Outlook for Natural Gas—a Quality Fuel

Edited by
PETER HEPPLE

APPLIED SCIENCE PUBLISHERS LTD

on behalf of

THE INSTITUTE OF PETROLEUM,
GREAT BRITAIN

APPLIED SCIENCE PUBLISHERS LTD
RIPPLE ROAD, BARKING, ESSEX, ENGLAND

The symbol I.P. on this book implies that the text has been officially accepted as authoritative by the Institute of Petroleum, Great Britain

ISBN: 085334 486 8

WITH 58 ILLUSTRATIONS AND 38 TABLES

Printed in Great Britain by Adlard & Son Ltd
Bartholomew Press, Dorking, Surrey

OUTLOOK FOR NATURAL GAS—
A QUALITY FUEL

The Proceedings of the Institute of Petroleum Summer Meeting, "Natural Gas – Outlook for a Quality Fuel", held at the Palace Court Hotel, Bournemouth, 6–9 June 1972

LIST OF CONTRIBUTORS

B. BONNETT
Exploration and Production Manager, Santos Ltd, Adelaide, Australia

D. G. M. BOYD
Head, Market Research and Evaluation Division, Shell International Gas Ltd, Shell Centre, London

H. J. BUCKLEY
Engineering Manager, Imperial Continental Gas Association, 2 Devonshire Square, Bishopsgate, London

S. E. CHURCHFIELD
Group Manager, Exploration and Production, Burmah Oil Trading Ltd, London

P. F. CORBETT
Marketing Services Manager, Gas Division, International Sales Department, British Petroleum Co. Ltd, London

B. DAVEY
Manager, Process Engineering, Air Products Ltd, New Malden, Surrey

R. C. FFOOKS
Naval Architect, Conch Methane Services Ltd, London

A. F. FOX, M.B.E.
Group Chief Exploration Manager, Tricentral Ltd, London

A. I. D. FRITH
Marketing Manager, Domestic and Commercial Gas, The Gas Council, London

M. D. J. GELLARD
Head of Energy, Economies and Economics, Gross Division, Shell International Petroleum Co. Ltd, Shell Centre, London

I. A. I. GRIFFITHS
Director, Operations, Shell International Gas Ltd, Shell Centre, London

J. HAMMOND
Gas Development Manager, Corporate Developments, Burmah Oil Trading Ltd, London

W. HENDRY
Sales Manager, Air Products Ltd, New Malden, Surrey

C. HIJSZELER
Head of Gastechnological Research and Advice Department, N.V. Nederlandse Gasunie, Groningen, The Netherlands

D. H. NAPIER
Senior Lecturer, Department of Chemical Engineering and Chemical Technology, Imperial College, London

M. W. H. PEEBLES
Manager of Planning and Finance Division, Shell International Gas Ltd, Shell Centre, London
N. W. ROBERTS
Business Development Manager, CJB (Projects) Ltd, London
J. M. SOESAN
Commercial and Legal Director, Conch Methane Services Ltd, London
G. G. SPALDING
Staff Engineer, Amoco (U.K.) Exploration Company, London
M. J. STEWART
Process Engineering Department, CJB (Projects) Ltd, London
R. M. THOROGOOD
Manager, Process Technology, Air Products Ltd, New Malden, Surrey
C. TUGENDHAT, M.P.

CONTENTS

World Review of Natural Gas Sources

By CHRISTOPHER TUGENDHAT, M.P.

It is a pleasure to be invited to give the keynote address to this Summer Meeting because I have been connected with the oil industry throughout my working life. Indeed, I notice several people here whom I interviewed when I was on the staff of the *Financial Times*. I have now moved into another sphere, but I am still very interested in the oil industry as a Member of Parliament and as a director, in addition to journalism.

Since I first began writing about oil, in the early 1960s, the growth rate has been explosive and huge changes have come about. Exploration is now centred on the offshore areas; vast new oilfields are coming into production, notably in Alaska, the North Sea and Australia; and we have seen the development of OPEC.

But there has been nothing more impressive than the growth of natural gas, which bids fair to become the third important phase of the oil industry's history. The first was the discovery and utilization of oil itself; then the emphasis moved towards petrochemicals, in the development of which my own father played an important role; now we are witnessing the rise of natural gas.

As has been so often the case in the oil industry, the U.S.A. led the way, for natural gas was used widely in the States before the Second World War. By 1945 it had a 15 per cent share in the total U.S. energy market and by the 1960s this had grown to 30 per cent.

Europe lagged far behind. Soon after the war important discoveries were made in Italy and France but these were of largely local interest. It was not until the early 1960s, with the really big finds in Holland – which pointed the way to the North Sea discoveries – and Algeria, that natural gas began to make a significant impact on Europe as a whole.

The first natural gas was imported into the U.K. from Algeria in 1964, the same year that natural gas sales began in Holland. In 1971, the fuel had taken 30 per cent of the total Dutch energy market and it will probably have a 45 per cent share by 1975. Within six years it is likely that the demand for natural gas will have quintupled.

Like the oil industry, the gas industry is intensely international. In Europe there are large-scale exports of gas from Holland to neighbouring

countries and imports from North Africa will go to Spain and Italy as well as existing markets in Britain and France. There are also developments further afield, from Alaska to Japan, for instance, from Algeria to the U.S.A., and from Brunei to Japan.

But what we have had up to now is a mere *hors d'oeuvre* – the real growth is still to come. One table (Table I) is sufficient to show the scale of natural gas reserves. Between the end of 1972 and the 1980s, international movements of LNG should increase more than 20 times. At this year-end the total will be about 2 billion cu ft/day (using billion as 1000 million): by the mid 1980s it is likely to be 40 billion cu ft/day.

The object of a keynote address is to establish the framework for a conference. I have already given you some idea of the scale of the industry we are talking about. For the remainder of this address I shall try to answer the following four questions:

1. Why will the natural gas industry grow?
2. Where will natural gas be needed?
3. Where will it come from?
4. What will happen to the price?

The first question is easy to answer, for the non-Communist world is becoming increasingly worried about energy supplies. Nuclear power has not lived up to expectations – even in Japan it is estimated that it will represent no more than 13–14 per cent of the total energy market in 1985. The coal industry is declining rapidly – faster, in my opinion, than has been supposed. Oil can fill part of the gap and is growing fast, but suffers from political unreliability. Therefore, natural gas can play a vital role.

There is another reason, too, and that is the growing concern over pollution and the environment. It is notable that in my book *Oil: The Biggest Business*, written only in 1968, there is no mention of pollution and I was never criticized for this omission, whereas at this very moment in Stockholm there is taking place a large international conference on the human environment. Natural gas is the cleanest of the fossil fuels and this fact will undoubtedly become more important.

The short answer to the second question is "everywhere". The biggest buyer will be the U.S.A., for by 1980 the demand is expected to exceed the domestic supply by 25 billion cu ft/day. Tanker shipments of LNG should provide at least 5 billion cu ft/day of this.

Japan is also a very big market. The Energy Council there recently forecast the LNG imports to that country will reach 3 billion cu ft/day by 1985.

Despite the production from Holland and the North Sea, Western Europe's needs will grow. Within the next four years a billion cu ft/day will be imported and this will be doubled by the end of the decade. In addition to the existing suppliers, one can expect Russian gas to come in by pipeline.

TABLE I

Gas Reserves by Country

Figures as from 1 January 1972 (as published in *Oil and Gas Journal*, 17 April 1972)

ASIA – PACIFIC	Billion cu ft
Afghanistan	4,900
Australia	24,800
Brunei – Malaysia	7,500
Burma	100
India	1,500
Indonesia	4,500
Japan	400
New Zealand	6,000
Pakistan	19,500
Taiwan	600
Total	69,800

MIDDLE EAST	
Abu Dhabi	10,000
Bahrain	5,000
Dubai	1,000
Iran	200,000
Iraq	22,000
Israel	60
Kuwait	35,000
Neutral Zone	8,000
Oman	2,000
Qatar	8,000
Saudi Arabia	52,000
Syria	700
Turkey	170
Total	343,930

EUROPE	
Austria	550
Denmark	500
France	6,900
Germany, W.	14,000
Italy, Sicily	6,000
Netherlands	83,000
Norway	10,000
Spain	500
United Kingdom	40,000
Yugoslavia	1,800
Total	163,250

AFRICA	Billion cu ft
Algeria	106,500
Angola	1,500
Egypt	7,500
Gabon	6,500
Libya	29,500
Morocco	18
Nigeria	40,000
Tunisia	1,500
Total	193,018

WESTERN HEMISPHERE	
Argentina	7,600
Bolivia	5,000
Brazil	5,000
Chile	2,200
Colombia	2,500
Ecuador	6,000
Mexico	11,500
Peru	2,500
Trinidad, Tobago	5,000
Venezuela	25,400
U.S.A.	269,596
Canada	54,376
Total	396,672

SOVIET BLOC	
Russia	546,000
China	4,000
Hungary	3,000
Poland	5,000
Total	558,000

TOTAL WORLD	1,724,670

The U.S.S.R. will be a major force in the world natural gas market. As the table shows, it contains around 30 per cent of total gas reserves, a larger proportion than any other country. Moreover, some of its largest fields are still unexploited. Production conditions are so difficult that outside help may be needed, but nobody doubts that one way or another Russia will be a major exporter. To some extent it will also be an importer as well. It is already bringing in supplies from Iran and Afghanistan. But this is simply because the fields in those countries are more conveniently situated to supply the southern part of the Soviet Union than Russia's own fields. The imports will enable it to export much more than would otherwise be the case to the West. There is a strong possibility that some at least of the exports will go to the U.S.A., perhaps in a barter deal involving the exchange of U.S. grain for Russian gas.

As the position of Russia shows, gas reserves do not follow the same pattern as those for oil. They frequently occur in the same place, but not always. As the Groningen field and the Southern North Sea have demonstrated, natural gas may be found alone. Although the Middle East accounts for 55 per cent of the world oil reserves, the figure for gas is far less, being only around 20 per cent.

The final question, about what will happen to the price, is also capable of being given a short answer. It will go up, the real point being by how much? The rise will occur worldwide, though there will be national variations depending on the extent of government intervention and market conditions. But in an international market in which the U.S.A., Western Europe and Japan are competing for supplies, some form of international price structure is bound to emerge.

The writing, in fact, is already on the wall. The landed price in Japan of gas from Shell's Brunei field will be 48·6 U.S. cents per 1000 cu ft but in a new contract signed a few months ago the figure is believed to be 80 cents. In the U.S.A., prices at the wellhead range from 22·5 to 26 cents per 1000 cu ft but the contract delivered price at New York City is 42 cents. Import estimates range from 60 to 90 cents.

This brings me inexorably to the North Sea, where I should like to finish my talk. The Gas Council has enough reserves to support its expansion plans up to the late 1970s, but thereafter it will need more. This will be so even if it wants only to maintain the level of consumption then reached and even more so if it wishes to continue to expand.

The first place to look towards is the North Sea itself, from which supplies are at present drawn from the southern part. But more natural gas has been discovered in Norwegian waters and in the Frigg field which straddles the boundary. These finds are part of the international market. The present price paid for North Sea natural gas is just over 31·2 U.S. cents per 1000 cu ft. Although comparisons are difficult, the international trend

is clear. Prices for new North Sea gas will have to rise considerably above present levels.

Nobody likes paying more, but in my opinion it will be worth it. The U.S.A. is now paying the penalty of shortage for holding down its internal prices. If we underprice North Sea gas, this valuable commodity will not be available in sufficient quantities to meet our needs.

Historical ~~Review of~~ Some Equipment and Techniques Available to the Natural Gas Industry

By B. BONNETT, S. E. CHURCHFIELD and J. HAMMOND

(Burmah Oil Trading Ltd)

SUMMARY

This paper reviews the history of six of the technical facets of the natural gas industry that have had a major influence on its development, these being reflection seismic survey, deep drilling, offshore drilling, gas processing, pipelining, and LNG.

Some of these techniques are common to, or closely associated with, those used in the oil industry, a notable exception being the recent developments in the field of LNG. It is concluded from the past performance that the industry will meet future technical challenges given adequate economic incentive.

Seepages of natural gas have been known since earliest historical times. The Chinese are reported to have piped gas through hollow bamboos in the Shu Han dynasty, while in 1821 hollow logs were used to transport natural gas from shallow wells to light the streets of Fredonia in New York State.

Drake's well, drilled at Titusville, Pennsylvania in 1859, usually considered to be the start of the oil industry, can also be regarded as the start of the natural gas industry, since within a few years gas was being produced and piped for sale.

Up until recent times, oil has been the primary objective of exploration and all the major gas provinces throughout the world were discovered in the course of the search for oil.

The techniques of exploration for oil and for gas are identical; much natural gas is produced in association with oil, and there are many similarities in equipment and techniques between oil and gas fields.

Historically, gas has been less valuable and is less easily transportable compared with oil, and whether associated or non-associated with oil its exploitation and sale has depended upon the availability of a market and within a technically and economically feasible distance. Pipelining, therefore,

has been a critical factor in the development of the natural gas industry, and here again there is much similarity between equipment and techniques used to lay and operate oil and gas pipelines.

Recovery of natural gasoline and treatment of associated gas for pipeline use is an integral part of the operation of many oilfields, and although natural gas processing has developed independently, there are many associations with the oil production and refining industries.

In contrast to exploration, production, pipelining, and processing, the equipment and techniques used in the most recent major development in the natural gas industry – the manufacture and transportation of LNG – are largely independent of the oil industry. The recent developments in the field of manufactured gas (SNG), while potentially of great future significance in the overall energy pattern, are considered to be outside the scope of this paper.

In subsequent sections of this paper the authors have attempted to outline the history of development of some equipment and techniques which they consider are relevant to the present and future state of the natural gas industry.

The criteria leading to the selection of the subjects are:

That the reflection seismic survey as the main source of pre-drilling subsurface geological information will remain a major tool in the exploration for petroleum (including natural gas);

That the continued development of techniques for drilling to greater depths and in offshore areas has been and will be a major factor in discovering and exploiting new gas accumulations;

That processing, and particularly pipelining techniques, have been critical in establishing natural gas as a major energy source in many areas of the world;

That this position will become worldwide by the transportation of liquefied natural gas.

The authors appreciate that their choice of subjects is controversial, and due to limitations of space they are not treated in the detail their importance merits, and that many which others may correctly feel are more significant have been left out.

EXPLORATION GEOPHYSICS

The major part of reserves of petroleum to be discovered in the future will be on the continental shelves, in isolated or inaccessible onshore basins, in horizons deeper than those presently explored, and in areas where geological complexities have not been unravelled by existing exploration techniques. Geophysics and, in particular, reflection seismic surveys, will be the main pre-

drilling exploration tool used to find these reserves.

Colonel Drake located his well in a valley close to an oil seepage and in the immediately following years creekology and surface manifestation of petroleum were the primary criteria used to locate exploration and extension wells.

The relation between oil seepages and anticlines was noted by Sir William Logan of the Canadian Geological Survey as early as 1848, and T. Sterry Hunt, also of the Canadian Geological Survey, formulated the anticlinal theory of accumulation of petroleum in 1861, but the theory was not accepted at the time as the accumulations in what was then the centre of activity in Pennsylvania are controlled by stratigraphy rather than structure. I. C. White revived the theory in the 1880s and successfully used it to find gas in West Virginia, and in the next 50 years surface geological mapping to locate anticlinal features was the main scientific exploration technique.

The concept of using artificial seismic waves for subsurface exploration was presented by Robert Mallet in a paper to the Royal Irish Academy in 1846. Experimental and theoretical studies were carried out in the following 70 years, and following the boost given by developments related to location of enemy gun positions during the First World War, a patent covering the use of refraction profiling for locating subsurface formations was applied for in 1919 by the German scientist Mintrop.

German seismic refraction crews started work in Mexico in 1923 and in the Gulf Coast in 1924 where, using the fan or arc shooting techniques, they were highly successful in locating salt domes. Refraction shooting was also used successfully during the 1930s in the Middle East, where geological conditions were favourable, but elsewhere results were frequently unsatisfactory and the method was replaced by the faster and cheaper siesmic reflection technique. Currently, use of refraction shooting is largely confined to problems not susceptible to reflection shooting.

The concept of reflection shooting was developed from sonic water depth sounding techniques and the first patent covering its use for mineral exploration was applied for in the U.S.A. in 1915. The method was developed in the U.S.A. during the 1920s and its value was fully established by 1930 following several significant discoveries resulting from its use in Oklahoma; by 1937 almost 250 seismic reflection crews were in operation.

The 1930s saw a steady improvement in instrumentation and techniques, the introduction of the automatic gain control and the development of dynamic geophones being major advances. In the 1940s there were further improvements in the design of recording equipment and considerable experimentation with geophone patterns and shooting techniques. The wartime development of underwater acoustic equipment and of position locating devices led to a rapid expansion of marine seismic surveys.

There were many innovations during the 1950s, including magnetic tape recording, visual display sections, and non-dynamite energy sources, but these were all overshadowed by the introduction of the Common Depth Point (CDP)