive or an excessively long sea route needs to be covered - natural gas is liquefied and transported by LNG carriers.

At present 25% of natural gas is transported via LNG carriers. Natural gas is liquefied at –161°C and its volume is reduced by 600 times as compared to the original natural gas. A LNG carrier on average carries 130,000 m3 of liquefied natural gas, i.e. 78 million cubic metres in the gaseous state. Transport costs are higher in the case of LNG carrier is because different transshipments are necessary. The first takes place from the field to the coast via a gas pipeline. Then the gas is liquefied and loaded onto an LNG carrier equipped with heat proof tanks. Finally, after it has been unloaded from the LNG carrier it is turned into gas and conveyed into the gas pipeline. During the maritime transport part of the natural gas evaporates and contributes to keep the temperature low, part of it is used as fuel for the LNG carrier itself.

Natural gas storage

The storage of natural gas plays an important role in regulating the supply in order to meet the great seasonal variation in demand. Consumption of natural gas is much greater in winter than in summer, while the supply of gas is relatively stable throughout the year. The excess supplies of natural gas produced or imported in the summer months are generally stored in depleted reservoirs and can be withdrawn in winter when demand is greater than supply. The storage of natural gas is implemented through an integrated infrastructure system that consists of depleted reservoirs, gas processing plants, gas compression stations and operational dispatching systems. The underground storage of gas has played and continues to play a significant role in the development and stabilization of the

gas market. Storage is called conventional when depleted or partially depleted gas production reservoirs are used, semi conventional when depleted oil reservoirs or aquifers are used and special when it takes place in caverns created in underground salt formations or in abandoned coal mines.
At present there are 10 natural gas storage fields in Italy with a total capacity of 16 billion cubic meters. In Italy, storage fields are obtained exclusively from nearly depleted gas reservoirs. This choice is a consequence of the geological characteristics of the country and of the fact that the depletion of some gas fields has provided structures that are suitable for use as storage facilities.

The distribution

From the large pipes of the national distribution network, thousands of kilometres of smaller pipes are derived to convey natural gas to industrial plants and households. In the city networks managed by the distribution firms the gas pressure is maintained at lower levels than the large transport networks for technical and safety reasons.
Before being conveyed to the distribution network, natural gas is added odour, i.e. it is mixed with a substance characterised by a strong smell called “mercaptans”. Therefore, users immediately realise if there is a leak. In indoor environments, (e.g. a room), natural gas is mixed with the air and if an igniting factor is present (a flame or a spark caused by switching on the light), it explodes. Therefore, if we come back home or walk indoor and smell a strong odour, we need to avoid switching on the lights or starting any fire. Rather, we have to open doors and windows (natural gas is not toxic) and let it be dispersed outside. For those who cannot smell odours, ad hoc devices were created to signal any leak through visual or acoustic signals. Since natural gas is lighter than the air, such devices ought to be placed near the ceiling.
Environmental impacts associated with the transportation and distribution phases are of two kinds:

- uncontrolled release of gas into the atmosphere as a result of leakage;
- loss of water and gasoline deposited at the bottom of the pipeline.

In order to prevent gas leaks, gas pipelines are monitored constantly and the pressure along the entire distribution line is controlled so that leaks can be detected promptly. It has been estimated that over a distance of 4000 km, less than 1% of the gas transported by pipelines is lost. Generally, leakages are greater in the low-pressure urban distribution networks that carry gas to the residential areas, because often the pipes are old. The substitution of old distribution networks and the use of innovative materials is the best solution to drastically reduce leaks.

The distribution of gas in Italy

In Italy, imported natural gas is introduced into the national network at **eight entry points**, where the network connects to the import pipelines (Tarvisio, Gorizia, Passo Gries, Mazara del Vallo, Gela) and at the LNG regasification terminals (Panigaglia, Cavarzere, Livorno). Natural gas imports originate from Russia and are injected into the national network at the entry point of Tarvisio and Gorizia. Natural gas produced in Italy is injected into the national network at 53 entry points from

the production facilities or from their collection and treatment plants; natural gas storage facilities are also connected to the network.
The gas distribution network reaches cities on the plains and in numerous valleys, bringing natural gas directly into the vast majority of homes. The transport of natural gas in Italy occurs at two main levels. The first, called “primary distribution”, involves transport at a national scale through large pipelines. The second level or “secondary distribution” supplies gas locally through a widespread system. Primary distribution is guaranteed by a 32,534 kilometre-long gas pipeline network that spans the whole of Italy, with the exception of Sardinia.
Secondary distribution is carried out by municipal companies, local governments or private companies. The local companies that receive natural gas at delivery points outside the cities oversee its distribution through their networks in over 5,000 municipalities, delivering natural gas to families, commercial businesses and small industries.

Environment and territory

When a gas field is depleted, the decommissioning of the production facilities follows. The activities carried out during the decommissioning phase include the safe removal of the pre-treatment plant, the platform structures, the compression structures and the hydrocarbon dispatch facilities and the removal of the wellheads and the pipelines that connect to the collection points. Following the dismantling of the production facilities, there is the environmental restoration phase. The areas where the wells and the treatment facilities were located are reclaimed and restored to pre-mining conditions, with the planting of grasses and trees. As far as the decommissioning of offshore facilities is concerned, operations to safely plug and abandon the well must be carried out and the installations and pipelines that connected the platform to treatment facilities on land must be removed. These operations are very delicate and require specialised personnel in order to avoid adverse environmental impacts. Once the installations have been removed, suitable sites must be identified for materials that cannot be reused and for the disposal of potentially polluting products. An alternative to the dismantling and removal of offshore installations envisages the reuse of disused platforms in-situ as artificial barriers, for example. In fact, it has been observed that many artificial structures placed in open water are soon colonised by benthic macrofauna and by a large number of fish species that find a suitable habitat to reproduce. Another alternative is the installation of offshore wind turbines on the disused platforms. In fact, these offshore platforms can support wind turbines with the advantage that they are far from the coast, where the winds are strong and constant, and where there they do not have a negative effect on the landscape. The option of leaving disused offshore platforms in place must be carefully evaluated from an environmental and a legislative point of view.

Impacts on air

The extreme flexibility of natural gas makes it one of the fuels easier to use, whereas the low content of pollutants makes it an environmentally friendly fuel. During combustion natural gas produces

carbon dioxide and nitrogen oxides (NOX), albeit to a lesser degree than other fuels. Moreover, coal and oil by-products also produce sulphur oxides and sulphur dioxide (SO_2), two pollutants toxic for mankind and the atmosphere. Sometimes the natural gas can be burnt with coal or oil (co-firing): this process can significantly reduce the emissions of SO_2 e NOX. Cogeneration allows to consume 25% less of energy as compared to a traditional plant and to reduce by 1% the emissions of SO_2 and by 50% NOX emissions, as compared to a coal or oil-based plant, even if it makes use of anti-pollution equipment.

As regards carbon dioxide in particular, the International Energy Agency (IEA) assessed that, if the same amount of energy is produced, carbon dioxide emissions caused by the combustion of natural gas are smaller by 25% and 40% as compared to those produced by the combustion of oil and coal by-products.

Finally, methane presents the advantage of being virtually "invisible" both during ground transport and when it is distributed in cities (it travels through underground pipes and only pumping stations are at ground level), a feature only few other energy sources share. Moreover, since it is gaseous at room temperature (20°C), should any leak occur during transport, it disperses into the air, does not dirty, or pollute waters or the soil. Natural gas can damage the environment if it is dispersed in its natural state because it is one of the greenhouse gases. In other words, after reaching the top layers of the atmosphere, it stops and stays there for many years, contributing to the formation of a gas layer that prevents the solar heat reflected by the earth's surface from being dispersed and leads to global warming (i.e. the greenhouse effect). Therefore, leaks of natural gas during its transportation should be reduced to a minimum or eliminated: not only is it a waste of a precious resource, but there is also the risk of contributing to a potentially dangerous phenomenon for mankind.

Gas flaring and gas venting

In an oil field, oil is almost always associated with a certain quantity of natural gas: newer oil wells are equipped for the recovery of both oil well gas and crude oil and hence the gas is an additional resource of the oilfield. However, the recovery of this gas presumes that there are the transportation infrastructures required to move it to the points of consumption: these infrastructures, which are both costly and often difficult to implement, are not finalised when the quantity of gas recovered from the oilfield as a "secondary" product is limited, since the potential revenue would not cover their cost. Hence the problem arises of what to do with the associated gas.

The term gas flaring indicates the combustion of gas (without energy recovery) in an open flame that burns unceasingly at the top of flare stacks in oil production sites. This practice has resulted in the burning of large quantities of gas with the consequent production of huge amounts of carbon dioxide together with sulphur dioxide and nitrous oxide, which have contributed substantially to atmospheric pollution. In order to better understand the scale of the problem, it is sufficient to observe nocturnal images of Earth from space: the gas flaring activity in regions corresponding to the major petroleum-producing areas are a proof that cannot go unnoticed! Consider that in Italy today (where the practice of gas flaring is limited not only because there are fewer oil fields respect to gas fields, but also because Italy attempts to use all the natural gas produced) one million tonnes

of carbon dioxide are produced every year as a result of gas flaring, while in Nigeria, where this practice is still greatly utilised, hundreds of millions of tonnes are produced! Besides the practice of gas flaring, there is also that of gas venting. Gas venting is the discharge of unburned gases into the atmosphere, often carried out in order to maintain safe conditions during the different phases of the treatment process. During venting operations methane, carbon dioxide, volatile organic compounds, sulphur compounds and gas impurities are released. In many cases gases that are being vented could be burnt rather than dispersed into the atmosphere; this would partially reduce the environmental impact in terms of greenhouse gases, because the gases would be oxidised to form carbon dioxide, which has a global warming potential 21 times lower than methane. Currently, the above-mentioned practices are subject to strong restrictions, both for economic (the gas produced could be sold and consumed rather than wasted!) but especially for environmental reasons. Under the Kyoto Protocol, there are incentives for the construction of plants that have minimum environmental impact and which, at the same time, do not waste precious resources. In more developed countries, this practice has been almost totally abandoned because it is a waste of an important resource and the infrastructures required to utilise the gas in situ are not difficult to implement. On the contrary, in many developing countries the gas is often not required at the production site and the costs of transportation are very high. For this reason, there are incentives to implement practices that are more feasible and less costly such as, for example, natural gas reinjection into the reservoir to increase its pressure and consequently its efficiency, small-scale natural gas liquefaction plants on the production site, the generation of electricity in situ, the distribution of natural gas to neighbouring urban areas, its use for transportation, etc. while costly operations, such as the construction of pipelines, are carried out only when the natural gas extracted justifies the high costs.

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