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ANZAAS

"AUSTRALIA'S NATURAL GAS RESERVES AND FUTURE NATURAL GAS POTENTIAL"

Paper presented to the forty-seventh Congress of the Australian and New Zealand Association for the Advancement of Science.

Section 3. Geology - Oil and Gas
at: Hobart, Tasmania
11 May 1976

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ABSTRACT

Australia is in a fortunate situation as regards natural gas reserves. The latest figures published by BMR (31 December 1975) give the estimated proved plus probable recoverable reserves of natural gas in fields declared commercial as 11.5 tcf* and natural gas liquids as 0.84 x 10^9 bbls; and theoretically recoverable reserves in fields which are either geologically proved but considered uneconomic under present conditions or are awaiting further appraisal as 18.7 tcf and natural gas liquids as 0.96 x 10^9 bbls.

Based on projections of local demand (Gartland & Howard, 1974) it is evident that these reserves will last until the end of this century. It should be stressed that over half of these reserves are unfavourably located in areas remote from present local markets.

Exploration to date indicates that large discoveries onshore are unlikely and that much of the future activity will be offshore. Advances in drilling and production technology will make deeper-water prospects available for exploitation.

Australia's position beyond the year 2000 will largely depend on the amount of natural gas as yet undiscovered. Estimates of the size of these undiscovered resources can only be speculative and the various methods of estimating undiscovered resources entail unavoidable uncertainties. Because of the critical importance of energy in national resource planning, increased emphasis must be placed on evaluation and assessment of Australia's natural gas potential.

RESTRICTIONS

This review has been prepared using all the data and information available to us, including confidential company information and proprietary data. In order to preserve this confidentiality we cannot, in some places, give as full a discussion as we would like or give as accurate an appraisal as possible.

We wish to stress these constraints and limitations, and regret any inconvenience or misinterpretation that may result.

* Throughout this review tcf denotes 10^{12} standard cubic feet.

INTRODUCTION

Australia is in a more favourable position with regard to reserves of natural gas than in regard to oil reserves. Known natural gas reserves are more widespread, and are being depleted at a slower rate than oil. Substantial reserves have been located, although it is likely that all 'easy' areas have been explored.

This review summarizes Australia's known reserves as at 31 December 1975; indicates which areas in Australia are likely to contain commercially recoverable natural gas accumulations; and gives a speculation as to the amount of undiscovered natural gas resources.

DEFINITIONS

Natural gas is defined as a mixture of hydrocarbons and usually small quantities of various non-hydrocarbons existing in the gaseous phase or in solution with crude oil in natural underground reservoirs. The principal hydrocarbons in the mixture are methane, ethane, propane, and butanes. In addition, non-hydrocarbon gases such as carbon dioxide, helium, hydrogen sulphide, and nitrogen may be contained in reservoir natural gas. With respect to its form of occurrence in reservoirs natural gas may be classified as 'associated' or 'non-associated'.

Associated gas occurs as either gas-cap (which overlies and is in contact with crude oil in the reservoir) and/or in solution with crude oil in the reservoir.

Non-associated gas occurs as a free-gas phase under original conditions in a reservoir.

Natural gas liquids are those hydrocarbons in the reservoir natural gas which are separated from the natural gas as liquids, either in the reservoir through the process of retrograde condensation, or at the surface through the process of condensation, absorption, adsorption, or other methods in field separators, scrubbers, gas processing plants, and cycling plants. Generally such liquids consist of propane and heavier hydrocarbons and are commonly referred to as condensate, natural gasoline, and liquefied petroleum gases.

Australia's total natural gas resources consist of identified (reserves) and undiscovered (resources) components (Fig. 1).

McKelvey (1972) pointed out that in order to distinguish between the known and recoverable reserves and the undiscovered and the uneconomic resources, a resources classification system is required which conveys two prime elements of information:

(1) the degree of certainty about the existence of the materials, and
(2) the economic feasibility of recovering them.

Accumulations of natural gas established by good geological assurance have so far been considered as reserves by BMR rather than resources according to McKelvey's (1972) definition. Reserves are subdivided into three categories; the definitions adopted by BMR are as follows:

Proved Reserves are those established by drilling in a reservoir of known lateral extent and arbitrarily included within a radius of one mile from the well bore.

Probable Reserves are those indicated in a reservoir beyond a radius of one mile from a well but reasonably assumed to be contained within the limits of the reservoir as defined by seismic, geologic, and reservoir engineering controls.

The least certain of reserve estimates is of the 'possible' category and to our knowledge only one Australian operator includes this kind of reserve in his estimates using the following criteria:

Possible Reserves are those volumes inferred to be within the overall limit of a reservoir, known elsewhere to be hydrocarbon-bearing. This includes undrilled sections indicated by seismic control, and hydrocarbons which may be present in an untested fault block of the structure, but which are above the inferred hydrocarbon-water contact. However, other Australian operators and BMR do not favour the publishing of this speculative estimate and as far as we are concerned they may be considered to belong to undiscovered resources.

Accumulations not yet discovered are here referred to as Undiscovered Resources.

HISTORY OF GAS FIELD DISCOVERIES

Natural gas was first discovered in Australia accidentally in an artesian bore in Roma, Queensland in 1900. Significant quantities of gas were established near the Roma area in 1927 and with the drilling of Hospital Hill No. 4 in 1954. The 1960s represented a very successful period of gas exploration with the discovery of the following fields:

Adavale Basin - Gilmore;

Amadeus Basin - Mereenie and Palm Valley;

Bass Basin - Pelican;

Bonaparte Gulf Basin (onshore) - Bonaparte, Keep River;

Bowen-Surat Basins - Back Creek, Beaufort, Blyth Creek, Bony Creek, Cabawin, Duarran, Grafton Range, Hope Creek, Hospital Hill, Lamen, Lyndon Caves, Maffra, Major, Mooga, Oberina, Pickanjinnie, Pine Ridge, Pleasant Hills, Pringle Downs, Raslie, Richmond, Rolleston, Snake Creek, Sunnybank, Tarrawonga, Timbury Hills, Wallumbilla, Yanalah;

Bowen Basin - Rolleston (includes Arcturus, Glentulloch, Westgrove);

Carnarvon Basin (onshore) - Barrow Island, Pasco Island;

Cooper Basin - Daralingie, Gidgealpa, Merrimelia, Moomba, Roseneath, Toolachee;

Gippsland Basin (offshore) - Barracouta, Bream, Flounder, Golden Beach, Marlin, Snapper, Tuna, Turrum;

Perth Basin (onshore) - Dongara, Gingin, Mondarra, Yardarino;

The onshore gas discoveries in the 1970s in the Bowen-Surat Basins (Boxleigh, Euthulla, Kincora, Noorindoo, Silver Springs, Westlands;) and Cooper Basin (Big Lake, Brolga, Brumby, Burke, Della, Dullingari, Durham Downs, Epsilon, Kanowana, Moorari, Mundrangie, Strzelecki, Tirrawarra, Wolgolla;) were augmented significantly by discoveries on the Northwest Shelf of Australia, (Angel, Dockrell, Goodwyn, North Rankin, Petrel, Puffin, Rankin, Scott Reef, Sunrise, Tern, Tidepole, Troubadour and West Tryal Rocks).

Four State capitals (Melbourne, Perth, Brisbane and Adelaide) are served with natural gas and a fifth (Sydney) will be served in the near future.

RESERVES

A summary of Australia's total proved plus probable recoverable reserves as at 31 December 1975 for producing or declared commercial gas fields is given in Table 1; the theoretically recoverable reserves in fields which are geologically proved but considered uneconomic under present conditions or are awaiting further appraisal are given in Table 2.

Australia's cumulative production to 31 December 1975 was 0.82 tcf natural gas and 75.3 x 10^6 bbls natural gas liquids.

These figures indicate that Australia is in a fortunate situation as regards proven natural gas reserves which should certainly meet the forecast local demand to the end of this century (Fig. 2). However, there will be difficulties in transporting this gas and perhaps problems in maintaining a desired production rate to market centres. These problems will be discussed by the next speaker.

FUTURE POTENTIAL

Now we will consider Australia's undiscovered natural gas potential. By undiscovered resources we mean accumulations yet to be discovered either in explored or unexplored areas by current and future technological means, including zones below those already drilled in known fields.

Since 1973 and the 'oil crisis', the estimation of undiscovered petroleum resources has assumed greater importance than hitherto to the energy-deficient nations of the world. Much thought has been given to ways of making quantitative estimates of undiscovered resources and to how meaningful such estimates are. The dangers of taking these estimates too literally are evident. For example, Cook (1974) points out that estimates of ultimately recoverable crude oil in the U.S.A. that have been published over the last 10 years show the highest estimate to be 15 times the lowest. McKelvey (1972) reminds us that in assessing natural resources 'it is even difficult to estimate measured or proved reserves with a high degree of accuracy until they have been largely produced'.

In the case of crude oil and natural gas it is seldom possible to make an accurate appraisal as the accumulations are inaccessible and hidden underground. Any estimate we make, therefore, must be treated cautiously, and must be subject to periodic revision as more data become available and advances occur in petroleum technology and changes occur in the economics of the petroleum industry.

Estimates of undiscovered resources were considered at an AAPG sponsored conference at Stanford University (Haun, 1974) and also at the 1975 9th World Petroleum Congress in Tokyo. At the former conference, methods of preparing estimates were outlined by government and industry representatives. Their findings indicate that basically there are two ways of estimating undiscovered resources: one, by geologic analogy and extrapolation and two, by a statistical study of exploitation rates of producing areas. In basins where there has been little or no production, such as in the majority of Australian basins, only the former method is practicable. This method includes volumetric calculations, basin classifications, and statistical techniques, which are each very dependent on geological factors which determine the incidence of petroleum. Weeks (1974) listed thirty such factors that should be considered when evaluating the potential of an area. The sum total of these factors have a major influence on the resource estimate.

The conclusions adopted by the conference were fivefold:

(i) Definitions or terms should be classified.

(ii) The basis for estimates should be made public.

(iii) Assessment methods should be flexible - no single method is applicable to all provinces.

(iv) More than one method of assessment should be used for all areas so that the reliability can be enhanced and the reasonableness of estimates can be tested.

(v) Estimates should be stated as ranges of probability.

With these difficulties in mind, we will first give a qualitative evaluation of Australia's gas potential, highlighting the most prospective provinces. The last fifteen years have seen extensive exploration in Australia both onshore and offshore, and sufficient data have been accumulated to allow predictions as to the more prospective gas-bearing regions. There seems little doubt that much of the future activity will be offshore and with the advances in drilling and production technology deeper-water prospects will be available for exploitation.

We will now discuss the onshore basins, offshore title areas, and deeper-water areas separately.

Onshore basins

Exploration onshore indicates that, with a few exceptions, the tectonic setting or sedimentary section are unfavourable for the generation and entrapment of hydrocarbons. Generally the age and stability of the Australian craton tends to downgrade the potential of the onshore basins.

It must be conceded, however, that many of the onshore test wells were sited on poor-quality seismic data and may have been drilled offstructure. Further exploration, using high-effort modern seismic techniques, may reveal prospective structures at depth.

The more prospective onshore basins have been extensively drilled and only small gas deposits have been located. Worldwide experience has shown that large deposits are found early in the exploration history of sedimentary basins, and it seems unlikely that any 'giant' fields remain undiscovered (Johnstone, 1975). However, there is little doubt that small discoveries will be made. In areas of high drilling density where the presence of hydrocarbons has been established, such as parts of the Cooper, Surat, Bowen, and Perth basins, stratigraphic trap possibilities are likely to assume increasing importance. Gas accumulations in the Amadeus Basin could prove to be significant, but further evaluation is needed. Smaller shows of gas in the onshore Bonaparte Gulf Basin and the Adavale Basin demonstrate that these basins have some potential. Prospects for gas discoveries exist in the Pedirka Basin, especially the southeastern portion (Simpson Desert Sub-basin), which shows several similarities to the Cooper Basin.

Older basins, such as the Ngalia, Georgina, and Galilee, which have not been extensively explored and are known to have prospective sediments, require further exploration.

Exploration in basins other than those mentioned has failed to give much encouragement, although, because of the low density of drilling, not all can be totally discounted at present.

Offshore title areas

The following comments do not apply to the offshore title areas in Queensland where evaluation has been suspended by the Commonwealth moratorium on exploration on the Great Barrier Reef. Otherwise, offshore exploration has been extensive using modern techniques, and most basins have been tested. In the usual pattern, major successes came early in the exploration history: in the Gippsland Basin the first four wells were discoveries and in the Dampier Sub-basin the sixth well drilled was the discovery well. Drilling has evaluated most of the large structures and one major oil and gas province (Gippsland Basin) and one major gas province (northern Carnarvon Basin) have been located.

About 75% of Australia's declared commercial reserves and estimated recoverable reserves of natural gas lie on the continental shelf.

The early optimism concerning the hydrocarbon potential of the offshore title areas has given place to a less optimistic assessment as is evidenced by industry's renewal of only 25% of the available acreage rather than the allowable 50%. While we appreciate that this figure may reflect influences other than geological, it may well provide a yardstick for assessing the prospectivity of the offshore title areas.

From our studies of the offshore title areas it is apparent that the Gippsland, northern Carnarvon, Browse, and Bonaparte Gulf Basins offer the best prospects for future discoveries. In the Gippsland Basin the future potential will be within intra-Latrobe Group fault-traps within the Palaeocene and Late Cretaceous, which are difficult to map seismically; there are also possibilities for stratigraphic traps along the updip margins of the basin and within the Latrobe Group; and prospects are likely in the deeper-water areas.

On the Northwest Shelf some large less-accessible (deeper-water and geographically remote) prospects remain undrilled. These will need to contain large accumulations to make them economically viable under present conditions.

The offshore Perth Basin, although disappointing to date, still has prospects for discoveries. Future activity is likely to be concentrated in the northern portion, especially in the Abrolhos Sub-basin, where prospective sediments and structural leads are known.

Exploration in the basins of the Great Australian Bight has produced only negative results. Remaining prospects are confined to deep water at the southern limits of the title areas.

Minor gas shows have been encountered in the Otway Basin and non-commercial discoveries have been made in the Bass Basin. Although the largest structures have been drilled, both basins still have some potential.

Deeper-water areas

Reconnaissance marine geophysical surveys have revealed the presence in deep water of marginal basins containing thick sedimentary sequences and major tectonic features. Water depths exceed 800 m and are beyond the reach of present production techniques. Further exploration and development will be expensive and difficult, and only major fields, and possibly only oil fields, will be of economic interest. In the absence of any significant drilling the hydrocarbon potential of these environments is speculative.

Gas associated with coal

Another source of natural gas not often mentioned is gas occluded in coal. This is a menace in mines and is a cause of explosions. It is already being recovered in some European and U.S.A. mines where it is drained from the coal beds in advance of mining, thus improving mine safety. As far as we are aware these resources have not been evaluated in Australia.

In view of our vast coal reserves, a substantial volume of gas awaits exploitation and in any discussion on gas potential it should not be discounted. These resources could prove to be significant in relation to the markets adjacent to our eastern Australian coalfields.

UNDISCOVERED RESOURCES

We have already stressed the difficulties in estimating undiscovered resources of natural gas and we feel that such estimates must be treated with caution. Because of the much lower degree of accuracy attached to estimates of undiscovered resources compared with estimates of reserves, we would prefer to use a word such as 'speculation' for undiscovered resources as this carries an implicit note of caution.

In attempting a speculation as to Australia's undiscovered natural gas resources we have been influenced mainly by geological rather than economic and political factors which are outside the scope of this review. However, we recognize that all three must be favourable if these resources are ever to be exploited.

We have looked at the various methods of quantitatively assessing undiscovered resources and consider that the method of basin classification, evaluation, and analysis used by the Geological Survey of Canada (McCrossan & Porter, 1973) is best suited to Australia with resource speculations given in a probabilistic form. The framework for this study is being established in the Bureau of Mineral Resources. The results of this work will make it possible to give a responsible speculation of Australia's undiscovered natural gas resources.

As a preliminary speculation, based partly on our studies of the prospectivity of petroleum exploration title areas and on world 'estimates' (Adams and Kirkby, 1975), we suggest that the total ultimate recoverable gas resources of onshore and offshore Australia to the limits of the present petroleum exploration title areas will range from a minimum of 2 to a maximum of 3 times (60-90 tcf) our present estimated identified natural gas reserves.

We expect that the larger discoveries will be made in the offshore areas and that while further discoveries are likely in onshore basins these will not contribute significantly to the total.

CONCLUSIONS AND RECOMMENDATIONS

Australia is in a favourable position with regard to natural gas; reserves have already been proven to meet the forecast local demand until the end of the century. From that time on, presently undiscovered resources will assume a critical importance.

As little has been published on estimates of Australia's natural gas resources there is a need for a continuing review by government and industry geoscientists to provide the most reliable basis possible for planning, decision-making, and formulating policy guidelines on undiscovered resources. The first responsibility for such a group would be to standardize definitions used in resource assessments.

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ESTIMATES OF THE RECOVERABLE, PROVED PLUS PROBABLE NATURAL GAS AND NATURAL GAS LIQUID RESERVES IN AUSTRALIA (AS AT 31.12.75)

(After BMR Petroleum Newsletter No. 64)

TABLE 1 - FIELDS DECLARED COMMERCIAL

BASIN AND FIELDS	NATURAL GAS (10^{12} ft^3)	CONDENSATE (10^6 bbl)	LPG (10^6 bbl)
BOWEN-SURAT			
Roma area gas fields	0.0695	0.1	-
GIPPSLAND			
Barracouta, Halibut, Kingfish, Marlin, Tuna, Snapper, Mackerel	7.4565	167.0	411.0
COOPER			
Gidgealpa, Merrimelia, Moomba, Daralingie, Roseneath, Tirrawarra, Toolachee, Della, Strzelecki, Mudrangie, Moorari, Fly Lake, Big Lake, Epsilon, Brumby, Brolga, Burke, Dullingari, Durham Downs, Wolgolla	3.3146	39.5	223.7
PERTH			
Dongara, Mondarra, Yardarino, Gingin	0.4580	0.5	-
CARNARVON			
Barrow Island	0.2169	1.9	1.5
TOTAL	11.5155 ($326.08 \times 10^9 m^3$)	209.0 ($33.30 \times 10^6 m^3$)	636.2 ($101.21 \times 10^6 m^3$)

TABLE 2 - FIELDS WHICH ARE EITHER GEOLOGICALLY PROVED, BUT CONSIDERED UNECONOMIC UNDER PRESENT CONDITIONS OR ARE AWAITING FURTHER APPRAISAL
(After BMR Petroleum Newsletter No. 64)

BASIN AND FIELDS	NATURAL GAS (10^{12} ft^3)	CONDENSATE (10^6 bbl)	LPG (10^6 bbl)
BOWEN-SURAT			
Rolleston area, Major, Kincora, Boxleigh, Silver Springs, Noorindoo, Cabawin & Roma area gas fields not in production	0.0996	1.2	-
ADAVALE			
Gilmore	0.0204	-	-
GIPPSLAND			
Bream, Cobia, Flounder, Golden Beach, Turrum	1.2965	28.5	47.5
CARNARVON AND BONAPARTE GULF			
Angel, Dockrell, Eaglehawk, Egret, Goodwyn, North Rankin, Pasco Island, Rankin, Tidepole, West Tryal Rocks, Sunrise, Troubadour	15.9027	434.2	411.7
AMADEUS			
Palm Valley, Mereenie	1.3680	10.0	25.1
TOTAL	18.6872 ($529.16 \times 10^9 m^3$)	473.9 ($75.35 \times 10^6 m^3$)	484.3 ($77.00 \times 10^6 m^3$)

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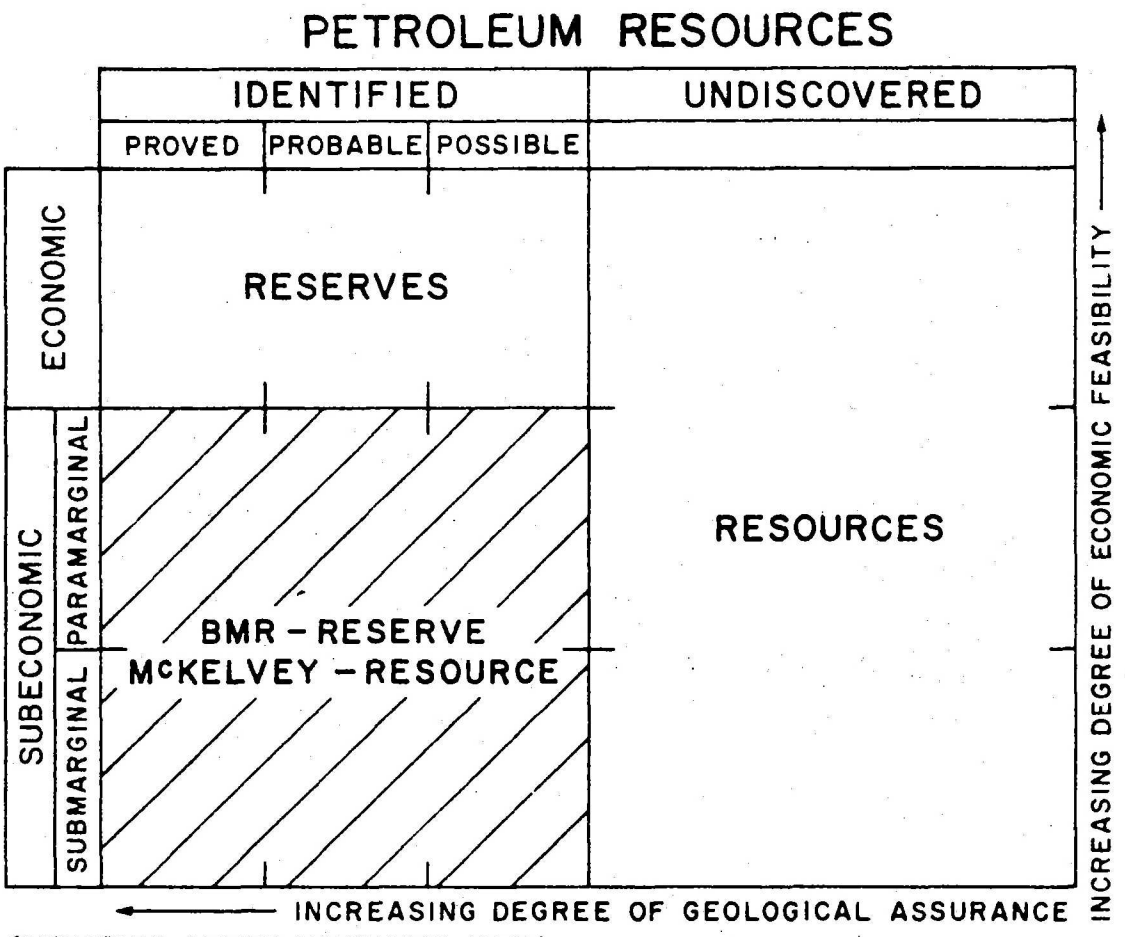
FIGURE 1



(MODIFIED AFTER McKELVEY, 1972)

FIGURE 2